Boundary Hydroelectric Project (FERC No. 2144)

Study No. 9
Fish Distribution, Timing, and Abundance Study

Interim Report

Prepared for
Seattle City Light

Prepared by
Eddie Cupp
Terrapin Environmental
and
Paul Grutter, Dana Schmidt, and Larry Hildebrand
Golder Associates, Inc.
(under contract to Tetra Tech)

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1 INTRODUCTION

Fishery resources in the Boundary Project (Project) area consist of native and introduced salmonids, native non-game species, and introduced warm water sport fish.

Relicensing participants (RPs) have expressed concern about the use of Boundary Reservoir by native salmonids including bull trout, westslope cutthroat trout, and mountain whitefish. During summer months, the water temperature of the Pend Oreille River upstream of Boundary Dam (i.e., Boundary Reservoir) is at the upper limit for trout, which means that during these months native salmonids may congregate in cold water refugia such as the mouths of tributary streams. When temperatures decline, native salmonids may redistribute throughout the reservoir, but little information is available on fish distribution in Boundary Reservoir during the late fall, winter, and early spring.

Bull trout is a native salmonid that has rarely been observed in Boundary Reservoir or its tributaries; however, the species is listed as threatened under the Endangered Species Act (ESA), and the potential recovery of bull trout is a concern of RPs. Available information specific to the distribution and abundance of native salmonids (Andonaegui 2003; USFS 2006a; R2 Resource Consultants, Inc. 1998; Terrapin Environmental 2000 and 2007; Cascades Environmental Services 1996; McLellan and O'Connor 2001; TERA Corporation 1982; RL&L Environmental Services Ltd. and Taylor & Associates 2001) suggests that bull trout are rare in Boundary Reservoir and are rare or not present in accessible tributaries. Westslope cutthroat trout and mountain whitefish are other native salmonids occurring in the Project that, although not listed under the ESA, are a concern of RPs. Cutthroat trout and mountain whitefish have been more frequently observed in Boundary Reservoir and its tributaries compared to bull trout (McLellan and O'Connor 2001; R2 Resource Consultants, Inc. 1998; USFS 2006a; Terrapin Environmental 2007).

Boundary Reservoir also supports smallmouth bass, largemouth bass, and other warm water sport fish (McLellan and O'Connor 2001; R2 Resource Consultants, Inc. 1998; USFS 2006a; Terrapin Environmental 2007) that typically spawn and rear in shallow littoral habitats. Other non-native salmonids inhabiting the reservoir include lake trout, brown trout, rainbow trout and brook trout. It is unclear how the non-native salmonids and other sport fish species interact with native salmonids. Understanding seasonal habitat use of the variety of fish inhabiting Boundary Reservoir will be important to evaluating the effects of operations scenarios.

Mainstem Pend Oreille River habitats in the Project area are affected by flow fluctuations associated with natural stream runoff, storage and release of water from upstream and downstream water control projects, and Boundary Project load-following operations. Existing Project operations cause daily changes in water depths and velocities in the Boundary Reservoir and the Project tailrace (Tailrace Reach), and affect the frequency of inundation and dewatering of littoral zone habitats. These changes to aquatic habitats can affect the growth and reproduction of fish and other aquatic organisms (Wright and Szluha 1980). An understanding of the timing, distribution, and abundance of native and non-native fish species that inhabit Boundary Reservoir and the Tailrace Reach habitats is needed to support an evaluation of the effects of existing Project operations and operations scenarios. Biological information such as seasonal movements of native salmonids and the magnitude and periodicity of fish movements can aid discussions regarding need for, and opportunities for protection, mitigation and enhancement (PME) measures.

Study No. 9, Fish Distribution, Timing, and Abundance, is being conducted in support of the relicensing of the Boundary Hydroelectric Project, Federal Energy Regulatory Commission (FERC) No. 2144, as identified in the Revised Study Plan (RSP; SCL 2007a) submitted by Seattle City Light (SCL) on February 14, 2007, and approved by the FERC in its Study Plan Determination letter dated March 15, 2007. This is the draft interim report for the 2007 Study 9 efforts completed through September (Biotelemetry) and October (Passive and Active Sampling) 2007. This study is designed to provide baseline biological information and supporting information for Study 7, Mainstem Aquatic Habitat Modeling; Study 8, Sediment Transport and Tributary Delta Habitats; Study 12, Fish Entrainment and Connectivity; and Study 13, Recreational Fishery, as it relates to tagging and capture of stocked triploid trout. Aquatic habitat modeling (Studies 7 and 8) requires information on the distribution and periodicity of different life stages for the fish species of interest. Study 12, Fish Entrainment, needs information on distribution, depth orientation, and local and seasonal abundance to help assess entrainment at the Boundary Dam intakes and spillways. Study 13, Recreational Fishery, needs information on distribution, movement, and abundance of stocked triploid rainbow trout. Not all life stages of the target fish species may be present in Boundary Reservoir; the details will be examined in the current studies.

Study 9 provides key life history information for fish species in Boundary Reservoir using two sampling approaches. The first sampling approach, designated as Passive and Active Sampling, uses a variety of passive (e.g., fyke nets) and active (e.g., electrofishing) fish capture methods to identify the seasonal changes in the distribution and abundance of fish at a variety of locations in Boundary Reservoir and downstream of Boundary Dam. The second sampling approach, designated Biotelemetry, uses biotelemetry to monitor the movements and habitat use of tagged fish.

The Passive and Active Sampling component is designed to investigate the spatial and temporal distribution of fish in Boundary Reservoir and the Tailrace Reach and assess potential movements into and out of Boundary Reservoir tributaries. This study component also provides baseline biological information and supporting information for the studies noted above. Fish to be tagged and tracked under the Biotelemetry component of Study 9 and the larger, carry-over stocked rainbow trout in the Triploid Trout Biotelemetry component of Study 13 are being captured and tagged under the Passive and Active Sampling component of Study 9.

Both the Passive and Active Sampling and Biotelemetry methods collect behavioral, habitat use, periodicity, and Habitat Suitability Index (HSI) data information for native salmonids in Boundary Reservoir and the Tailrace Reach. Under the Biotelemetry component, HSI data were recorded for tagged native salmonid species (bull trout, westslope cutthroat trout, and mountain whitefish), and smallmouth bass. Use of tributaries as cold water refugia by tagged salmonid species was also assessed. This assessment included identifying use of cold water habitat that occur during warmer summer months at the confluence of the Pend Oreille River and select cold-water tributaries and detection of upstream movement of tagged fish from the reservoir into these tributaries.

Due to the low density of native salmonids, particularly bull trout and westslope cutthroat trout in Boundary Reservoir, capture or observation methods such as electrofishing, gill netting, angling, traps, weirs, or snorkeling/scuba may not collect or observe sufficient numbers of fish to draw conclusions concerning their use of reservoir habitats. In contrast to other methods, biotelemetry collects a relatively large amount of information on relatively few individuals.

2 STUDY OBJECTIVES

The goal of this study is to fill data gaps in the existing information regarding the abundance, distribution, and periodicity of fish in Boundary Reservoir; provide insights into effects of existing Project operations on fish behavior; and to provide additional information to aid discussions regarding the feasibility and need for habitat connectivity for native salmonids at the Project.

The objectives of this study are as follows:

1. Determine seasonal changes in the distribution and relative abundance of native salmonids, non-native salmonids and non-salmonids, particularly important sport fish species, in Boundary Reservoir.
2. Determine seasonal changes in the distribution and relative abundance of native salmonids and the magnitude and periodicity of upstream and downstream adfluvial fish migration behavior in selected tributaries to Boundary Reservoir.
3. Determine seasonal changes in the distribution and relative abundance of native salmonids in the Tailrace Reach.
4. Identify movements of target fish species (i.e., bull trout, westslope cutthroat trout, and mountain whitefish) in Boundary Reservoir and the Boundary Tailrace Reach.
5. Evaluate the effects of existing Project operations on hourly, daily, weekly, monthly and seasonal native salmonid movements in the Boundary Reservoir and the Boundary Tailrace Reach through Passive and Active Sampling and fixed station and intensive biotelemetry.

6. Obtain information on habitat-use characteristics of target fish species to support validation of Habitat Suitability Curves (HSC) and HSI[1] using site-specific data (see HSC/HSI-fish component of the Mainstem Aquatic Habitat Modeling Study, Study No. 7).
7. Collect tissue samples to identify the genetic signature of any bull trout or cutthroat trout captured in Boundary Reservoir or Tailrace Reach.

3 STUDY AREA

The study area encompasses all of Boundary Reservoir from Box Canyon Dam downstream to the tailrace of Boundary Dam and a portion of upper Seven Mile Reservoir that could potentially be affected by operations scenarios. The study area was divided into four reaches (Figure 3.0-1). The four reaches are:

- Upper Reservoir Reach — Box Canyon Dam downstream to Metaline Falls (Project river mile [PRM] 34.5 to PRM 26.8)
- Canyon Reach — Metaline Falls to downstream end of Z-Canyon (PRM 26.8 to PRM 18.0)
- Forebay Reach — downstream end of Z-Canyon to Boundary Dam (PRM 18.0 to PRM 17.0)
- Tailrace Reach — Boundary Dam to Redbird Creek, British Columbia (PRM 17.0 to PRM 13.9)

In addition to the four mainstem reaches, the lower reaches of tributaries draining to Boundary Reservoir are also being monitored to determine the size, species and timing of fish potentially moving between the tributaries and Boundary Reservoir. Through discussion with RPs during a March 22, 2007 Fish and Aquatics Workgroup meeting, Sullivan Creek, Slate Creek, Sweet Creek were identified as the primary tributary streams for fyke net and snorkel sampling. Flume Creek had been identified as a study stream in the RSP, but the use of a fyke net at Flume Creek was dropped at the suggestion of RPs during the March 22, 2007 meeting.

[1] The abbreviation HSI is used in this document to refer to either Habitat Suitability Index (HSI) models or Habitat Suitability Curves (HSC), depending on the context. HSI models provide a quantitative relationship between numerous environmental variables and habitat suitability. An HSI model describes how well each habitat variable individually and collectively meets the habitat requirements of the target species and lifestage, under the structure of Habitat Evaluation Procedures (USFWS 1980). Alternatively, HSC are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC describes the instream suitability of habitat variables related only to stream hydraulics and channel structure. Both HSC and HSI models are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). Both models and habitat index curves are hypotheses of species-habitat relationships and are intended to provide indicators of habitat change, not to directly quantify or predict the abundance of target organisms. For the Boundary Project aquatic habitat studies, HSC (i.e., depth, velocity and substrate/cover) and HSI (i.e., light availability, duration of inundation and dewatering) models will be integrated to analyze the effects of alternate operational scenarios.

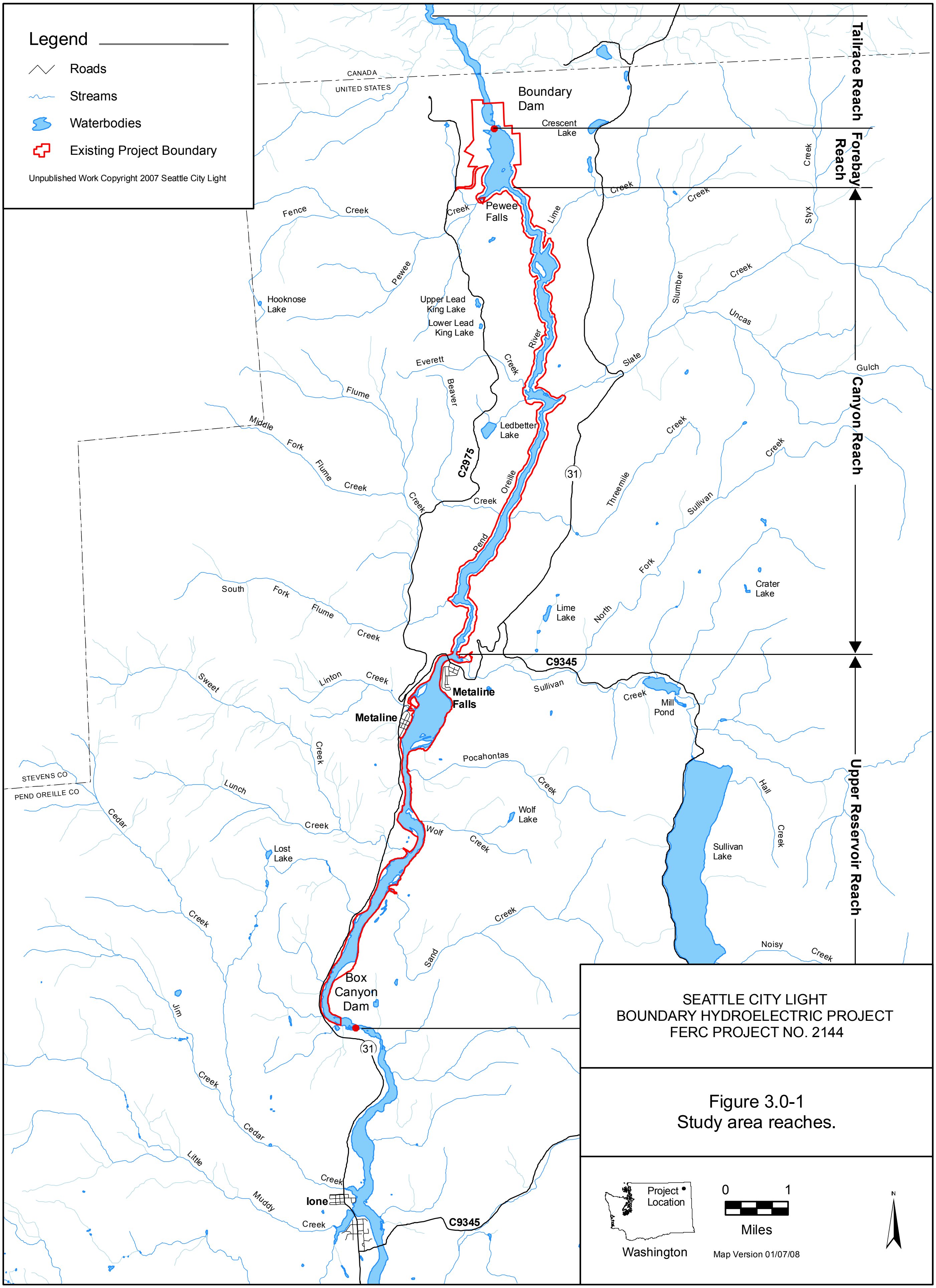

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Figure 3.0-1
Study area reaches.

4 METHODS

4.1. Passive and Active Sampling

The RSP (SCL 2007a) outlined five different sampling methods to be conducted monthly at more than 60 sample locations: gillnetting, electrofishing, fyke net trapping, snorkeling, and angling. A combination of these methods, comprising 11 individual tasks, was used to sample fish in the Tailrace Reach, Boundary Reservoir, and the lower reaches of selected tributaries to the reservoir. This section describes in detail the task methods and provides a basis for their use.

4.1.1. Sample Design

The basic challenge of a sampling design is to ensure that varied fish population characteristics of interest can be determined with accuracy through partial sampling of those populations. The sampling area for this study encompasses all regions and habitats that fish populations of interest may use within the reservoir and nearby adjoining aquatic habitats.

A stratified sampling design was used to characterize relative fish use across the range of available habitats. Major strata were identified using bathymetric maps, aerial photos, and site reconnaissance and defined primarily by reservoir reach (Upper Reservoir, Canyon, Forebay, Tailrace [see Figure 3.0-1]) and water depth (shallow, moderate, deep). Consistent with the RSP (SCL 2007a), within each major stratum, sample sites were selected to characterize relative fish densities across the range of available habitats.

4.1.2. Habitat Mapping

To allow for sampling gear limitations, sample sites in shallow water were selected to encompass a range of conditions including varied nearshore slope (steep, moderate, or shallow), dominant substrate types (bedrock/boulder, large/small cobble, small cobble/gravel, or sand/fines), macrophyte conditions (abundant, scattered and localized, or absent), and proximity to tributary deltas. Consequently, sampling sites were selected to be representative of different shoreline characteristics observed on aerial photos and during site reconnaissance. During low-pool events during September 2007, nearshore slope profiles, substrate types, and cover conditions were verified along all electrofishing sample sites situated along shorelines.

4.1.3. Field Sampling Techniques

Eleven tasks comprising a variety of fish capture techniques were conducted for the Passive and Active Sampling component. Each task is described below.

4.1.3.1. Reservoir Gill Net Sampling

Gill nets were deployed in the reservoir at 15 study sites, approximately once per month from February through October 2007. Study site locations were selected to represent the range of water depths found within each reach that are too deep for electrofishing. Five sample sites were established in each of the Upper Reservoir, Canyon, and Forebay reaches (Figure 4.1-1).

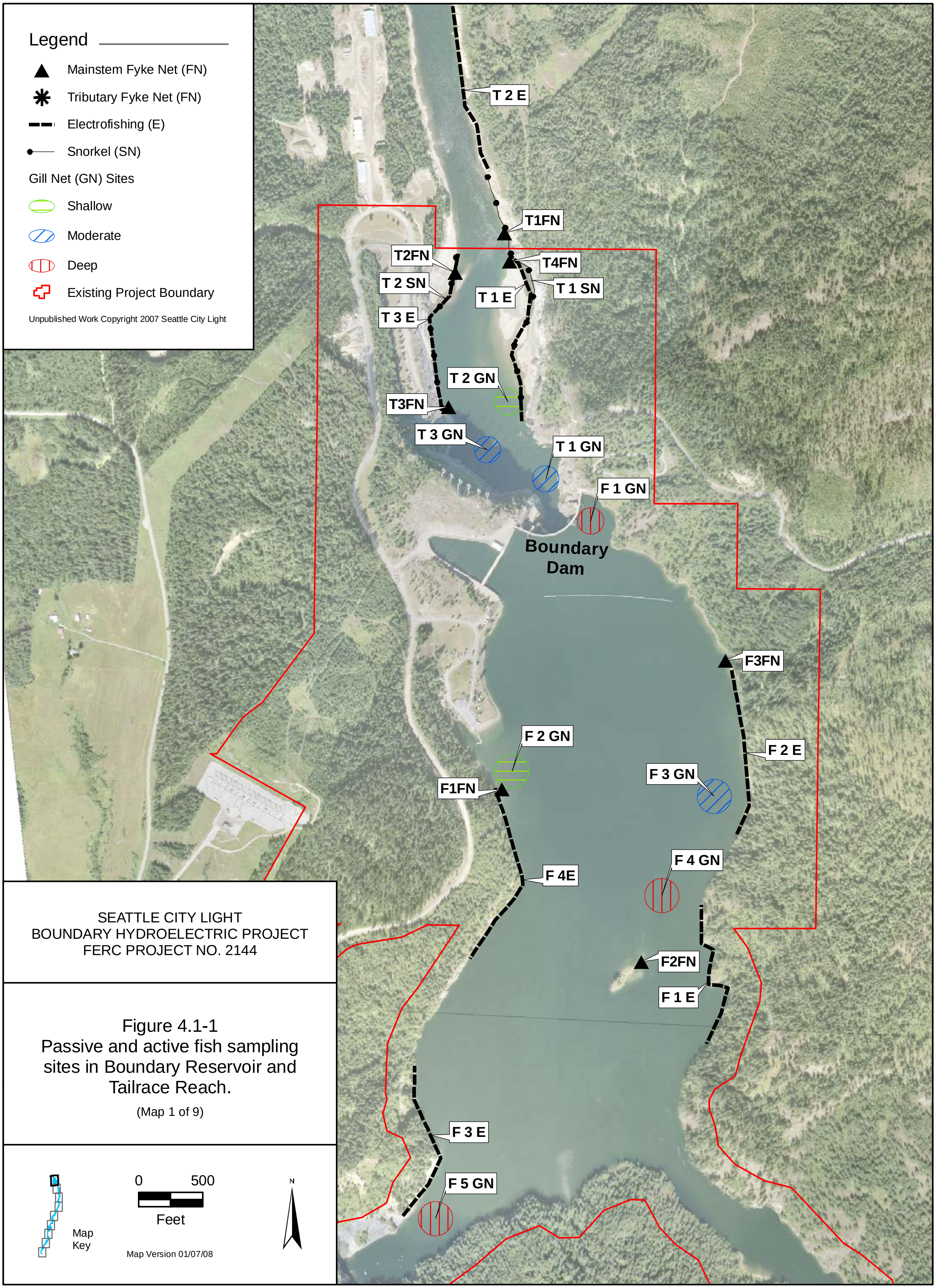

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Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 1 of 9)

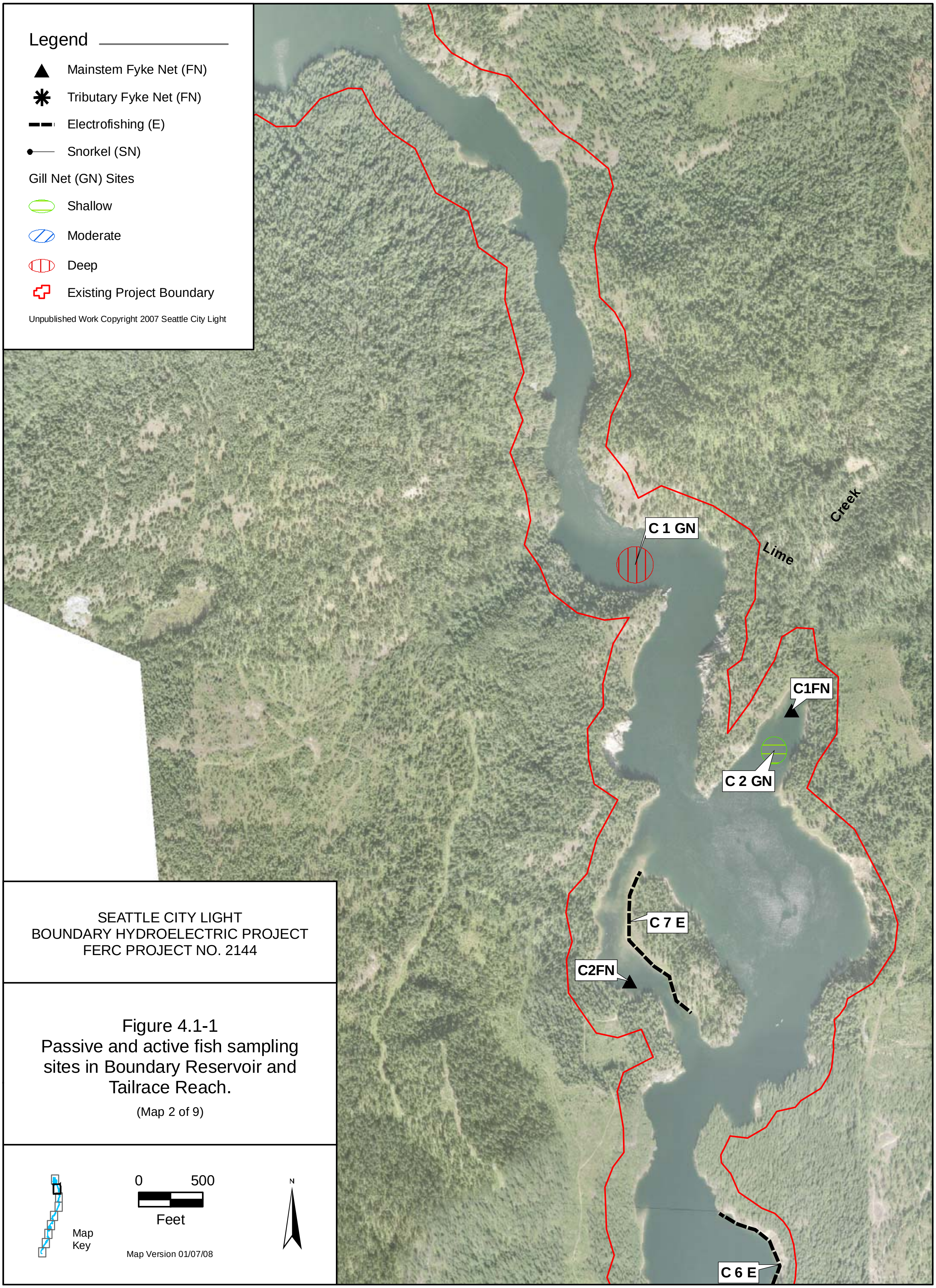

Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 2 of 9)

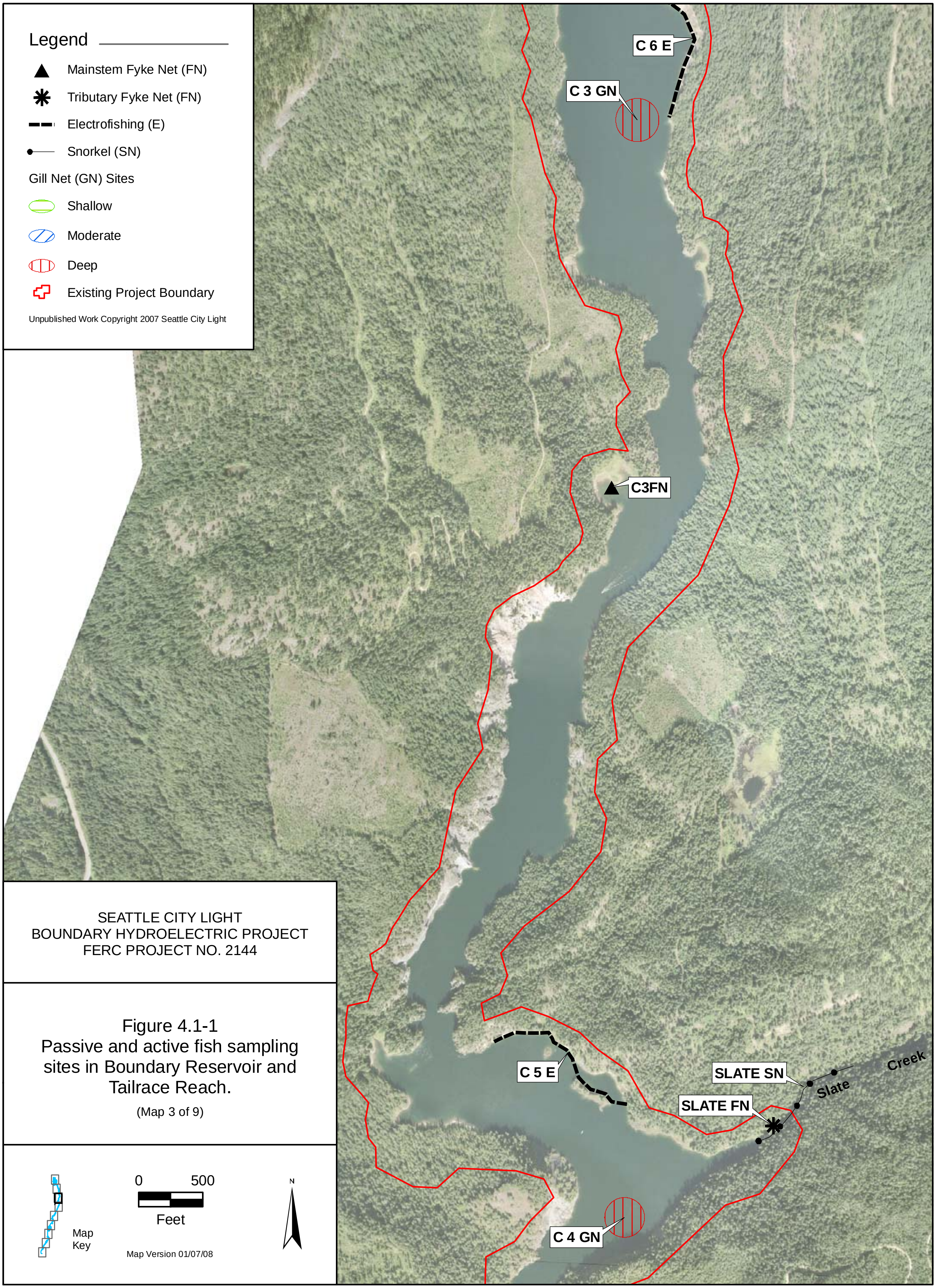

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Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 3 of 9)

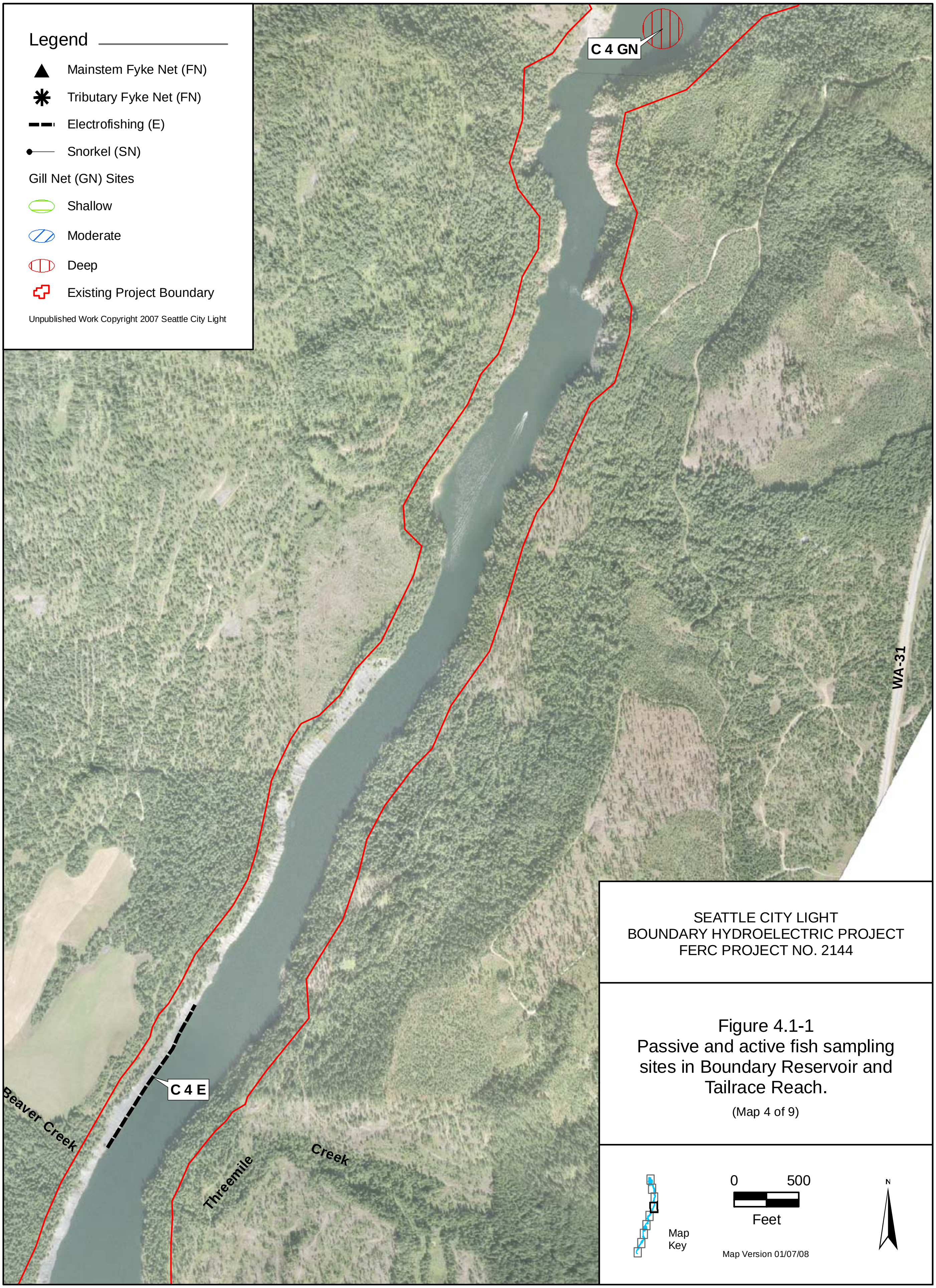
Legend
Mainstem Fyke Net (FN)
Tributary Fyke Net (FN)
Electrofishing (E)
Snorkel (SN)
Gill Net (GN) Sites
Shallow
Moderate
Deep
Existing Project Boundary
Unpublished Work Copyright 2007 Seattle City Light
C 4 GN
WA-31
C 4 E
Beaver Creek
Threemile
Creek
SEATTLE CITY LIGHT
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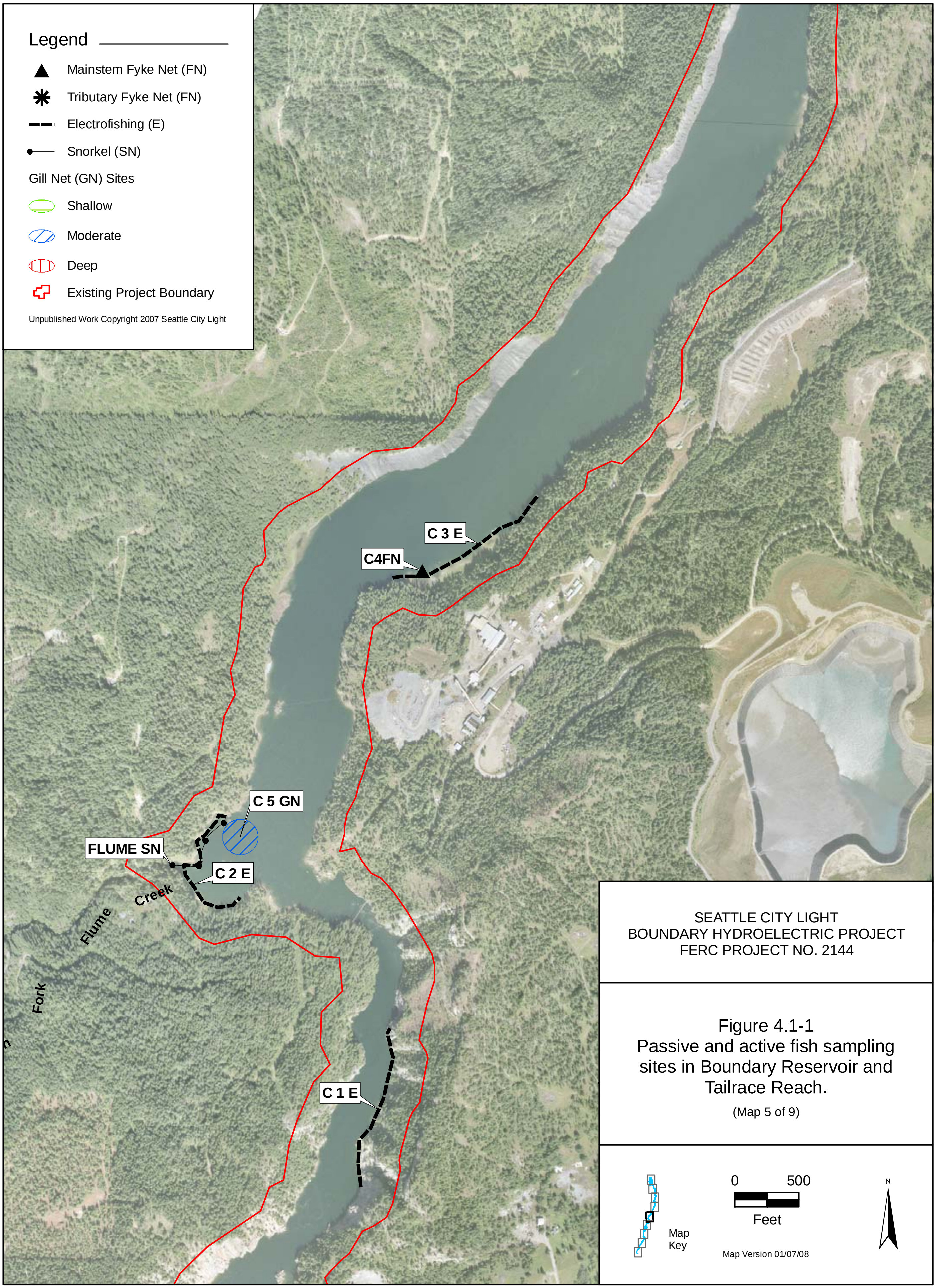
Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 4 of 9)
Map Key
0
500
Feet
Map Version 01/07/08
N



Legend
Mainstem Fyke Net (FN)
Tributary Fyke Net (FN)
Electrofishing (E)
Snorkel (SN)
Gill Net (GN) Sites
Shallow
Moderate
Deep
Existing Project Boundary
Unpublished Work Copyright 2007 Seattle City Light
C 3 E
C4FN
C 5 GN
FLUME SN
C 2 E
Creek
Flume
Fork
C 1 E
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 5 of 9)
Map Key
0
500
Feet
Map Version 01/07/08
N

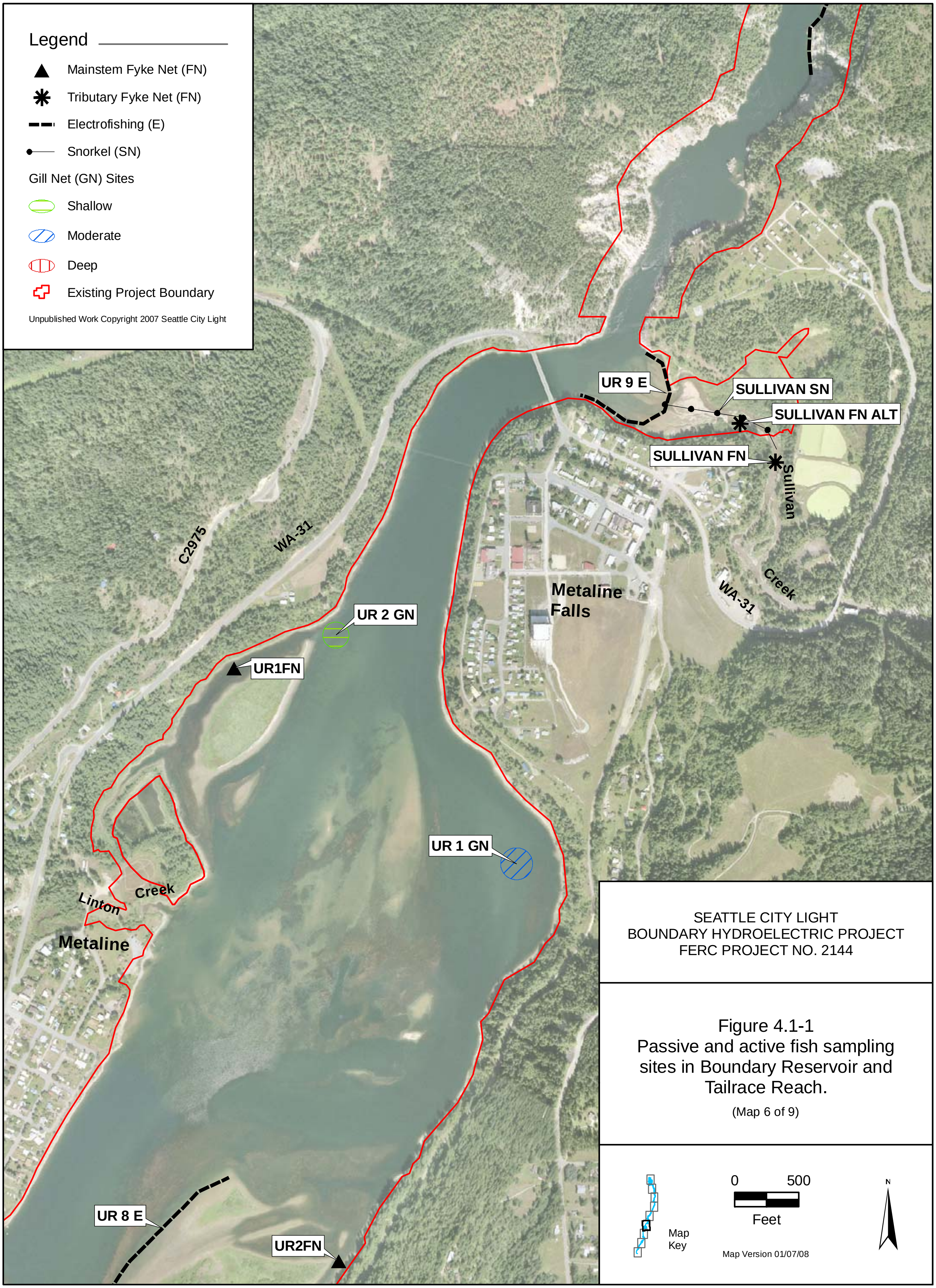


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Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 6 of 9)

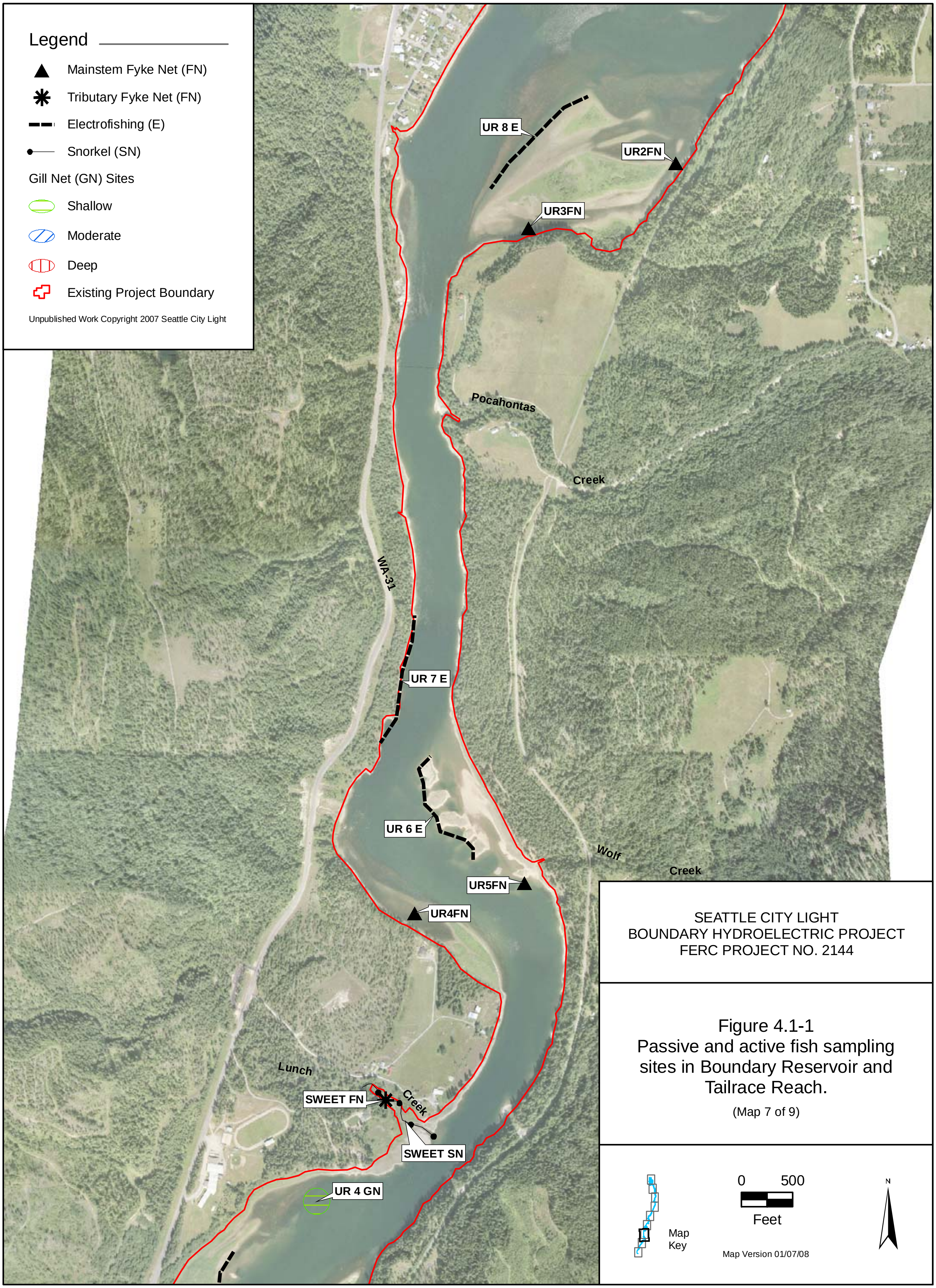

Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 7 of 9)

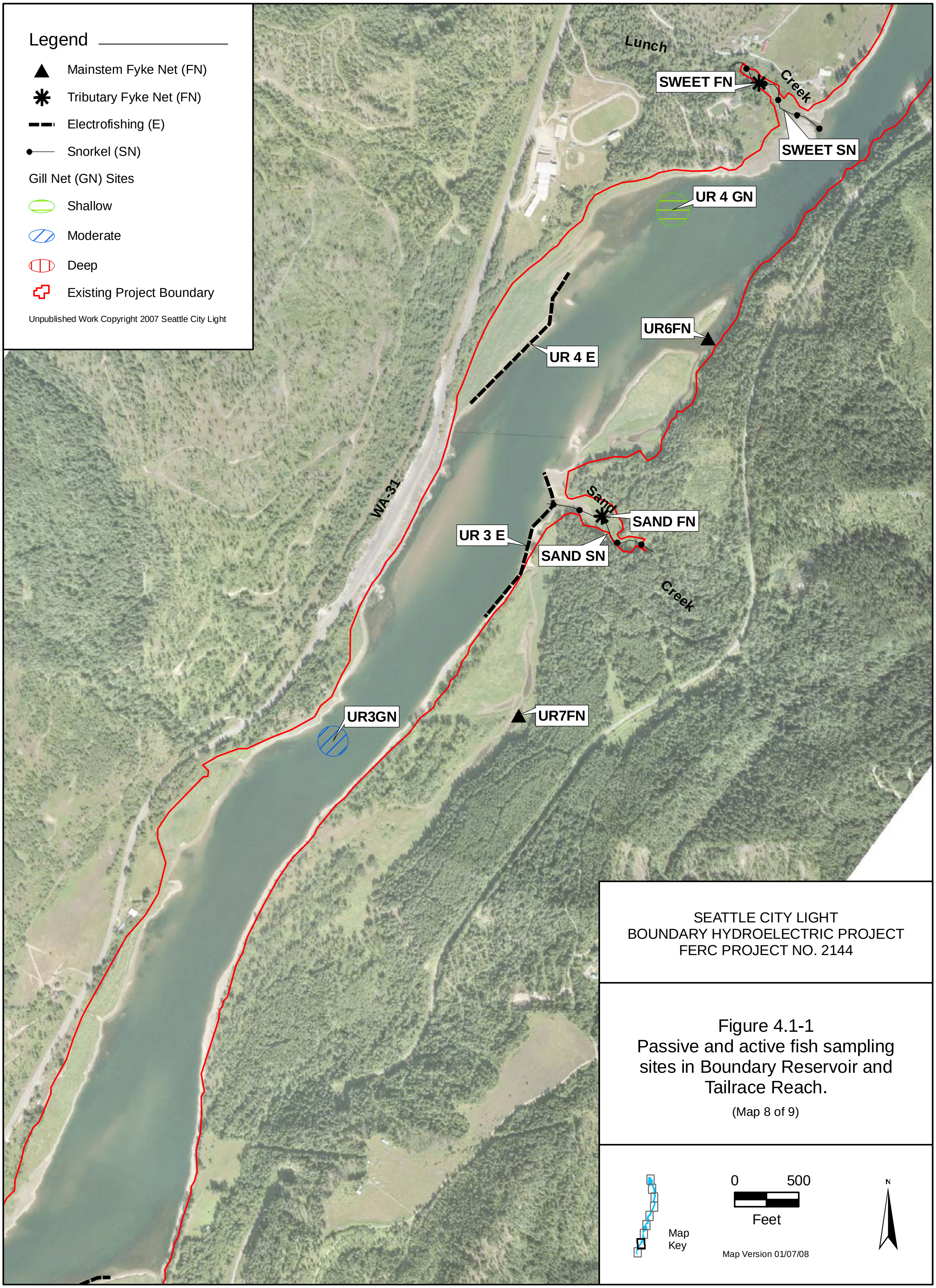

Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 8 of 9)

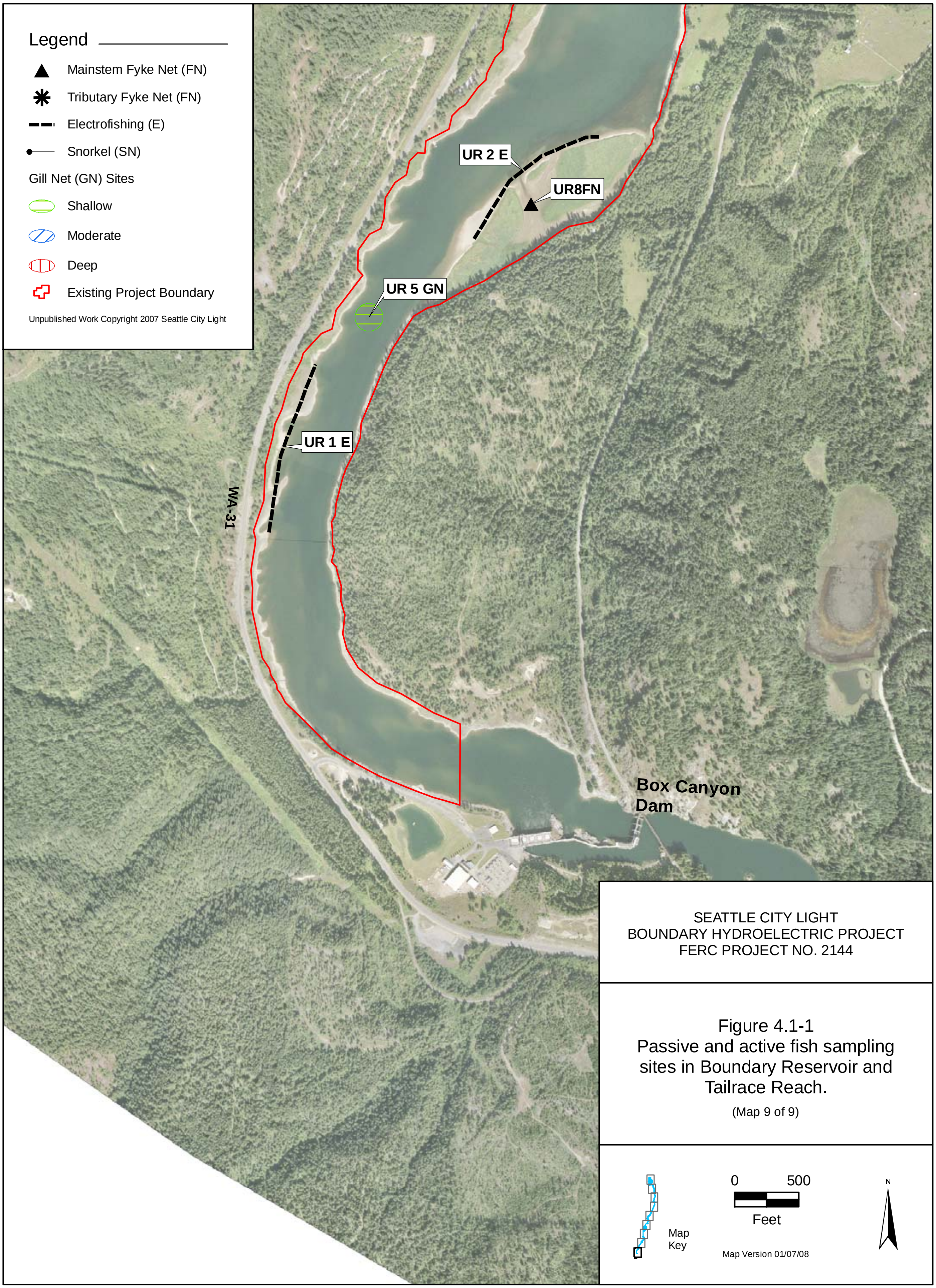

Figure 4.1-1
Passive and active fish sampling sites in Boundary Reservoir and Tailrace Reach.
(Map 9 of 9)

The Upper Reservoir Reach includes three shallow water (less than 30 feet deep) sites and two moderate depth (30 to 80 feet deep) sites. The Canyon and Forebay reaches each include three deep water (greater than 80 feet deep) sites, one moderate depth site (30 to 80 feet deep), and one shallow water site (less than 30 feet deep).

Although the location of each gill net set was standardized to the extent practicable, set locations varied slightly with changing reservoir inflow. For example, to reduce excessive net movements, sets were moved closer to shore during periods of high inflow to take advantage of velocity shelters. Variations in monthly deployment locations were tracked using handheld Global Positioning System (GPS) units. These locations were marked on high-resolution aerial photographs.

Shallow water sites were sampled using single gill nets placed horizontally. At sites with moderate water depths (greater than 30 feet but less than 80 feet deep), sampling included use of paired horizontal sets, with one net deployed at the surface and one net deployed near the bottom. Deep water sites (greater than 80 feet deep) were sampled using four separate single gill nets deployed vertically, each with a different mesh size, in the upper 100 feet of the water column. In addition, a horizontal gill net was placed near the channel bottom at each vertical gill net site.

Extra sampling (at least two locations per sampling period) was conducted near tributary mouths with horizontal gill nets. These nets were deployed in an effort to obtain additional target species for telemetry studies and to augment information on possible use of tributary delta areas by bull trout, westslope cutthroat trout, and mountain whitefish.

The length, number of panels, and mesh of the monofilament gill nets used to sample mainstem reservoir habitats were consistent with nets used by the Washington Department of Fish and Wildlife (WDFW) to sample the reservoir in 2000 (McLellan and O’Connor 2001). The following describes the two types:

- Horizontal gill nets used during regular sampling were multi-mesh and 200 feet long, consisting of four 50-foot by 8-foot (0.5-, 1.0-, 1.5-, and 2.0-inch square mesh) panels. Horizontal sets near the shoreline were placed perpendicular to the shore with the smallest mesh closest to the shore.
- Vertical gill nets were single mesh and 100 feet long by 8 feet wide. Each set included deployment of four vertical nets of different mesh sizes (e.g., 0.5-, 1.0-, 1.5-, and 2.0-inch square mesh).

During their 2000 sampling efforts, WDFW researchers intentionally avoided sampling near tributary deltas to avoid injuring or killing native salmonids (McLellan and O’Connor 2001). Since one of the objectives of the Study 9 fish sampling efforts was to capture native salmonids for subsequent radio-tagging, gill net size and set times were modified to minimize fish mortalities while increasing the opportunity to capture native salmonids. Horizontal gill nets used at the tributary deltas were the same mesh as regular sampling nets, except they were 100 feet in length and 6 feet in depth with individual panels 25 feet in length.

All gill net sampling occurred between approximately 1 hour prior to sunset and approximately 2 hours after sunrise. In coordination with RPs (see March 22, 2007 fish and aquatic workgroup summary), gill net sampling protocols were developed to extend sampling intervals where native salmonids were not expected, but reduce the duration of net deployment where the risk of injury to native salmonids was high (Table 4.1-1).

Table 4.1-1. Gill net sampling duration by location.

Deployment Location	Water Temperature (ºC) [1]	Gill Net Set Interval (hr)			
		0.5	1.0	4.0	10.0[2]
Tailrace	> 16	X			
Tailrace	14 – 16		X		
Tailrace	< 14				X
Reservoir: near tributary mouths	> 16	X			
Reservoir: near tributary mouths	14 – 16		X		
Reservoir: near tributary mouths	< 14			X	
Reservoir: open water	> 16				X
Reservoir: open water	14 – 16				X
Reservoir: open water	< 14				X

Notes:
1 Water temperatures are based on surface measurements taken at mainstem mid-channel prior to net deployment.
2 The gill net set times are reduced if bull trout or native trout mortalities are observed.

4.1.3.2. Tailrace Gill Net Sampling

Gill nets were deployed in the Boundary Dam Tailrace Reach (Figure 4.1-1) once per month from April through November. The Tailrace Reach is characterized by moderate to deep pools (exceeding 75 feet) in the spillway and turbine afterbays, but is generally less than 25 feet deep elsewhere. Variable mesh gill nets were deployed horizontally in the pool at the base of the spillway, within the turbine outfall pool, and at one site upstream of the first hydraulic control below the tailrace. Sample sites in water exceeding a depth of 50 feet consisted of paired net sets, with one net set at the surface and one net set in mid-water (30 to 50 feet deep). Gill nets deployed in the spillway and turbine afterbay were suspended at least 20 feet from the channel bottom and at least 30 feet away from the base of the dam to avoid entanglement with protruding rebar and construction debris. The location of each gill net set was mapped using handheld GPS units and marked on high-resolution aerial photographs. The gill net set duration followed the protocol in Table 4.1-1. The length, number of panels, and mesh of the horizontal gill nets were the same as the 200-foot-long horizontal nets described above for the reservoir sampling.

4.1.3.3. Reservoir Electrofishing

Two types of electrofishing sampling were performed, as described below.

4.1.3.3.1. Regular Sampling

Boat-mounted electrofishing surveys were conducted monthly using standardized transects within the Upper Reservoir (eight transects), Canyon (seven transects), and Forebay (four transects) reaches of Boundary Reservoir (Figure 4.1-1). Transects were sampled moving downstream to effectively capture stunned fish as they drift downstream with the current. Transects 1,300 feet long were located to represent the range of nearshore habitat conditions occurring throughout the reservoir that were observable from aerial photos and site reconnaissance.

Sampling crews created bottom profile, substrate, and cover type maps for each electrofishing transect to determine habitat conditions associated with captured fish. Initial site visits included identifying and mapping the transects, marking the transects along the shoreline, and affixing permanent arbitrary benchmarks from which to measure water surface elevations during each electrofishing visit. Habitat maps of each transect were finalized during periods of extended low pool elevation events to more accurately reflect substrate characteristics at varying pool levels. Electrofishing was conducted monthly (weather conditions permitting) to evaluate temporal changes in species catch. Water surface elevation was determined relative to the local benchmark by one crew member standing at the water’s edge with a stadia rod and illuminating the stadia with a 100,000 candle power spotlight and one using a hand level from the local benchmark. Absolute water elevation during the sampling will later be determined by measuring the true elevation of each of the arbitrary benchmarks.

4.1.3.3.2. HSC/HSI Validation Sampling

Habitat-use characteristics of target fish species were examined to support validation of HSC/HSI curves used for the Mainstem Aquatic Habitat Modeling Study (SCL 2007b). Habitat availability and fish habitat use data were collected from three to four “point” samples near each electrofishing transect during each monthly survey (Figure 4.1-2). Point sampling locations occur within 660 feet (200 meters) upstream and/or downstream of the 1,300-foot (400-meter) electrofishing transects. A 660-foot (200-meter) segment was added to the upstream and downstream end of each electrofishing transect, and each of these 660-foot (200-meter) segments was divided into 10 “cells” 66 feet (20 meters) in length. Width of the 66-foot (20-meter) cells (distance from bank to outer edge of cell), like the electrofishing transects, varied depending on the steepness of the bottom slope. Widths were narrow along steep slopes, but wider along shallow banks with gradual slopes. The 66-foot (20-meter) cell boundaries were marked along the banks for identification during nocturnal sampling surveys and were programmed as waypoints within boat-mounted GPS units.

During each monthly survey, two cells were randomly selected without replacement during each monthly survey from each of the 660-foot (200-meter) segments below and above each of the sampling transects. One, two, or three point samples (depending upon cell slope) were taken within each selected cell, for sample sizes of two to six point samples per study site per visit (i.e., one point each at steep banks, and 2 to 3 points each at moderate and low gradient banks). The samples from multiple point cells were staggered within the selected cells to ensure that electrofishing at one point sample did not displace or disturb fish prior to electrofishing at the next point (Figure 4.1-2).

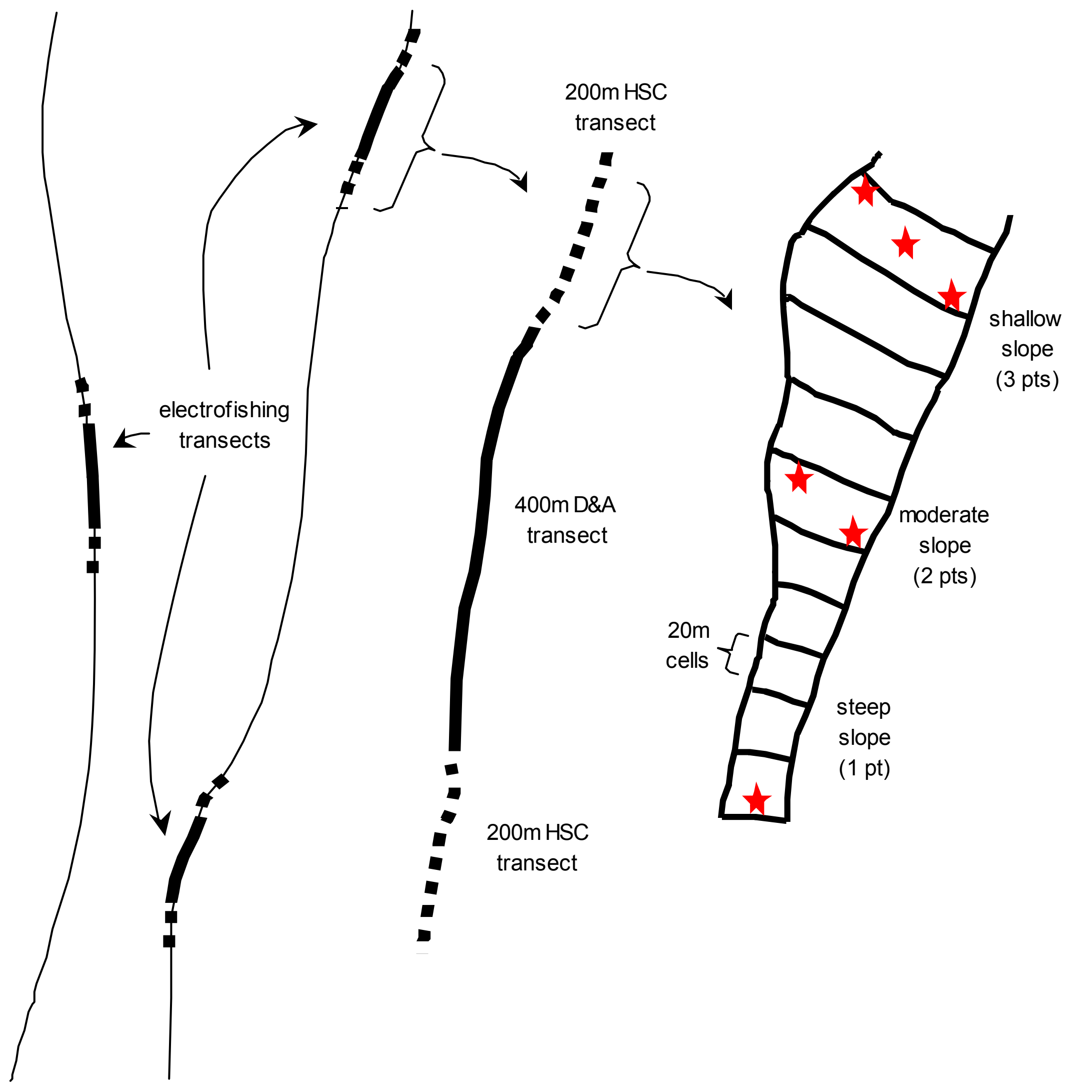

Figure 4.1-2. Illustration of HSC/HSI sample cell location relative to the electrofishing transect**.**

NOTE: D&A transect identifies the electrofishing distribution and abundance transect. The stars represent individual sample points where measurements are taken.

HSC/HSI point samples were approached slowly from downstream and, after energizing the electrofisher, observed target fish were netted and identified to species and measured for total length and weight. A GPS reading was taken at each point sample so that geographical information system (GIS) analyses can be used to determine habitat characteristics at that point, based on the detailed habitat map (for substrate and cover) and known water surface elevation (for depth and distance to bank). Mean water column velocity was measured following electrofishing at each point sample. Proximity to prominent surface velocity shear, if present, was also recorded at each sample point. If a target fish was observed to be drawn to the boat from a distance well away from the point location, habitat data were collected from the estimated initial location of the fish. If a school of target species was observed to occupy a large area surrounding the point sample, a mean habitat value was calculated from multiple habitat measurements in the area occupied by the school. Non-target species observed and/or captured during point sampling were noted as present, but were not measured.

Additionally, depth, velocity, substrate, and cover measurements were made at each regular transect to help characterize habitat availability at the time of sampling. Five regularly spaced points along each of the 1,300-foot electrofishing transects were measured for depth and velocity (mean column) during each monthly sampling trip.

4.1.3.4. Tailrace Electrofishing

A boat-mounted electrofisher was used to sample three 1,300-foot transects monthly within the tailrace area between Boundary Dam and the U.S.-Canada border (Figure 4.1-1). As with the reservoir sampling, the tailrace electrofishing transects were sampled monthly to evaluate temporal changes in fish distributions. Electrofishing was conducted along two transects during daylight hours while the powerhouse was operating and conducted along all three transects during nighttime hours, generally when the powerhouse was shut down. The same method noted for HSC/HSI validation under reservoir electrofishing was used in the tailrace.

4.1.3.5. Reservoir Fyke Net Sampling

Fyke nets were deployed for a 24-hour period once per month from March through October (Figure 4.1-1). The location of the reservoir fyke net sets varied between sampling periods. Many set locations were associated with off-channel sloughs or in areas where near-shore benches or shelves create shallow littoral areas. Fyke nets were set overnight once per month in shallow (6 feet deep or less), low-gradient, low-velocity (< 1 foot/second) areas of Boundary Reservoir (Figure 4.1-1) from March through November. During each monthly survey, fyke nets were deployed at two sites in the Upper Reservoir Reach, one site in the Canyon Reach, and one site in the Forebay Reach. The locations of the fyke net sets were mapped using a handheld GPS unit and marked on high-resolution aerial photographs.

Fyke nets used in the reservoir were configured and operated as follows:

- The front frame of the trap mouth was 3 feet high by 4 feet wide and constructed of 3/4-inch aluminum pipe. The five rings were 30 inches in diameter and constructed of 1/4-inch stainless steel. Net mesh size was 3/16 inch.

- The traps were designed to either sink or float by incorporating removable buoys. The traps included a 4-foot curtain that could be zipped onto the front of the frame to prevent fish from swimming over the mouth of the trap while the trap was affixed to the reservoir bottom or under the mouth when the trap was floating.
- The traps had one central lead that ran perpendicular from the shoreline to the trap mouth. The central lead was constructed of 50-foot panels with 3/16-inch mesh and included a bottom leadline and top floatline. Up to four panels could be zippered together to create a central lead up to 200 feet in length to ensure adequate coverage as reservoir levels dropped and the trap could be moved farther toward the water. This net design also provided flexibility for varying deployment sites.
- The reservoir fyke traps also included two wings (15 feet in length and 8 feet in depth with 3/16-inch mesh) with leadline and floatline. A live box measuring 2 feet by 2 feet by 4 feet constructed of 1/8-inch mesh was located at the small end of the final fyke throat to hold captured fish until they could be processed. One half of the depth (1 foot) of the live box contained a vinyl lining, providing a watertight holding area if the reservoir level dropped below the bottom of the deployment site. The live box was supported by a PVC frame.
- The live box was checked as needed to ensure that captured fish did not become trapped during receding water levels. If necessary, the trap and live box were repositioned when water levels changed.
- The live box, trap, and wings were held in place using a series of weighted anchors (e.g., 8 to 20 pounds or heavier). The landward end of the leadline was affixed directly to rock anchors or live trees.

4.1.3.6. Tailrace Fyke Net Sampling

One fyke net was set once per month in a shallow (6 feet deep or less), moderate velocity (less than 3 feet per second) area of the Tailrace Reach from April through November. Two sites were used for tailrace fyke net deployment (Figure 4.1-1). The location of the fyke net varied across sampling periods. High velocities, deep water, and sharp changes in the bottom profile limited opportunities for effective fyke and wing net deployment in the Tailrace Reach.

The fyke net used in the Tailrace Reach was configured and operated as described for the reservoir, with the following exceptions:

- There was no central lead as described for the reservoir.
- The tributary tailrace fyke traps consisted of two wings 30 feet in length and 4 feet deep, with leadline and floatline, of 5/16-inch mesh. The two wings were deployed at 45 degree angles downstream from the trap mouth to capture fish moving upstream. One wing was affixed to the bank to lead fish moving upstream along the shoreline into the trap.
- Alternatively, if velocities and water levels made the two-wing deployment difficult, only one 30-foot wing was run perpendicular from the shoreline to the trap mouth. The lead was constructed of 50-foot panels with 5/16-inch mesh and included a bottom leadline and top floatline. The trap and wing were positioned to catch fish moving upstream.

- The live box included a nylon front to provide a velocity break for fish that were captured.
- The fyke net wings and live box were checked regularly to clear debris and to ensure that captured fish were not injured.
- As noted in the RSP (SCL 2007a), native salmonids that exhibited upstream migration behavior were considered for transport and release in upstream habitats. Upstream behavior would be indicated by repeat capture in the fyke net and SCL would consult with RPs on whether to transport and release fish in upstream habitats.

4.1.3.7. Tributary Fyke Net Sampling

Fyke nets designed to collect fish moving downstream were deployed near the mouth of Slate, Sullivan, Sand, and Sweet creeks (Figures 3.0-1 and 4.1-1) upstream of the effects of changes in reservoir pool levels. The traps were operated continuously for a 3-day period every 2 weeks from April through October 2007 (weather and flow conditions permitting). The location of each fyke net set remained consistent for Sweet, Sand, and Slate Creeks throughout the entire sample period (Figure 4.1-1). Sites were characterized by sufficiently low velocities and depths for holding box placement, situated immediately downstream of shallow, and moderate to high velocity reaches. During high discharge in late April and May, the Sullivan Creek fyke net was placed in the left bank side channel approximately 400 feet upstream of the influence of reservoir pool levels to avoid high water velocity and prevent equipment damage. During other months, the Sullivan Creek fyke net was located approximately 900 feet upstream of the influence of reservoir pool levels.

The fyke net used in the tributaries was configured as described for the reservoir and the tailrace with the following exceptions:

- There was no central lead as described for the reservoir.
- The tributary fyke traps included two wings with zippered ends that were 30 feet in length and 4 feet deep, with leadline and floatline, and a 3/16-inch mesh. The trap was configured with two wings running 45 degrees upstream from the trap mouth.
- Where practical, the wings spanned most of the channel width. Areas for upstream fish passage were provided at one or both wings.
- The trap and holding box was installed as a bottom set.
- Fyke net anchor lines were affixed to both banks by the use of rock bolts, climbing hardware, webbing around trees, countersunk rebar, or anchor bags.
- Anchors were installed on the bottom corner of the traps and holding box.
- The wings were sufficiently secure to the bottom to ensure that small fish could not swim beneath them.

4.1.3.8. Tributary Snorkel Surveys

Two biologists conducted monthly nighttime snorkel surveys within 1,000-foot reaches starting within or below the reservoir fluctuation zone and extending upstream into the tributary above the maximum reservoir water surface elevation in Slate, Sullivan, Flume, Sand, and Sweet creeks (Figures 3.0-1 and 4.1-1). The location of snorkel surveys remained constant throughout the entire sample period, although the differences in water clarity, discharge, and reservoir levels and water surface elevation in delta areas resulted in variability in sampling effectiveness. Sand Creek was snorkeled only during March through June, as stream flow infiltrated the porous channel by mid June. Very shallow depths prohibited effective snorkel observations in all but a few small pools situated in Sweet Creek. Likewise, much of the sample area in Sullivan Creek was limited by shallow and rapid flows. Crews snorkeled in all habitats in which they could effectively submerge their mask. Snorkelers recorded water temperatures at the start and end of the survey and visually identified and recorded the number of fish by size category and species. Size categories used were less than 60 millimeters (mm), 60 to 120 mm, 120 to 250 mm, and greater than 250 mm. To determine if fish may be using cold water refugia within the inundated delta areas, fish observations were tallied separately for those observed within the inundated delta areas and those observed within tributary habitats upstream of the reservoir pool at the time of survey. The intent was to separate fish that were actually in the stream or riverine habitat from those that were in the stream plume entering the reservoir or generally in the inundated portion of the delta. Fish that were tallied as occurring within the tributary channel include observations made within the study stream upstream of the reservoir pool at the time of the survey. These observations could include fish occurring within the riverine habitat areas of the delta if the reservoir level was below the upstream limit of the reservoir fluctuation zone.

4.1.3.9. Tailrace Snorkel Surveys

Two biologists conducted snorkel surveys along two standardized 1,000-foot transects in littoral areas during both day and night during each field survey effort (Figure 4.1-1). Snorkelers recorded water temperatures at the start and end of the survey and visually identified and recorded the number of fish by size category (following categories described in Section 4.1.3.8) and species.

4.1.3.10. Angling

During field trips organized for gill net sampling, hook-and-line angling with artificial lures with single barbless hooks was conducted on an opportunistic basis to capture native salmonids for use in the Biotelemetry study and to evaluate seasonal fish distribution.

4.1.3.11. Fish Handling

All fish collected during each of the sampling procedures were:

- Identified to species, measured to the nearest millimeter total length;
- Weighed to the nearest gram; and
- Enumerated, and scanned for presence of visible tags.

If present, observations of poor fish condition, lesions, external tumors, or other abnormalities were noted. Fish were examined for external signs of gas bubble trauma when scheduled fish surveys below Boundary Dam were conducted within 1 week following a spill event.

Although a systematic appraisal of all fish captured for gas bubble trauma was only conducted during the 1-week period following a spill event, records were kept of any fish showing obvious signs of gas bubble trauma, regardless of when those fish were captured in relation to spill. The following information was recorded for each fish showing signs of trauma: species, life-stage, and capture location, time, and date. All fish showing signs of trauma were photographed.

When more than 30 fish of a single species less than 100 mm total length (TL) were collected at one time, the total number was recorded and a subset of the sample was measured and weighed to provide at least 30 measurements for each species.

All native salmonids greater than 250 mm in length were scanned for passive integrated transponder (PIT) tags using a portable tag reader. A PIT tag was implanted into all native trout/char that did not have tags and were 250 mm or more in length.

All sport fish greater than 250 mm in length, other than native salmonids and triploid trout, that were in good condition received a numbered external yellow Floy tag with a unique number and contact phone number. This tag differed from the external red streamer tag used for fish with biotelemetry tags (see below).

Internal radio transmitters and combined acoustic and radio transmitter (CART) tags were surgically implanted in target species, which include bull trout, westslope cutthroat trout, mountain whitefish, smallmouth bass, and triploid rainbow trout. See Section 4.2 for details regarding types of tags and number and size of target species. The following steps were followed:

- Implantation of the tags was conducted in the field as the fish were captured using a mobile surgery and recovery setup.
- Radio transmitters or CART tags were surgically implanted via a 1- to 2-centimeter (cm) incision in the peritoneal cavity immediately anterior to the pelvic girdle.
- All fish with internal tags were also tagged with an external red polystreamer tag. These tags had a unique number and a contact phone number.
- Each fish was released near its capture location as soon as its equilibrium was regained and it could swim away of its own volition.

A fin punch was collected from all cutthroat trout that appeared to be of the westslope subspecies and all apparent bull trout captured within the Boundary Reservoir and Tailrace Reach. Fin punches were also collected from rainbow trout that appeared to be of wild origin (no fin damage, stubbed dorsals, shortened operculum, or eroded scales) in the Boundary Tailrace reach only. Tissue samples were preserved in 100 percent ethanol for later genetic analysis.

Sampling operations were halted or modified at locations that had a high likelihood of capturing native salmonids when elevated water temperatures (greater than 20°C) presented an increased risk of mortality to the salmonids.

4.1.4. Data Management

The date, start and stop times, and level of effort (time sampled) were recorded for all sampling efforts. Water temperature was recorded at all sample locations. Where appropriate, data were incorporated into GIS format (e.g. GPS coordinates recorded).

4.2. Biotelemetry

The design of the Biotelemetry component of Study 9 was defined within the RSP (SCL 2007a) in regard to the target index species, the total number of each species to be tagged, the number and location of fixed receiver stations, and the frequency of servicing and mobile tracking. The RSP identified the target species for biotelemetry as bull trout, westslope cutthroat trout, smallmouth bass, and mountain whitefish. Up to 50 of each species, except smallmouth bass, were to be implanted with internal tags, with a maximum of 30 of each species tagged in the Boundary Reservoir and 20 of each species tagged in the tailrace of Boundary Dam. Up to 20 smallmouth bass were to be tagged, all in the reservoir. The target fish species were to be tagged with either radio tags, which only indicate position, or internal CART sensor tags, which indicate position and transmit temperature and pressure data embedded within the acoustic signal.

4.2.1. Telemetry Equipment

Based on the monitoring equipment criteria outlined in the RSP (SCL 2007a), equipment was purchased from Lotek Wireless Inc. (Lotek). This manufacturer was selected based on advanced telemetry features available, equipment reliability, and extensive use of their product throughout the Pacific Northwest on other similar projects. Use of Lotek equipment on telemetry studies conducted by Pend Oreille Public Utility District (PUD) and BC Hydro upstream and downstream of the Project, respectively, and the potential for information exchange among studies, were also factors in the decision to use Lotek telemetry equipment. Based on the RSP, objectives of the study, various discussions, and expected abundance of target fish, the specifications for the number and type of tags and equipment were determined. These included the following priorities: a minimum 1-year life expectancy for all tags, a short pulse interval to allow effective mobile tracking, and the ability to provide temperature and pressure sensor data.

Three types of radio tag transmitters were deployed during the 2007 Biotelemetry study. Previous Boundary Project area fisheries study results were used to determine likely size and number of fish available. Based on this information and a programming configuration that enabled tags to have a life expectancy of approximately 1 year, Nanotag NTC-6-2 radio tags were selected as the primary positional tag. With a weight in air of 4.5 grams, these tags could be implanted in fish with weights as low as 180 grams. In total, 105 NTC-6-2 tags were purchased. In the event sub-adult individuals were captured, 10 NTC-6-1 tags, with a weight in air of 2.8 grams, were purchased for implantation into fish that weighed between 112 and 180 grams. These smaller tags were to be held in reserve for use on small bull trout and westslope cutthroat trout. Larger index species were to be tagged with CH-TP11-18 CART tags. In addition to indicating position, the CART tags could also transmit temperature and pressure data encoded within an acoustic signal. The CART tags had weight in air of 11 grams and could be implanted in a fish with a minimum weight of approximately 440 grams. A total of 55 CART tags were purchased.

The CART tag temperature sensor range was from -6 to +34ºC (accuracy +/- 0.8ºC) and the depth sensor pressure sensor range was from 0 to 50 pounds per square inch (psi) (accuracy +/- 1 psi), which corresponded to depths between 0 and 35 meters (115 feet) (accuracy +/- 0.7 meter [2.3 feet]).

The full allotment of 170 tags needed to meet the RSP objectives were not purchased in advance. Based upon test gill netting during 2006 and previous studies in Boundary Reservoir (McLellan and O'Connor 2001, R2 Resource Consultants 1998), it was anticipated that few bull trout and westslope cutthroat trout might be captured. Consequently, only 110 tags were initially purchased with the rationale that as tags were deployed over time, more tags could be ordered as required to achieve the full RSP objectives. A comparison of the initial tag purchase for native salmonids and smallmouth bass and the RSP tagging objectives for these species is provided in Table 4.2-1.

Table 4.2-1. Planned distribution of radio and CART tags initially purchased for use in 2007 and RSP tagging objectives.

Tag Purchase 2007	Bull Trout	Westslope Cutthroat Trout	Mountain Whitefish	Smallmouth Bass	Total
CART CH-TP11-18	5	5	15	10	**35**
NTC-6-2 radio tags	15	15	25	10	**65**
NTC-6-1 radio tags	4	3	3		**10**
Total	**24**	**23**	**43**	**20**	**110**
RSP tagging objectives					
Reservoir	**30**	**30**	**30**	**20**	**110**
Tailrace	**20**	**20**	**20**	**0**	**60**
Total	**50**	**50**	**50**	**20**	**170**

The Lotek SRX_400 radio receiver/datalogger was selected for deployment at the shore-based stations and for use during boat-based mobile tracking. In both fixed station and mobile tracking configurations, a four-element Lindsay antenna (gain 8 dBi) was used to detect coded radio signals. Stock lengths of Beldon 9311 coaxial cable of 20 feet or less were used to connect the receiver and the antenna. For tracking CART tags, the acoustic telemetry equipment used was a MAP™600 RT two-port receiver and two LHP 3DF hydrophones. The hydrophones were connected to the receiver with two 30-foot lengths of marine-grade cable.

Details of the biotelemetry equipment, including radio frequency, tag type, acoustic tag temperature pressure ratios, and detailed specifications and reasons for selection, are provided in Appendix 1.

4.2.2. Location and Deployment of Detection Equipment

4.2.2.1. Station Site Selection

The tentative locations of the shore-based monitoring stations were initially identified in the Proposed Study Plan (SCL 2006), subsequently refined in the RSP (SCL 2007a) after discussions between SCL and its technical contractors, and then finalized in coordination with SCL and RPs. Minor adjustments were needed based upon field conditions during deployment of the stations. The locations of the receivers were determined in part by the objective to track large-scale movements of fish between the Upper Reservoir, Canyon, Forebay, and Tailrace reaches. Some station locations were selected based on where fish were likely to aggregate and potentially move into tributaries. Information from anglers indicated fish aggregated in relatively large numbers at the confluence of the mainstem Pend Oreille River and the mouths of Sweet Creek, Sullivan Creek, Slate Creek, and the base of Pewee Falls. These areas were reported to provide thermal refugia for salmonids when summer reservoir water temperatures were high (greater than 21ºC) (Al Solonsky, SCL, personal communication, April 2007). An additional study objective was to monitor the extent and duration of tributary use as thermal refugia by target species with dual-antenna receivers to detect upstream and downstream movement of fish between the reservoir and selected tributaries. To meet these objectives, the following sites for shore-based receivers and antenna configurations were selected as outlined in the RSP (SCL 2007a):

- Near Redbird Creek in Canada, single antenna
- Upstream of the International Border, single antenna
- Downstream of Boundary spillway and turbine outfall pools, single antenna
- Upstream of Boundary Dam, single antenna
- Base of Pewee Falls, single antenna
- Downstream end of the Canyon Reach, single antenna
- Near the mouth of Slate Creek, dual antenna
- Pend Oreille River below Metaline Falls, single antenna
- Near the mouth of Sullivan Creek, dual antenna
- Pend Oreille River above Metaline Falls, single antenna
- Near the mouth of Sweet Creek, dual antenna
- Downstream of Box Canyon Dam, single antenna

Based on the general locations identified in the RSP, the final location of each station was determined in the field during deployment and installation (Figure 4.2-1). Once in the general area identified in the RSP, final positioning of the station was based on site accessibility, site hazards, sight lines, electronic interference and noise, and station security. All sites were positioned to allow walk-in access from either a boat or a truck. Sites with hazards (e.g., rock fall hazards and height hazards) that could not be mitigated were not selected. Once on site, a clear, vegetation-free line of sight between the antenna location and the portion of river to be monitored was required. This was accomplished by manually removing vegetation. The site was also assessed in terms of proximity to potential sources of electronic radio frequency noise (e.g., power lines, switchyards, etc.). Prior to placement of the antenna, the background noise of the site was assessed and the antenna positioned in the direction of least noise. The details of the station characteristics are presented in Appendix 1. Minor differences from the locations identified in the RSP include movement of the Pewee Falls station (R5) farther to the east to mitigate safety issues, and movement of the mainstem station above Metaline Falls (R9) closer to Pocahontas Creek.

4.2.2.2. Station Installation Procedures

Each station consisted of a weather-resistant lockable metal box containing a receiver and two deep-cycle batteries, flexible aluminum conduit to protect the RG58 coaxial antenna cable(s), and one or more antenna mounts. With the exception of Stations R3 (Boundary Forebay) and R10 (Sweet Creek), large trees near the river edge were used as an anchor for the station box and

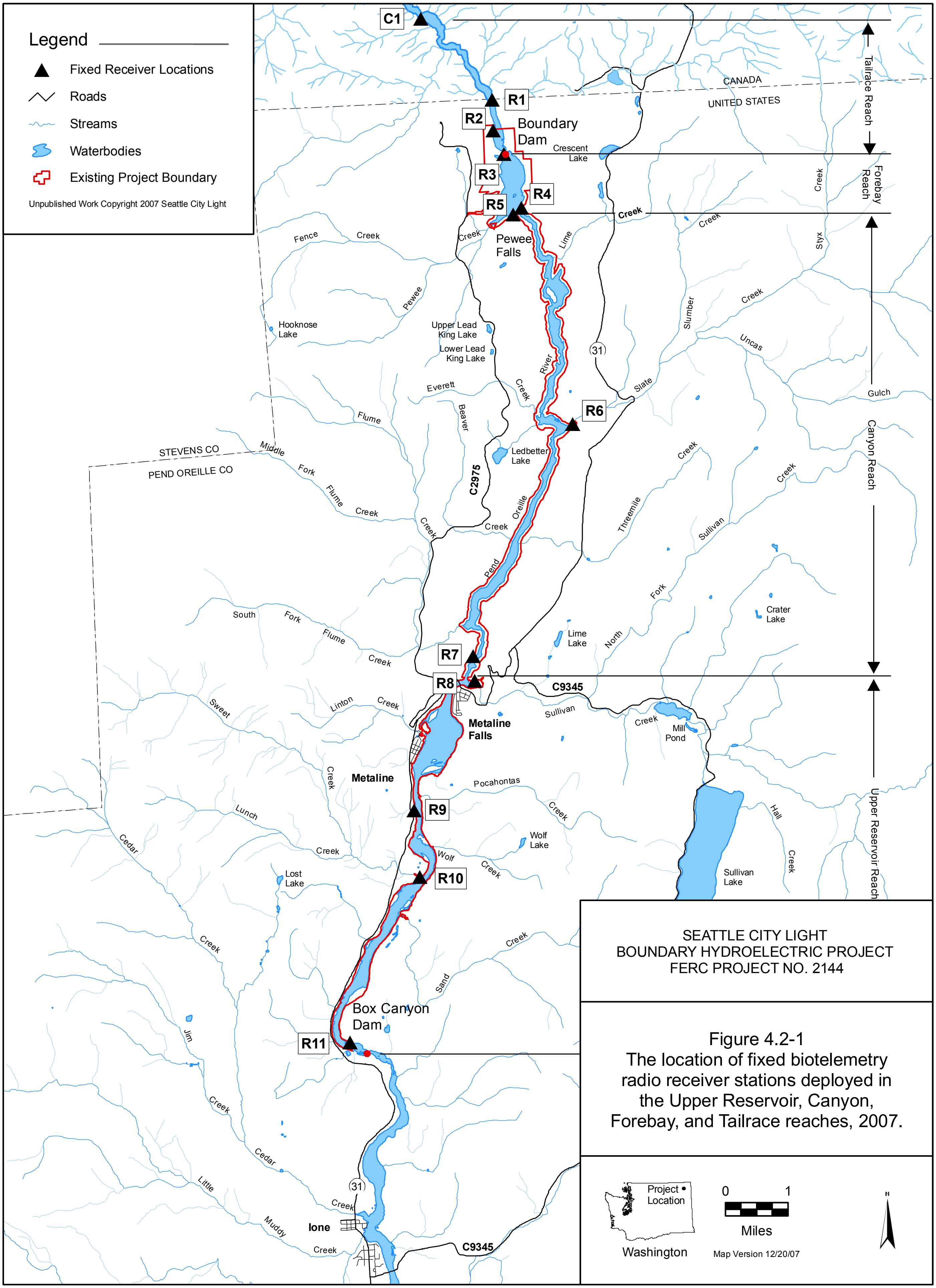

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Figure 4.2-1
The location of fixed biotelemetry radio receiver stations deployed in the Upper Reservoir, Canyon, Forebay, and Tailrace reaches, 2007.

as a mast for the antenna mount. A flat area was first excavated and leveled on the upslope side of the tree. The station box was then positioned and attached to the tree with braided metal cable secured with metal cable crimps and cable clamps. Antennas were usually bolted to local trees. Some sites require metal conduits for wire installation and attachment. A boat was used to access most sites for installation. Each site was affixed with information on the outside identifying its purpose. Further details on station installation procedures, access procedure methods, and marking identification details are provided in Appendix 1.

4.2.2.3. Station Installation QA/QC Measures

Several procedures were followed to minimize error: 1) background noise levels were checked and receiver gain optimized; 2) overlapping reception at creek mouths was reduced using dual antennas to ensure fish movement into streams could be determined; and 3) range checks were made of overall level of reception using a reference tag. Further details concerning station installation quality assurance/quality control (QA/QC) measures are provided in Appendix 1.

4.2.3. Fish Collection and Tagging

Fish implanted with radio CART tags were captured and tagged during boat electrofishing and, to a lesser extent, during gillnet and fyke net sampling in the Boundary Dam Reservoir and Tailrace Reach as part of the fish Passive and Active Sampling component. Tags were deployed progressively during monthly field sessions from April to September 2007, with the number of tags deployed dependent on the successful capture of suitable target species during a given sample session. Species tagged during this work included bull trout, cutthroat trout, mountain whitefish, and smallmouth bass. Anticipating interest by RPs, a northern pike, a species which until recently had not been observed in Boundary Reservoir, that was captured during electrofishing, was implanted with a radio tag. Smallmouth bass captured by anglers during a local fishing derby on May 5, 2007, were also radio-tagged.

Upon capture of a target species, the decision as to whether to implant a tag was made based on 1) the size and health of the fish; and 2) for each given species, the total number of tagged individuals released in relation to the RSP objectives for the reach where the fish was captured. A 2.5 percent ratio of tag weight to fish weight was used to determine whether a fish met the minimum size criteria for implantation with a radio or CART tag. The NTC-6-2 tags were deemed suitable for implantation in fish over 180 grams. For fish between 180 grams down to 112 grams, 10 NTC-6-1 tags were used. The CART tags were implanted in fish in excess of 440 grams. Prior to implantation, the general health of the fish was assessed. Fish with damaged fins, signs of lethargy, or an inability to remain upright in the water column were not selected for tagging. Whenever possible, salmonids captured and tagged during the summer and late fall were held and released into receiving waters less than 15ºC. Due to logistic constraints, holding times were usually less than 24 hours and fish were typically released at the end of the sample session. A tagged fish was released in the approximate location where it was captured.

Further details of the surgical implantation procedure are provided in Appendix 1.

4.2.4. Shore-based and Mobile Tracking

4.2.4.1. Shore-based Station Servicing and Data Download

After installation, the shore-based stations were serviced on a bi-monthly basis from April through September to replace batteries and as a measure of quality control and quality assurance to ensure that the station remained functional and the data were routinely offloaded from the receiver to avoid data loss should the logger fail or be damaged. Overall, this servicing schedule was accomplished; however, over the monitoring period, disruptions such as boat failure, scheduling conflicts, low water events, and forest fires, resulted in the postponement of servicing some stations in the U.S. and Canada. The details of the servicing procedure are described in Appendix 1.

4.2.4.2. Mobile Tracking

Mobile telemetry tracking was conducted on a twice monthly basis, concurrently with station servicing, over a 3-day period (see Tables A.1-2 and A.1-3 in Appendix 1). Typically, during Day 1, the Canyon Reach stations (i.e., R4, R5, R6, and R7) were serviced in an order proceeding upstream from the Forebay Reach to the upper end of the Canyon Reach near Metaline Falls and Station R7. Mobile tracking then was conducted for the remainder of the day, moving downstream, between Station R7 and the Forebay Reach. On Day 2, the boat was launched at the Metaline boat launch, and the Upper Reservoir Reach stations (i.e., R9, R10, and R11) were serviced in order proceeding upstream to Box Canyon Dam. Once complete, mobile tracking of the Upper Reservoir was conducted, moving downstream, between Box Canyon Dam and Sullivan Creek. Day 3 involved driving to and servicing Sullivan Creek station (R8), followed by driving to the Project and servicing the Boundary Forebay station (R3), the Tailrace station (R2), and then launching the boat to conduct mobile tracking between Boundary Dam and the international border. Once mobile tracking in the tailrace was completed, the International Border station (R1) was serviced. The Red Bird Creek station in Canada was usually serviced the week following the U.S. service session.

4.2.4.2.1. Radio Tracking Procedures

Mobile radio telemetry tracking was conducted using a Valco river boat and two-person crew. The crew included a boat operator, who was responsible for all aspects of boat safety and also served as the data recorder, and a second crew-person who operated the telemetry equipment. Tracking was conducted with a SRX_400 receiver connected to a four element Lindsay-manufactured yagi antenna mounted on a moveable mast attached to the guard rail on the bow. A crew member positioned on the bow operated the receiver and directed the antenna. In addition to operating the boat, the boat operator also recorded data.

Tagged fish were relocated by cruising at a low speed in a sinuous pattern with the antenna directed forward and with the receiver at maximum gain. In this manner, electrical interference produced by the boat engine and onboard electronic was minimized and radio signals were more readily detected. Radio tag signals were audible on the receiver speaker. When a strong audible tone was received, the boat engine was typically shut off and the receiver settings changed to decode the tag code. Once the tag code was identified, the boat was moved slowly in the direction of the signal, with the receiver gain continually reduced as distance to the tag decreased and signal strength increased. This procedure allowed a more accurate estimation of fish location. The ability to locate the actual position of the fish, however, was limited by the fish movement in response to the boat, the depth and aspect of the fish, and other environmental factors such as water velocity, turbulence, and weather conditions. Field crews estimated that fish could be located to within 10 meters (33 feet) within a 30º to 40º arc in front of the boat. At this point, the field crew would choose an arbitrary point within this range as the representative fish location. This location was based in part on habitat attributes in the area (e.g., eddy, shear-zones, overhead cover, etc.). The boat operator then recorded the date and time, tag type, tag frequency and code, a universal transverse mercator (UTM), and the nearest PRM. The position of the fish was plotted on an aerial photo. As fish often move at the approach of the tracking vessel, improving relocation of fish of fish with a more precise antenna would not likely be feasible. If an accurate location (i.e., to within 10 meters [33 feet]) of the fish could not be determined, a general UTM grid values from a GPS receiver and PRM were recorded to identify that this fish was in this general section of the river. If the fish was a target species, HSC data were collected (see Section 4.2.4.2.3).

The primary limitation of mobile tracking as a means to identify the exact fish location was movement of the fish, either due to the presence of the boat or normal behavior (e.g., feeding). Radio tracking during high flows was even more difficult and fish were harder to locate accurately. Under these conditions, the boat would drift rapidly past the fish before an accurate location could be determined. When the boat was held against the current in a stationary position, increased electrical interference from the boat engine increased the difficulty in accurately locating a signal. This problem is a common occurrence with outboard engines, and attempts to suppress radio frequency interference have been unsuccessful in the past. Certain areas of the river had high background noise levels, usually due to the presence of power lines or residences. In these high noise areas, tracking was less efficient and accurate fish locations were difficult to obtain.

Before conducting radio telemetry tracking, the radio receiver was fully charged and the antenna and antenna cable inspected for damage. A test tag was then activated to ensure that the receiver was properly operating. During tracking, care was taken to ensure the receiver was protected from damage. The frequency setting was routinely checked to ensure that correct frequency was being monitored. All mobile tracking data were recorded on water-resistant paper.

4.2.4.2.2. Acoustic Tracking Procedure

Because of long acoustic pulse intervals and hydrophone limitations, acoustic mobile tracking of CART tagged fish was not possible. During radio telemetry tracking, if a CART tag radio tag was detected, the boat was either anchored in mid-channel or tied to shore if sufficient depth was available. Both hydrophones were lowered into the water by their cables, typically to a depth of between 6 to 10 feet below the boat hull. A second method involved deploying the hydrophones and then drifting downstream until the acoustic signals were decoded, at which point, the boat anchor was deployed. Up to six pressure and three temperature readings were recorded for each fish, and the hydrophones were retrieved. Radio telemetry was then used to more accurately locate the position of the fish.

Reception of acoustic signals was substantially reduced in locations with high hydraulic noise, turbulence, and elevated dissolved gas levels during high flow conditions. Physical obstacles, such as shoals, macrophyte beds, and suspended organic matter also reduced signal reception. Under low flow conditions, reception range was estimated at approximately from 650 to 1,000 feet.

Prior to use, all acoustic monitoring equipment and connections were inspected for wear, damage, and fit. Prior to the start of acoustic monitoring, an acoustic test tag was activated to ensure that the receiver was properly operating. During tracking, care was taken to protect the receiver and hydrophone from damage, especially when drifting downstream. All CART tag sensor data were recorded on water-resistant paper and managed identically with the shore-based station service logs.

4.2.4.2.3. HSC/HSI Data Collection

Data were collected for radio- and CART-tagged target species (i.e., bull trout, westslope cutthroat trout, smallmouth bass, and mountain whitefish) during mobile tracking to validate HSC/HSI information to be used in the Aquatic Habitat Model study (Study 7). Details on measurement procedures and parameters measured are presented in Appendix 1. A summary of the general parameters record for HSC data collected at the estimated fish locations determined during radio telemetry tracking is provided below:

1. Water temperature (+/- 0.1ºC) was measured at the estimated fish location.
2. Distance was measured from the estimated fish location to the nearest river bank with a laser range finder (+/- 1 meter).
3. Water depth was measured with an onboard Lowrance X45 depth sounder (+/- 0.1 meter). Due to uncertainty of fish location (i.e., estimated to be within a 10-meter [33-foot] radius), two additional depth measurements were taken at 5 m (17 feet) on either side of the fish (near bank and away from bank relative to estimated fish position).
4. Concurrently with the three depth measurements, and near surface water velocity (Marsh McBirney or Swoffer 2100 flow meters) was recorded and averaged over a 10-second interval at approximately the same locations as depth measurements.
5. Substrate at each fish location was classified as either “hard” or “soft” when in deeper water, but when substrate could be viewed, specific codes were used (see Appendix 1 for details).
6. Cover was documented within a 10-meter (33-foot) radius of the fish location, and cover criteria (defined in Appendix 1) applied.
7. The presence of shear zones relative to the estimated fish location was noted.
8. Because the ability of the tracking crew to accurately locate fish varied under different conditions (e.g., fast flows versus slow flows), a confidence ranking of the representative fish location was estimated.

4.2.5. Intensive Tracking

Intensive tracking was conducted to assess the use of cold water refugia by a CART-tagged cutthroat trout when reservoir temperatures were in excess of 18ºC. Cold water refugia were assumed to be primarily associated with confluence areas or lower reaches of cold water tributaries in the study area. An intensive monitoring session was initiated immediately after the bi-monthly mobile tracking sessions were conducted in late July and August. During the intensive monitoring session, a CART-tagged fish was located near a potential cold water refugia habitat.

During the morning of the first day of intensive monitoring, radio telemetry was used to relocate the CART-tagged fish at the location near the cold water refugia identified during mobile tracking. If the fish was still present, the boat was moored either near shore or anchored mid-channel and the acoustic receiver and hydrophones deployed. If a strong and consistent acoustic signal was successfully received and decoded, sensor data from the CART tagged fish were monitored continuously for 24 hours, with an interruption for a crew change after 12 hours. Care was taken to minimize acoustic noise during the crew transfer and physical disturbance to the area where the fish was assumed to be positioned. From the anchored boat location, radio telemetry tracking was done periodically to verify where the target fish was located. Continuous mobile radio telemetry tracking was not performed out of concern for displacing the fish from the refugia and losing the opportunity to record sensor data from the CART tag.

The sensor data from the target fish, and other adjacent CART tags within range of the receiver, were recorded and saved as a digital file. Data consisted of time interval with a corresponding temperature or pressure reading. Under optimum reception conditions, sensor data were recorded at approximately one reading per minute. Periods of reduced or lost signal reception of up to 20 minutes were deemed acceptable. After 20 minutes without a decoded signal, efforts were made to improve signal reception by first repositioning the hydrophones. If still not successful, the boat was moved to relocate the fish through mobile radio telemetry. Once relocated, the hydrophones were redeployed. If an acoustic signal was received and decoded, the boat was anchored and continuous monitoring resumed.

At the end of the 24-hour monitoring period, temperature profile measurements were obtained from within the cold water refugia using a digital reel thermometer (Point Four custom reel digital thermometer +/- 0.1ºC). Where water depths were shallow, temperature readings were measured on the river bottom, mid-column, and near the water surface. Water depths at these locations were measured with a depth sounder and by measuring the length of temperature reel cable deployed.

4.2.6. Data Processing, Entry, and Verification

Hardcopy mobile tracking, HSC, and CART tag sensor data were entered manually into Microsoft Excel® spreadsheets, followed by entry verification by a second person. Station service logs were not entered into a spreadsheet. Periods of missing data or suspect data were identified. Where the quality of the data was in question, limitations in the collection of the data were identified and discussions held with the field crews as to possible methods to improve the collection method within the scope and objectives of the study. All the velocity data recorded during the HSC data collection program were considered suspect due to the difficulty of maintaining the boat in a stationary position while velocity measurements were taken.

During intensive tracking, CART tag sensor data were saved to a digital file using the data capture feature of the Maphost software. These data were also copied to a separate Excel spreadsheet periodically during an intensive tracking session as a backup. Written records were kept and the data transcribed manually as a back up during the first intensive tracking session on August 3.

To eliminate false tag signals and error codes, fixed station data were first screened with several filters that checked record tag codes against a list of known deployed tags and the deployment dates. These data were then imported into an Access database, within which output from the database was further screened to remove tag records of less than one event for each 10 minute averaged interval (i.e., one 5- or 10-second signal recorded over 10 minutes). When plotted, the corresponding PRM of the one-event records tended to differ substantially from other multi-event records that were more reliable. For these one-event records to be valid, the fish typically would have to move a large distance in an unrealistic amount of time. The sources of these false one-event records were attributed to electrical noise from outboard boat engines and switchyards. Once the one-event false tag code detections were removed, if a number of false tag code records (usually less than five events per ten minute interval) were still evident, these were removed based on inspection of the data. The cleaned movement data from the fixed station and mobile telemetry tracking were then plotted for each tag. Information extracted from the biotelemetry database was occasionally cross-checked with the original data file to verify that the data queries were properly functioning.

Tributary use was determined by comparing signal strengths from the tributary and reservoir antennas for tagged fish that were present in the creek mouth. These data were extracted from the database and plotted. To ensure that valid tag signals were used, only records with five or greater events (i.e., "pings" detected from a transmitter) were considered for analysis. The criterion used to determine upstream movement into the tributary was a greater signal strength on the tributary antenna compared to the reservoir antenna. Ideally, with extensive upstream movement into the tributary, signals from the reservoir antenna would eventually attenuate and detections would only be recorded on the tributary antenna.

4.2.7. Data Analysis Methods

Data analysis for this interim report was limited to the telemetry data recorded from shore-based stations, mobile tracking, and intensive tracking surveys conducted between March 30 and September 27, 2007. Due to the low number of tagged native salmonids and a moderate loss rate of fish that were tagged, statistical analysis of movement data in response to environmental variables was not possible. Due to this limitation, analysis of the salmonid and telemetry data was descriptive and relied on professional judgment to interpret the available data and identify potential trends. These trends may have a statistical analysis conducted for the 2008 report if a sufficient number of radio- and CART-tagged salmonids can be tracked through the remainder of the study.

One northern pike tagged within this period was analyzed; therefore, only descriptive analysis of the telemetry results is provided for this species. A larger number of smallmouth bass were tagged and survived. Consequently, statistical analysis of movement and environmental variables was conducted for this species. All analyses were conducted using R software, Version 2.5.1 (R Development Core Team 2007).

Due to the low number of native salmonids that were CART-tagged, intensive tracking data were limited to those obtained from one westslope cutthroat trout that was tracked at the mouth of Sweet Creek. Because of this limitation, analysis of the intensive tracking data was descriptive and relied on professional judgment to interpret the data and identify potential trends. As noted above, these trends may be analyzed with parametric statistics later, pending a substantial increase in the number of salmonids tagged with radio and CART tags and their subsequent survival.

5 PRELIMINARY RESULTS

This section presents the preliminary results of Passive and Active Sampling (Section 5.1) and Biotelemetry (Section 5.2). These results are integrated in Section 6 (Discussion) and evaluated relative to meeting the study objectives.

5.1. Passive and Active Sampling

The Passive and Active Sampling results section begins with a description of the general habitat characteristics of the study area (Section 5.1.1) to provide context for the distribution and abundance analysis that follows. A fish sampling summary briefly describes the total effort and findings of each capture method (Section 5.1.2). Section 5.1.3 combines the habitat assessment and all of the capture methods to describe the species and life history stage distribution and relative abundance in relation to environmental conditions.

5.1.1. Habitat Characteristics

Four reaches are delineated within the Boundary Project based upon habitat characteristics that result from the reservoir physiography (Figure 3.0-1). The Tailrace Reach portion that had fish sampling extended from the U.S.-Canada border (PRM 16.0) upstream to Boundary Dam (PRM 17.0). The Forebay Reach extended from Boundary Dam (PRM 17.0) to the lower end of Z Canyon (PRM 18.0), a distance of approximately 1 mile. The Canyon Reach began at the downstream end of Z Canyon and extended approximately 8.8 miles upstream to Metaline Falls (PRM 26.8). The Upper Reservoir extended from Metaline Falls upstream to Box Canyon Dam (PRM 34.5), a distance of approximately 7.6 miles. Characteristics of the fish habitat in these four reaches are described below. These four reaches, together with the tributary delta habitats form a framework for describing the distribution of fish as determined by ongoing sampling.

5.1.1.1. Tailrace Reach

The Tailrace Reach portion that was sampled included the deep spillway pool and turbine afterbay areas immediately downstream of the Boundary Dam, extending downstream to the U.S.-Canada border. The reach study site is characterized by deep pools (exceeding 75 feet) in the spillway and turbine afterbays, but is generally less than 30 feet deep elsewhere. Downstream of the spillway and afterbay pools, the Tailrace Reach is relatively swift, with cobble and boulder substrates. Habitat diversity is provided primarily by instream boulders and alcoves along the channel margins. The Seven Mile Hydroelectric Project, operated by BC Hydro is located on the Pend Oreille River at RM 6.0, downstream of Boundary Dam in British Columbia. At full pool (1,730 feet elevation MSL), Seven Mile Reservoir encroaches upon the tailrace area of Boundary Dam.

5.1.1.2. Forebay Reach

The Forebay Reach is a wide and deep portion of Boundary Reservoir immediately upstream of Boundary Dam. This section of the reservoir is steep-walled and has water depths extending to approximately 260 feet. There is little shallow, littoral habitat in this area. A small island near the center of the Forebay Reach provides some habitat complexity, although the shores of the island are extremely steep. One tributary, Pewee Creek (PRM 17.9), drains into this section of the reservoir approximately 0.5 mile west of the mouth of Z Canyon. The mouth of Pewee Creek is a vertical 164-foot (50-meter) falls (McLellan and O’Connor 2001).

5.1.1.3. Canyon Reach (Z Canyon to Metaline Falls)

The Canyon Reach extends from the downstream end of Z Canyon to just downstream of Sullivan Creek and is predominantly narrow with steep, rock walls. A few large embayments and backwater channels in this portion of the reservoir provide localized silt-bottom, shallow habitats with aquatic macrophyte beds. The reservoir bathymetry is steep, reflecting submerged canyon walls. Rock outcroppings in this zone provide habitat complexity. Downstream of Slate Creek (PRM 22.2), the canyon is more constricted and water depths generally exceed 100 feet, while mainstem reservoir depths upstream of Slate Creek are typically 80 to 100 feet (R2 Resource Consultants 1998). In addition to Slate Creek, six other tributaries drain into the Canyon Reach, including Lime Creek (PRM 19.0), Everett Creek (PRM 21.9), Whiskey Gulch (PRM 21.9), Beaver Creek (PRM 24.3, west side), Threemile Creek (PRM 24.3, east side), and Flume Creek (PRM 25.8). The upstream end of the Canyon Reach is bounded by Metaline Falls, which is periodically inundated by Boundary Reservoir under high pool levels.

5.1.1.4. Upper Reservoir Reach (Metaline Falls to Box Canyon Dam)

Compared to the Forebay Canyon reach, the Upper Reservoir Reach is relatively wide and shallow, with silt, sand, and hard substrates (R2 Resource Consultants 1998). Typical water depths range from 10 to 25 feet. Habitat diversity is provided primarily by islands, back channels, and nearshore aquatic vegetation. Sullivan Creek (PRM 26.9) is the largest tributary that drains into Boundary Reservoir and is located just upstream of Metaline Falls. Other tributaries that drain into the Upper Reservoir Reach include Linton Creek (PRM 28.1), Pocahontas Creek (PRM 29.4), Wolf Creek (PRM 30.3), Lunch Creek/Sweet Creek (PRM 30.9), Sand Creek (PRM 31.7), and Lost Creek (PRM 32.2).

5.1.1.5. Habitat Types

Habitat characteristics across the Project reaches were described by bottom slope (steep, moderate, or shallow) and dominant substrate types (bedrock/boulder, large/small cobble, small cobble/gravel, or sand/fines). Six habitat types have been described for the Project varial zone (Figure 5.1-1) and a total of eight habitat types were used to describe all mainstem reservoir habitats (Table 5.1-1). Habitats are further distinguished by position relative to the varial zone elevation (in or out of varial zone), presence of aquatic vegetation cover, and the influence of groundwater or tributary discharge. Study sites were distributed across the array of habitat types in an effort to represent the variety of conditions found throughout the Project.

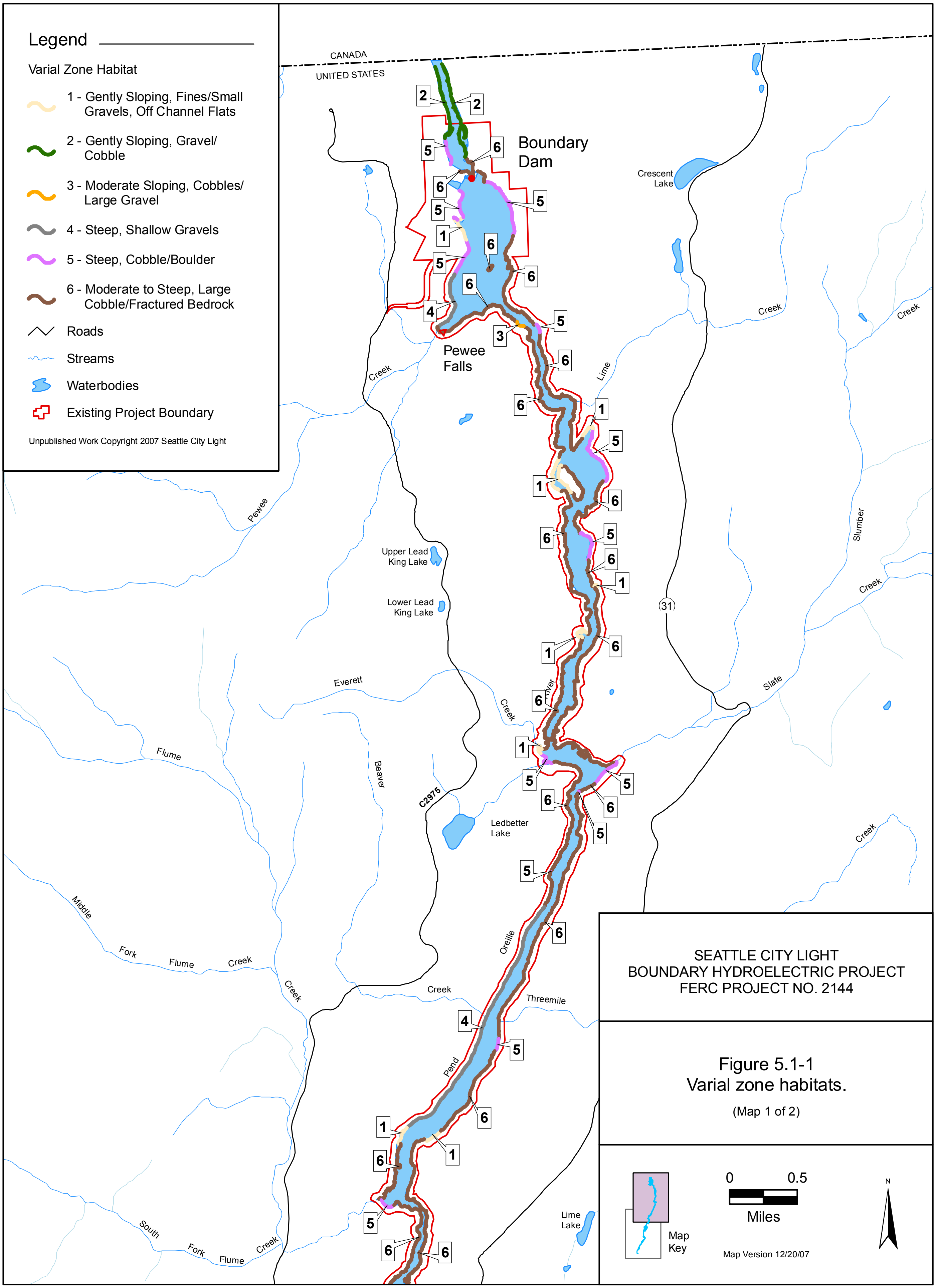

Figure 5.1-1
Varial zone habitats.
(Map 1 of 2)

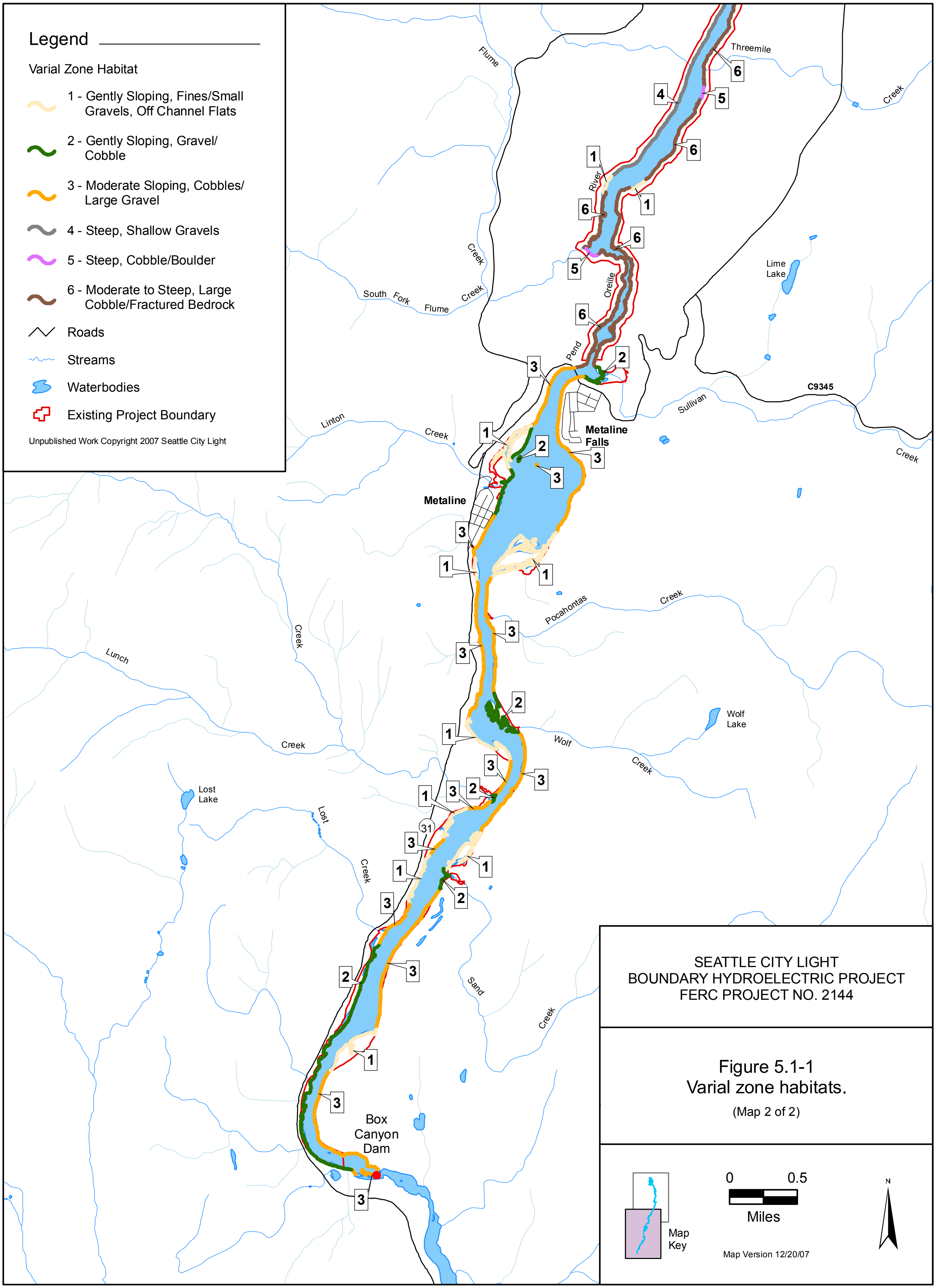

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Figure 5.1-1
Varial zone habitats.
(Map 2 of 2)

Table 5.1-1. Habitat typing system used to describe the varial zone and deep water characteristics within the Boundary Project.

Number	Habitat Type	Bottom Slope
1	Gently sloping, fines/small gravels, off channel flats	Low relief, gently sloping bottom with shallow water depths; substrate consists primarily of fines and small gravels; instream cover limited where regularly dewatered, otherwise cover provided by aquatic vegetation and localize stumps and wood
2	Gently sloping, gravel /cobble	Low to moderate slope profile, but with local areas of large cobbles and small boulder; higher velocities and alcove depressions commonly provide cover; other cover generally very limited, provided largely by stumps, rootwads, and washed wood
3	Moderate sloping, cobbles/large gravel	Stable banks with moderate sloping bottom profiles; small cobble/large gravel substrates predominating; generally uniform shoreline and varial zone configuration; velocities adjacent to the bank generally low to moderate; cover generally limited to cobble interstices with occasional stumps and down trees; local areas of boulders and irregular bank configuration provide diverse cover
4	Steep, shallow gravels	High steep eroding banks consisting of shallow crumbling shale deposits; varial zone profiles continually steep from valley wall, with a thin veneer of plate like gravels; cover locally provided by submerged stumps and down trees from high bank sloughs
5	Steep, cobble/boulder	High steep, non consolidated banks; often consists of loose till deposits; substrates are dominated by cobbles and gravel; localized areas of large cobble and boulders provide cover; steep profile continues into varial zone and beyond; localized small scale bank sloughs provide wood cover
6	Moderate to steep, large cobble / fractured bedrock	Valley walls form banks and continue into varial zone; substrate primarily small and large cobbles with frequent boulder and fractured bedrock; generally deep water with abundant rock and alcove cover; occasional velocity shears caused by protruding fractured bedrock and boulder; includes areas of sheer bedrock walls
7	Mid-channel troughs	Low relief areas that are essentially the inundated river and tributary floodplains and valley bottoms
8	Deep water shoals	Topographic benches that are formed by residuum or old glacial terraces

5.1.2. Fish Sampling Summary

Gillnetting, electrofishing, fyke netting, snorkeling, and angling in Boundary Reservoir, Boundary Tailrace reaches, and selected tributaries to the reservoir were conducted at more than 60 sample locations from February through October 2007 (Table 5.1-2). During the course of all sampling (monthly locations and additional sampling efforts), a total of 31,953 fish representing at least 28 species and 9 families were observed; 10,892 of the observed fish were captured (Table 5.1-3). Electrofishing yielded the highest total catch and observations within the regular monthly site sampling (Table 5.1-4).

Table 5.1-2. Summary of effort conducted at the Passive and Active Sampling study sites in the Boundary Project during February through October, 2007.

Sampling Technique	Project Reach	Sites	Sample Period	Total Effort [1]
Gill Net	*Monthly Study Sites*			
	Tailrace	3	April - November	91
	Forebay	5	February - October	992
	Canyon	5		1,403
	Upper Reservoir	5		520
	Sub Total	18		3,006
	Extra Study Sites			
	Forebay	2	March - October	7
	Canyon	2		16
	Upper Reservoir	3		46
	Sub Total	7		69
	Total	25		3,075
Electrofish	Tailrace	3	March - October	368
	Forebay	4		432
	Canyon	7		631
	Upper Reservoir	8		737
	Total			2,168
Fyke Net	Tailrace	3	May - October	169
	Forebay	2		120
	Canyon	5		155
	Upper Reservoir	6		269
	Tributary	4		2,510
	Total			3,222
Snorkel Observation	Tributary	5	March - October	34
	Tailrace	2	February -October	16
	Total			50
Opportunistic Angling	Tailrace		April - October	2
	Forebay			8
	Canyon			9
	Upper Reservoir			5
	Tributary			3
	Total			26

Note:
1 Units for total effort are as follow: gill netting – hr/1000 feet^2 net; electrofishing – run time (minutes); fyke net – hrs; snorkel observations – site visit; angling – hrs.

Table 5.1-3. The total number, mean total length, and biomass of fish catch, and number of fish observed but not captured during the electrofishing, gill netting, fyke netting, snorkeling, and angling sampling in the Boundary Project, February through October 2007.

Species	Catch [1]		Mean Length (mm) [2]		Total Species Biomass (kg) [3]		Observed Not Captured [4]		Total Catch and Observed [5]	
Catostomidae	**4,840**	**(0.437)**	**189**	**(30-995)**	**944.6**	**(0.413)**	**11,284**	**(0.536)**	**16,124**	**(0.505)**
Longnose sucker	39	(0.004)	329	(129-440)	16.4	(0.004)			39	(0.001)
Largescale sucker	3,074	(0.281)	249	(38-995)	923.2	(0.301)	5,149	(0.244)	8,223	(0.257)
Sucker sp	1,727	(0.152)	74	(30-295)	5.0	(0.108)	6,135	(0.291)	7,862	(0.246)
Centrarchidae	**1,599**	**(0.148)**	**150**	**(23-494)**	**172.8**	**(0.159)**	**2,056**	**(0.098)**	**3,655**	**(0.114)**
Largemouth bass	38	(0.004)	135	(44-412)	6.9	(0.004)	3	(0.000)	41	(0.001)
Smallmouth bass	1,099	(0.102)	174	(34-494)	155.3	(0.109)	1,399	(0.066)	2,498	(0.078)
Pumpkinseed	329	(0.031)	102	(34-202)	8.4	(0.033)	346	(0.016)	675	(0.021)
Black crappie	133	(0.012)	81	(23-275)	2.1	(0.013)	308	(0.015)	441	(0.014)
Cottidae	**20**	**(0.002)**	**62**	**(30-86)**	**0.1**	**(0.002)**	**1**	**(0.000)**	**21**	**(0.001)**
Sculpin sp	20	(0.002)	62	(30-86)	0.1	(0.002)	1	(0.000)	21	(0.001)
Cyprinidae	**1,673**	**(0.156)**	**254**	**(36-839)**	**425.4**	**(0.156)**	**792**	**(0.038)**	**2,465**	**(0.077)**
Longnose dace	18	(0.002)	86	(36-131)	0.2	(0.002)		(0.000)	18	(0.001)
Northern pikeminnow	671	(0.063)	277	(40-839)	181.6	(0.062)	346	(0.016)	1,017	(0.032)
Peamouth	777	(0.073)	207	(46-382)	86.0	(0.071)	434	(0.021)	1,211	(0.038)
Redside shiner	9	(0.001)	94	(76-125)	0.1	(0.001)		(0.000)	9	(0.000)
Tench	198	(0.018)	379	(60-477)	157.4	(0.020)	12	(0.001)	210	(0.007)
Esocidae	**18**	**(0.002)**	**602**	**(420-786)**	**38.9**	**(0.002)**		**(0.000)**	**18**	**(0.001)**
Northern pike	18	(0.002)	602	(420-786)	38.9	(0.002)		(0.000)	18	(0.001)
Gadidae	**16**	**(0.001)**	**470**	**(197-599)**	**11.2**	**(0.002)**		**(0.000)**	**16**	**(0.001)**
Burbot	16	(0.001)	470	(197-599)	11.2	(0.002)		(0.000)	16	(0.001)
Ictaluridae	**36**	**(0.003)**	**279**	**(153-332)**	**11.0**	**(0.004)**	**3**	**(0.000)**	**39**	**(0.001)**
Brown bullhead	36	(0.003)	279	(153-332)	11.0	(0.004)	3	(0.000)	39	(0.001)
Percidae	**1,449**	**(0.135)**	**144**	**(48-640)**	**97.1**	**(0.145)**	**1,370**	**(0.065)**	**2,819**	**(0.088)**
Walleye	22	(0.002)	496	(124-640)	31.7	(0.002)	6	(0.000)	28	(0.001)
Yellow perch	1,427	(0.133)	138	(48-297)	65.4	(0.143)	1,364	(0.065)	2,791	(0.087)
Salmonidae Native	**295**	**(0.027)**	**153**	**(27-717)**	**36.0**	**(0.030)**	**412**	**(0.020)**	**707**	**(0.022)**
Bull trout[6]	1	(0.000)	285		0.2	(0.000)		(0.000)	1	(0.000)
Cutthroat trout[7]	87	(0.008)	99	(28-416)	3.9	(0.009)	322	(0.015)	409	(0.013)
Rainbow trout[8]	12	(0.001)	346	(194-717)	5.3	(0.001)	5	(0.000)	17	(0.001)
Lake whitefish	2	(0.000)	439	(432-445)	1.4	(0.000)		(0.000)	2	(0.000)
Mountain whitefish	193	(0.018)	162	(27-476)	25.2	(0.019)	85	(0.004)	278	(0.009)
Salmonidae Non-native	**946**	**(0.087)**	**300**	**(27-717)**	**258.7**	**(0.088)**	**1,443**	**(0.069)**	**2,389**	**(0.075)**
Brook trout	6	(0.001)	216	(129-269)	0.6	(0.001)	79	(0.004)	85	(0.003)
Brown trout	67	(0.006)	327	(50-591)	34.0	(0.007)	29	(0.001)	96	(0.003)
Char hybrid [9]	1	(0.000)	332		0.3	(0.000)		(0.000)	1	(0.000)
Kokanee	3	(0.000)	175	(161-192)	0.1	(0.000)	1	(0.000)	4	(0.000)
Lake trout	12	(0.001)	482	(388-616)	10.1	(0.001)	2	(0.000)	14	(0.000)

Table 5.1-3, continued…

Species	Catch [1]		Mean Length (mm) [2]		Total Species Biomass (kg) [3]		Observed Not Captured [4]		Total Catch and Observed [5]	
Rainbow trout[10]	832	(0.076)	297	(43-599)	207.9	(0.077)	1,233	(0.059)	2,065	(0.065)
Rainbow trout[11]	25	(0.002)	267	(165-418)	5.5	(0.002)	69	(0.003)	94	(0.003)
Unidentified trout							29	(0.001)	29	(0.001)
Unidentified char [12]							1	(0.000)	1	(0.000)
Not Determined							**3,700**	**(0.176)**	**3,700**	**(0.116)**
Not determined							3,700	(0.176)	3,700	(0.116)
Grand Total	**10,892**		**197**	**(23-995)**	**1996**		**21,061**		**31,953**	

Notes:
1 Proportion of total catch in parentheses.
2 Range of total length in parentheses.
3 Proportion of total biomass in parentheses.
4 Proportion of total observations in parentheses.
5 Proportion of total catch and observed in parentheses.
6 Genetic analysis completed by the USFWS in November (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.
7 Exhibited characteristics indicative of the westslope cutthroat trout variety.
8 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout.
9 Genetic analysis completed by the USFWS in November 2007 identified specimen as bull trout / brook trout hybrid.
10 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
11 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.
12 Specimen observed in Sullivan Creek during snorkel survey with characteristics indicative of a bull trout, but not confirmed through capture.

Relative abundance was based on data pooled across sites and sampling events.
Table does not include fish captured and observed as during the HSI/HSC validation sampling.

Table 5.1-4. Summary of catch and fish observed but not captured (including mean catch or observations per unit effort) of five sample techniques in the Boundary Project during conduct of the monthly study site sampling in February through October 2007.

	Captured[1]									Observed Not Captured[1]							
	Reservoir and Tailrace						Tributary			Reservoir and Tailrace				Tributary			
Species	**Gill Net**		**Electrofish**		**Fyke Net**		**Fyke Net**		**Total Catch**	**Electrofish**		**Snorkel**		**Snorkel**		**Total Observed**	**Total**
Black crappie	3	(0.00)	82	(0.04)	48	(0.02)	0	(0.00)	*133*	308	(0.13)	0	(0.00)	0	(0.00)	*308*	**441**
Brook trout	1	(0.00)	5	(0.00)	0	(0.00)	0	(0.00)	*6*	0	(0.00)	2	(0.12)	77	(2.66)	*79*	**85**
Brown bullhead	0	(0.00)	26	(0.01)	10	(0.02)	0	(0.00)	*36*	3	(0.00)	0	(0.00)	0	(0.00)	*3*	**39**
Brown trout	4	(0.00)	44	(0.02)	0	(0.00)	12	(0.01)	*60*	5	(0.00)	0	(0.00)	24	(0.83)	*29*	**89**
Bull trout [2]	0	(0.00)	1	(0.00)	0	(0.00)	0	(0.00)	*1*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**1**
Burbot	7	(0.01)	5	(0.00)	1	(0.00)	1	(0.00)	*14*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**14**
Char hybrid [3]	0	(0.00)	1	(0.00)	0	(0.00)	0	(0.00)	*1*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**1**
Cutthroat trout[4]	0	(0.00)	11	(0.00)	0	(0.00)	74	(0.03)	*85*	0	(0.00)	2	(0.12)	320	(11.03)	*322*	**407**
Kokanee	0	(0.00)	3	(0.00)	0	(0.00)	0	(0.00)	*3*	1	(0.00)	0	(0.00)	0	(0.00)	*1*	**4**
Lake trout	2	(0.00)	6	(0.00)	0	(0.00)	0	(0.00)	*8*	0	(0.00)	0	(0.00)	2	(0.07)	*2*	**10**
Lake whitefish	0	(0.00)	2	(0.00)	0	(0.00)	0	(0.00)	*2*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**2**
Largemouth bass	6	(0.00)	30	(0.01)	2	(0.00)	0	(0.00)	*38*	3	(0.00)	0	(0.00)	0	(0.00)	*3*	**41**
Largescale sucker	157	(0.16)	2,615	(1.13)	279	(0.48)	6	(0.01)	*3,057*	4,594	(2.25)	509	(29.94)	46	(1.59)	*5,149*	**8,206**
Longnose dace	0	(0.00)	0	(0.00)	0	(0.00)	18	(0.01)	*18*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**18**
Longnose sucker	2	(0.00)	33	(0.02)	4	(0.01)	0	(0.00)	*39*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**39**
Mountain whitefish	8	(0.01)	103	(0.05)	0	(0.00)	73	(0.03)	*184*	77	(0.04)	8	(0.47)	0	(0.00)	*85*	**269**
Northern pike	14	(0.00)	1	(0.00)	1	(0.00)	0	(0.00)	*16*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**16**
Northern pikeminnow	266	(0.30)	335	(0.15)	42	(0.05)	1	(0.00)	*644*	288	(0.15)	53	(3.12)	5	(0.17)	*346*	**990**
Not determined	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	*0*	3,700	(2.00)	0	(0.00)	0	(0.00)	*3,700*	**3,700**

Table 5.1-4, continued…

	Captured[1]									Observed Not Captured[1]							
	Reservoir and Tailrace						Tributary			Reservoir and Tailrace				Tributary			
Species	**Gill Net**		**Electrofish**		**Fyke Net**		**Fyke Net**		**Total Catch**	**Electrofish**		**Snorkel**		**Snorkel**		**Total Observed**	**Total**
Peamouth	173	(0.20)	564	(0.25)	1	(0.00)	0	(0.00)	*738*	431	(0.20)	0	(0.00)	3	(0.10)	*434*	**1,172**
Pumpkin seed	7	(0.01)	185	(0.08)	137	(0.19)	0	(0.00)	*329*	344	(0.15)	2	(0.12)	0	(0.00)	*346*	**675**
Rainbow trout [5]	50	(0.07)	692	(0.36)	7	(0.01)	25	(0.01)	*774*	959	(0.51)	153	(9.00)	121	(4.17)	*1,233*	**2,007**
Rainbow trout [6]	1	(0.00)	20	(0.01)	1	(0.00)	0	(0.00)	*22*	0	(0.00)	0	(0.00)	69	(2.38)	*69*	**91**
Rainbow trout [7]	0	(0.00)	12	(0.01)	0	(0.00)	0	(0.00)	*12*	0	(0.00)	5	(0.29)	0	(0.00)	*5*	**17**
Redside shiner	1	(0.00)	4	(0.00)	0	(0.00)	4	(0.00)	*9*	0	(0.00)	0	(0.00)	0	(0.00)	*0*	**9**
Sculpin sp	0	(0.00)	1	(0.00)	0	(0.00)	19	(0.01)	*20*	1	(0.00)	0	(0.00)	0	(0.00)	*1*	**21**
Smallmouth bass	53	(0.04)	964	(0.46)	50	(0.08)	0	(0.00)	*1,069*	1,020	(0.47)	260	(15.29)	119	(4.10)	*1,399*	**2,466**
Sucker sp	0	(0.00)	1,719	(0.88)	2	(0.00)	6	(0.00)	*1,727*	5,900	(2.32)	0	(0.00)	235	(8.10)	*6,135*	**7,862**
Tench	32	(0.05)	25	(0.01)	138	(0.19)	1	(0.00)	*196*	12	(0.01)	0	(0.00)	0	(0.00)	*12*	**208**
Unidentified char[8]	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	*0*	0	(0.00)	0	(0.00)	1	(0.03)	*1*	**1**
Unidentified trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	*0*	4	(0.00)	4	(0.24)	21	(0.72)	*29*	**29**
Walleye	11	(0.01)	10	(0.01)	0	(0.00)	0	(0.00)	*21*	3	(0.00)	3	(0.18)	0	(0.00)	*6*	**27**
Yellow perch	135	(0.08)	855	(0.38)	432	(0.74)	0	(0.00)	*1,422*	1321	(0.54)	43	(2.53)	0	(0.00)	*1,364*	**2,786**
All Species	**933**	**(0.96)**	**8,354**	**(3.88)**	**1,155**	**(1.82)**	**240**	**(0.12)**	**10,682**	**18,974**	**(8.78)**	**1,044**	**(32.63)**	**1,043**	**(30.68)**	***21,061***	**31,743**

Notes:

1 Units for catch or observations per unit effort in parentheses are as follows: gill netting - value per 1000 feet^2 net set time [hr]; electrofishing - fish per electrofishing run time [minute]; fyke netting - fish per fyke net set time [hr]; angling - fish per rod hour; snorkeling - fish per site visit.

2 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.

3 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout / brook trout hybrid.

4 Exhibited characteristics indicative of the westslope cutthroat trout variety.

5 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).

Table 5.1-4, continued…

6 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.

7 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout.

8 Specimen observed in Sullivan Creek during snorkel survey with characteristics indicative of a bull trout, but not confirmed through capture.

Summary data include all fish captured or observed by gill netting, electrofishing, and fyke netting, and snorkeling during monthly samples of repeated study site locations. Summary does not include fish captured in the extra gill netting sets, captured during opportunistic angling, or observed or captured during HSC/HSI validation sampling.

Reservoir and Tailrace – During sampling of the monthly study site locations in the Boundary Reservoir and Tailrace Reach, a total of 10,442 fish were captured via gillnetting, fyke netting, and electrofishing, and 1,044 fish were observed through snorkel surveys (Table 5.1-4). Native salmonids comprised about 1 percent of the catch (135 fish), and tailrace snorkel observations accounted for an additional 15 native salmonids in the Boundary Reservoir and Tailrace Reach. Mountain whitefish dominated the native salmonid catch and snorkel observations (119 fish). Seventeen wild rainbow trout that may be descendants of native redband trout were captured or observed in the Tailrace Reach. Thirteen cutthroat trout that exhibited characteristics of the westslope cutthroat trout subspecies were captured or observed in the Reservoir and Tailrace reaches. One bull trout, confirmed through genetic analysis (P. DeHaan, USFWS, personal communication, November 14, 2007), was captured in the Tailrace Reach. Two other char were captured (one in the Tailrace Reach and one in the Upper Reservoir Reach) that exhibited bull trout characteristics; they were later determined to be a brook trout (Tailrace Reach specimen) and a bull trout/brook trout hybrid (Upper Reservoir Reach specimen).

Tributaries – Monthly snorkeling and twice-monthly fyke netting at selected tributary channels/delta reaches resulted in the observation of 1,043 fish and capture of 240 fish, respectively. Native salmonids comprised 61 percent of the catch (147 fish) in the tributary fyke nets. The native salmonid catch consisted of mountain whitefish (73 fish) and cutthroat trout (74 fish). Cutthroat trout, exhibiting characteristics of the westslope cutthroat trout subspecies, accounted for all native salmonids observed in tributaries and comprised 31 percent (320 fish) of all fish observed. One unidentified char that exhibited characteristics of a bull trout was observed during a snorkel survey of Sullivan Creek. No native salmonids were observed within the inundated delta immediately adjacent the channel mouth during monthly snorkel observations.

Most salmonids captured or observed during the monthly sampling program were either hatchery triploids or non-native naturally reared species, including rainbow, brown, brook, and lake trout. Of the 799 rainbow trout captured, 98 percent were considered non-native. A total of 416, or 52 percent of these rainbow trout exhibited signs indicating hatchery origin (eroded fins, shortened and damage operculum, irregular scale patterns). Another 349 (44 percent) rainbow trout were noted as believed to be of hatchery origin due to less apparent signs (elliptical or "football shape" body, blunt heads, coarse or rough scale patterns). The remaining 34 captured rainbow trout were noted as possible wild origin, where none of the features noted above were observed. Most of the rainbow trout considered to be naturally reared, non-hatchery fish (specimens with intact fins, finer scale patterns, fusiform body form) were observed during snorkel surveys within tributary channels or captured in tributary fyke net sampling.

5.1.2.1. Gill Net Sampling

A total of 483 separate gill net sets were deployed across 25 site locations in Boundary Reservoir and Tailrace Reach for a total of 2,852 hours (3,075 hours per 1,000 square feet net). Eighteen of the study sites were sampled each month (referred to as the monthly sites herein). Although the location of each gill net set at the monthly sites was standardized to the extent practicable (Figure 4.1-1), set locations varied slightly between sample periods with changing reservoir inflow. For example, to reduce excessive net movements in some of the deep set locations, nets were moved closer to shore during high discharges to take advantage of velocity shelters. Seven sites were sampled intermittently (referred to as extra gill net sites) in an effort to capture target species for tagging.

A total of 933 fish representing 19 species and 7 families were captured across the 18 monthly sites in the reservoir and tailrace sample sites. Another 121 fish representing 13 species were captured in the seven extra sites (Table 5.1-5; Appendix 2, Table A.2-1). Northern pikeminnow, peamouth, largescale sucker, and yellow perch accounted for 78 percent of the total numerical catch within the 18 monthly study sites. By number, northern pikeminnow were the most abundant species (29 percent) captured in gillnets (Table 5.1-5). Smallmouth bass and non-native rainbow trout accounted for 10 percent of the monthly site total catch. Thirteen species comprised the remaining 12 percent of the catch.

Salmonids represented 6 percent of the total numerical catch and 6 percent of the catch biomass. They were captured at 14 of the 18 monthly sites. Only 1.2 percent of the salmonid monthly gill net sites (8 of 66 fish) comprised native salmonids. Mountain whitefish were the only native salmonid captured at the monthly gillnetting study sites.

Relative abundance of salmonids was greater and yellow perch lower at the extra sites (Table 5.1-5), which were located with the intent to capture native salmonids and carry-over rainbow triploids for tagging purposes. Although northern pikeminnow, peamouth, and suckers were still common at the extra sites (the three species comprised 61 percent of the extra site total catch), native salmonids comprised 9 percent of the catch (9 mountain whitefish and 2 cutthroat trout) at the extra sites. Other non-native salmonids comprised another 20 percent of the catch. Relative abundance of mountain whitefish, cutthroat trout, rainbow trout, and brown trout was higher at the extra sites as compared to the monthly sites. Six of the seven extra gill net sites were situated near the mouths of tributary streams.

The monthly gill net sets were distinguished as shallow (< 30 feet), moderate (30 – 80 feet) and deep (> 80 feet). Shallow sites included one net that was generally placed on or near the bottom. Moderate depth sites sets included two nets, one placed at the surface and one at the bottom. Deep sets included 5 nets, with 4 hung vertically from the surface fishing 100 feet of the water column. A horizontal net was placed horizontally along the bottom of the deep sets. Catch rates differed among the gill net set types. The shallow, moderate surface, and moderate bottom set types consistently had higher catch rates (Table 5.1-6, Figure 5.1-2, and Appendix 2 Table A.2-2). Catch rates of the deep bottom sets varied through the course of the study. The four deep vertical nets deployed at each of the six deep water study sites in the Forebay and Canyon reaches consistently had very low catch rates, less than 10 percent of any other gill net set types with only 18 fish captured during the entire study period (with over 1,000 hours of net deployment).

Table 5.1-5. The total number, mean total length, and biomass of fish captured at the gill netting study sites in Boundary Reservoir and Tailrace Reach during February through October 2007.

	Number Captured in Monthly Sites[1]		**Number Captured in Extra Sites[1]**		**Total Number Captured[1]**		**Mean Length (mm)[2]**		**Total Species Biomass (kg)[3]**	
Catostomidae	**159**	**(0.17)**	**17**	**(0.14)**	**176**	**(0.17)**	**392**	**(103-515)**	**118**	**(0.27)**
Longnose sucker	2	(0.00)		(0.00)	2	(0.00)	395	(349-440)	1	(0.00)
Largescale sucker	157	(0.17)	17	(0.14)	174	(0.17)	392	(103-515)	117	(0.27)
Centrarchidae	**69**	**(0.07)**	**3**	**(0.02)**	**72**	**(0.07)**	**284**	**(34-426)**	**30**	**(0.07)**
Largemouth bass	6	(0.01)		(0.00)	6	(0.01)	357	(325-387)	5	(0.01)
Smallmouth bass	53	(0.06)	3	(0.02)	56	(0.05)	302	(92-426)	25	(0.06)
Pumpkinseed	7	(0.01)		(0.00)	7	(0.01)	84	(34-127)	0	(0.00)
Black crappie	3	(0.00)		(0.00)	3	(0.00)	213	(169-275)	0	(0.00)
Cyprinidae	**472**	**(0.51)**	**59**	**(0.49)**	**531**	**(0.50)**	**317**	**(98-839)**	**166**	**(0.38)**
Northern pikeminnow	266	(0.29)	22	(0.18)	288	(0.27)	340	(125-839)	107	(0.25)
Peamouth	173	(0.19)	35	(0.29)	208	(0.20)	283	(115-374)	38	(0.09)
Redside shiner	1	(0.00)		(0.00)	1	(0.00)	125	(125-125)	0	(0.00)
Tench	32	(0.03)	2	(0.02)	34	(0.03)	344	(98-476)	22	(0.05)
Esocidae	**14**	**(0.02)**	**2**	**(0.02)**	**16**	**(0.02)**	**619**	**(420-786)**	**37**	**(0.09)**
Northern pike	14	(0.02)	2	(0.02)	16	(0.02)	619	(420-786)	37	(0.09)
Gadidae	**7**	**(0.01)**		**(0.00)**	**7**	**(0.01)**	**518**	**(405-599)**	**6**	**(0.01)**
Burbot	7	(0.01)		(0.00)	7	(0.01)	518	(405-599)	6	(0.01)
Percidae	**146**	**(0.16)**	**5**	**(0.04)**	**151**	**(0.14)**	**208**	**(95-575)**	**31**	**(0.07)**
Walleye	11	(0.01)	1	(0.01)	12	(0.01)	519	(461-575)	19	(0.04)
Yellow perch	135	(0.14)	4	(0.03)	139	(0.13)	181	(95-297)	12	(0.03)
Salmonidae Native	**8**	**(0.01)**	**11**	**(0.09)**	**19**	**(0.02)**	**403**	**(312-476)**	**11**	**(0.03)**
Cutthroat trout[4]		(0.00)	2	(0.02)	2	(0.00)	326	(312-339)	1	(0.00)
Mountain whitefish	8	(0.01)	9	(0.07)	17	(0.02)	412	(349-476)	11	(0.02)
Salmonidae Non-native	**58**	**(0.06)**	**24**	**(0.20)**	**82**	**(0.08)**	**343**	**(213-616)**	**36**	**(0.08)**
Brook trout	1	(0.00)		(0.00)	1	(0.00)	269	(269-269)	0	(0.00)
Brown trout	4	(0.00)	7	(0.06)	11	(0.01)	385	(236-505)	7	(0.02)
Lake trout	2	(0.00)	1	(0.01)	3	(0.00)	500	(435-616)	3	(0.01)
Rainbow trout [5]	50	(0.05)	14	(0.12)	64	(0.06)	332	(236-599)	25	(0.06)
Rainbow trout [6]	1	(0.00)	2	(0.02)	3	(0.00)	284	(213-418)	1	(0.00)
Totals	**933**		**121**		**1054**		**321**	**(34-839)**	**437**	

Notes:
1 Proportion of total catch for gillnetting in parentheses.
2 Range of total length in parentheses.
3 Proportion of total biomass in parentheses.
4 Exhibited characteristics indicative of the westslope cutthroat trout variety.
5 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
6 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.
Relative abundance was based on data pooled across sites and sampling events.

Table 5.1-6. Total catch for the five types of gill netting sets used in the monthly gill netting study sites in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington, February through October 2007.

Species	Shallow		Moderate Surface		Moderate Bottom		Deep Bottom		Deep Vertical		All Nets Combined	
Black crappie	0	(0.00)	2	(0.01)	1	(0.01)	0	(0.00)	0	(0.00)	3	(0.00)
Brook trout	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Brown trout	2	(0.01)	0	(0.00)	2	(0.00)	0	(0.00)	0	(0.00)	4	(0.00)
Bull trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
Burbot	1	(0.00)	2	(0.01)	2	(0.01)	1	(0.00)	1	(0.01)	7	(0.01)
Lake trout	1	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
Largemouth bass	5	(0.01)	0	(0.00)	1	(0.00)	0	(0.00)	0	(0.00)	6	(0.00)
Largescale sucker	65	(0.29)	10	(0.07)	21	(0.15)	58	(0.14)	3	(0.03)	157	(0.16)
Longnose sucker	0	(0.00)	0	(0.00)	2	(0.01)	0	(0.00)	0	(0.00)	2	(0.00)
Mountain whitefish	4	(0.02)	3	(0.02)	0	(0.00)	1	(0.00)	0	(0.00)	8	(0.01)
Northern pike	8	(0.01)	4	(0.00)	2	(0.00)	0	(0.00)	0	(0.00)	14	(0.00)
Northern pikeminnow	111	(0.45)	46	(0.30)	56	(0.29)	45	(0.12)	8	(0.11)	266	(0.30)
Peamouth	50	(0.15)	75	(0.53)	36	(0.13)	8	(0.02)	4	(0.06)	173	(0.20)
Pumpkinseed	4	(0.01)	2	(0.03)	1	(0.00)	0	(0.00)	0	(0.00)	7	(0.01)
Rainbow trout [1]	24	(0.13)	17	(0.09)	6	(0.01)	2	(0.03)	1	(0.01)	50	(0.07)
Rainbow trout [2]	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Redside shiner	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Smallmouth bass	19	(0.10)	5	(0.01)	8	(0.02)	21	(0.03)	0	(0.00)	53	(0.04)
Tench	20	(0.09)	2	(0.01)	6	(0.04)	4	(0.02)	0	(0.00)	32	(0.05)
Walleye	7	(0.02)	2	(0.01)	2	(0.01)	0	(0.00)	0	(0.00)	11	(0.01)
Yellow perch	44	(0.10)	3	(0.02)	24	(0.13)	63	(0.14)	1	(0.01)	135	(0.08)
All Species	**367**	**(1.03)**	**175**	**(0.75)**	**170**	**(0.59)**	**203**	**(0.23)**	**18**	**(0.02)**	**933**	**(0.35)**

Notes:

1 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).

2 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.

Mean CPUE as defined by fish per 1,000 square feet net set time (hr) in parentheses.

Each catch rate is computed by first calculating the species CPUE for each sampling event at each site, and then computing the mean CPUE for net set type.

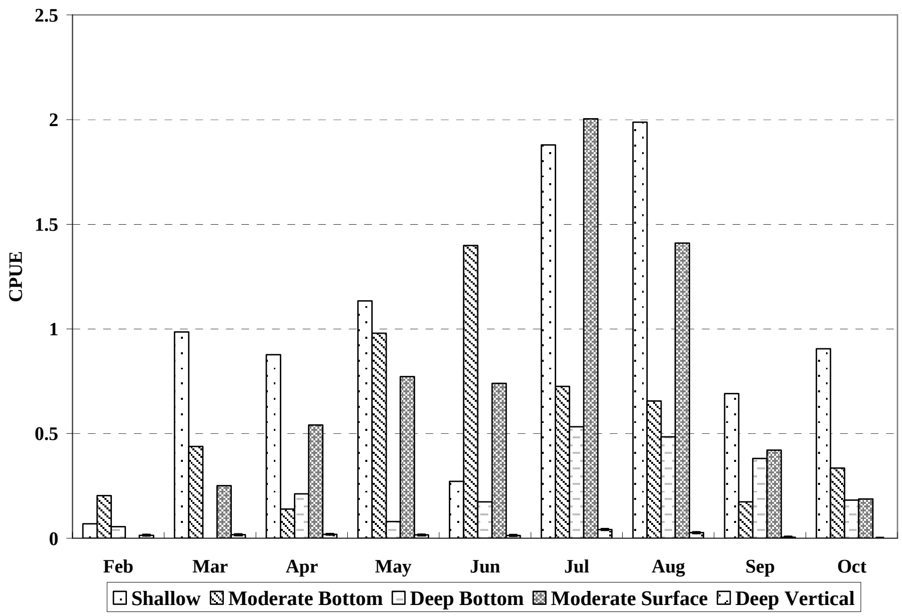

Figure 5.1-2. Mean catch-per-unit-effort (CPUE: fish per 1000 square feet net set time [hr]) of all fish species combined for the five types of gill netting sets used in the monthly gill netting study sites in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Note: Each catch rate is computed by first calculating the CPUE for all species combined for each sampling event at each site, and then computing the mean monthly CPUEs for net set type.

5.1.2.2. Reservoir Electrofishing

5.1.2.2.1. Transect Sampling

Boat-mounted electrofishing surveys were conducted monthly at twenty two 1,300-foot long standardized transects from March through October for a total of 35.9 hours of electrofishing total run time. Electrofishing occurred along the same near shore transect during each sample visit, although fluctuations in reservoir and tailrace levels resulted in minor variations in site location. A total of 8,354 fish representing 25 species and 9 families were captured across the 22 electrofishing study sites (Appendix 2, Table A.2-3). Nearly twice as many fish were observed but not captured, as they were only momentarily attracted to the electrofishing unit, or netters were unable to capture all specimens encountered.

Catostomids (mostly largescale suckers) comprised 52 percent of the total numerical catch and 69 percent of the fish observed but not captured (observed) (Table 5.1-7). Smallmouth bass and rainbow trout accounted for 12 and 9 percent of the monthly site total catch, respectively. Largescale sucker, northern pikeminnow, smallmouth bass, and rainbow trout were captured at least once at all 22 of the electrofishing sites. Native salmonids represented 2 percent of the total numerical catch and 8 percent of the catch biomass. Rainbow trout dominated the salmonid monthly site catch.

Table 5.1-7. Total number, mean total length, and biomass of fish captured, and number of fish observed but not captured by electrofishing in the Boundary Reservoir and Tailrace Reach during March through October 2007.

Species	Catch[1]		Mean Length (mm)[2]		Total Species Biomass (kg)[3]		Observed Not Captured[4]		Total Catch and Observed[5]	
Catostomidae	**4,367**	**(0.52)**	**188**	**(34-995)**	**814.3**	**(0.59)**	**10,494**	**(0.55)**	**14,861**	**(0.54)**
Longnose sucker	33	(0.00)	320	(129-440)	13.1	(0.01)		(0.00)	33	(0.00)
Largescale sucker	2,615	(0.31)	258	(38-995)	796.3	(0.58)	4,594	(0.24)	7,209	(0.26)
Sucker sp	1,719	(0.21)	74	(34-295)	4.9	(0.00)	5,900	(0.31)	7,619	(0.28)
Centrarchidae	**1,261**	**(0.15)**	**151**	**(23-494)**	**130.9**	**(0.09)**	**1,675**	**(0.09)**	**2,936**	**(0.11)**
Largemouth bass	30	(0.00)	93	(44-412)	2.4	(0.00)	3	(0.00)	33	(0.00)
Smallmouth bass	964	(0.12)	169	(34-494)	122.6	(0.09)	1020	(0.05)	1984	(0.07)
Pumpkinseed	185	(0.02)	101	(40-174)	4.5	(0.00)	344	(0.02)	529	(0.02)
Black crappie	82	(0.01)	77	(23-238)	1.4	(0.00)	308	(0.02)	390	(0.01)
Cottidae	**1**	**(0.00)**	**86**	**(86-86)**	**0.0**	**(0.00)**	**1**	**(0.00)**	**2**	**(0.00)**
Sculpin sp	1	(0.00)	86	(86-86)	0.0	(0.00)	1	(0.00)	2	(0.00)
Cyprinidae	**928**	**(0.11)**	**208**	**(40-604)**	**141.3**	**(0.10)**	**731**	**(0.04)**	**1,659**	**(0.06)**
Northern pikeminnow	335	(0.04)	246	(40-604)	72.1	(0.05)	288	(0.02)	623	(0.02)
Peamouth	564	(0.07)	179	(46-382)	48.5	(0.03)	431	(0.02)	995	(0.04)
Redside shiner	4	(0.00)	97	(80-110)	0.0	(0.00)		(0.00)	4	(0.00)
Tench	25	(0.00)	386	(219-477)	20.7	(0.01)	12	(0.00)	37	(0.00)
Esocidae	**1**	**(0.00)**	**445**	**(445-445)**	**0.6**	**(0.00)**		**(0.00)**	**1**	**(0.00)**
Northern pike	1	(0.00)	445	(445-445)	0.6	(0.00)		(0.00)	1	(0.00)
Gadidae	**5**	**(0.00)**	**446**	**(197-582)**	**2.9**	**(0.00)**		**(0.00)**	**5**	**(0.00)**
Burbot	5	(0.00)	446	(197-582)	2.9	(0.00)		(0.00)	5	(0.00)
Ictaluridae	**26**	**(0.00)**	**271**	**(153-332)**	**7.4**	**(0.01)**	**3**	**(0.00)**	**29**	**(0.00)**
Brown bullhead	26	(0.00)	271	(153-332)	7.4	(0.01)	3	(0.00)	29	(0.00)
Percidae	**865**	**(0.10)**	**139**	**(48-640)**	**49.2**	**(0.04)**	**1,324**	**(0.07)**	**2,189**	**(0.08)**
Walleye	10	(0.00)	469	(124-640)	12.7	(0.01)	3	(0.00)	13	(0.00)
Yellow perch	855	(0.10)	135	(48-278)	36.4	(0.03)	1,321	(0.07)	2,176	(0.08)
Salmonidae Native	**129**	**(0.02)**	**189**	**(27-717)**	**23.2**	**(0.02)**	**77**	**(0.00)**	**206**	**(0.01)**
Bull trout [6]	1	(0.00)	285	(285-285)	0.2	(0.00)		(0.00)	1	(0.00)
Cutthroat trout[7]	11	(0.00)	269	(130-416)	2.8	(0.00)		(0.00)	11	(0.00)
Rainbow trout [8]	12	(0.00)	346	(194-717)	5.3	(0.00)		(0.00)	12	(0.00)
Mountain whitefish	103	(0.01)	156	(27-470)	13.6	(0.01)	77	(0.00)	180	(0.01)
Lake whitefish	2	(0.00)	439	(432-445)	1.4	(0.00)		(0.00)	2	(0.00)
Salmonidae Non-native	**771**	**(0.09)**	**303**	**(129-591)**	**215.1**	**(0.16)**	**969**	**(0.05)**	**1,740**	**(0.06)**
Brook trout	5	(0.00)	205	(129-261)	0.5	(0.00)		(0.00)	5	(0.00)
Brown trout	44	(0.01)	377	(151-591)	26.5	(0.02)	5	(0.00)	49	(0.00)
Char hybrid [9]	1	(0.00)	332	(332-332)	0.3	(0.00)		(0.00)	1	(0.00)
Kokanee	3	(0.00)	175	(161-192)	0.1	(0.00)	1	(0.00)	4	(0.00)
Lake trout	6	(0.00)	459	(388-528)	4.2	(0.00)		(0.00)	6	(0.00)
Rainbow trout [10]	692	(0.08)	299	(201-476)	179.0	(0.13)	959	(0.05)	1,651	(0.06)
Rainbow trout [11]	20	(0.00)	269	(165-395)	4.4	(0.00)		(0.00)	20	(0.00)
Unidentified trout							4	(0.00)	4	(0.00)
Not Determined							**3,700**	**(0.20)**	**3,700**	**(0.14)**
Not determined							3,700	(0.20)	3,700	(0.14)
Grand Total	**8,354**		**191**	**(23-995)**	**1,384.8**		**18,974**		**27,328**	

<u>Notes:</u>

1 Proportion of total catch in parentheses.

2 Range of total length in parentheses.

3 Proportion of total biomass in parentheses.

Table 5.1-7, continued…

4 Proportion of total observations in parentheses.
5 Proportion of total catch and observed in parentheses.
6 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.
7 Exhibited characteristics indicative of the westslope cutthroat trout variety.
8 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout.
9 Genetic analysis completed by the USFWS in November 2007 identified specimen as bull trout / brook trout hybrid.
10 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
11 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries. Relative abundance was based on data pooled across sites and sampling events.

5.1.2.2.2. HSC/HSI Validation Sampling

HSC data were collected on a total of 446 sample points across the three reservoir reaches and tailrace during electrofishing (Table 5.1-8). Smallmouth bass, peamouth, and northern pikeminnow were the dominant target species observed. The majority of peamouth and northern pikeminnow encountered exceeded 10 cm total length, and as such, were not considered as the part of the forage base of the predatory target species for modeling purposes. A total of 251 target specimens were observed at 113 sample points. An additional 1,160 other fish species were observed at the sample points. No fish were observed on 175 points. Also shown in Table 5.1-8 are the HSC data recorded during biotelemetry including the number of tagged fish and total number of HSI measurements (several fish were relocated multiple times). The majority of data was for tagged smallmouth bass. The details of these measurement values are presented in the Study 7 Interim Report (SCL 2008a).

Table 5.1-8. Summary HSC validation sample points for electrofish and biotelemetry visited during April through September 2007 on the Project.

Sampling Method	Month	# Electro-fishing Cells	Fish Species[1]							
			Bull Trout	Cut-throat Trout	Rainbow Trout (wild)	Mountain Whitefish	Smallmouth Bass			Forage <10cm
							<6 cm	6-15 cm	>15cm	
Boat Electro-fishing	March	11	0	0	1	0	0	0	0	1
	April	103	0	0	1	0	0	2	3	4
	May	87	0	0	1	1	0	5	10	4
	June	0	0	0	0	0	0	0	0	0
	July	60	0	0	0	0	1	4	4	0
	Aug	97	0	0	0	0	9	28	13	14
	Sept	96	0	0	0	0	2	19	4	7
	Total # Cells	454	0	0	3	1	12	58	34	30
	Total # Fish	NA	0	0	3	1	12	93	44	92
Bio-telemetry	# Tagged Fish	NA	0	2	3	1	0	0	15	0
	# HSC Obser.	NA	0	6	0	2	0	0	44	0

Note:
1 Forage species are cyprinids less than about 10 cm.

Species Periodicity

In addition to analyzing HSC/HSI information for instream flow modeling, Study 7 (Mainstem Habitat Aquatic Modeling) will summarize timing and length data collected as part of Study 9 Passive and Active Sampling to develop periodicity information. In addition to data collected as part of Study 9, fish periodicity tables will incorporate data on fish timing and length collected during stranding and trapping surveys conducted as part of Study 7 in July, August and September. To supplement the literature-based provisional periodicity tables constructed for the Project, length frequency histograms were developed from data collected from all the Study 9 sampling procedures for target species that will be used in the model analysis under Study 7 (see Appendix 2, Figure A.2-1).

Westslope Cutthroat Trout – Current study result information aids in identifying the timing of life history stages of target species in Boundary Reservoir. While not complete, some of this information is summarized below for the key target species. Specific determination of when certain life history stages are present within the study area relating to Study 7 modeling will be presented in that study. The following information is preliminary and may change with additional analysis.

Consistent with previous findings (McClellan 2001), cutthroat trout were rarely captured in Boundary Reservoir, but were commonly observed in Sullivan, Sweet, Slate, and Sand creeks. Young of year and fingerling were exclusively observed in Slate and Sweet creeks. Young of year cutthroat trout were first captured in Slate Creek fyke netting in late June and were a common part of the catch and observations in July and early August. Young of year cutthroat captured in July and August averaged 44 mm (30 to 58 mm). No young of year or what were presumed to be yearling cutthroat trout were captured or observed in the electrofishing, fyke netting, or trapping and stranding studies conducted in the tailrace and reservoir.

Other studies suggest that westslope cutthroat trout spawn from March through July, when water temperatures warm to approximately 10°C (50°F) (USFWS 1999). Fry emergence is usually complete by the end of August, which is generally consistent with the timing in which fry were observed in the tributaries. Suitable spawning habitat in the Project appears limited to the tributary channels.

Westslope cutthroat trout can exhibit resident, adfluvial, or fluvial life history patterns. Resident westslope cutthroat trout generally mature at a smaller size than fluvial or adfluvial fish (Wydoski and Whitney 2003). The USFWS (1999) suggested that westslope cutthroat trout that spawned in tributaries to the Pend Oreille River were historically either fluvial or resident fish and under current conditions the fluvial form may have converted to the adfluvial form. Under an adfluvial life history pattern, mature adults spawn in a tributary stream. Young fish rear in the tributary for up to several years, but eventually move downstream to rear in a lake or reservoir. Additional rearing occurs in the lacustrine or reservoir environment for several years (usually two or more) as the fish grows to adulthood. The degree to which cutthroat trout may exhibit this life history pattern in Boundary Reservoir is unknown. All of the cutthroat trout observed in the tributaries were less than 300 mm TL, and the majority of larger fish were less than 250 mm.

Intensive sampling of the tributary channels during April and May 2008 may reveal seasonal changes in the abundance of larger, mature cutthroat trout.

Mountain Whitefish – Data collection on mountain whitefish provides information on when the young of the year life stage may first appear in the Project area. May was when young of the year first appeared in regular sampling, averaging 33 mm (27-36 mm). By June, mean size had increased to 63 mm (45 to 76 mm) for assumed young of the year fish. During stranding surveys in July, August, and September, no mountain whitefish were observed (SCL 2008a). Studies on systems in British Columbia have indicated the newly emerged mountain whitefish are consistently about 17 mm at emergence (McPhail and Troffe 1998). Small fish of this size may have been missed with the current boat electrofishing sampling methods; it is likely the first emergence is in April. Literature suggests spawning may occur from September into February (Wydoski and Whitney 2003, Scott and Crossman 1973, SCL 2007b). However, while spawning temperatures range from 0 to 11ºC, spawning more commonly occurs in cooler water (i.e., 3-5ºC) and usually not until the temperature cools to 6ºC (R.L and L. Environmental Services 1996). Such cool temperatures usually do not occur in the Pend Oreille River system locally until November. In the Box Canyon system, mountain whitefish were noted as a late winter spawner (Ashe and Scholz 1992). It is probable that mountain whitefish in Boundary Reservoir spawn in the late fall to early winter period, but the exact timing is not available. Sampling conducted in November and December may reveal seasonal changes in adult mountain whitefish and abundance. The analysis of periodicity will be analyzed further in Study 7.

Smallmouth Bass – Smallmouth bass young of year first appeared in the monthly study sites in July; these were abundant in August to September samples (224 fish with TL ranging from 50 to 90 mm) (Appendix 2, Figure A.2-1). However, stranding study observations on July 11 noted over a thousand smallmouth bass in the 40 to 50 mm range in off-channel backwaters and pools with vegetation mats. Again, collection of the earliest small-size fish is likely not occurring in current sampling. Wydoski and Whitney (2003) noted that spawning occurs in the temperature range of 12.8 to 18.3ºC. The average daily water temperature at the Boundary tailrace (USGS Station # 12398600 Pend Oreille River) over the period of 2001-2007 was in this range from May 18 to June 28. In 2007, at this station, those temperature ranges occurred from approximately May 13 to July 4. McLellan and O'Connor (2001) noted in 2000 that 13ºC did not occur until mid-June. Thus, the spawning period could vary by year, but for 2007 the range was likely mid-May through June in Boundary Reservoir.

Northern Pikeminnow and Peamouth – Northern pikeminnow and peamouth are target species because they are considered representative of potential prey resources (SCL 2007a). Both of these species are generally considered late spring to early summer spawners (Wydoski and Whitney 2003). Peamouth may spawn earlier (typically late May to early June) while northern pikeminnow spawn from late May into July, but primarily in June. Very few young of year of either species were captured. Peamouth first appeared in the late July sampling (one fish at 46 mm), with more in August (three at 65 to 78 mm). Northern pikeminnow young of year may not have appeared in samples until September (four fish with TL ranging from 40 to 65 mm). Neither species as young of the year appeared in any of the stranding study surveys that occurred from July through September, with the possible exception of one occurrence of juvenile (not measured) northern pikeminnow in September 8 in a dry pool near Sand Creek (SCL 2008a).

Boat electrofishing crews noted abundant larval-stage fishes that they were unable to capture along the shorelines in the Upper Reservoir Reach in the July and August sampling. Sampling conducted to date has been unable to determine when peamouth and northern pikeminnow young of year first occur in the system, but no peamouth less than 70 mm TL were observed until late July. Northern pikeminnow young of year were not observed until September. Neither species were observed in the stranding and trapping surveys conducted in early July, although numerous unidentified larval fishes were observed.

5.1.2.3. Fyke Net Sampling

5.1.2.3.1. Reservoir and Tailrace

A total of 28 separate fyke net sets were deployed across 16 different site locations in Boundary Reservoir and Tailrace. Fyke nets were deployed for approximately 24 hours during each monthly set for a total of 712 hours effort. A total of 1,155 fish representing 19 species and 7 families were captured at the 16 study sites (Appendix 2, Table A.2-4). Only four fish (smallmouth bass and pumpkinseed) were captured in tailrace sets.

Yellow perch, largescale sucker, tench, and pumpkinseed dominated the fyke catch (Table 5.1-9). Fish were typically small in fyke net catches in the reservoir and tailrace with the mean TL of fyke net captures at 145 mm (SE = 27); over 70 percent of the captures were less than 150 mm TL. Eight non-native rainbow trout were captured in the reservoir fyke nets, two of which appeared to be of wild origin.

Warmwater sport fish species encountered in the shallow off channel areas sampled by the fyke nets included pumpkinseed, smallmouth bass and black crappie. One northern pike (484 mm TL) was captured in the fyke sets of the Upper Reservoir Reach.

5.1.2.3.2. Tributary

Fyke net sets were deployed in the Slate, Sullivan, and Sweet creek sample sites for a continuous 3-day period twice monthly between May and October. In total, 240 fish were captured in the tributary fyke nets. Salmonids dominated the catch (Table 5.1-9). Nearly all salmonids captured were less than 150 mm TL, although the catch included four triploid rainbow trout that had a mean TL of 316 mm. Additional discussion of the results of tributary fyke net sampling is presented in Section 5.1.3.3.4.

Table 5.1-9. The total number and mean total length of fish captured by fyke netting in the Project during April through October 2007.

Taxa	Reservoir and Tailrace				Tributaries				
	Catch[1]		Mean Length (mm)[2]		Catch[1]		Mean Length (mm)[2]		Total Catch
Catostomidae	**285**	**(0.247)**	**85**	**(48-439)**	**12**	**(0.050)**	**197**	**(30-426)**	**297**
Longnose sucker	4	(0.003)	366	(268-439)					4
Largescale sucker	279	(0.242)	82	(48-433)	6	(0.025)	345	(72-426)	285
Sucker sp	2	(0.002)	64	(58-70)	6	(0.025)	49	(30-98)	8
Centrarchidae	**237**	**(0.205)**	**98**	**(39-295)**					**237**
Largemouth bass	2	(0.002)	99	(64-133)					2
Smallmouth bass	50	(0.043)	96	(52-295)					50
Pumpkinseed	137	(0.119)	105	(39-202)					137
Black crappie	48	(0.042)	79	(61-149)					48
Cottidae					**19**	**(0.079)**	**61**	**(30-79)**	**19**
Sculpin sp					19	(0.079)	61	(30-79)	19
Cyprinidae	**181**	**(0.157)**	**317**	**(40-496)**	**24**	**(0.100)**	**97**	**(36-355)**	**205**
Longnose dace		(0.000)			18	(0.075)	86	(36-131)	18
Northern pikeminnow	42	(0.036)	88	(40-496)	1	(0.004)	355	(355-355)	43
Peamouth	1	(0.001)	170	(170-170)					1
Redside shiner					4	(0.017)	85	(76-90)	4
Tench	138	(0.119)	388	(60-470)	1	(0.004)	72	(72-72)	139
Esocidae	**1**	**(0.001)**	**484**	**(484-484)**					**1**
Northern pike	1	(0.001)	484	(484-484)					1
Gadidae	**1**	**(0.001)**	**464**	**(464-464)**	**1**	**(0.004)**	**218**	**(218-218)**	**2**
Burbot	1	(0.001)	464	(464-464)	1	(0.004)	218	(218-218)	2
Ictaluridae	**10**	**(0.009)**	**302**	**(276-320)**					**10**
Brown bullhead	10	(0.009)	302	(276-320)					10
Percidae	**432**	**(0.374)**	**130**	**(57-280)**					**432**
Yellow perch	432	(0.374)	130	(57-280)					432
Salmonidae Native					**147**	**(0.613)**	**89**	**(28-265)**	**147**
Cutthroat trout[3]					74	(0.308)	67	(28-248)	74
Mountain whitefish					73	(0.304)	112	(31-265)	73
Salmonidae Non-native	**8**	**(0.007)**	**289**	**(242-346)**	**37**	**(0.154)**	**108**	**(43-360)**	45
Brown trout					12	(0.050)	92	(50-239)	12
Rainbow trout[4]	7	(0.006)	295	(262-346)	4	(0.017)	316	(284-360)	12
Rainbow trout[5]	1	(0.001)	242	(242-242)	21	(0.088)	88	(43-224)	22
Grand Total	**1,155**		**145**	**(39-496)**	**240**		**97**	**(28-426)**	**1,395**

Notes:
1 Proportion of total catch for study location in parentheses.
2 Range of total length in parentheses.
3 Exhibited characteristics indicative of the westslope variety.
4 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
5 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.

5.1.2.4. Snorkel Surveys

A total of 35 separate nighttime snorkel surveys were conducted across the five tributary sites and the two tailrace sites from March through October. Survey efficiency varied among the sample periods. This was especially notable during March and April in the tributary surveys, when moderately high stream discharge and turbidity levels resulted in low underwater visibility and prohibited access to a significant portion of each of the study reaches. Access associated with stream discharge improved during the May tributary surveys, but visibility remained notably less than during the June through October survey period. High turbidity levels and/or algal blooms in the reservoir also reduced visibility in the inundated tributary deltas and in the tailrace from March through mid-June. In addition, sampling efficiency in the tailrace was affected by variability in generation levels and tailrace water surface elevations between sample periods.

A total of 1,044 observations representing nine species were made in the Tailrace Reach during monthly snorkel surveys, and 1,051 fish observations were made representing 13 species in the five tributary streams (Slate, Flume, Sullivan, Sweet, and Sand creeks) (Table 5.1-4; Appendix 2, Tables A.2-5 and A.2-6).

Daytime surveys in the tailrace resulted in 454 fish observations, whereas 590 fish were observed during nighttime surveys. Largescale suckers comprised 48 percent of the total fish observations in the tailrace, followed by smallmouth bass (25 percent) and rainbow trout (16 percent).

Cutthroat trout and non-native, naturally reared rainbow trout dominated the snorkel observations within the tributary channels upstream of the reservoir pool level at the time of surveys. Brook trout and brown trout were also observed at least once in all of the sites. A total of 635 salmonid observations were made in the five tributary channels upstream of the reservoir pool level at the time of surveys. Only five of these fish were estimated to exceed 300 mm TL, and 16 percent exceeded 250 mm TL. In contrast, all of the salmonids observed within the inundated deltas and in the coldwater plumes at the mouth of the channels were estimated to exceed 250 mm. No native salmonids were observed within the inundated deltas during snorkel surveys or via observations from the deck of the survey boat.

One unidentified char (approximately 350 mm TL) with characteristics indicative of a bull trout was observed in Sullivan Creek in a large scour pool associated with a wood jam approximately 1,100 feet downstream of the highway crossing during a snorkel survey in September. Triploid rainbow trout, large-scale sucker, and smallmouth bass were commonly observed within the delta areas of Sullivan, Flume, Sweet, and Slate creeks through snorkel surveys and observations made from the boat deck platform.

5.1.2.5. Angling and Other Anecdotal Observations

During July and August, field staff conducted opportunistic angling surveys in an effort to capture cutthroat trout and carry-over triploid rainbow trout near the mouths of selected tributaries. At that time, large triploid rainbow trout were observed congregated in the cold water plumes Sweet, Flume, and Slate Creeks, and to a lesser extent around the mouth of Sullivan Creek. An estimated 48 rainbow trout with characteristics indicative of non-native hatchery fish, and 11 smallmouth bass, were observed from the boat deck at the mouth of Sweet Creek on July 27 (Appendix 2, Table A.2-6). Similarly, a total of 65 triploids were tallied at the mouth of Flume Creek and 35 at the mouth of Slate Creek. Similar concentrations were commonly observed between mid-July and mid-August. Recreational anglers were often seen pursuing trout in these locations.

5.1.2.6. Fish Handling

Species with apparent visible abnormalities were largely stocked triploid rainbow trout and largescale suckers. Most of the triploid rainbow trout had deformed or eroded dorsal fins and many had a shortened operculum. Six percent of the largescale sucker catch exceeding 300 mm TL (89 of 1,442 specimens) were reported with deformities, including deformed or eroded caudal fins, tubercles, and damaged or missing eyes. No fish were observed showing apparent external signs of gas bubble trauma below Boundary Dam or in the reservoir.

All native salmonids greater than 250 mm in length and all northern pike were scanned for PIT tags using a portable tag reader. No PIT tags were detected.

Two hundred thirty (230) specimens representing eight sport fish species were affixed with numbered anchor tags prior to release during the monthly Passive and Active Sampling (Appendix 2, Table A.2-7). Another 31 specimens, representing six target species that were affixed with biotelemetry tags and PIT tags (Table A.1-2) are further described under Section 5.2 of this report.

Fifty-seven fish representing four species with affixed Floy tags were recaptured. Seventeen recaptures (3 brown trout, 1 northern pike, 10 smallmouth bass, and 3 rainbow trout) were fish that were initially tagged by the Passive and Active Sampling Crew conducting the monthly samples (Appendix 2, Table A.2-7). The remaining 40 fish were triploid rainbow trout that were part of the 1,000 triploids affixed with numbered Floy tags prior their release in March 2007 as part of Study 13. Another seven rainbow trout were captured that had apparent scars where previously installed Floy tags were lost. In addition, three rainbow trout with attached Floy tags were observed within the tributary channel during snorkel surveys during August, with one each in Slate, Sullivan, and Sweet Creeks. Seven rainbow trout with attached Floy tags were also observed within the inundated delta portions of the tributaries (two in Flume Creek, three in Sweet Creek, two in Slate Creek).

5.1.3. Fish Relative Abundance and Distribution Data Correlation with Environmental Variables

A combination of descriptive statistics and a variety of exploratory analyses was used to evaluate temporal and spatial variation in species composition, abundance, and size-class structure among and between Project reaches and habitat types. Spatial and temporal variation in species-specific life history stages abundance was evaluated using the results of all sample methods both separately and combined. Presented herein is a brief overview of the preliminary data investigations.

5.1.3.1. Overall Relative Abundance in Reservoir and Tailrace

Suckers (mostly largescale), yellow perch, smallmouth bass, rainbow trout, peamouth, and northern pikeminnow accounted for 91 percent of the total numerical catch of the monthly gill net, electrofishing, and fyke net study sites combined (Table 5.1-10). Salmonids represented 9.6 percent of the total numerical catch. Rainbow trout dominated (91 percent believed to be hatchery triploid rainbow trout) the salmonid monthly study site catch. Mountain whitefish were captured in all Project reaches, but were most common in the Upper Reservoir Reach. Relative abundance of salmonids was greater and yellow perch markedly lower in the Tailrace Reach. Cyprinids, primarily peamouth and northern pikeminnow, comprised the highest catch in the Upper Reservoir Reach and were notably less common in the Forebay Reach catch. The catch of peamouth and tench was notably lower in the Tailrace Reach, and relatively few largescale sucker were caught lower in the Upper Reservoir Reach.

Yellow perch were a higher catch component within the Canyon and Upper Reservoir reaches as compared to the Forebay and Tailrace reaches.

Table 5.1-10. Between-reach comparisons of total catch by species in the Project during February through October 2007.

Taxa	Tailrace		Forebay		Canyon		Upper Reservoir		Total	
Catostomidae	**596**	**(0.49)**	**1,766**	**(0.68)**	**878**	**(0.42)**	**1,571**	**(0.34)**	**4,811**	**(0.46)**
Longnose sucker	2	(0.00)	3	(0.00)	3	(0.00)	31	(0.01)	39	(0.00)
Largescale sucker	573	(0.47)	1,062	(0.41)	459	(0.22)	957	(0.21)	3,051	(0.29)
Sucker sp	21	(0.02)	701	(0.27)	416	(0.20)	583	(0.13)	1,721	(0.16)
Centrarchidae	**236**	**(0.19)**	**193**	**(0.07)**	**415**	**(0.20)**	**723**	**(0.16)**	**1,567**	**(0.15)**
Largemouth bass			4	(0.00)		(0.00)	34	(0.01)	38	(0.00)
Smallmouth bass	233	(0.19)	134	(0.05)	348	(0.17)	352	(0.08)	1,067	(0.10)
Pumpkinseed	2	(0.00)	53	(0.02)	61	(0.03)	213	(0.05)	329	(0.03)
Black crappie	1	(0.00)	2	(0.00)	6	(0.00)	124	(0.03)	133	(0.01)
Cottidae		**(0.00)**		**(0.00)**		**(0.00)**	**1**	**(0.00)**	**1**	**(0.00)**
Sculpin sp		(0.00)		(0.00)		(0.00)	1	(0.00)	1	(0.00)
Cyprinidae	**114**	**(0.09)**	**127**	**(0.05)**	**317**	**(0.15)**	**1,023**	**(0.22)**	**1,581**	**(0.15)**
Northern pikeminnow	76	(0.06)	77	(0.03)	123	(0.06)	367	(0.08)	643	(0.06)
Peamouth	38	(0.03)	42	(0.02)	146	(0.07)	512	(0.11)	738	(0.07)
Redside shiner					1	(0.00)	4	(0.00)	5	(0.00)
Tench			8	(0.00)	47	(0.02)	140	(0.03)	195	(0.02)
Esocidae						**(0.00)**	**16**	**(0.00)**	**16**	**(0.00)**
Northern pike						(0.00)	16	(0.00)	16	(0.00)
Gadidae					**4**	**(0.00)**	**9**	**(0.00)**	**13**	**(0.00)**
Burbot					4	(0.00)	9	(0.00)	13	(0.00)
Ictaluridae				**(0.00)**	**4**	**(0.00)**	**32**	**(0.01)**	**36**	**(0.00)**
Brown bullhead				(0.00)	4	(0.00)	32	(0.01)	36	(0.00)
Percidae	**16**	**(0.01)**	**272**	**(0.10)**	**297**	**(0.14)**	**858**	**(0.19)**	**1,443**	**(0.14)**
Walleye	11	(0.01)	1	(0.00)		(0.00)	9	(0.00)	21	(0.00)
Yellow perch	5	(0.00)	271	(0.10)	297	(0.14)	849	(0.19)	1,422	(0.14)
Salmonidae - Native	**19**	**(0.02)**	**11**	**(0.00)**	**8**	**(0.00)**	**99**	**(0.02)**	**137**	**(0.01)**
Bull trout [1]	1	(0.00)		(0.00)		(0.00)			1	(0.00)
Cutthroat trout[2]	2	(0.00)	4	(0.00)	1	(0.00)	4	(0.00)	11	(0.00)
Rainbow trout [3]	12	(0.01)		(0.00)		(0.00)			12	(0.00)
Mountain whitefish	4	(0.00)	7	(0.00)	5	(0.00)	95	(0.02)	111	(0.01)
Lake whitefish		(0.00)		(0.00)	2	(0.00)		(0.00)	2	(0.00)
Salmonidae - Non-native	**245**	**(0.20)**	**222**	**(0.09)**	**147**	**(0.07)**	**223**	**(0.05)**	**837**	**(0.08)**
Brook trout	3	(0.00)		(0.00)	2	(0.00)	1	(0.00)	6	(0.00)
Brown trout	13	(0.01)	6	(0.00)	6	(0.00)	23	(0.01)	48	(0.00)
Char hybrid [4]						(0.00)	1	(0.00)	1	(0.00)
Kokanee	2	(0.00)					1	(0.00)	3	(0.00)
Lake trout	1	(0.00)	3	(0.00)	3	(0.00)	1	(0.00)	8	(0.00)
Rainbow trout [5]	226	(0.18)	209	(0.08)	124	(0.06)	190	(0.04)	749	(0.07)
Rainbow trout [6]			4	(0.00)	12	(0.01)	6	(0.00)	22	(0.00)
Grand Total	**1,226**		**2,591**		**2,070**		**4,555**		**10,442**	

Notes:

1 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.

2 Exhibited characteristics indicative of the westslope cutthroat trout variety.

3 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout.

Table 5.1-10, continued….

4 Genetic analysis completed by the USFWS in November 2007 identified specimen as bull trout / brook trout hybrid.
5 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
6 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries
Proportion of total catch for reach in parentheses.
Summary data includes all fish captured by gill netting, electrofishing, and fyke netting monthly samples. Summary does not include fish observed but not captured in the electrofishing sites, fish captured in the extra gill netting sets, or fish observed or captured in the tributary snorkeling surveys.

5.1.3.2. Relative Abundance Between Capture Methods

The four capture techniques targeted different habitat conditions and each had limitations to where they could be conducted and the size of fish they would target. The boat electrofishing targeted littoral habitats situated within the varial zone of the reservoir and tailrace and generally targeted waters 2 feet to 8 feet deep. The gill net sites were located off shore and targeted water from 8 to 100 feet depth. Reservoir fyke netting was mostly situated in backwater and off-channel, often in areas where aquatic vegetation limited the effectiveness of gillnetting and electrofishing techniques. Tributary fyke nets were located in flowing water above the influence of existing Project operations and targeted capture of small fish moving downstream.

The captured fish species composition differed between capture techniques (Table 5.1-11). Four species were collected by all four capture methods. One species (longnose dace) was collected only in the tributary fyke netting. Boat electrofishing captured all species except for the longnose dace. Most common species were captured at multiple sites and sampling events.

5.1.3.3. Catch Rates Between Project Reaches and Sample Periods

There are inherent differences in catch rates and susceptibly of species and size classes to the different gear types. Therefore analysis of the influence Project Reach, habitat types, and depths on species relative abundance (using numerical catch data) and catch rates (using catch per unit effort measures) was conducted separately for each of the capture methods.

5.1.3.3.1. Gill Netting

Mean gill net catch rates of all species combined were highest in the Tailrace and Upper Reservoir reaches and substantially lower in the Forebay and Canyon reaches (Figure 5.1-3). The Forebay and Canyon reaches are typified by very deep areas (commonly exceeds 80 feet) with very steep bottom profiles, whereas the Upper Reservoir and Tailrace reaches open water areas are typified by moderate depths (generally less than 30 feet) with moderate and gently sloping lake bottoms.

Species abundance differed among reaches. Northern pikeminnow and peamouth consistently dominated the open water catch rates in the Upper Reservoir and Canyon reaches, whereas largescale suckers had the highest catch rates in the Forebay Reach (Figure 5.1-4). Gill net catch rates in the monthly study sites for all species and reaches combined were greatest in July and August, which also corresponded with the highest water temperatures (Figure 5.1-5). Catch rates of northern pikeminnow and peamouth were ranked one or two from March through August (Figure 5.1-6).

Table 5.1-11. Between-capture-gear comparisons of relative total fish catch from the standard monthly sample locations in the Boundary Project during February through October 2007 .

Species	Boat electrofishing			Gill netting			Reservoir fyke netting			Tributary fyke netting			Combined RA
	RA [1]	TL [2]		RA [1]	TL [2]		RA [1]	TL [2]		RA [1]	TL [2]		
Largescale sucker	31.3	258	(3)	16.8	394	(6)	24.2	82	(4)	2.5	345	(55)	28.6
Sucker sp	20.6	74	(0)	-			0.2	64	(6)	2.5	49	(12)	16.2
Yellow perch	10.2	135	(2)	14.5	181	(5)	37.4	130	(3)	-			13.3
Smallmouth bass	11.5	169	(3)	5.7	298	(10)	4.3	96	(9)	-			10.0
Rainbow trout [3]	8.3	299	(2)	5.4	336	(9)	0.6	295	(11)	1.7	316	(23)	7.0
Peamouth	6.8	179	(4)	18.5	285	(2)	0.1	170		-			6.9
Northern pikeminnow	4.0	246	(7)	28.5	341	(5)	3.6	88	(11)	0.4	355		6.0
Pumpkinseed	2.2	101	(2)	0.8	84	(14)	11.9	105	(2)	-			3.1
Tench	0.3	386	(13)	3.4	341	(13)	11.9	388	(5)	0.4	72		1.8
Mountain whitefish	1.2	156	(13)	0.9	414	(17)	-			30.4	112	(3)	1.7
Black crappie	1.0	77	(5)	0.3	213	(32)	4.2	79	(2)	-			1.2
Cutthroat trout [4]	0.1	269	(27)	-			-			30.8	67	(4)	0.8
Brown trout	0.5	377	(17)	0.4	361	(26)	-			5.0	92	(17)	0.6
Rainbow trout [5]	0.2	269	(15)	0.1	213		0.1	242		8.8	87	(9)	0.4
Longnose sucker	0.4	320	(18)	0.2	395	(46)	0.3	366	(37)	-			0.4
Largemouth bass	0.4	93	(17)	0.6	357	(10)	0.2	99	(35)	-			0.4
Brown bullhead	0.3	271	(7)	-			0.9	302	(5)	-			0.3
Walleye	0.1	469	(47)	1.2	519	(12)	-			-			0.2
Sculpin sp	<0.1	86		-			-			7.9	61	(3)	0.2
Longnose dace	-			-			-			7.5	86	(7)	0.2
Northern pike	<0.1	445		1.5	634	(23)	0.1	484		-			0.1
Burbot	0.1	446	(72)	0.8	518	(24)	0.1	464		0.4	218		0.1
Rainbow trout [6]	0.1	346	(39)	-			-			-			0.1
Redside shiner	<0.1	97	(6)	0.1	125		-			1.7	85	(3)	0.1
Lake trout	0.1	459	(25)	0.2	442	(7)	-			-			0.1
Brook trout	0.1	205	(27)	0.1	269		-			-			0.1
Kokanee	<0.1	175	(9)	-			-			-			<0.1
Lake whitefish	<0.1	439	(7)	-			-			-			<0.1
Bull trout [7]	<0.1	285		-			-			-			<0.1
Char hybrid [8]	<0.1	332		-			-			-			<0.1

Table 5.1-11, continued...

Notes:
1 Relative abundance (RA; percent of total catch for gear type).
2 Mean total length (TL; standard error in parentheses).
3 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
4 Exhibited characteristics indicative of the westslope cutthroat trout variety.
5 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.
6 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout
7 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.
8 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, personal communication with SCL) identified specimen as bull trout / brook trout hybrid.

Summary data include all fish captured by gill netting, electrofishing, and fyke netting and standard monthly sample locations. Summary does not include fish observed but not captured in the electrofishing sites, fish captured in the extra gill netting sets, or fish observed while snorkeling

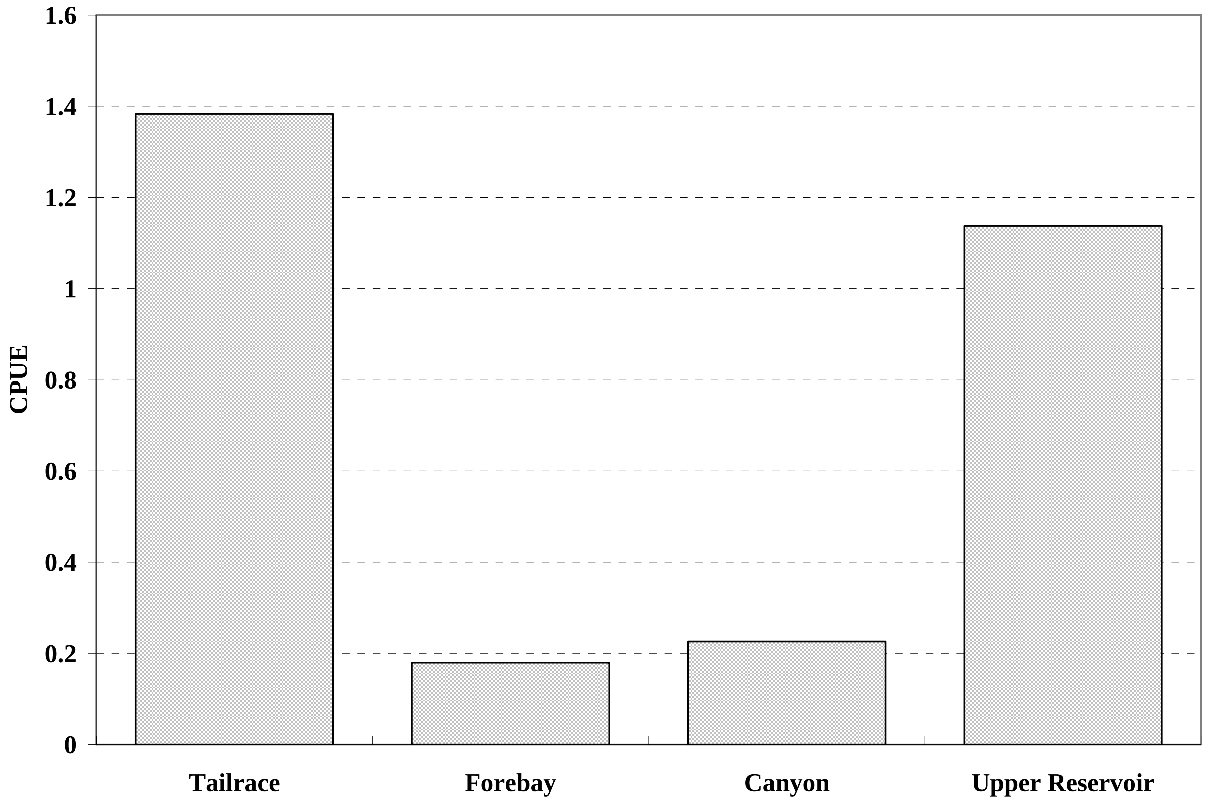

Figure 5.1-3. Mean catch per unit (CPUE: fish per 1000 square feet net set time [hr]) from monthly gill net sites by the Project Reaches of the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

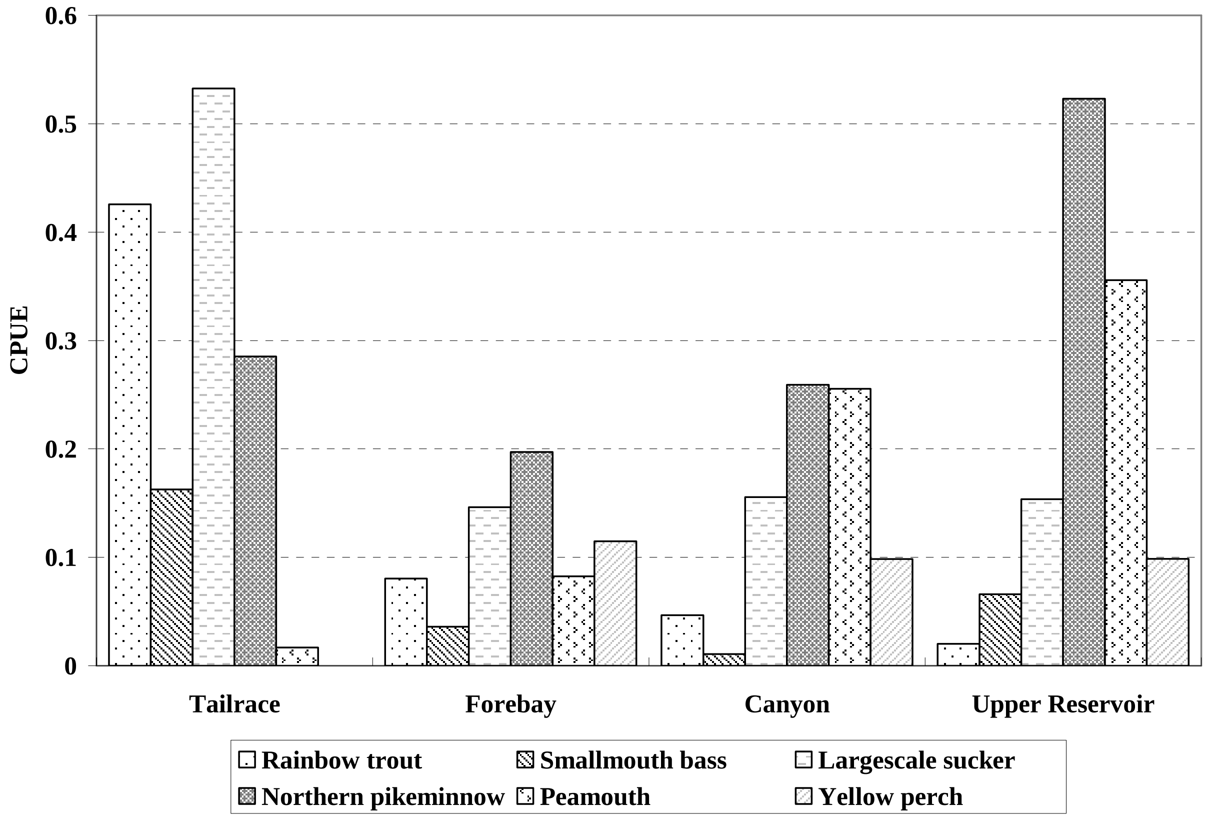

Figure 5.1-4. Mean catch per unit effort (CPUE: fish per 1000 square feet net set time [hr]) of the six most commonly captured species in gill net sites by Project Reaches in the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

Note: Rainbow trout catch summary includes triploids and naturally reared specimens.

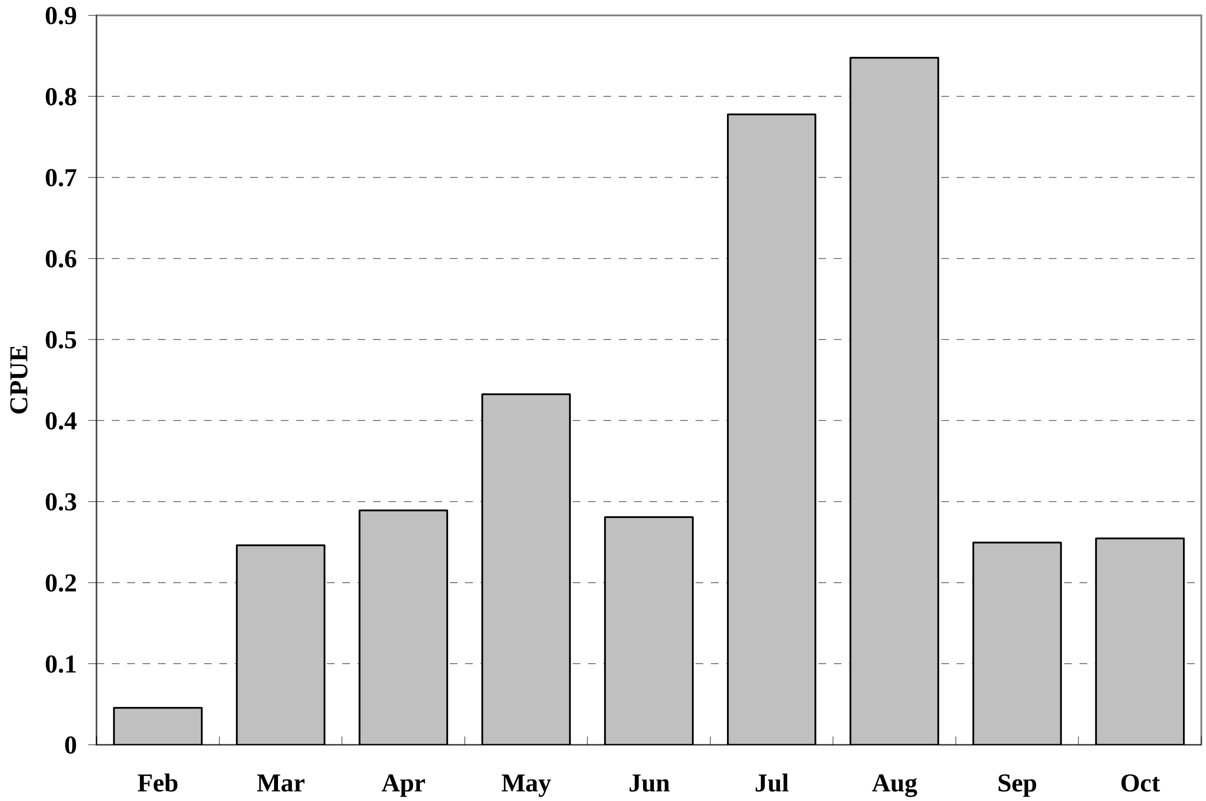

Figure 5.1-5. Mean catch per unit effort (CPUE: fish per 1000 square feet net set time [hr]) of monthly Gill Net Sites by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

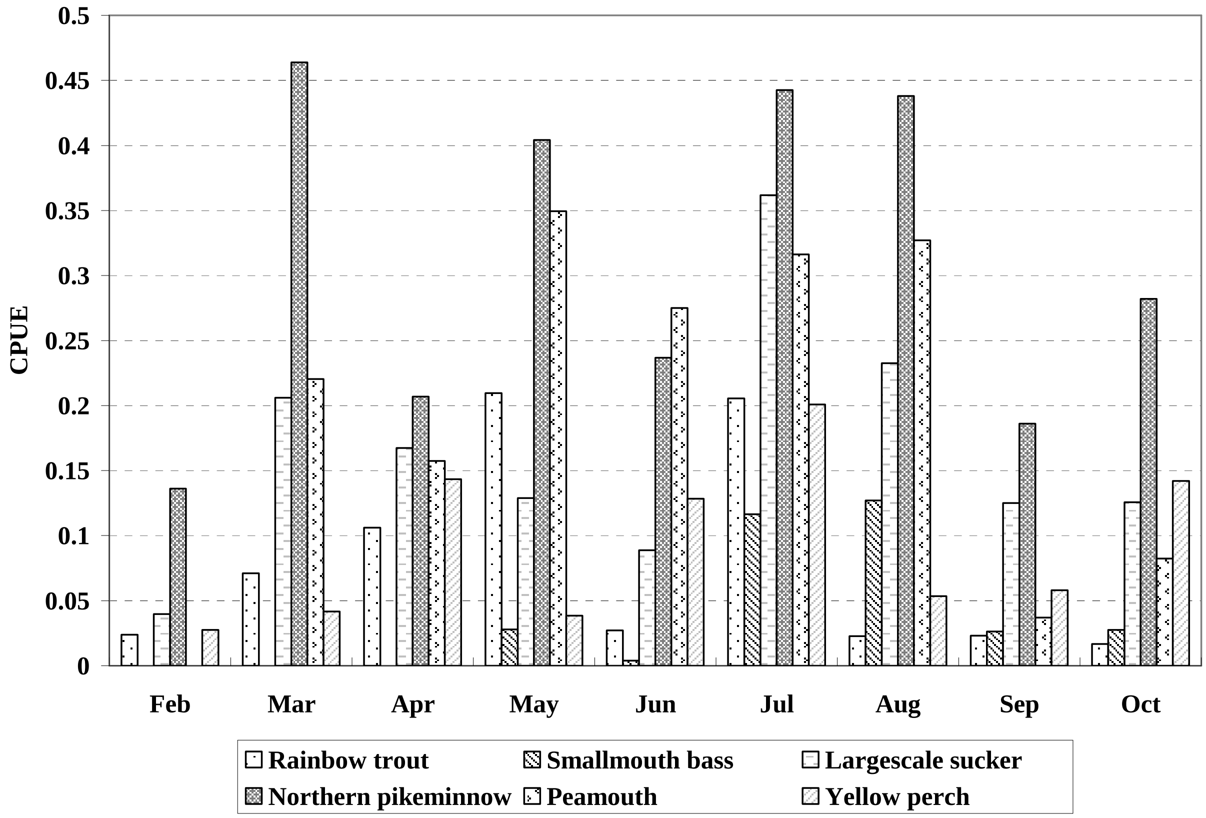

Figure 5.1-6. Mean catch per unit effort (CPUE: fish per 1000 square feet net set time [hr]) of six commonly captured species in gill net sites by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Note: Rainbow trout catch summary includes triploids and naturally reared specimens.

5.1.3.3.2. Boat Electrofishing

Mean electrofishing catch rates of all species combined were highest in the Forebay and Upper Reservoir reaches (Figure 5.1-7 and Table 5.1-12). Catostomid electrofishing CPUE was notably high in the Forebay Reach. Rainbow trout and smallmouth bass catch rates were greatest in the Tailrace Reach (Figure 5.1-8). Smallmouth bass also led the catch rates in the canyon. Mountain whitefish CPUE was greatest in the Upper Reservoir Reach. Overall catch rate was greatest during April through June, peaking in the May sample (Figure 5.1-9). The highest catch rate of smallmouth bass and rainbow trout also occurred during April through June (Figure 5.1-10). Electrofishing catch rates were notably low in July, one of the warmest water periods of the year, although total observations of fish that were not captured peaked during July. Crews recognized the increase in non-captured fish observations as compared to previous sampling. Numerous small fish responded to the electrofishing current, but were not sufficiently stunned for capture. However, field staff were reluctant to increase voltage or amperage output, due to the vulnerability of large-bodied cold water species to electrofishing stress under such warm water conditions.

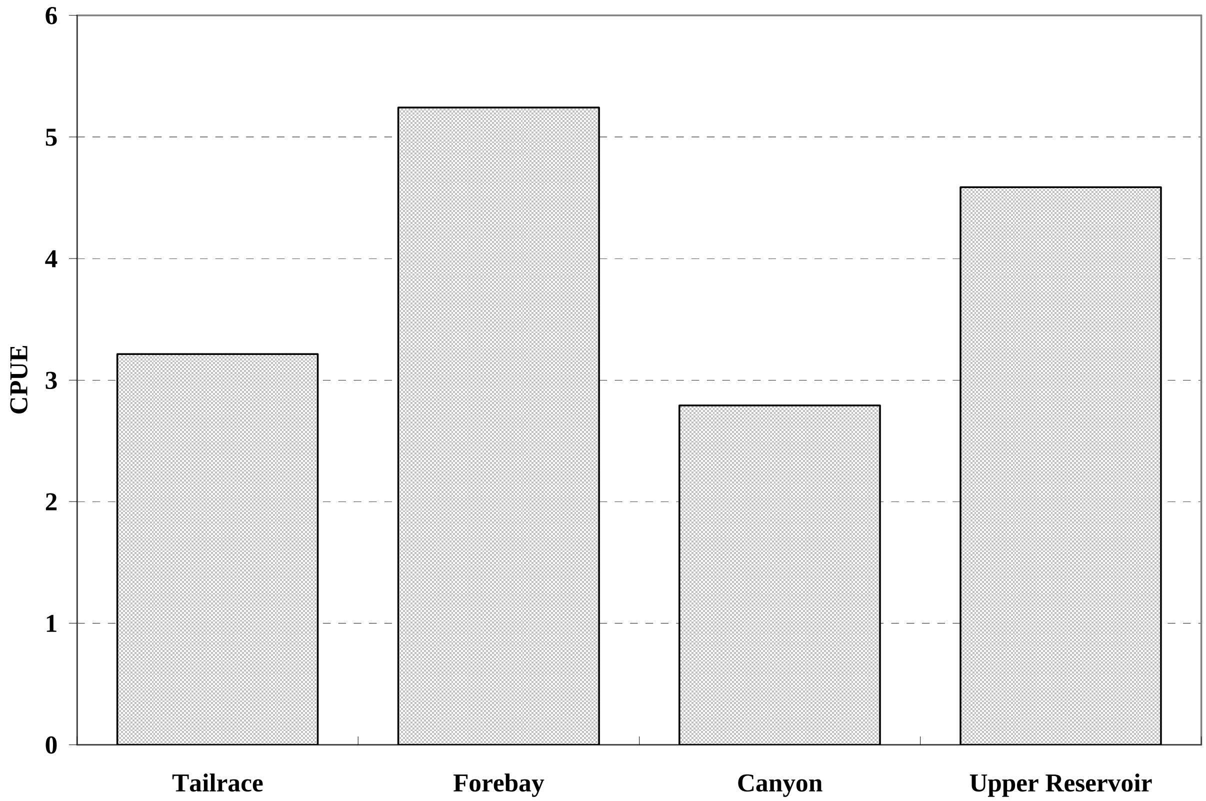

Figure 5.1-7. Mean catch per unit (CPUE: fish per electrofishing run time [minute]) from monthly boat electrofishing sites across the Project Reaches of the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

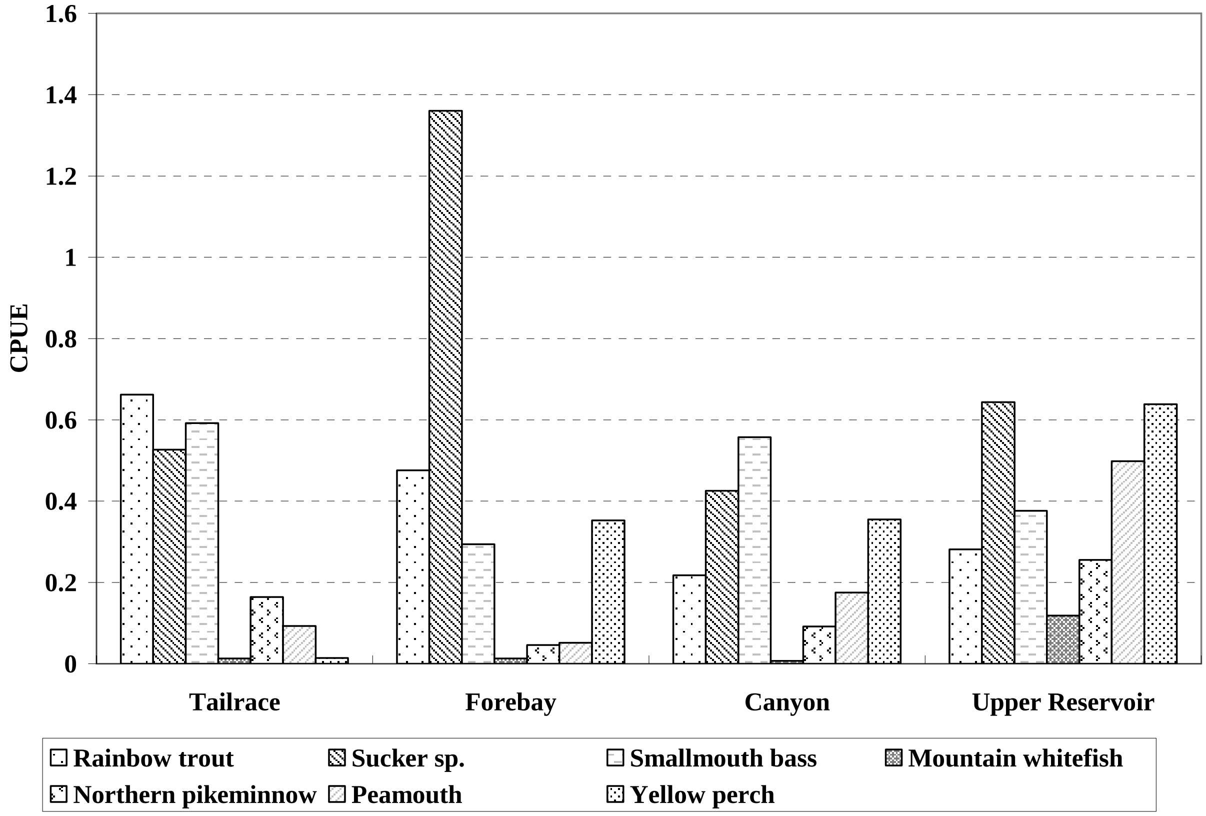

Figure 5.1-8. Mean catch per unit effort (CPUE: fish per electrofishing run time [minute]) of the seven commonly captured species in boat electrofishing sites by Project Reaches in the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

Note: Rainbow trout catch summary includes triploids and naturally reared specimens.

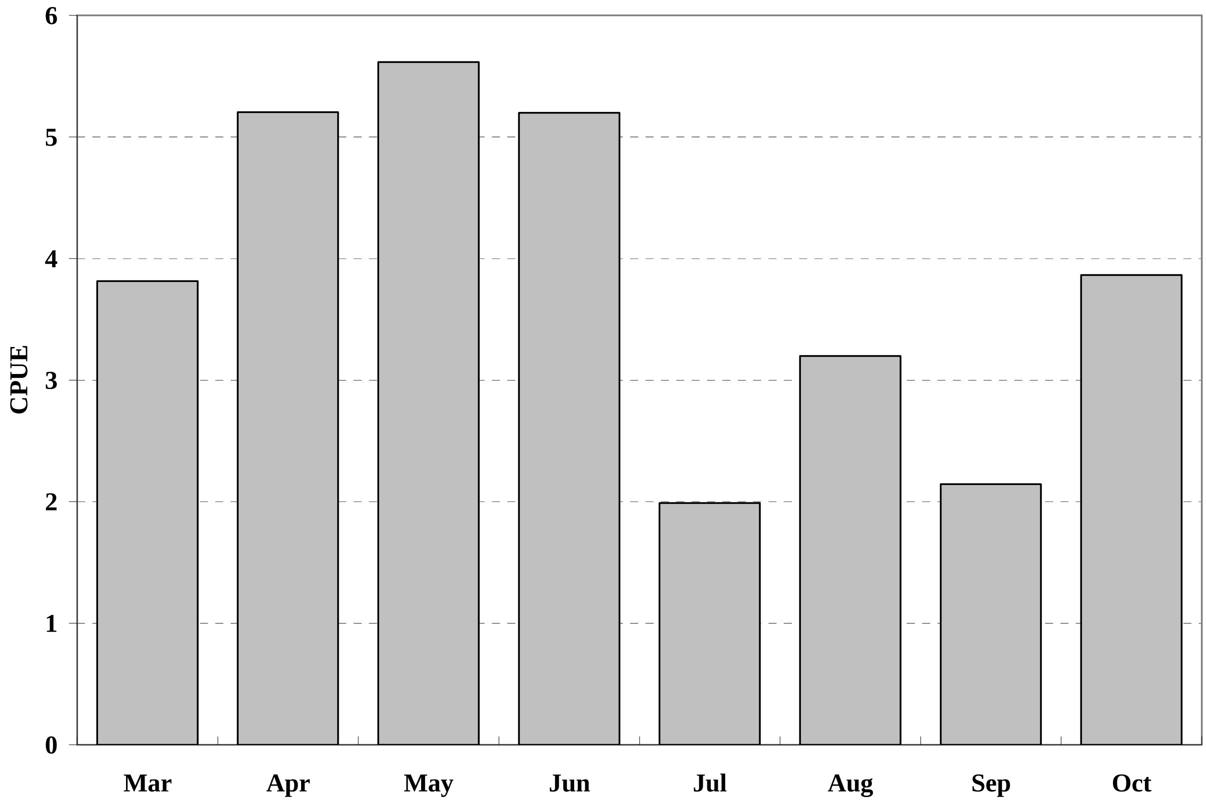

Figure 5.1-9. Mean catch per unit effort (CPUE: fish per electrofishing run time [minute]) by month for boat electrofishing sites in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Table 5.1-12. Between-reach comparisons of catch per unit effort in the Boundary Project during March through October, 2007.

Taxa	Gill Net					Electrofish					Fyke Net					
	Tailrace	**Forebay**	**Canyon**	**Upper Reservoir**	**All Reaches**	**Tailrace**	**Forebay**	**Canyon**	**Upper Reservoir**	**All Reaches**	**Tailrace**	**Forebay**	**Canyon**	**Upper Reservoir**	**Tributary**	**All Reaches**
Catostomidae	**0.14**	**0.05**	**0.05**	**0.04**	**0.05**	**0.53**	**1.36**	**0.43**	**0.64**	**0.67**	**0.00**	**0.11**	**0.01**	**0.32**	**0.00**	**0.08**
Longnose sucker	0.43	0.13	0.14	0.13	0.16	1.51	2.03	0.57	0.93	1.13	0.00	0.32	0.03	0.95	0.01	0.22
Largescale sucker	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.02	0.00	0.00	0.01	0.01	0.00	0.00
Sucker sp	0.00	0.00	0.00	0.00	0.00	0.06	2.05	0.71	0.96	0.88	0.00	0.00	0.00	0.01	0.00	0.00
Centrarchidae	**0.03**	**0.01**	**0.00**	**0.03**	**0.02**	**0.15**	**0.09**	**0.16**	**0.16**	**0.15**	**0.01**	**0.09**	**0.03**	**0.11**	**0.00**	**0.03**
Largemouth bass	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.09	0.04	0.00	0.00	0.00	0.04	0.00	0.01
Smallmouth bass	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.00
Pumpkinseed	0.00	0.00	0.00	0.03	0.01	0.00	0.06	0.07	0.14	0.08	0.01	0.36	0.08	0.27	0.00	0.09
Black Crappie	0.13	0.03	0.01	0.06	0.04	0.59	0.29	0.56	0.38	0.46	0.03	0.00	0.05	0.13	0.00	0.04
Cottidae	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
Sculpin sp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Cyprinidae	**0.05**	**0.06**	**0.11**	**0.16**	**0.11**	**0.05**	**0.02**	**0.05**	**0.16**	**0.08**	**0.00**	**0.00**	**0.04**	**0.08**	**0.00**	**0.02**
Longnose dace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Northern pikeminnow	0.23	0.18	0.24	0.45	0.30	0.16	0.05	0.09	0.26	0.15	0.00	0.01	0.00	0.11	0.00	0.02
Peamouth	0.01	0.08	0.24	0.31	0.20	0.09	0.05	0.17	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Redside shiner	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tench	0.00	0.02	0.07	0.06	0.05	0.00	0.00	0.00	0.03	0.01	0.00	0.01	0.21	0.30	0.00	0.09
Esocidae	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Northern pike	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gadidae	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Burbot	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ictaluridae	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.04**	**0.01**	**0.00**	**0.00**	**0.01**	**0.04**	**0.00**	**0.01**
Brown bullhead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.01	0.04	0.00	0.01

Table 5.1-12, continued...

Taxa	Gill Net					Electrofish					Fyke Net					
	Tailrace	Forebay	Canyon	Upper Reservoir	All Reaches	Tailrace	Forebay	Canyon	Upper Reservoir	All Reaches	Tailrace	Forebay	Canyon	Upper Reservoir	Tributary	All Reaches
Percidae	**0.03**	**0.05**	**0.05**	**0.05**	**0.05**	**0.02**	**0.18**	**0.18**	**0.32**	**0.19**	**0.00**	**0.38**	**0.14**	**0.63**	**0.00**	**0.17**
Walleye	0.06	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Yellow perch	0.00	0.10	0.09	0.09	0.08	0.01	0.35	0.35	0.64	0.38	0.00	0.75	0.29	1.26	0.00	0.34
Salmonidae Native	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**
Bull trout [1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cutthroat trout[2]	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
Rainbow trout [3]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake whitefish	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.12	0.05	0.00	0.00	0.00	0.00	0.03	0.02
Mountain whitefish	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Salmonidae Non-native	**0.04**	**0.01**	**0.01**	**0.00**	**0.01**	**0.08**	**0.06**	**0.03**	**0.03**	**0.04**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**
Brook trout	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown trout	0.00	0.01	0.00	0.00	0.00	0.03	0.01	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.00
Char hybrid [4]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kokanee	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake trout	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainbow trout [5]	0.34	0.07	0.04	0.02	0.07	0.62	0.47	0.20	0.27	0.36	0.00	0.01	0.04	0.00	0.01	0.01
Rainbow trout [6]	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Unidentified trout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.1-12, continued...

Notes:

1 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout.
2 Exhibited characteristics indicative of the westslope variety.
3 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout.
4 Genetic analysis completed by the USFWS in November 2007 identified specimen as bull trout / brook trout hybrid.
5 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).
6 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.

Summary data include all fish captured by gill netting, electrofishing, and fyke netting. Summary does not include fish observed but not captured, nor does it include the extra gill net sites aimed at target species. Each catch rate is computed by first calculating the CPUE for individual species for each sampling event at each site, and then computing the mean reach CPUE for each species.

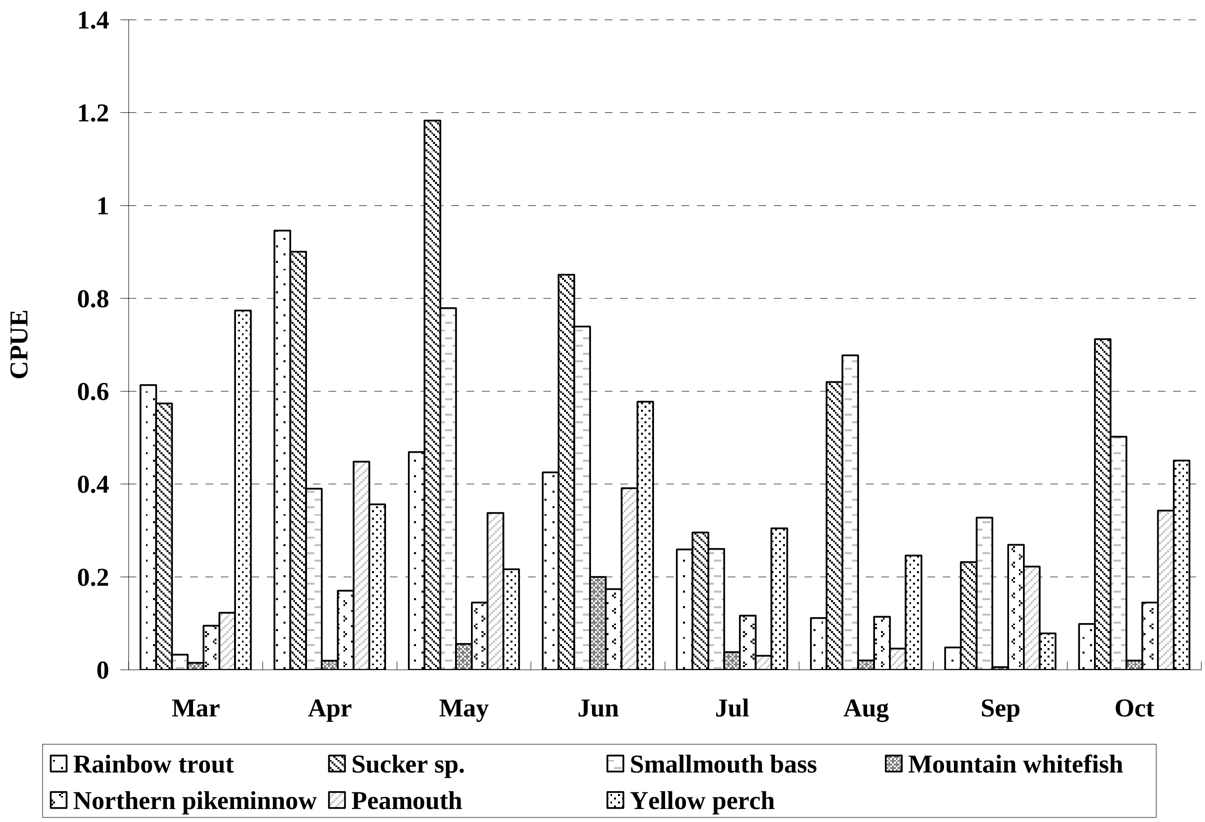

Figure 5.1-10. Mean catch per unit effort (CPUE: fish per electrofishing run time [minute]) of seven commonly captured species for boat electrofishing sites by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Note: Rainbow trout catch summary includes triploids and naturally reared specimens.

5.1.3.3.3. Reservoir Fyke Netting

Reservoir fyke net CPUE of all species combined was, on average, over three times greater in the Upper Reservoir Reach than all other reaches (Figure 5.1-11 and Table 5.1-12). Yellow perch dominated the fyke net catch in the entire reservoir (Figure 5.1-12). Catch rates of pumpkinseed, black crappie, and smallmouth bass were notably higher in the Upper Reservoir Reach, while sucker CPUE was lowest in the Canyon Reach (Appendix 2, Table A.2-4). Catastomids CPUE in the Forebay Reach was three times less than the Upper Reservoir Reach. In contrast, electrofishing Catastomids CPUE in the Forebay Reach was more than double that of the Upper Reservoir Reach. Fyke catch rates of triploid rainbow trout were highest in the Canyon Reach. No triploid rainbow trout were captured in fyke nets in the Upper Reservoir or Tailrace reaches.

The Upper Reservoir Reach fyke nets captured the greatest number of species. Comparison of reservoir fyke net catch rates between periods was not included in this report, as the site locations were not consistent between periods. Each monthly set targeted similar habitat conditions, but specific locations varied widely.

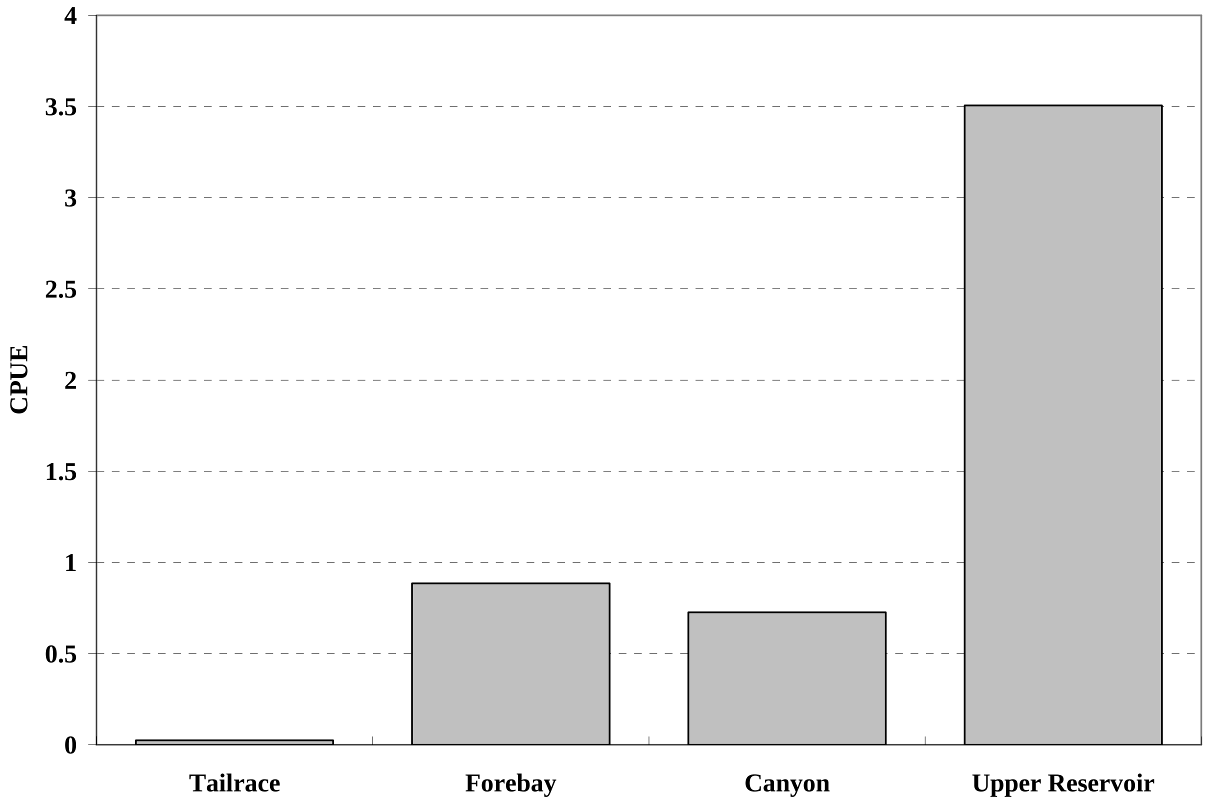

Figure 5.1-11. Mean catch per unit (CPUE: fish per fyke net set time [hr]) from monthly reservoir fyke net sites by the Project Reaches of the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

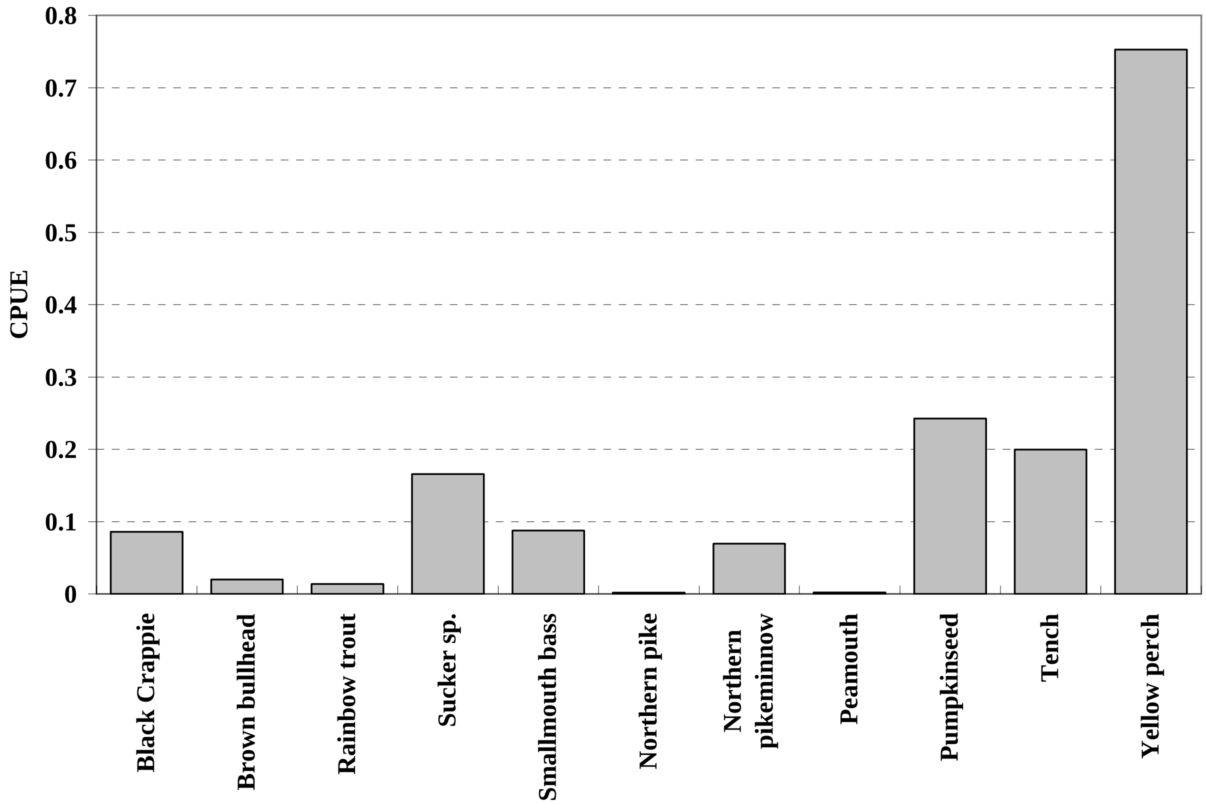

Figure 5.1-12. Mean catch per unit effort (CPUE: fish per fyke net set time [hr]) of the all species in the reservoir fyke net sites in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Note: All rainbow trout captured in the reservoir fyke nets exhibited characteristics of non-native, hatchery reared triploids.

5.1.3.3.4. Tributary Fyke Netting

Tributary fyke net CPUE of all species combined was on average at least twice as high in the Sullivan Creek as compared to Sweet, Sand, and Slate creeks (Figure 5.1-13 and Appendix 2, Table A.2-4). Cutthroat trout and mountain whitefish catch rates were highest for the entire sample period and all sample sites combined (Figure 5.1-14), but only mountain whitefish were captured in Sullivan and Sweet creeks. Cutthroat trout dominated the fyke catch in Slate Creek, whereas Sullivan Creek and Sweet Creek fyke nets captured a variety of salmonids, including mountain whitefish, brown trout, cutthroat trout, and rainbow trout (Appendix 2, Table A.2-4). The Sullivan Creek catch was the most diverse, including a burbot, suckers, mottled and torrent sculpins, and a tench. The overall catch rate was greatest during July and August (Figure 5.1-15), which corresponded to the highest mountain whitefish and cutthroat trout catch rates. A total of 134 salmonids were captured in the tributary fyke netting during July and August (72 mountain whitefish, 41 cutthroat trout, 11 brown trout, 8 non-native wild rainbow trout, and 2 triploid rainbow trout). All but five of salmonids captured during July and August were less than 200 mm TL. Throughout the entire sample period, only 7 of the 184 salmonids captured exceeded 200 mm TL, including 5 triploid trout, 1 cutthroat trout captured during mid-August (248 mm TL) in Sweet Creek, and 1 mountain whitefish (265 mm TL) captured in Sullivan Creek during early September.

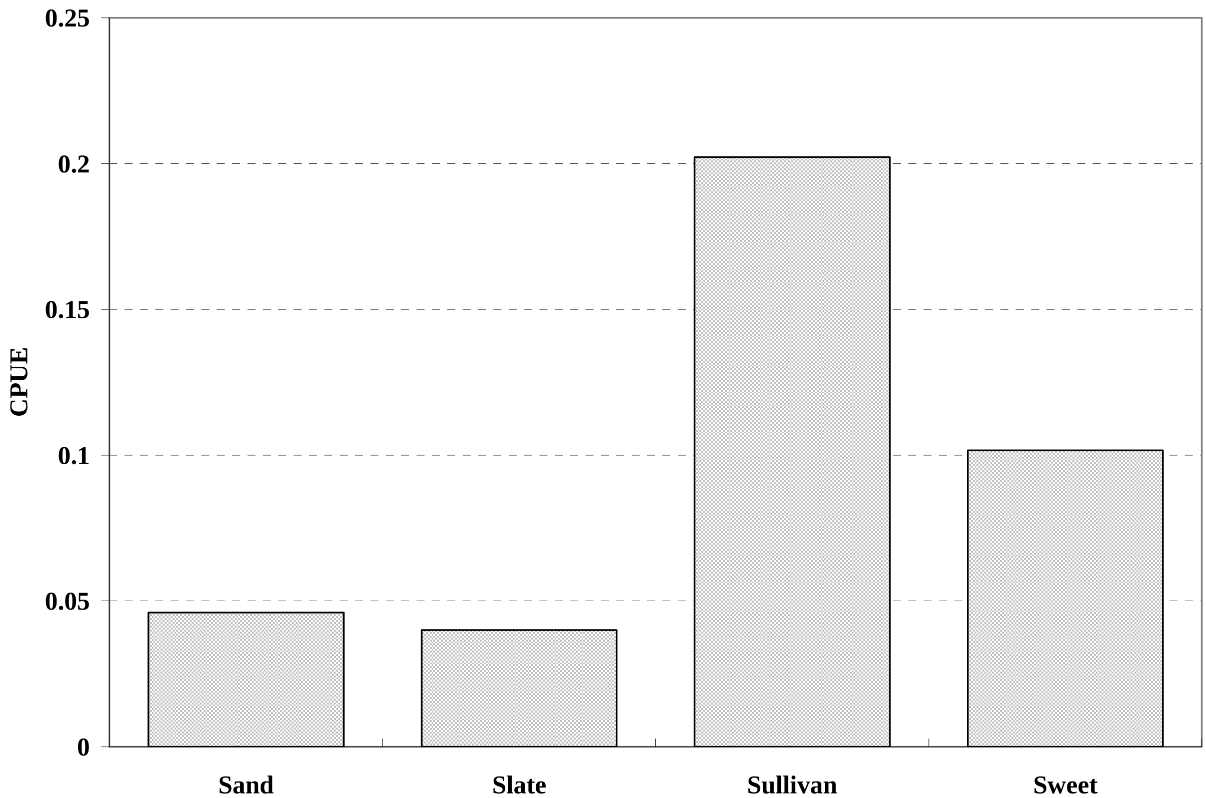

Figure 5.1-13. Mean catch per unit (CPUE: fish per percent discharge per fyke net set time [hr]) from twice-monthly tributary fyke net sites across the four study streams of the Boundary Project on the Pend Oreille River, Washington.

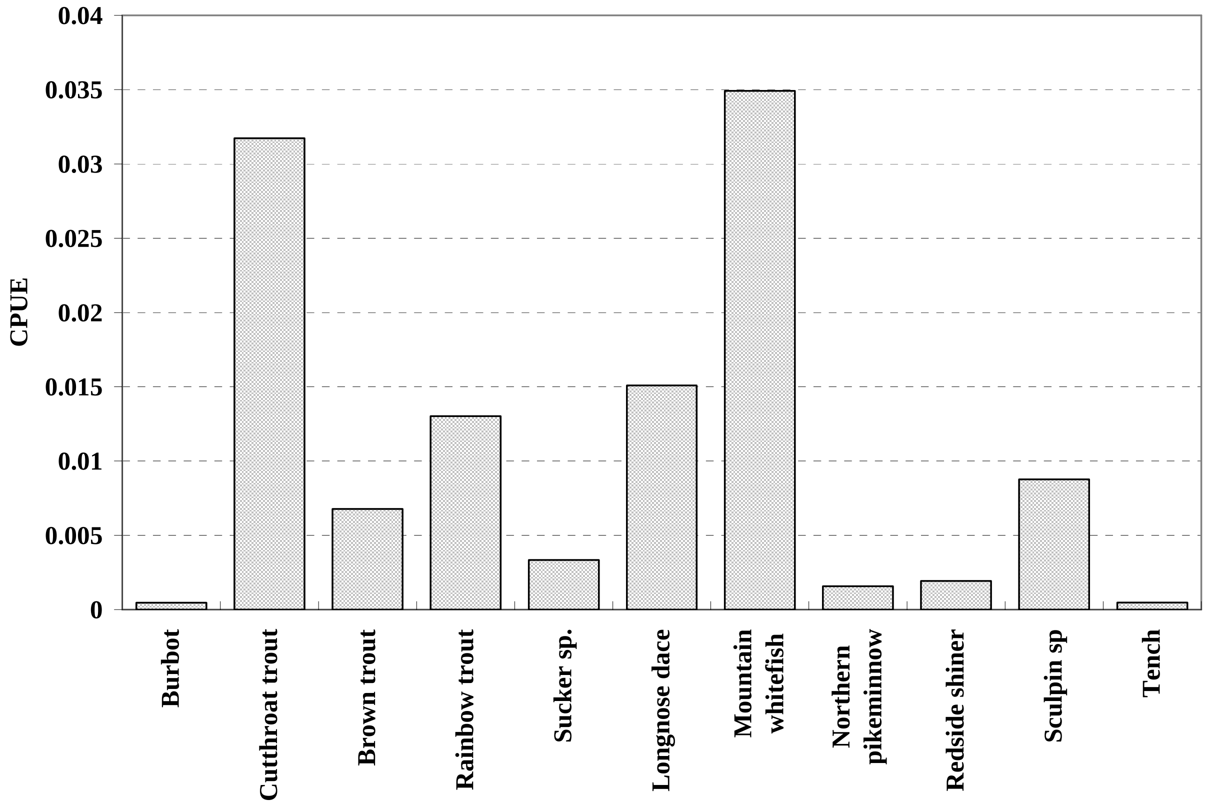

Figure 5.1-14. Mean catch per unit effort (CPUE: fish per percent discharge per fyke net set time [hr]) of all species captured in the tributary fyke net sites in the Boundary Project on the Pend Oreille River, Washington.

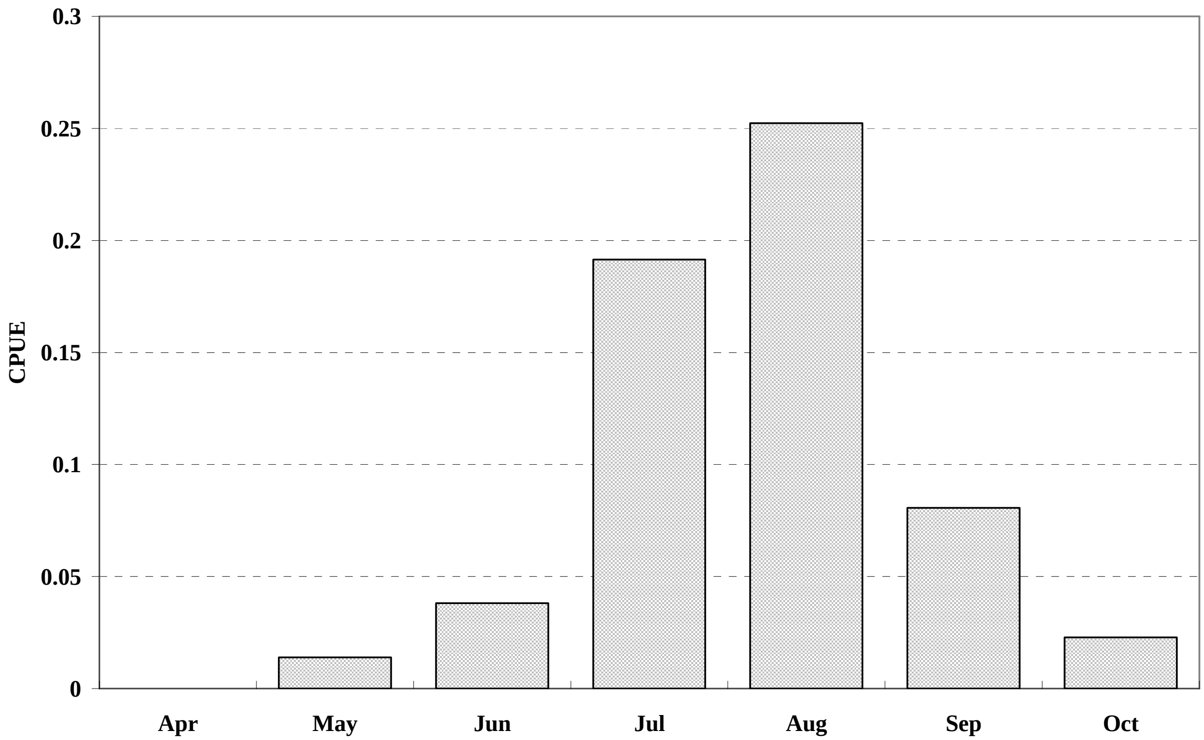

Figure 5.1-15. Mean catch per unit effort (CPUE: fish per percent discharge per fyke net set time [hr]) by month for all species combined in the tributary fyke net sites in the Boundary Project on the Pend Oreille River, Washington.

5.1.3.3.5. Tributary Snorkeling and Delta Observations

Tributary and delta snorkel observations varied between months (Appendix 2, Table A.2-6). Fish counts were lowest during March, April, and May in both the channel upstream of the reservoir level at the time of survey and in the inundated delta near the channel mouth. Counts in the channel upstream of the reservoir pool level at the time of survey were highest during June through September, peaking during July or August across all sites surveyed. During July and August, there was also a concurrent increase in the number of salmonids in the inundated deltas, apparently where these fish were congregating at cold water plumes from the tributary flow. All but two of these fish (lake trout) were non-native rainbow triploid trout. No native salmonids were observed using the cold water plumes during snorkel surveys or by observations from the boat deck during July and August. Smallmouth bass were also observed around the outer edges of the triploid rainbow trout concentrations.

Stream discharge and high turbidity reduced sampling effectiveness during March, April, and May, while conditions for observations were much improved in later months; therefore, direct comparisons of relative numbers of fish between this spring period and later months (June through October) are limited.

Despite increases in fish observations in the inundated deltas during July and August, snorkel surveys within the adjacent tributary channels provided little evidence that salmonids, especially native salmonids, ascended beyond the inundated delta seeking thermal refugia. The peak in salmonid counts in the tributary channels upstream of the reservoir pool during July and August were predominantly increases in young of year and fingerling size trout and mountain whitefish. However, concurrent summertime increases in the inundated deltas were mostly adult salmonids (exceeding 250 mm). No young of year or fingerling trout were observed in the inundated deltas during any of the snorkel surveys. All naturally reared trout species less than 120 mm total length were observed in the tributary channels either through snorkel observations or fyke netting. Nevertheless, the observations of salmonids exceeding 250 mm TL in the channels across all tributary sites increased from 13 fish in June to a high of 24 fish in August. The net increase in adult fish was largely non-native trout, including brook trout (5 fish), triploid rainbow trout (2 fish), and brown trout (1 fish). A net increase of three cutthroat trout exceeding 250 mm TL was observed between June and August.

The source of increased number of salmonids in the tributary channel in the summer may be from upstream. Salmonids (both sub-adults and adults) within the channels may be fish dispersing downstream in response to reduction in stream discharge and reduction in suitable habitat areas upstream. Tributary fyke net data suggest this may be occurring because captures increased substantially during July and August. As discharge decreases in the summer, the availability of habitat in the tributaries also decreases. Locations with sufficient depth and velocity to provide good foraging opportunities may become limited as discharge approaches summer base flow. This reduction in habitat may be a primary motivator of summer movement, especially as fish grow and space becomes limited. In addition, as sub-adult fish grow through the summer, they are more likely to maintain positions in deeper pools where they are more vulnerable to detection.

No larger (total length exceeding 300 mm) adult cutthroat trout or non-native, wild rainbow trout were detected during the April and May sampling, a period when the two species are likely to spawn in the study streams. However, with the exception of Sand Creek, snorkeling effectiveness was reduced by high stream discharge and poor visibility during these early sample periods. Aside from the one unidentified char observation during September described above, three other large fish were observed in Sullivan Creek during three other sampling periods. One rainbow trout (estimated 340 mm TL) that appeared to be a wild, naturally reared fish was observed in Sullivan Creek during the July sampling. In addition, two large brown trout were observed in Sullivan Creek, one in mid-August (estimated 360 mm TL) and one in October (estimated 360 mm TL).

5.1.3.4. Seasonal Distribution Patterns of Target Species

5.1.3.4.1. Native Salmonids

Four species of native salmonids (bull trout, westslope cutthroat trout, mountain whitefish, and wild rainbow trout in the tailrace) were captured or observed during the sample period. Currently, the paucity of capture data for cutthroat trout, bull trout, and wild tailrace rainbow trout restricts analysis on seasonal use patterns within the reservoir and tailrace. Mountain whitefish was the most commonly observed native salmonid species.

Bull Trout – Only one bull trout (285 mm TL) was captured during the 2007 sampling. This fish was encountered in the Tailrace Reach in June. Two other char specimens that were believed to be bull trout at the time of capture were later confirmed by DNA analysis to be a brook trout (captured in the Tailrace Reach in April) and a char hybrid (captured in the Upper Reservoir Reach in April) (P. DeHaan, USFWS, personal communication, November 14, 2007).

Rainbow Trout – Eleven rainbow trout ranging from 194 to 400 mm TL that exhibited characteristics of naturally reared wild fish were captured in the tailrace. Another five specimens were observed in the tailrace during snorkel observations. Wild rainbow trout inhabiting the tailrace are considered potential descendants of the native redband trout. The tailrace wild rainbow specimens were captured in the March through April sample periods and again in September and October. All were captured in the electrofishing transects downstream of the hydraulic control, where riverine-like conditions with boulder substrates predominate. None of the fish captured in the tailrace gill net sets were considered wild.

Westslope Cutthroat Trout – Cutthroat trout were infrequently captured in the reservoir and tailrace. A total of 13 cutthroat trout, with external characteristics indicative of the westslope cutthroat trout variety, were observed or captured between March and October in the Reservoir Reaches (9 specimens) and Tailrace Reach (4 specimens). At least one cutthroat trout was captured in each of the Project reaches. Two of the 13 cutthroat trout were captured at the mouth of tributary streams in the extra gill net sites. Cutthroat trout captured in the tailrace and reservoirs ranged from 130 to 415 mm TL. No young of year fish were captured in the reservoir or tailrace. However, cutthroat trout were commonly observed (394 fish) in Slate and Sweet Creeks, and to a lesser extent Sand and Sullivan Creeks. Cutthroat trout use of tributaries and lacustrine delta habitat use is described in Section 5.1.3.5.

Mountain Whitefish – Mountain whitefish were captured in all Project reaches, but catch rates were greatest in the Upper Reservoir Reach (Table 5.1-12), especially in the electrofishing transects during May and June (Figure 5.1-16). During May and June, mountain whitefish catch rates were notably higher at sites with moderate sloping gravel and cobble bottom (Figure 5.1-17), a habitat condition that occurs throughout the Upper Reservoir Reach. The increased catch rates at these locations during May and June were attributed largely to a substantial increase in fish less than 120 mm TL, including many young of the year fish (Figure 5.1-18). Mountain whitefish gill net catch rates were also highest in the Upper Reservoir Reach, but were highest during August through October (Appendix 2, Table A.2-1) and consisted primarily of fish exceeding 250 mm. Whitefish were captured in the gill net sites in the Forebay and Canyon reaches during July sampling only (Appendix 2, Table A.2-1).

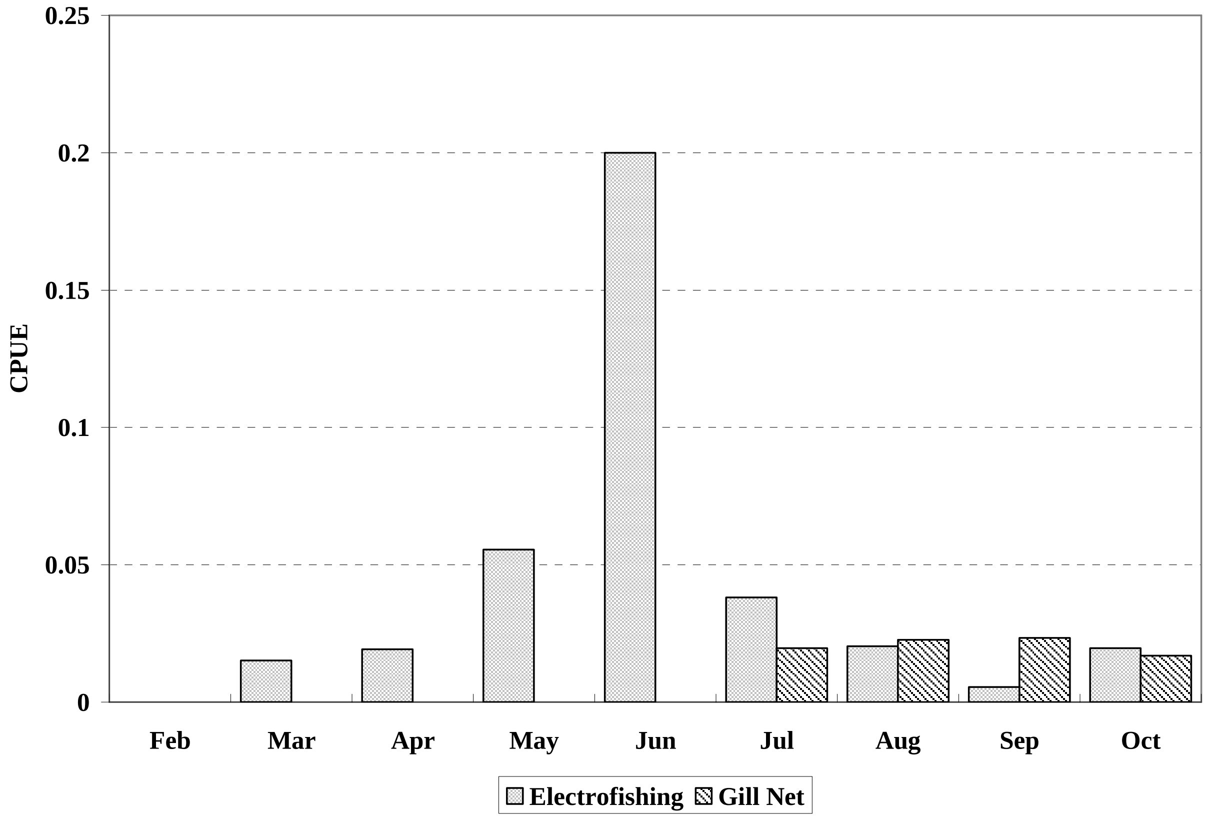

Figure 5.1-16. Mean catch per unit effort of mountain whitefish for electrofishing (CPUE: fish per electrofishing run time [minute]) and gill netting (CPUE: fish per 1000 square feet net set time [hr]) by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

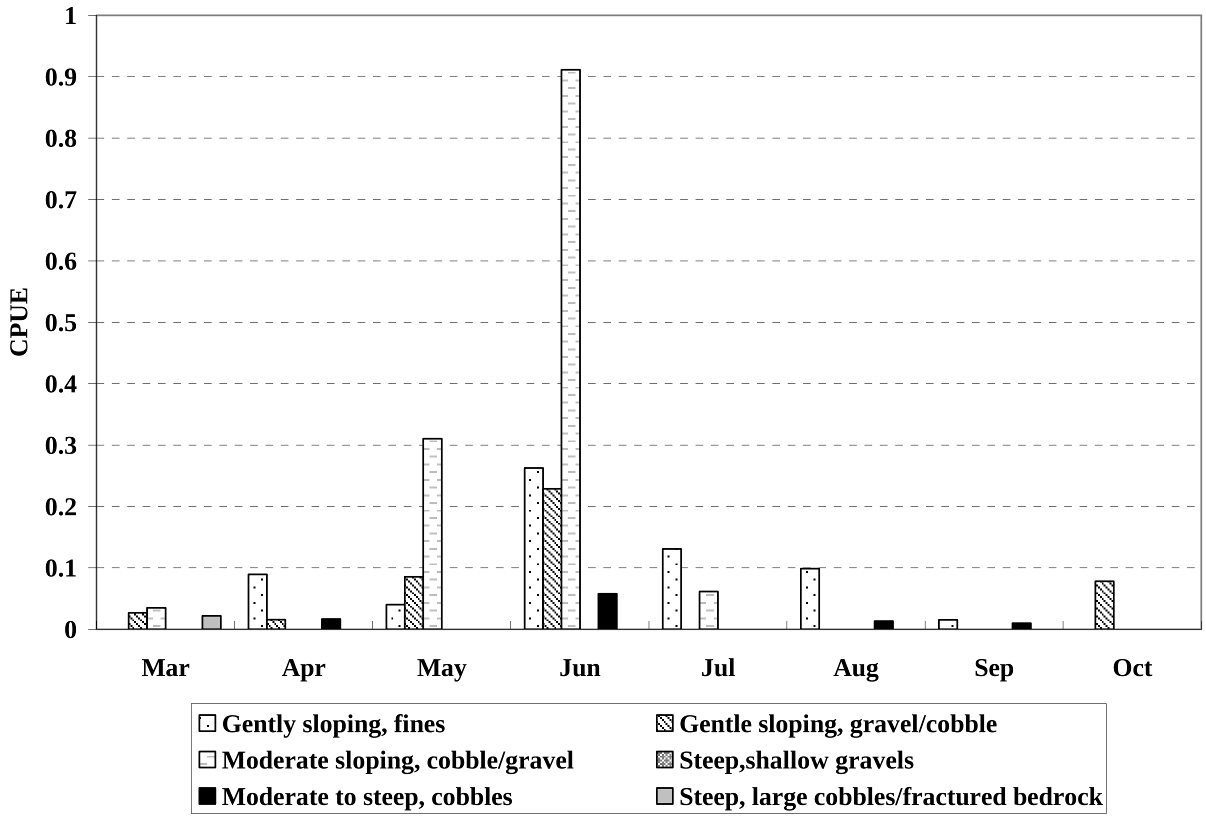

Figure 5.1-17. Mean catch per unit effort of mountain whitefish for electrofishing (CPUE: fish per electrofishing run time [minute]) by month in the six varial zone habitat type groups in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

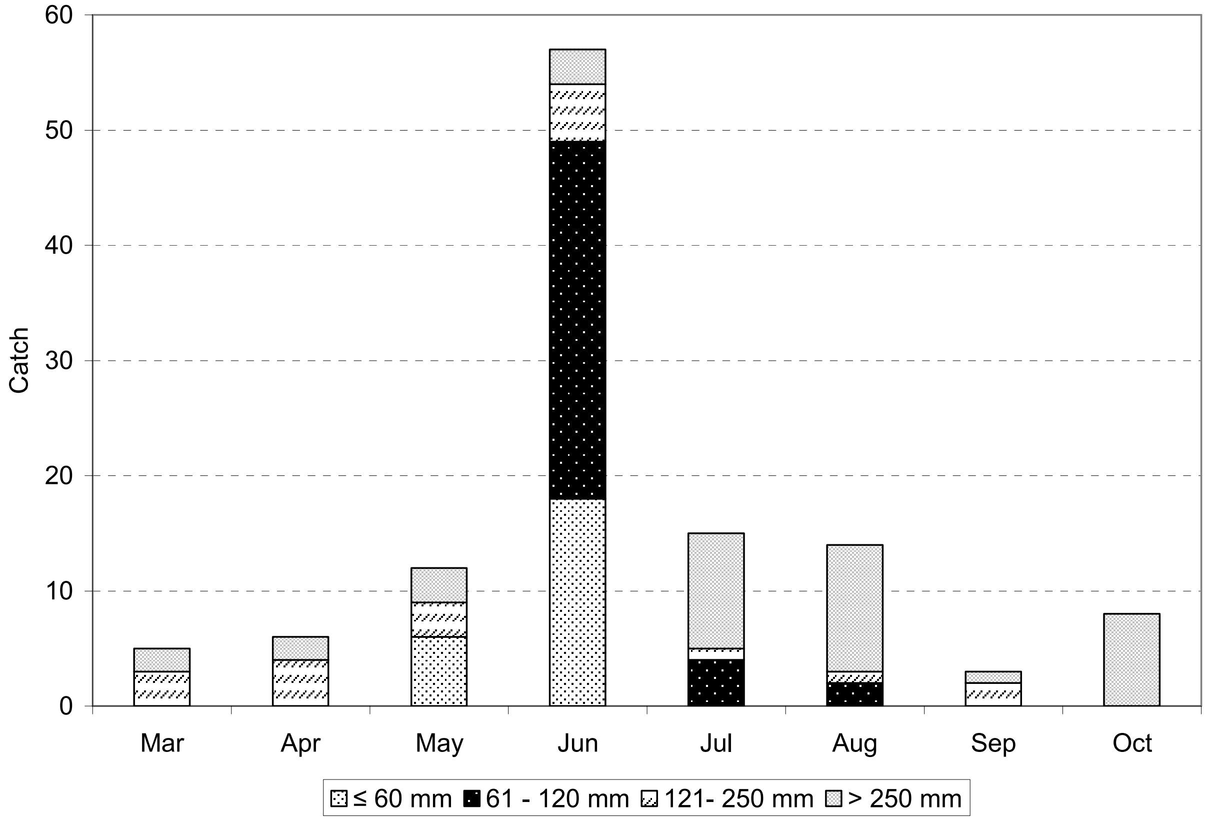

Figure 5.1-18. Catch by total length categories for mountain whitefish from monthly gill netting, electrofishing, and fyke netting by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

5.1.3.4.2. Other Target Species

Smallmouth Bass – Smallmouth bass were captured in all Project reaches by all sampling methods. Overall smallmouth bass catch rates for both electrofishing and gill net study sites were greatest in the Tailrace Reach (Figures 5.1-4 and 5.1-8). Average electrofishing catch rates in the Canyon Reach nearly equaled rates of the tailrace. However, average gill net catch rates in the Canyon Reach were nearly 10 times less than the tailrace and substantially lower than the Upper Reservoir Reach.

Low overall gill net catch rate in the Forebay and Canyon reaches is partly related to inclusion of vertical nets in the CPUE calculations. Catch rates for vertical nets were very low in all reaches (Figure 5.1-2 and Table 5.1-6), which was likely due to low offshore pelagic abundance of all species. Relative abundance of smallmouth bass catch was lowest in the Forebay Reach, although it still comprised 5 percent of the total catch in the reach.

Smallmouth bass CPUE for gill nets peaked during July and August, at which time rates were more than 5 times greater than any other months. No smallmouth bass were captured in gill net during February through April. Smallmouth bass electrofishing CPUEs peaked during May and June, and were again high during August. The relative abundance of smallmouth bass captured in the electrofishing sites exceeding 250 mm (presumed to be potentially reproductive age) was greatest during May and June (Figure 5.1-19), whereas smaller size classes dominated the catch in subsequent months (Figure 5.1-6). Although relative abundance of larger smallmouth bass decreased in the total catch during July through October, gill net catch rates increased during July and August (Figure 5.1-20), with 75 percent of the gill net catch exceeding 250 mm. At the same time, the relative abundance of larger smallmouth bass was proportionally reduced in the electrofishing transects (Figure 5.1-19). High smallmouth bass catch rates in August reflected an increased catch in fry and juvenile sized fish. In the Upper Reservoir Reach, the smallmouth bass electrofishing catch was dominated by fish of less than 120 mm (104 of 163 specimens) during August through October. Relative abundance of smallmouth bass less than 120 mm TL remained low in the tailrace (5 of 224 specimens) throughout the entire study period.

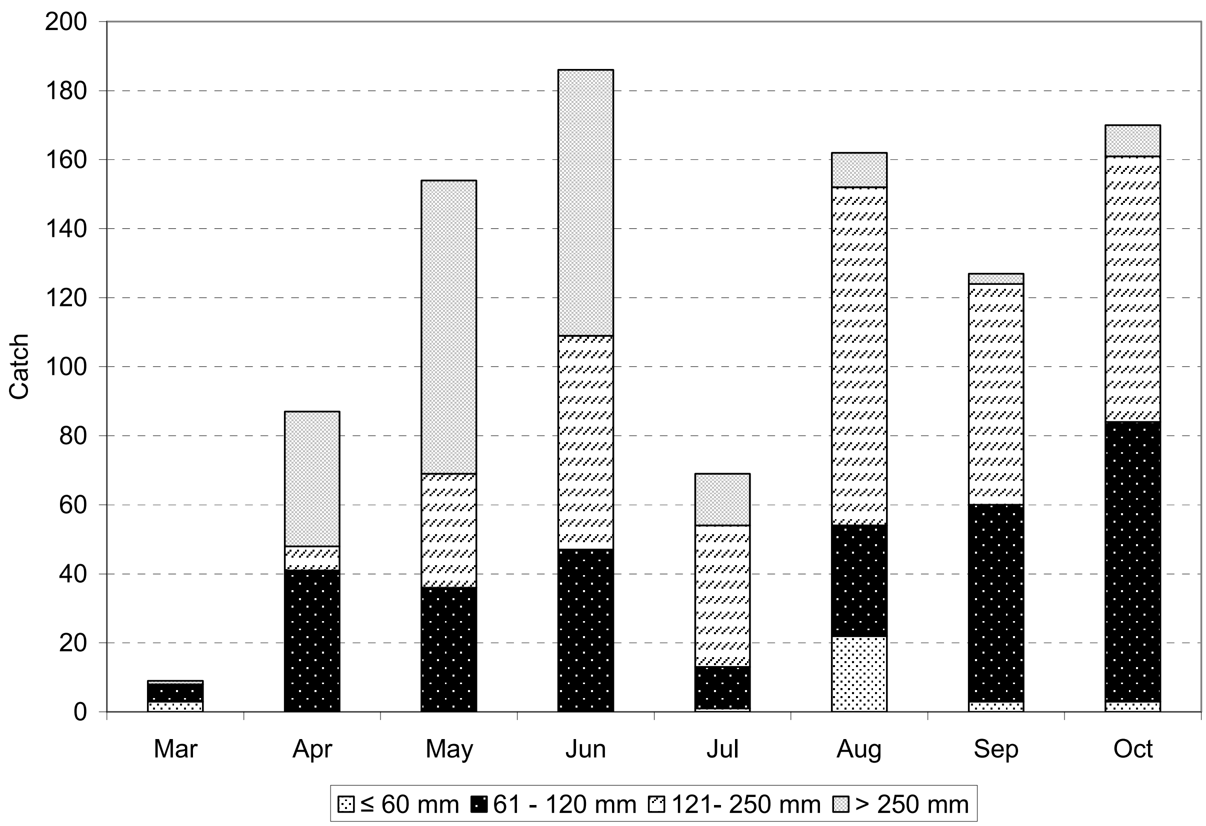

Figure 5.1-19. Catch by total length categories for smallmouth bass from monthly electrofishing by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

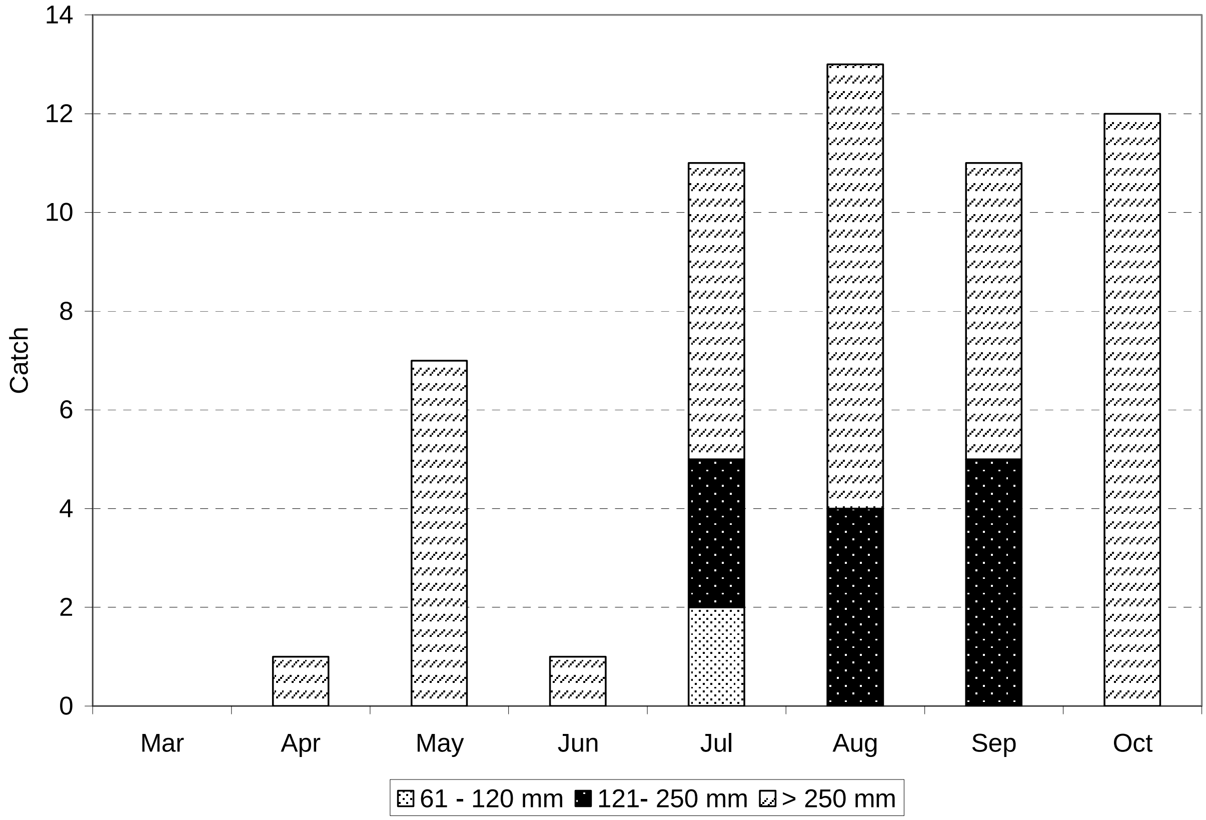

Figure 5.1-20. Catch by total length categories for smallmouth bass from monthly gill netting by month in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

Non-native Rainbow Trout – Non-native rainbow trout, including naturally reared fish in the reservoir and hatchery reared triploids, were widespread throughout the Project reaches and were observed at least once in all of the tributaries investigated. All naturally reared rainbow trout in the Reservoir and tributaries are considered non-native. Non-native rainbow trout were captured at least once at all gillnet and electrofishing study sites. Only 4 of the 799 rainbow trout captured in the reservoir and tailrace were less than 210 mm TL, which was the minimum size of triploid rainbow trout at the time of release.

Within the tributaries sampled, an additional 27 non-native rainbow trout were captured in the fyke nets and 190 observed in the snorkeling surveys. Four triploid rainbow trout were captured in the tributary fyke nets, while 85 of the fish observed during the tributary snorkel survey were believed to be triploid rainbow trout. All but four of the triploid rainbow trout observed during the snorkel surveys were sighted within the inundated deltas of the tributaries, and most were observed during July and August when water temperatures were greatest.

Rainbow trout catch rates were highest in the Tailrace Reach for both the electrofishing and gill net sampling (Figures 5.1-4 and 5.1-8). The Tailrace Reach gill net rainbow trout (native and non-native combined) CPUE was more than 5 times greater than that of the Forebay Reach and nearly 10 times greater than the Upper Reservoir Reach. The disparity in rainbow trout catch rates among the reaches was less pronounced in the electrofishing sites, although the Tailrace and Forebay reaches were both nearly double that of the Canyon and Upper Reservoir reaches. Both native and non-native wild rainbow trout catch rates were consistently higher at sites dominated by gently sloping, gravel and cobble bottoms and reaches with moderate to steep, cobble and boulder substrates (Figure 5.1-21). Catch rates of rainbow trout within the varial zones electrofishing sites was greatest during March through June, falling sharply from August through October (Figure 5.1-10). Similar trends in rainbow trout CPUE were observed in the open water gill net sets, although catch remained high in July (Figure 5.1-6), especially in the Tailrace Reach (Appendix 2, Table A.2-1).

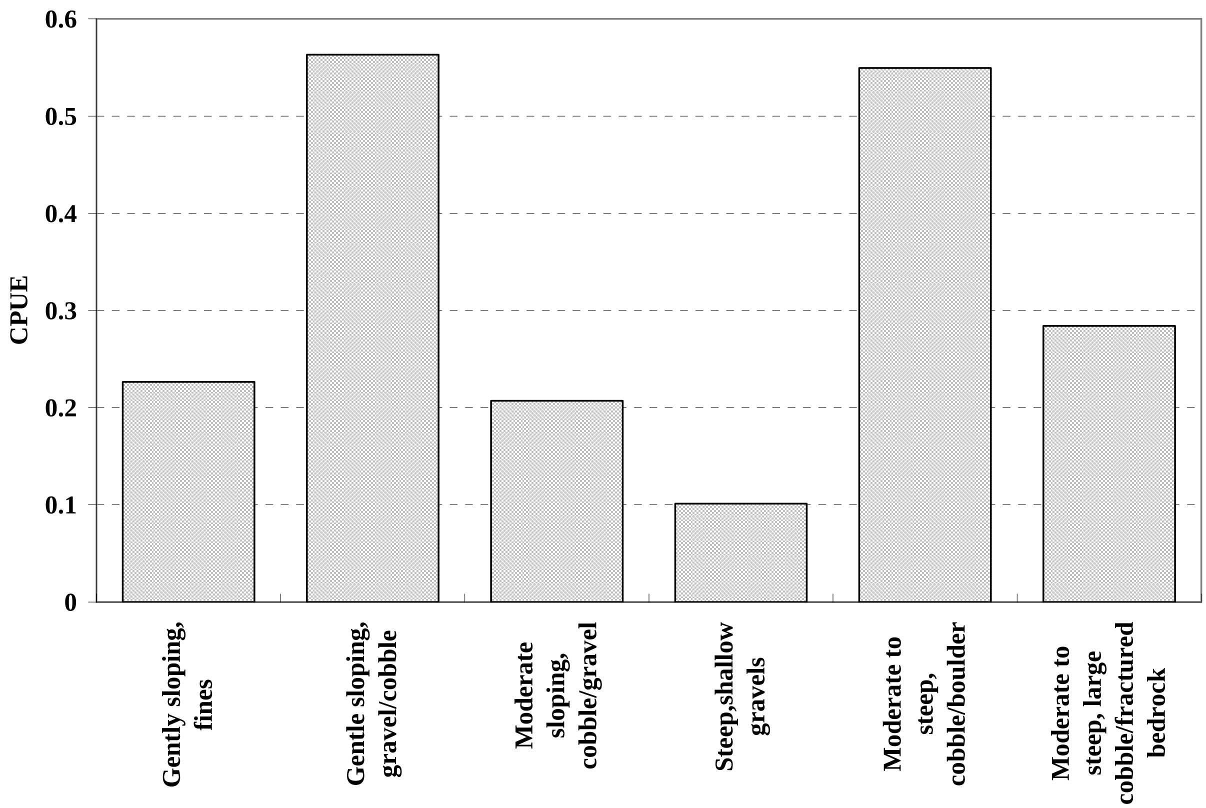

Figure 5.1-21. Mean catch per unit effort of rainbow trout for electrofishing (CPUE: fish per electrofishing run time [minute]) in the six varial zone habitat types in the Boundary Reservoir and Tailrace on the Pend Oreille River, Washington.

Note: Summary data includes native, non-native wild, and triploids; triploids comprised 96 percent of the rainbow trout catch.

Cyprinid Forage Species – The cyprinid forage target species are represented by any pikeminnow or peamouth (fry or juvenile) and redside shiner less than 10 cm in length. Only five redside shiners were captured; all but one was captured in the Upper Reservoir Reach. Both peamouth and northern pikeminnow are widespread throughout the reservoir. A total of 777 peamouth and 671 northern pikeminnow were captured within the monthly gill net, electrofishing, and fyke net sites throughout the reservoir and tailrace reaches (Table 5.1-3).

Northern pikeminnow were widespread across all reaches but were most common component of the total catch in the Upper Reservoir Reach (Table 5.1-10). The relative abundance of northern pikeminnow and peamouth was highest in the open water gill net sets, accounting for 48 percent of the total numerical catch within the 18 monthly gill net sites (Table 5.1-5). Northern pikeminnow were the most abundant species captured in gillnets.

Northern pikeminnow gill net catch rates ranked as the top three of all species captured from March through August in the open water gill net sets (Figure 5.1-4). Electrofishing CPUE for northern pikeminnow remained generally consistent throughout all months sampled, while peamouth catch rates declined in July and August (Figure 5.1-10). Overall, catch rates of peamouth nearly doubled that of northern pikeminnow in the electrofishing sites. Electrofishing catch rates of both peamouth and northern pikeminnow were highest in the Upper Reservoir Reach. Peamouth catches were notably higher in the gently sloping, sandy bottom habitats of the Upper Reservoir Reach (Figure 5.1-22).

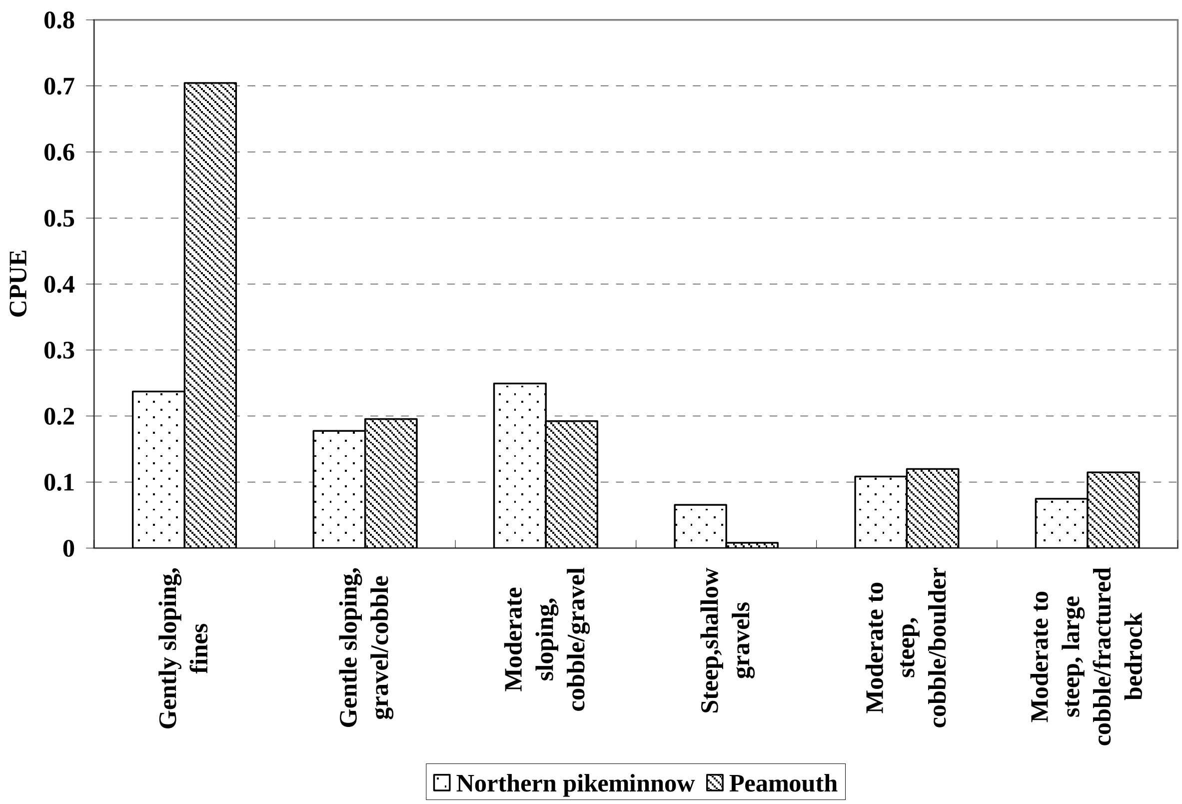

Figure 5.1-22. Mean catch per unit effort of northern pikeminnow and peamouth for electrofishing (CPUE: fish per electrofishing run time [minute]) in the six varial zone habitat types in the Boundary Reservoir and Tailrace Reach on the Pend Oreille River, Washington.

5.1.3.4.3. Other Sport Fish Species

Several other fish species encountered that are commonly pursued by anglers in the reservoir, include black crappie, largemouth bass, northern pike, yellow perch, walleye, brook trout, brown trout, and lake trout (Table 5.1-5). Yellow perch had the highest relative abundance of all of the other sport fish species. Yellow perch were in all reservoir reaches, reaching their highest relative abundance in the Upper Reservoir Reach (Table 5.1-10). Gelatinous egg masses of what were presumed to be yellow perch eggs were commonly noted by field staff during late April throughout the submerged aquatic vegetation in the Upper Reservoir Reach.

Black crappie and largemouth bass also reached their highest relative abundance in the Upper Reservoir Reach. Young of year black crappie were commonly observed among dense vegetation beds in the electrofishing transects and during the stranding and trapping studies conducted as part of Study 7. Several spawning beds (8 to 15 inches in diameter) that may have been constructed by black crappie were observed in backwater areas with deep mud substrates. Largemouth bass were rarely captured prior to August (6 specimens). During August, largemouth bass electrofishing catch rates increased over 600 percent in the Upper Reservoir Reach (Appendix 2, Table A.2-3), owing largely to an increase in fish less than 80 mm TL (19 of 20 specimens). Largemouth bass gill netting catch rates also increased during October in the Upper Reservoir Reach. Five of the six largemouth bass captured in gill netting during the entire study were captured in October in the Upper Reservoir Reach (Appendix 2, Table A.2-1).

Brown trout was the most common non-native salmonid sport fish species encountered (Table 5.1-10). Brown trout catch rates were highest in the Tailrace Reach. Brown trout were encountered in Sullivan Creek, Sweet Creek, and Slate Creek during snorkeling surveys, with the greatest number of observations in Sullivan Creek (Appendix 2, Table A.2-6). Juvenile brown trout were captured in both the Sullivan and Sweet Creek fyke net site. Eight brown trout less than 100 mm TL were captured in the monthly reservoir electrofishing sites, suggesting brown trout rear within the reservoir and tailrace. Lake trout were observed at least once in all reservoir and tailrace reaches, but most commonly encountered in the Forebay and Canyon reaches. Kokanee and brook trout were uncommon (three and five specimens, respectively), but were captured in both the Reservoir and Tailrace reaches.

5.1.3.5. Tributary Use by Native Salmonids

Confirmed observations of native salmonids in tributary channels were limited to westslope cutthroat trout in Sullivan, Sweet, Sand, and Slate creeks and mountain whitefish in Sullivan and Sweet creeks. During a snorkel survey in September one unidentified char (approximately 350 mm TL) with characteristics indicative of a bull trout was observed in Sullivan Creek in a large scour pools associated with a wood jam that was approximately 1100 feet downstream of the highway crossing. The fish was not observed during a return visit 2 days after the initial sighting.

Westslope cutthroat trout were observed during snorkel surveys in all but Flume Creek. Slate Creek observations were dominated by cutthroat trout, with specimens ranging from approximately 60 mm to over 250 mm. Cutthroat trout comprised a smaller proportion of the snorkel observations in Sullivan, Sweet, and Sand creeks as compared to Slate Creek. Trends in capture rates were apparent in fyke net sampling, especially young of year size classes (Figure 5.1-23). For example, cutthroat trout catch rates in the Slate Creek and Sweet Creek fyke nets increased in late July peaked in September, and declined in October. The catch in both streams consisted predominantly of young of year fish.

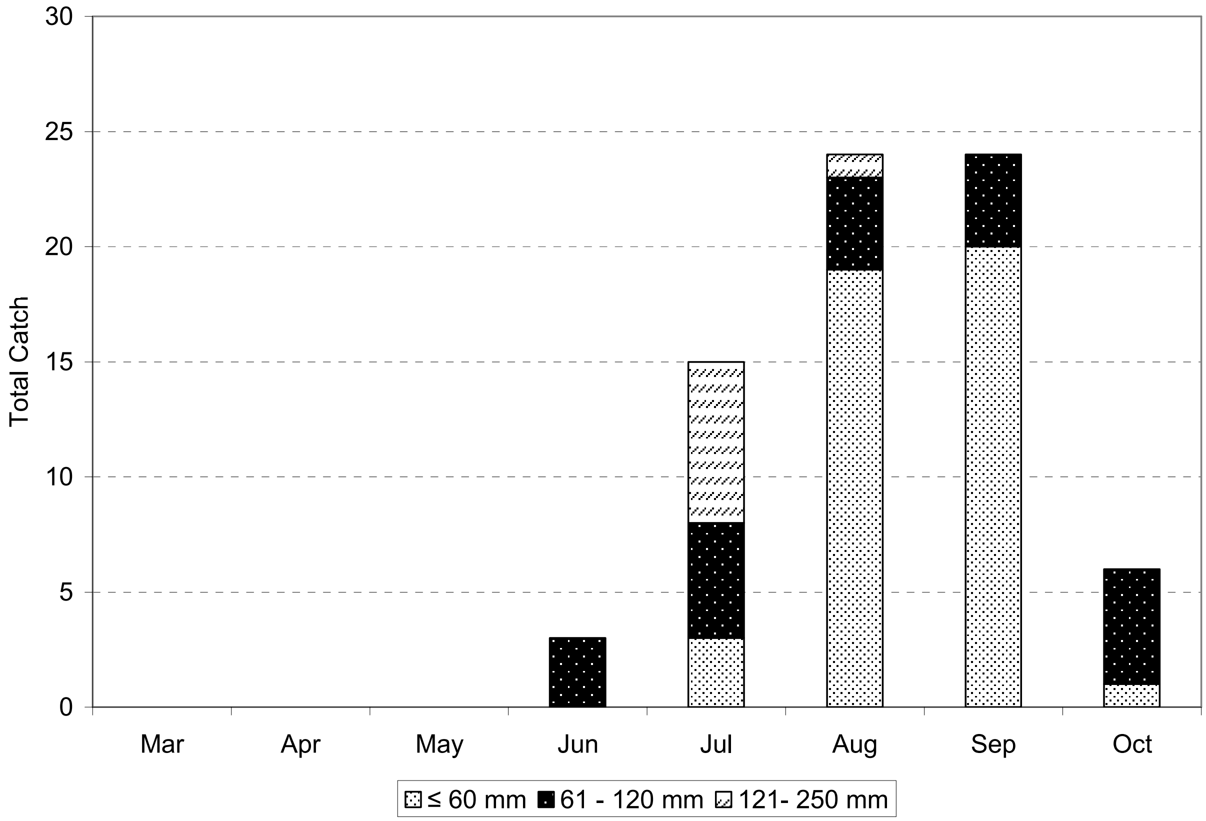

Figure 5.1-23. Catch by total length categories for cutthroat trout from twice-monthly tributary fyke netting by month in selected tributary sites in the Boundary Project on the Pend Oreille River, Washington.

Mountain whitefish use of the selected tributaries has been confirmed only by captures in the downstream fyke net traps in Sullivan and Sweet Creeks. To date, no mountain whitefish have been observed within the tributary channels or the delta areas via snorkel surveys.

Seven mountain whitefish were captured within the inundated portion of Sullivan Creek at the extra gill net sites during mid August. Another 23 mountain whitefish were captured during three monthly electrofishing sites situated along the delta embayment of Sullivan Creek from June through August. No mountain whitefish were captured at these gill net and electrofishing sites in September and October.

Between late July and early September, a total of 73 mountain whitefish were captured in downstream migrant fyke nets in Sullivan Creek (73 fish) and Sweet Creek (24 fish). The total length of whitefish captured in the two systems averaged 112 mm (range 31 to 265 mm). Only one fish with a total length of less than 80 mm was captured in the fyke nets.

5.1.4. Native Salmonid Genetics

A fin punch was collected from rainbow trout that appeared to be of wild origin (dorsal fins well formed) downstream of Boundary Dam, from all cutthroat trout in the tailrace and reservoir that appeared to be of the westslope subspecies, and all apparent bull trout. Tissue samples were preserved in 100 percent ethanol for later genetic analysis. Tissues were collected from a total of 26 fish. The results of genetic sampling from native rainbow trout below Boundary Dam and cutthroat trout above and below Boundary Dam will be presented in the 2008 Annual Report.

Three char with markings indicative of a bull trout were captured (two in the Tailrace Reach, one in the Upper Reservoir Reach). Genetic analysis, conducted by Patrick DeHaan, of the USFWS, Abernathy Fish Technology Center, Longview, Washington, determined that one of the tailrace char captured in April was a brook trout, while the Upper Reservoir Reach specimen also captured in April was identified as a hybrid between a brook trout and bull trout (P. DeHaan, USFWS, personal communication, November 14, 2007). The remaining fish, captured in June in the Tailrace Reach, was confirmed to be a bull trout and was given a population assignment to the South Salmo River in British Columbia**.** Genetic samples from suspected bull trout will continue to be sent to Abernathy Genetics Laboratory and in 2008 will be analyzed within 30 to 45 days of their capture.

5.2. Biotelemetry

This section presents the preliminary results of the Biotelemetry component.

5.2.1. Tag Implantation Survival and Post-Release Survival

In total, eight native salmonids (one bull trout, three mountain whitefish, and four westslope cutthroat trout) were implanted with radio or CART tags from April 28 to September 26, 2007. Over the same period, 21 smallmouth bass and 1 northern pike were also implanted with either radio or CART transmitters. Attempts were made to implant additional fish including two suspected bull trout (one later confirmed through genetic analysis to be an eastern brook trout and the other a char hybrid); one smallmouth bass; and three mountain whitefish, but these either did not survive the implantation procedure or died during the holding period.

Post-release survival of the 31 tagged fished was assessed based on several sources of information. An estimated 74 percent (23 fish) survived to the end of September (Table 5.2-1) and Appendix 3, Table A.3-1. However, some of these fish assumed to be alive either have left the study area or have not been detected during September 2007. This included one bull trout (last observed July 5) that traveled downstream from the Tailrace Reach and did not return, one cutthroat in the Upper Reservoir Reach, which has not been detected since 6 August, and four smallmouth bass assumed to be alive, but whose tags have not been detected during September because of tag failure (one fish) or because they may be in water too deep for detection by the radio telemetry equipment.

Recovered tags, either provided by anglers or found on shore during mobile tracking, were the most direct means of identifying mortalities. One indirect means of determining mortality was to mobile track a tag that remained stationary for an extended period. Typically, during successive mobile tracking sessions, these tags would be relocated at the same location within a 10-m (33-foot) radius. Another indirect indicator was the detection of tags above the high water level, where some were recovered, but others could not be located. Mortality was also suspected based on mobile and shore-based telemetry data that indicated either continual or gradual downstream movement immediately following tagging, or if very few reliable signal detections were recorded over the entire monitoring period. The specific tag release information and the current location and status of the tagged fish are provided in Appendix 3 (Table A.3-1). The tag implantation records and release data are also provided in Appendix 3 (Table A.3-2).

Table 5.2-1. Survival of tagged salmonids, smallmouth bass, and northern pike tagged in the Project area, April to September 2007.

Species	Total Number Released with Tags	Dead or Suspected Dead	Survival (percent)	Suspected Cause of Mortality
Bull trout	1	0	100	N/A
Char hybrid	1	1	0	unknown
Westslope cutthroat trout	4	1	75	unknown
Mountain whitefish	3	2	33	Surgery and capture
Smallmouth bass	21	4	81	anglers
Northern pike	1	0	100	N/A
All fish	31	8	74	See above

Elevated reservoir water temperature may have been a possible factor in the post-tagging mortality of salmonids, with lower survival expected as water temperatures increased. Field crews indicated that both the char hybrid and the westslope cutthroat trout mortalities appeared healthy at release. However, mobile tracking data suggested both fish species appeared to die almost immediately after release and near the release locations. Mountain whitefish are, relative to other salmonids, less robust in their response to normal sampling activities and likely to be affected by the tagging process as well.

Anglers were suspected to be the primary source of mortality for smallmouth bass, as evidenced by the return of a CART tag removed from a smallmouth bass by an angler and returned by mail to SCL. A robust fish, smallmouth bass recovered from surgery relatively quickly and demonstrated higher survival under warm water holding and release conditions. Northern pike also seem to exhibit similar recovery rates and constitution as bass.

5.2.2. Native Salmonid Movement and Distribution

Due to the low number of salmonids captured, correlations of fish movement in relation to environmental variables could not be conducted. Fish movement of all species was plotted in relation to reservoir water temperature, discharge, and water level elevation. These figures are presented in Appendix 3.

In plotting fish movement relative to the environmental variables, the location of the fish determined what data were used to represent the discharge and water level fluctuations to which the fish would be subjected. For fish located upstream of Metaline Falls, movement data were compared with smoothed Box Canyon Dam total discharge and water level elevations recorded at the USGS gage station 1.2 miles downstream of Box Canyon Dam. Movement data from fish downstream of Metaline Falls were compared to estimated Boundary Dam inflows and water elevation data as measured in the Boundary Forebay. For all reservoir fish, movement data were also compared to the inverse reservoir residence time in days (e.g., 2 days residence time = 0.5 inverse residence time), which served as an analog of reservoir water velocity and was calculated based on the discharge storage curve, Boundary Forebay elevations, and total Boundary Dam outflows. Movement data of fish in the tailrace of Boundary Dam were compared to reservoir water temperature, total Boundary Dam discharge, total spill, and Boundary Tailrace elevation.

Between April 28 and September 27, average water temperature in the Pend Oreille River was 18.4ºC and ranged between 9.5ºC and 24.7ºC as measured at the USGS total dissolved gas (TDG) monitoring station in the Boundary Forebay. The maximum water temperature occurred on July 29 and daily average water temperatures exceeded 20.0ºC for 68 days between July 6 and September 11. Due to the rapid turnover of the reservoir, thermal stratification does not occur during the summer; consequently, water temperatures in deep portions of the reservoir essentially are equal to near surface water temperatures (isothermal).

Average total river discharge during the study period as measured at Box Canyon Dam was approximately 25,000 cubic feet per second (cfs) and a maximum discharge of approximately 55,000 cfs occurred on June 9. Discharge at Boundary Dam was nearly identical to that at Box Canyon Dam. Maximum daily average spill of 4,683 cfs was recorded at Boundary Dam on June 9. Reservoir elevations at the USGS gage station located 1.2 miles downstream of Box Canyon Dam ranged between 1,983.1 feet and 2,001.3 feet NGVD 29[2] (1,987.1 feet and 2,005.3 feet NAVD 88). All subsequent elevations used in this section of the report are based on NAVD 88. The Boundary Forebay elevation ranged between 1,970.0 feet and 1,992.1 feet (NAVD 88) (1966.0 feet and 1988.1 feet NGVD 29), and the Boundary Tailrace water elevation ranged between 1,723.1 feet and 1,740.4 feet (NAVD 88) (1719.1 feet and 1736.4 feet NGVD 29). Substantial reductions in reservoir elevation were recorded in late-August and mid-September. These reductions were associated with sampling needed for the Aquatic Habitat Model (Study 7) and were not typical of the normal magnitude of reduction associated with power production at Boundary Dam during this period (Table 5.2-2).

[2] SCL is in the process of converting all Project information from an older elevation datum (National Geodetic Vertical Datum of 1929 [NGVD 29]) to a more recent elevation datum (North American Vertical Datum of 1988 [NAVD 88]). As such, elevations are provided relative to both data but NAVD 88 is generally used throughout this document. The conversion factor between the old and new data is approximately 4 feet (e.g., the crest of the dam is 2,000 feet NGVD 29 and 2,004 feet NAVD 88).

Table 5.2-2. Water level elevation and discharge recorded within the Project area during the telemetry tracking program, April 28 to September 27, 2007.

Water Level Elevation	Residence time-1 (days)	Date	USGS Gage Elevation[1] (ft)	Date	Boundary Dam Forebay Elevation (ft)	Date	Boundary Dam Tailrace Elevation (ft)	Date
average	1.5		1,993.0		1,987.6		1,732.1	
min	0.3	8/12/2007	1,983.1	9/9/2007	1,970.0	8/9/2007	1,723.2	8/25/2007
max	4.6	5/16/2007	2,001.3	6/8/2007	1,992.1	5/27/2007	1,740.4	6/9/2007

Discharge	Box Canyon Dam Outflows (cfs)	Date	Boundary Dam inflows (cfs)	Date	Boundary Dam Outflows (cfs)	Date	Boundary Dam, Spill (cfs)	Date
average	23,733		23,473		23,442		115	
min	6,333	8/13/2007	6,911	8/13/2007	3,513	9/9/2007	0	
max	54,462	6/9/2007	52,230	6/10/2007	54,297	6/9/2007	4,683	6/9/2007

Note:
1 Located 1.2 miles downstream of Box Canyon Dam. Elevations are in NAVD 88.

5.2.2.1. Bull Trout Movement

The bull trout (Fish 184; 273 mm fork length [FL]) captured and tagged on June 22 in the Tailrace Reach was consistently detected in the reach until July 5, after which time it moved rapidly downstream and was last recorded at the Red Bird Creek station in Canada (Appendix 3, Figure A.3-1). This rapid movement did not coincide with any obvious operational change at Boundary Dam but occurred when water temperatures approached 20ºC. Bull trout are known to be one of the least thermally tolerant species of salmonids. The upper lethal temperature limit for this species is 20.9ºC and optimal growth and feeding occurs at 13.2ºC (Selong et al. 2001). Generally, bull trout inhabit systems with water temperatures less than 15ºC (Wydoski and Whitney 2003). To date, mobile tracking of the reach of river between the International Border and the Salmo River has not detected this fish, nor has the fixed receiving station operated by BC Hydro in the Salmo River.

5.2.2.2. Cutthroat Trout Movement

Most of the telemetry data for westslope cutthroat trout were obtained from two fish captured in the Upper Reservoir Reach. The first westslope cutthroat trout (Fish 181; 312 mm FL) was captured and released on May 17 near Wolf Creek during the spring freshet period when discharge was relatively high. Initial movement of this fish was downstream to a location near Pocahontas Creek and may have been related to a combination of the high reservoir flows at the time of release and recovery from the surgery. This fish was next detected upstream at Sweet Creek on June 2 following a sharp reduction in flow and velocity. It remained at Sweet Creek until it disappeared on August 6 and was not subsequently detected (Appendix 3, Figure A.3-2). Simultaneous detections of Fish 181 on both the reservoir and tributary antennas at Sweet Creek during portions of this period suggest at times this cutthroat trout utilized the delta habitat located at the mouth of the creek. However, Fish 181 did not ascend Sweet Creek.

A larger westslope cutthroat trout (Fish 24; 395 mm FL) was captured upstream at Sweet Creek and implanted with a CART tag on May 24. After release, this fish moved downstream to Sweet Creek and following some local movements, traveled upstream to near Box Canyon Dam and then rapidly back downstream to Sweet Creek. The upstream and downstream movement occurred following seasonal peak flows and velocities. This downstream movement also occurred when water temperatures exceeded 17ºC. The fish was subsequently detected at Sweet Creek and in the general area until August 22, at which time the fish moved upstream toward Box Canyon Dam and remained there for a short period of time. This movement may have occurred during or following a substantial decrease in reservoir elevation on August 22 and a decrease in reservoir water temperature to below 21ºC. The fish moved back to Sweet Creek by early September (Appendix 3, Figure A.3-3). Simultaneous detections of Fish 24 on both the reservoir and tributary antennas at Sweet Creek during July suggest this cutthroat trout utilized the delta habitat located at the mouth of the creek. However, Fish 24 did not ascend Sweet Creek.

A westslope cutthroat trout (Fish 176; 308 mm FL) released on September 23, was located at the International Border on September 24 and then moved downstream into Canada. This fish was not subsequently detected at the Red Bird Creek station (Appendix 3, Figure A.3-4). A second cutthroat trout implanted with a CART tag (Fish 59; 357 mm FL) on June 22 and released in the Tailrace Reach has remained at approximately the same location since its release and is likely dead. This tag is periodically detected at the International Border station and these detections seem to correspond to low tailrace elevation levels that may result in exposure of the tag. When out of the water, the tag signal strength increases and the signal can be detected by nearby stations (Appendix 3, Figure A.3-5).

5.2.2.3. Mountain Whitefish Movement

Of the three mountain whitefish released with tags, only the fish in the Tailrace Reach (Fish 179; 341 mm FL) appears to be alive as of 26 September. Released in the Tailrace Reach on May 22, this fish remained in the tailrace area immediately below Boundary Dam until July 4, at which point the fish moved rapidly downstream (0.65 miles/hr) and was detected on July 4 at the Red Bird Creek station in Canada. This rapid movement occurred when the reservoir water temperature exceeded 18ºC. The fish was not detected again until September 5 when river temperatures had cooled to about 20ºC , first at the International Border, and then more consistently at the Boundary Tailrace station, where it has remained (Appendix 3, Figure A.3-6).

Two mountain whitefish tagged in the Upper Reservoir Reach were either not detected after release (Fish 160; 352 mm FL) or demonstrated continual and gradual downstream movement before effectively disappearing (Fish 159; 346 mm FL). Fish 160 was released at Sweet Creek on June 21. During and immediately after release, however, valid tag signals could not be detected. Given the release location and relatively shallow river depth (e.g., compared to the

Canyon Reach), it is suspected that either the tag failed or was not properly activated prior to implantation.

Fish 159 was released on April 26 after being held overnight in Sand Creek, immediately upstream of Sweet Creek. Once released, telemetry data indicated this fish moved continuously downstream and was detected at all of the stations between Sweet Creek and Metaline Falls, where it was last detected on April 28 before moving into the Canyon Reach. The fish was detected during mobile tracking on August 24 near Slate Creek; however, field crews indicated that they were unable to pinpoint the location of the fish (Appendix 3, Figure A.3-7). Given the tendency for gradual downstream movement of this fish, its health and status were suspect.

5.2.3. Smallmouth Bass and Northern Pike Movement

5.2.3.1. Smallmouth Bass Movement

Smallmouth bass were tagged in two distinct groups: the first group was implanted with radio tags during the local "Bassin' Assassin'" smallmouth bass derby and released on May 5; the second group was captured during the boat electrofishing surveys, tagged with CART tags, and released between May 23 and September 10. No size information was collected from fish tagged during the derby. Each of these groups is discussed below.

5.2.3.1.1. May 5 Derby Releases (Radio-Tagged Fish)

Smallmouth bass tagged during the fishing derby on May 5 were obtained from two distinct locations. Five were captured in the Upper Reservoir Reach and five were captured in the Canyon Reach. These capture locations were provided by the anglers who captured the fish.

Fish captured in the Upper Reservoir Reach were implanted with tags 97, 98, 105, 106, and 107 and released across from the Metaline Falls launch near PRM 28.1. With the exception of Fish 107, these fish were subsequently always detected in the reach of the river between Sullivan Pocahontas creeks, with occasional movements by Fish 105 towards Sweet Creek. Fish 107 initially moved up to Box Canyon Dam after release and then moved downstream to near the Metaline Launch (Appendix 3, Figures A.3-8 to A.3-12). Relatively few detections were recorded for Fish 97, 98, and 107; mobile tracking indicated these fish were located near the Metaline launch area, out of reception range of the shore-based receivers. Fish 105 and 106 were located closer to Pocahontas Creek and were more frequently detected by shore-based receivers. Movement of these fish did not correspond to notable changes in the environmental variables examined. The movement data suggest that these fish may have eventually established home territories after release and remained relatively stationary.

Four of the five smallmouth bass captured in the Canyon Reach were implanted with tags 99, 101, 102, and 103. The fifth fish was in poor health prior to tagging and did not recover fully after the surgical procedure. This fish was sacrificed and the tag recovered. Due to low water and treacherous flow conditions through Metaline Falls, a decision was made to release these four fish at the upper end of Metaline Falls on the assumption these fish would be transported downstream to their original capture location.

Fish 99 (320 mm TL) initially went downstream of Metaline Falls, held near Flume Creek, and then gradually moved upstream to the Box Canyon tailrace where it apparently remained until July 28. This upstream movement occurred during the descending limb of the spring freshet (Appendix 3, Figure A.3-13). After July 28, the fish was caught by an angler who kept the fish and left the tag in a creel survey box.

Fish 101 (415 mm TL) exhibited similar movements to Fish 99 (add length) and moved from downstream of Metaline Falls upstream to the Box Canyon tailrace where it has since remained. Unlike Fish 99, Fish 101 traversed this distance in a shorter period of time and prior to the start of the spring freshet, during a period when discharge and water velocity were low (Appendix 3, Figure A.3-14).

Unlike Fish 99 and 101, Fish 102 (394 mm TL) primarily remained in the vicinity of Metaline Falls and Sullivan Creek after its release. However, in mid-May and mid-July, this fish moved upstream near Pocahontas Creek and Sweet Creek, respectively, for short periods of time. These movements did not appear to occur during periods of abrupt change in the environmental variables examined (Appendix 3, Figure A.3-15).

Fish 103 (427 mm TL) was initially located downstream of Metaline Falls after release and then exhibited a gradual downstream movement to the Forebay Reach where it was consistently detected by the two receiver stations near the canyon opening and at Pewee Falls. After July 17 however, this fish was no longer detected by the shore-based receivers (Appendix 3, Figure A.3-16).

5.2.3.1.2. CART Tag Releases After May 23

Between May 23 and September 10, CART tags 14, 15, 16, 17, 21, 22, 23, 26, 27, 29, and 42 were implanted in smallmouth bass that were captured during boat electrofishing surveys. The fish were released in the approximate location where they were captured.

Fish 14 (325 mm FL) was released at PRM 25.8 near the mouth of Flume Creek on May 23. After release, valid tag signals were not detected. The absence of detections by shore-based and mobile tracking suggests that this fish may not be alive.

Fish 15 (308 mm FL) was initially captured near the Metaline launch and released upstream near Sweet Creek on May 24. Post-release, this fish moved downstream and then returned upstream to Sweet Creek, where it remained except for a short upstream movement on June 7 after which it returned to Sweet Creek region by June 11. Mobile tracking indicated that after June 15, the fish moved to a location between Pocahontas Creek and the Metaline Launch, but then returned to Sweet Creek on July 2. The movements after release occurred during the ascending and descending limbs of the freshet discharge period. After July 2, the fish moved back upstream near Sweet Creek and held in this general area from early July to mid-September. Over this period, mobile tracking data, combined with a few detections at the Sweet Creek receiver station, indicated that the fish resided approximately one half mile upstream of Sweet Creek (Appendix 3, Figure A.3-17).

Fish 16 (388 mm FL) was captured, tagged, and released immediately upstream of Sweet Creek on May 24. By May 28, this fish had moved rapidly upstream and was located in the tailrace of Box Canyon Dam. This upstream movement coincided with a decrease in reservoir water velocity (as indexed by the inverse reservoir residence time; Appendix 3, Figure A.3-18). In mid-July, this fish was captured by an angler and the tag returned to SCL.

Fish 17 (328 mm FL) was captured and released near Flume Creek on May 23. After release, the fish moved downstream to Slate Creek by June 19, and then upstream to Sweet Creek by June 28 where it resided for the remainder of the summer and early fall. This upstream movement occurred during the declining limb of the hydrograph (Appendix 3, Figure A.3.-19).

Fish 21 (303 mm FL) was captured and released on May 24, near the USGS gage station, 1.2 miles downstream of Box Canyon Dam. After release, this fish moved continuously downstream until reaching a location between Pocahontas Creek and the Metaline Launch on 4 June, where it was detected repeatedly for the remainder of the summer and into early fall during mobile surveys. A relationship between this movement and substantial changes in the environmental variables examined was not evident (Appendix 3, Figure A.3-20).

Fish 22 (307 mm FL) was captured near Sweet Creek, and the fish was released near the Metaline launch. The fish initially was detected near Sullivan Creek and then later upstream near Pocahontas Creek. At some point in June, the fish was apparently killed and the tag removed and deposited somewhere on the left bank of the river, immediately upstream of the Metaline Falls road bridge, where it presently remains (Appendix 3, Figure A.3-21). A search for this tag on foot was unsuccessful.

Fish 23 (300 mm FL) was captured and released near Sweet Creek on May 24, moved downstream by June 3 and resided near Pocahontas Creek until August 2. After August 2, the mobile tracking indicated that this fish moved farther downstream to near the Metaline Launch where it was detected on August 6, then returned to near Pocahontas Creek station by Sept 8. Movement of the fish does not appear to correspond to changes in the environmental variables examined (Figure A.3.-22).

Fish 26, 27, 29, and 42 were captured and released in the Forebay Reach. Fish 27 (363 mm FL) was captured and tagged on June 14 and was detected primarily near the Canyon opening and Pewee Falls until July 14, after which time the fish was not re-located (Appendix 3, Figure A.3-23). Fish 26 (332 mm FL), 29 (315 mm FL), and 42 (334 mm FL) were captured and released in September and minimal telemetry data were recorded prior to the data collection cut-off point (i.e., September 27) for this report (Appendix 3, Figures A.3-24 and A.3-25). During this period, Fish 26 was not detected. During the limited monitoring period after release, Fish 29 apparently remained in the Forebay Reach (Figure A2.-24), but its specific location and movements relative to the three receiving stations (Boundary Dam, Pewee Creek, and Canyon opening) in close proximity could not be resolved from the pattern of detections (Appendix 3, Figure A.3-25).

5.2.3.2. Northern Pike Movement

A northern pike captured near the mouth of Sullivan Creek on April 29, Fish 158 (465 mm FL), was tagged and released across from the Metaline Launch on April 30. This fish apparently remained near the release site throughout most of the summer as it was routinely detected in this area during mobile tracking. This area is characterized by shallow water habitat with large amounts of submerged terrestrial and aquatic vegetation. Between mid-July and late August the fish moved downstream in the river near Sullivan Creek.

During a large reduction in reservoir levels (August 22 to 24) implemented as part of sampling for the Aquatic Habitat Study (Study 7), this fish, after appearing near Sullivan Creek at the start of the drawdown on August 22, moved rapidly upstream from Sullivan Creek to the vicinity of the Pocahontas Creek station where it remained until just after additional major reservoir draw downs ended in mid-September. At this point, the fish moved upstream to the vicinity of the Sweet Creek station. Periodic movements of Fish 158 between Pocahontas Creek and Sweet Creek vicinity were detected through the remainder of September (Appendix 3, Figure A.3-26).

5.2.4. Smallmouth Bass Movement: Correlations with Environmental Variables

5.2.4.1. Assessment of Smallmouth Bass Response to Project Operation Factors

Smallmouth bass was the only species with sufficient numbers of tagged individuals to allow a statistical analysis of upstream and downstream movements with respect to environmental variables. Data collection methods only allowed for statistically assessing the effects of large temporal (days) and spatial (miles) movements. Seventeen smallmouth bass were monitored between May 5, 2007, and September 26, 2007.

Approximately every 2 weeks, the entire reservoir was traversed with mobile tracking equipment to determine the location of each tagged individual. In addition, 12 fixed stations continuously recorded the passage of any tagged individuals past their respective locations in the reservoir. The period of interest was divided into 10 discrete time intervals (approximately every two weeks) punctuated by the mobile tracking sessions. The detected movement within each time interval was calculated in units of miles/fish/day. The total movement was the sum of the absolute differences between the detection locations in river miles of each fish, divided by the total number of fish, divided by the number of days. The net movement was simply the sum of the differences (start day location minus final day location), divided by fish, and divided by average number of days.

Three environmental variables were selected for analysis based on the hypothesis that they could potentially affect fish movement and the assumption that these effects were independent of the location of the fish within the reservoir. The environmental variables were: 1) discharge from Box Canyon Dam, 2) summed outflow and spill from Boundary Dam, and 3) the inverse of the daily estimated water residence time in Boundary Reservoir in days as a surrogate for velocity.

The time series for each of the three environmental variables were compared in turn to the time series of fish movement using linear regression to determine if there was a significant relationship between the movement and either the discharge or the velocity surrogate measure. Both net movement (where upstream movements were classed as positive values and downstream movements were classed as negative values) and total movement (where the absolute value of all movements were summed together) were assessed in relation to each environmental variable.

Neither net nor total movement was significantly correlated with any of the three environmental explanatory variables. Since none of the correlations were significant, there was no need to correct for autocorrelation in the time series (Chatfield 1996) or to conduct multiple comparisons.

When the total fish movement (miles/fish/day) was regressed against the smoothed discharge values from Box Canyon Dam, the relationship was not significant (p=0.3728) and no relationship was apparent (Figure 5.2-1). Altering the movement to net movement made the relationship even weaker (p=0.4466).

Because much of the fish movement was farther downstream and closer in proximity to Boundary Dam than to Box Canyon Dam, the net and total movement of fish were also assessed in relation to the sum outflow and spill from Boundary Reservoir through Boundary Dam. The relationship between the two measures of flow was very close to unity so it is no surprise that neither net movement (p=0.4622) nor total movement (p=0.3918) had any significant relationship to the sum of the outflow and spill from Boundary Dam (Figure 5.2-2).

The final variable tested in relation to total and net fish movement was the surrogate measure of velocity (inverse of reservoir water residence time). Total movement regressed against the surrogate velocity was not statistically significant (p=0.2419, Figure 5.2-3); net movement was also not statistically significant (p=0.4204).

The relationship between the movement of smallmouth bass and the water temperature was also assessed from the period from May 5 to September 26, 2007 (Figure 5.2-4). There was no significant relationship between the movement and the water temperature. The linear model fitted to the one factor model had a p value of 0.3293.

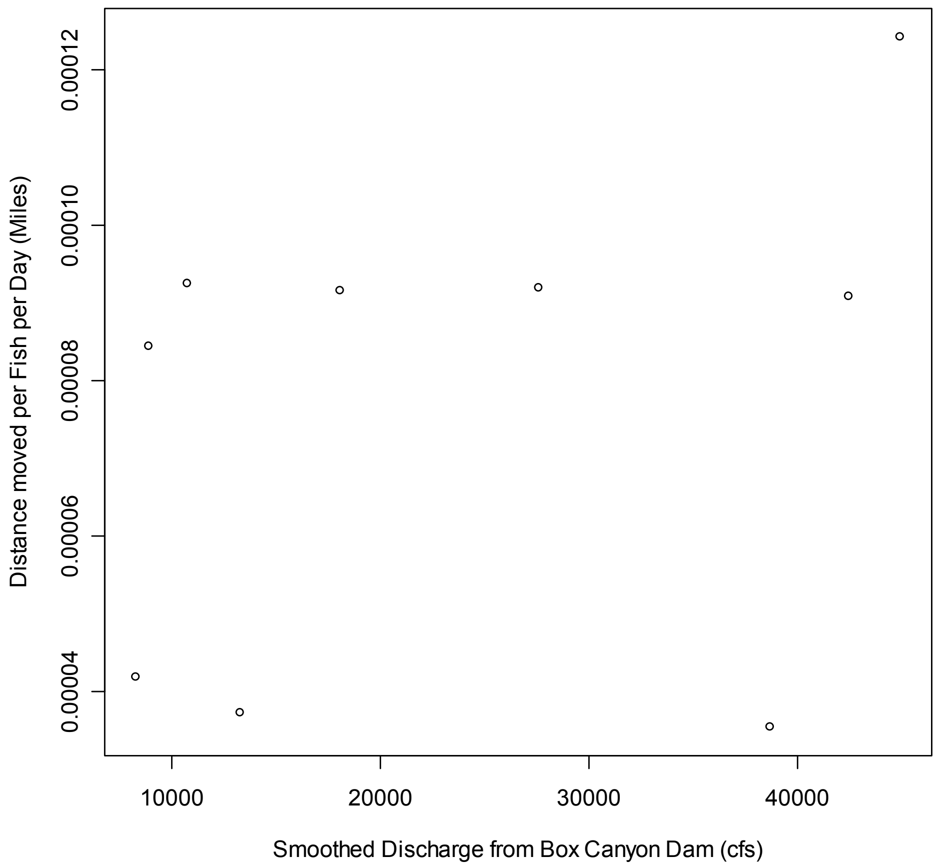

Figure 5.2-1. Relationship between total fish movement and discharge from Box Canyon Dam for smallmouth bass.

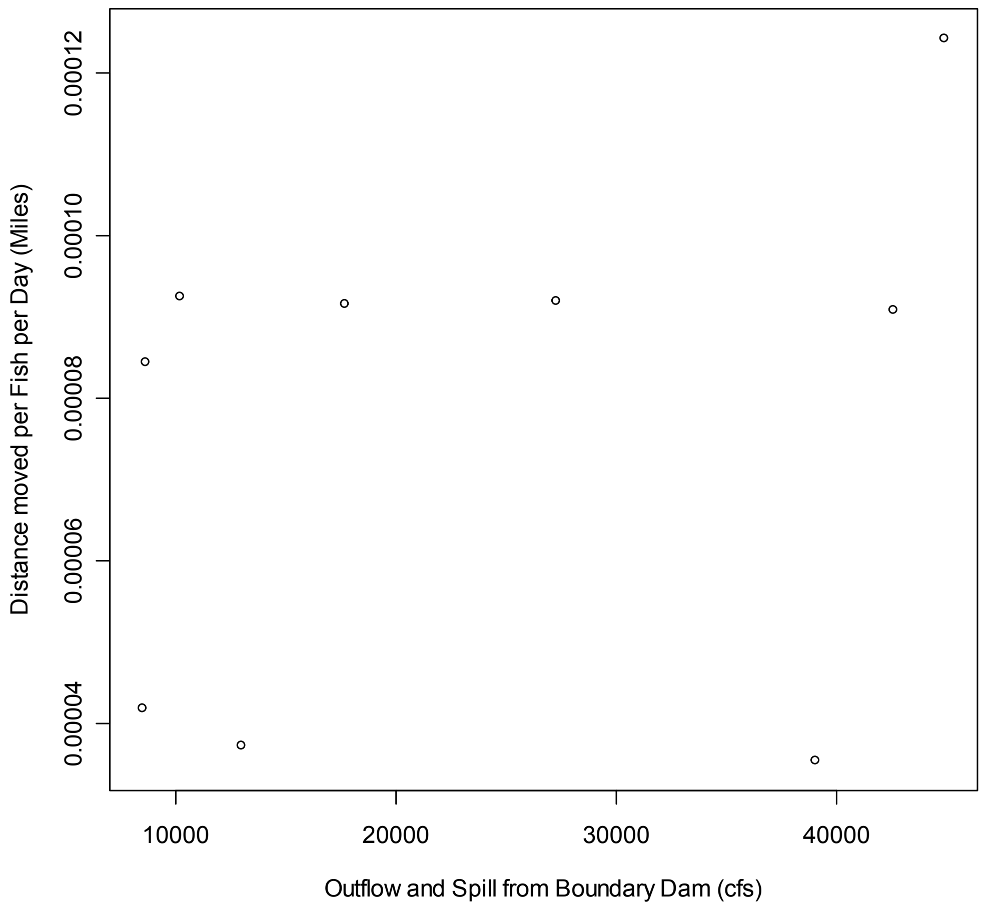

Figure 5.2-2. Relationship between total fish movement for smallmouth bass and summed outflow and spill from Boundary Dam.

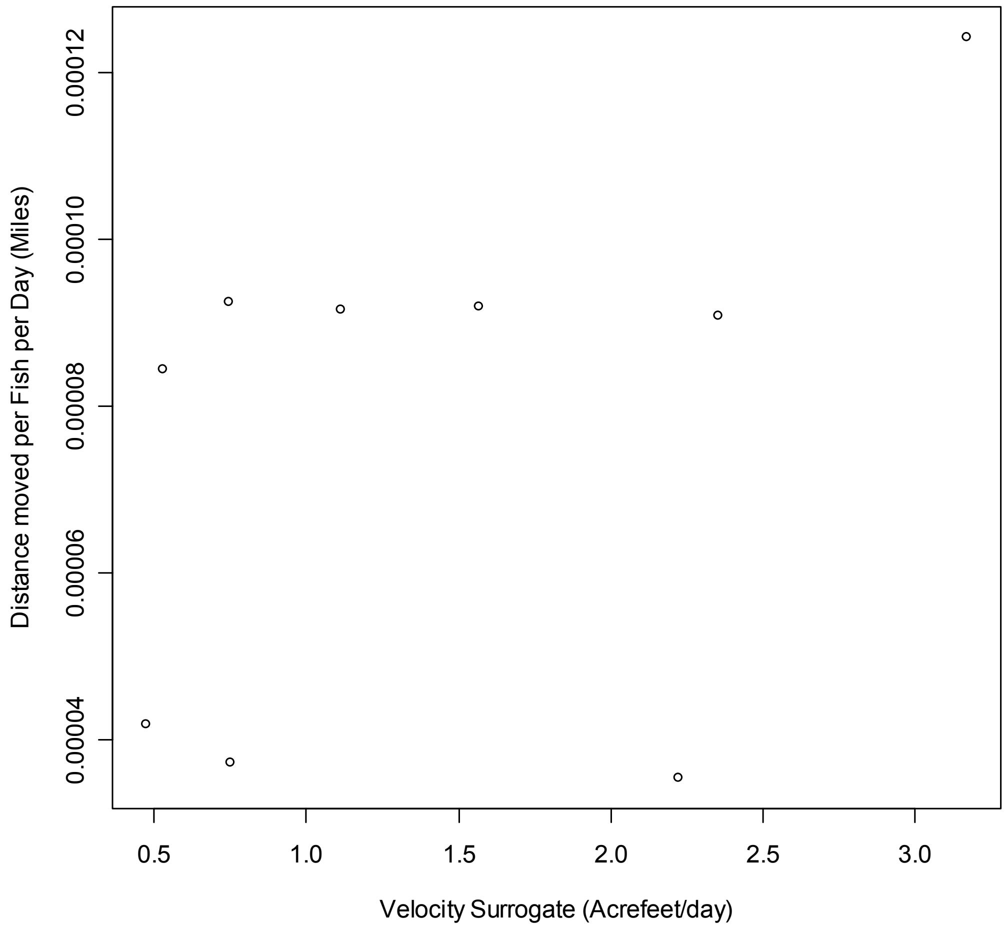

Figure 5.2-3. Relationship between total fish movement for smallmouth bass and the surrogate for velocity at Boundary Dam.

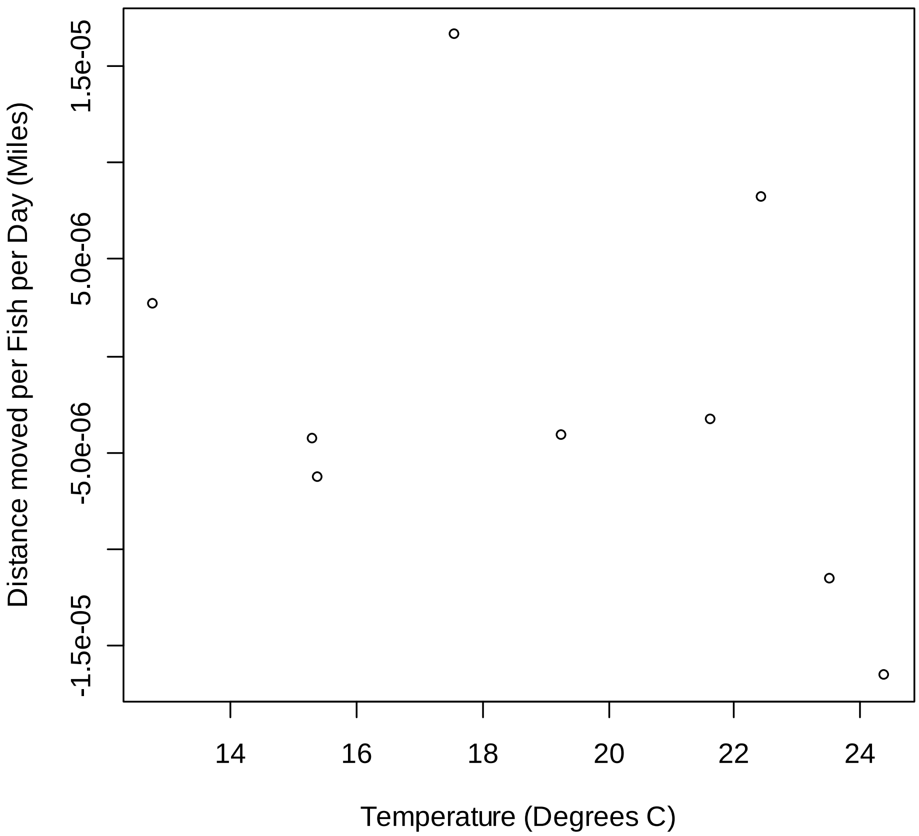

Figure 5.2-4. Relationship between total fish movement for smallmouth bass and the reservoir daily average temperatures during the study period from May 5 to September 26, 2007.

5.2.4.2. Assessment of Movement and Depth of Smallmouth Bass in Relation to Spawning Season

Smallmouth bass within the assumed spawning season (May and June based on Scott and Crossman (1973), Wydoski and Whitney (2003), and SCL (2007b) and outside of the spawning season were assessed to determine if their habitat preferences differed between these two time periods. More exact data on spawn timing for smallmouth bass in Boundary Reservoir will be obtained following studies in 2008. All fish with radio tags had their depth estimated based on mobile tracking data when the fish were located and subsequently tracked. When each of the five smallmouth bass tagged with CART tags were located, water pressures were recorded multiple times during the tracking session and converted to depth during analysis.

Fish with both tag types were related to the binomial variable of spawning season using a quasibinomial model to determine if depth (i.e., total depth at the estimated fish location as determined by the boat-based sounder) or river mile were significant predictors of the spawning season. In other words, does the fact that a fish is in spawning mode mean that it is selecting a different depth or portion (i.e., Project river mile region) of the reservoir? The subset of fish tagged with CART tags was assessed separately because CART tags allow a more precise estimate of depth. Once the quasibinomial model fitting was completed, a generalized linear mixed model with the random effect of individual fish was fitted to the data. This was to see if modeling the extra-binomial variation as a random effect altered the results. However, the results of the generalized linear mixed model were approximately equivalent to the quasibinomial model due to data structure so only the results from the quasibinomial models are reported here.

5.2.4.2.1. Results

The effect of the explanatory variable of river mile was significant (p value= 0.0196) when the whole data set was analyzed. The fish appear to be using different zones of the river after June 30, which was taken to be the end of the spawning period. In later summer, smallmouth bass appear to have a higher probability of being farther upstream (Figure 5.2-5). No response was found between the spawning season and the depth of the fish. When the entire data set was used, the single factor models for river mile and representative depth were fitted as well as the additive, two-factor model with both river mile and representative depth. The one-factor model for depth was not significant (p=0.787) and the effect of depth was also not statistically significant in the additive model (p=0.584). The effect of river mile remained significant in the two factor model (p=0.0185).

When the subset of the data which only included the CART data was assessed, neither river mile nor CART tag mean depth were statistically significant in either the two factor additive or single factor models.

Clark et al. (1998) states that suitability for smallmouth bass nest-building is at a depth from 3 to 8 feet (1 to 2.5 m) in depth, with substrate particle size near 1.3 inches (30 mm). A summary of various literature sources used to develop HSC curves for smallmouth bass spawning in Boundary reservoir suggest a low use of habitat below 4 feet, but one reservoir study considered some use of depths up to about 14 feet (SCL 2007b). This indicates that smallmouth bass in general have a preference for typically shallow depths during the spawning season. However, the preliminary tracking data from the Boundary Project, did not detect a preference for different river depths between the spawning and the non-spawning seasons. The lack of significant depth relationship could be the result of many factors (e.g., similar depths used in both seasons, some tagged fish may have been non-spawners, fish were not near redd sites during tracking, lack of precision in depth measurements) and should not be interpreted to indicate no depth preferences during the spawning season.

The data show that fish tend to be found farther upstream in the reservoir after the assumed spawning period. Data collected in 2008 may aid in determining if this trend is typical.

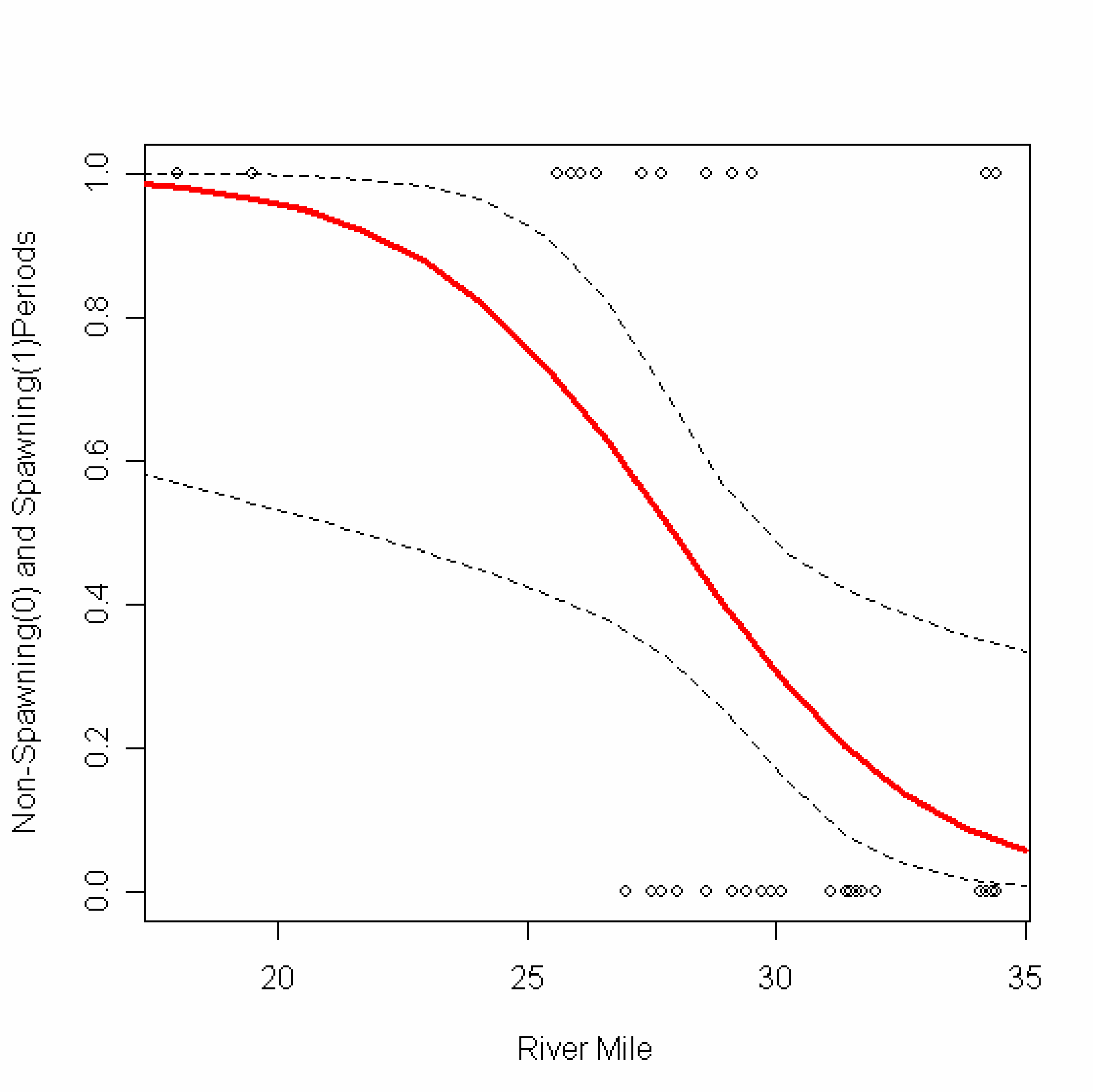

Figure 5.2-5. Fish location (circles) by river mile during and, outside of the spawning season and quasibinomial generated curve and 95 percent confidence interval showing relationship to river mile.

5.2.5. Native Salmonid Intensive Tracking

Intensive tracking was conducted to monitor the use of cold water refuge by CART-tagged native salmonids when water temperature in the mainstem Pend Oreille River exceeded 18ºC. Based on mobile telemetry tracking and data recorded at shore-based receivers, use of the confluence area of Sweet Creek and the Pend Oreille River was confirmed for the one westslope cutthroat trout implanted with a CART tag (Fish 24). Two full monitoring sessions were conducted on August 3 and 17, each approximately 24 hours in duration. A third session planned for August 31 was conducted for approximately 2 hours and then was cancelled due to lightning and a weather forecast of more storms that evening.

Data recorded during the intensive tracking consisted of the CART tag temperature and pressure data at the time interval the data were received. Coarse positional data were also recorded if large scale movement was noted. When these movements occurred, the acoustic telemetry signal was usually lost and the boat was re-positioned. Data recorded during each session were plotted in relation to reservoir water temperature and water level elevation as measured at the USGS Gage station 1.2 miles downstream of Box Canyon Dam (Figure 5.2-6).

On August 3, water temperature of the Pend Oreille River ranged between 24.1 and 24.7ºC (Figure 5.2-6 [A]). Water level elevation ranged between 1,988.0 and 1,993.6 feet (NAVD 88) (1984.0 and 1989.6 feet NGVD 29) (5.6 foot range of depth change), with the lowest elevation recorded at midnight. Fish temperature during this period averaged about 20.0ºC over a 14.8º to 22.8ºC range. The fish maintained an average depth of 1.6 m (5.2 feet) over a range from 0.7 to 3.4 m (2.2 feet to 11.2 feet).

The fish appeared to adjust its location to remain in the cooler water outflow plume at the confluence of Sweet Creek. Throughout the intensive tracking period, the fish experienced water temperatures substantially less than the ambient mainstem river water temperature. As the pool elevation declined and water temperatures increased at the fish location, the fish appeared to make at least one significant movement at 1600 hours, demonstrated by the rapid change in depth from about 6.8 feet to about 12 feet, but quickly returned to a depth of about 6.8 feet. Between approximately 1900 hours and midnight, the fish appeared to make additional movements to find a more suitable temperature. During this period the temperature experienced by the fish declined substantially from about 22°C to about 17°C. Coincidental to the drop in temperature experienced by the fish at midnight, the fish also experienced its shallowest depth and the pool level reached its minimum.

On August 17, water temperature of the Pend Oreille River ranged between 22.2 and 22.7ºC (Figure 5.2-6 [B]). Water level elevation ranged between 1,987.5 and 1,992.6 feet (NAVD 88) (1983.5 and 1988.6 feet NGVD 29) (5.1 depth range), with the lowest elevation recorded at 2200 hours. Based on the CART tag data, fish temperature over the same period maintained an average of approximately 19.6ºC and ranged between 17.2 and 22.0ºC. The fish maintained an average depth of 1.8 m (5.9 feet) with a range between 0.7 and 4.8 m (2.3 to 15.7 feet). Similar to the movements noted for this fish on 3 August, the fish appeared to adjust its location by changing depth and likely location, to remain in the influence of cooler water from Sweet Creek. This movement response did not occur until a substantial increase in its temperature occurred. Similar to the previous intensive monitoring session, the lowest temperature experienced by the fish corresponded to the shallowest depths. During the lowest water elevation, reception was lost and the boat was re-positioned downstream. During this period, mobile telemetry tracking indicated that the fish had moved downstream approximately, 330 feet (200 m), but then fairly quickly moved back to the creek confluence area.

On August 31, mobile tracking determined that the fish had left Sweet Creek and was located upstream near the USGS gage station (~PRM 33.5). During the two hour intensive tracking, water level elevation and reservoir water temperature were 1,991.7 feet (NAVD 88) (1987.7 feet NGVD 29) and 20.2ºC, respectively. Based on the CART tag data, the average fish temperature over the same period was 20.4ºC and the fish maintained an average depth of 1.6 m (5.2 feet) over a range between 1.4 and 2.1 m (4.5 feet to 6.9 feet) (Figure 5.2-6 [C]). The fish did not appear to be

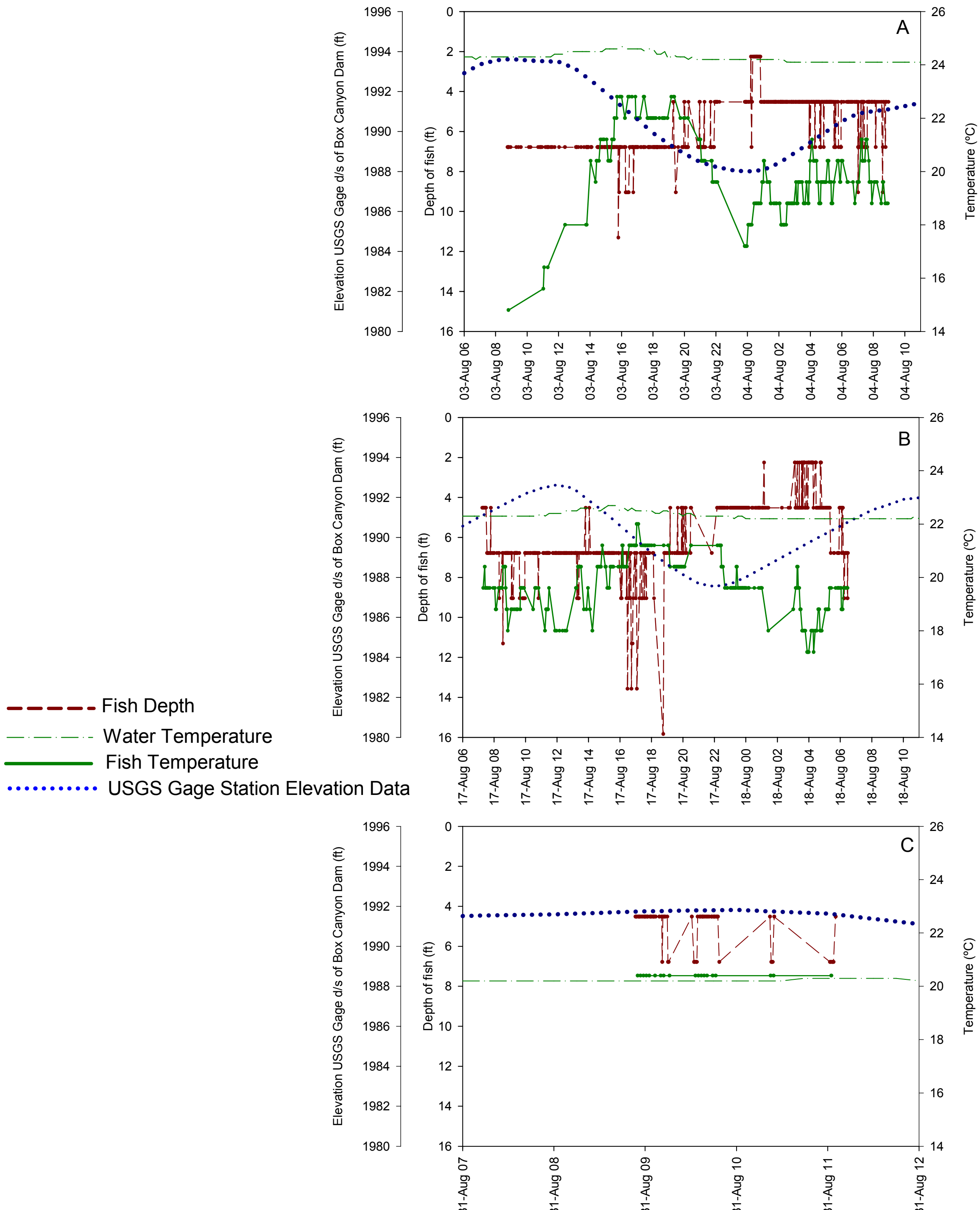

Figure 5.2-6. CART tag temperature and depth data recorded from a westslope cutthroat trout (Fish 24) near the mouth of Sweet Creek on August 3 (A), August 17 (B), and upstream at PRM 33.5 on August 31 (C) in relation to reservoir water temperature and water level elevation in the Upper Reservoir Reach of the Boundary Reservoir, 2007.

seeking thermal refuge at this lower reservoir temperature (20ºC) compared to previous intensive trackings. However, the extent of cold-water refuge at the creek confluence at this time was not determined.

During the August 3 monitoring sessions, temperature profiling in the immediate area where Fish 24 was assumed to be holding, did not indicate a substantial difference in temperature between the presumed thermal refuge at the Sweet Creek confluence and the reservoir temperature. Observations of the numerous triploid trout within the thermal refuge indicated the fish either positioned themselves close to the substrate within the direct influence of Sweet Creek inflow or in shallow depressions near the plume that would likely fill with cooler water over time. Water depth in the reservoir within the influence of the Sweet Creek cool water plume ranged from less than 3 feet (1 m) to approximately 8 feet (2.5 m). Temperature profiling within the plume area determined that within approximately 0.5 feet (0.15 m) off the bottom, water temperatures were 6 to 8ºC cooler than the layer above. Above 0.5 feet (0.15 m) off the bottom, water temperatures were effectively equal to the reservoir water temperature. For further details on temperature profiling efforts, please see the Study 8 Interim Report [SCL 2008b] for details.

5.2.6. Tributary Delta use by Native Salmonids, Smallmouth Bass, and Northern Pike

Tributary use by reservoir resident fish was determined for Slate, Sullivan, and Sweet creeks based on telemetry data from dual-antenna receivers positioned near the mouth of each creek. To identify evidence of upstream movement into the tributary, the strength of a signal received by both the reservoir and tributary antenna was compared. The signal comparisons were evaluated in the following manner. If the signal strength was greater on the reservoir antenna compared to the tributary antenna, this indicated that the fish was likely in the reservoir. If the signal strength was equal for both antenna or slightly greater on the tributary antenna, this would indicate that the fish may be using the lower most section of the tributary, but effectively still resided in the reservoir. If the signal strength recorded by the tributary antenna was substantially greater than the reservoir antenna and remained so for an extended period of time, this would indicate the fish resided in the lower reach of the tributary. If the signal was received only by the tributary antenna, this was interpreted to mean the fish had moved a substantial distance into the tributary.

At Slate Creek, only two fish were recorded on the tributary antenna and both were smallmouth bass, Fish 17 and 103, respectively. Neither fish attempted to move into Slate Creek (Appendix 3, Figures A.3-27 and A.3-28).

Sullivan Creek is the largest of the three tributaries with dual antennas. In total, five smallmouth bass (Fish 17, 72, 99, 102, and 103) were detected at this station. All of the smallmouth bass, with the exception of Fish 17, had brief periods when signal strength record by the tributary antenna exceeded the signal strength recorded by the reservoir antenna, but at all times these fish were detected on the reservoir antenna. These periods occurred during high water when the large flat alluvial fan of Sullivan Creek was likely inundated. When fully inundated, the high water extends to a point effectively perpendicular with the antenna array location, if not past it. Therefore, it was likely that the tagged smallmouth bass were not in Sullivan Creek, but instead were within the shallow inundated habitat within the reservoir.

Sweet Creek was a focal point for many of the tagged fish in the Upper Reservoir Reach. In total, nine fish were recorded on the tributary antenna, and of these, six were smallmouth bass (Fish 15, 21, 23, 99, 101, and 107). Similar to the tagged bass recorded at Sullivan Creek, these fish likely were within the inundated habitat at the mouth of Sweet Creek during high reservoir water elevations and as such would have been within the reception range of both antennas (Appendix 3, Figures A.3-35 to A.3-40). The remaining two fish consisted of two westslope cutthroat trout (Fish 24 and 181). For both fish, the signal strength received by the tributary antenna either never or very rarely exceeded the signal strength received by the reservoir antenna. Fish 181 was located several times using the inundated alluvial fan of Sweet Creek during high reservoir water elevations, and it was during these periods when Fish 181 was detected on both antennas at almost equal strength (Appendix 3, Figures A.3-41 and A.3-42).

5.2.7. HSC Data Summary for Native Salmonids and Smallmouth Bass

All HSC data are summarized in the Study 7 interim report (SCL 2008a). Sensor data recorded from CART-tagged fish during mobile tracking are summarized in Appendix 3, Table A.3-3.

6 DISCUSSION

The following discussion provides an overview of key findings from the 2007 Passive and Active Sampling and the Biotelemetry Program and discusses them in the context of program objectives and assumptions as outlined in the RSP. The extent to which the objectives could be better achieved with collection of additional data in 2008 is also discussed. If a study objective cannot be met with or without substantial changes to the study design, or if uncertainty would still exist, the reasons for not meeting the objectives or the basis for the uncertainty are provided.

6.1. Fish Distribution and Relative Abundance

Evaluating the distribution, relative abundance, and life histories of the variety of fish species in the Boundary Project is a primary focus of Study 9 under the RSP (SCL 2007a). Objectives 1 and 3 in the RSP separately address the reservoir and tailrace, respectively (see Section 2). Native salmonids are the primary focus of the tailrace objective, whereas the native and non-native salmonids along with important sport fish species are the focus of the reservoir objective. Assumptions related to the effect of different capture gear on some fish species prompted the use of a variety of capture gear in different habitats in the Project. The multiple sampling methods were intended to identify potential biases in the different methods and improve estimates of fish distribution and relative abundance.

Interim results suggest objectives 1 and 3 can be addressed through the current study design. Although some of the native species and sport fish species of interest were not captured in large quantities, seasonal changes in their presence and relative abundance can be evaluated by location, habitat, and environmental condition. There are limited data on bull trout and cutthroat trout in the reservoir. The data on cutthroat trout suggest that the primary spawning and rearing of cutthroat trout occurs in the tributaries, because none of the 11 specimens captured in the reservoir was less than 130 mm, despite the fact that several young of year and juvenile fish were captured in the tributary fyke nets.

Mountain whitefish, rainbow trout, smallmouth bass, and important prey species including northern pikeminnow, peamouth, and sucker species have all been captured in quantities allowing analysis of their distribution and abundance relative to reach location, habitat types, and season. Field sampling gear enabled the capture of a range of life history stages and provided information on the timing and distribution. However, the results also support making minor modifications to study plans for 2008 field seasons. Two examples follow.

6.1.1. Mountain Whitefish

Mountain whitefish were the most commonly encountered native salmonid in the reservoir, with a peak in both relative abundance and catch rates in the Upper Reservoir Reach, a finding consistent with previous sampling efforts (McLellan and O'Connor 2001, Terrapin Environmental 2007). During May and June 2007, a sharp increase in mountain whitefish catch rates was accompanied by a marked increase in relative abundance of young of year fish, especially notable in the moderately sloped, gravel/cobble dominated areas in the Upper Reservoir Reach. A notable increase in catch rates of yearling fish was also detected in downstream migrant fyke nets, yet the increase in fyke nets was observed nearly 2 months after the first detections of the young of year in the reservoir. These results may suggest that mountain whitefish reproduction occurs in waters connected to the Project (e.g., Box Canyon Reservoir and tributaries). However, it is unclear if spawning location and other activities occur in areas potentially affected by operations scenarios. Some juvenile mountain whitefish may potentially originate from Box Canyon reservoir, because that system has an abundant mountain whitefish population (Ashe and Scholz 1992). Adult mountain whitefish were captured throughout a variety of site conditions in the Upper Reservoir, Canyon, and Tailrace reaches, with no apparent congregations identified. Specifically directed sampling may aid in identifying congregations of pre-spawn mountain whitefish in areas of potentially suitable habitats both within the reservoir and tributary channels.

6.1.2. Smallmouth Bass

Smallmouth bass are a common component of the catch throughout the reservoir and tailrace, with the highest catch rates in the Canyon and Tailrace reaches. Although catch rates of smallmouth bass were high in the Tailrace Reach, the relative abundance of young of year and yearling fish was very low throughout the course of the study in the tailrace, suggesting limited spawning and rearing occurred there. Smallmouth bass catch and observation rates remained high in the Tailrace Reach through much of the summer, but catch rates declined dramatically during September and October at the electrofishing, gill netting, and snorkeling sites. The data suggest that the smallmouth bass may have moved downstream into Seven Mile Reservoir during late summer and early fall.

Smallmouth bass of various lengths were captured in the reservoir, with catch rates of juvenile fish (<120 mm) highest in the Upper Reservoir Reach. Catch data also demonstrated comparative trends in habitat use. Smallmouth bass catch rates along the varial zone electrofishing sites peaked during May and June. During those months, the relative abundance and catch rates of larger adult fish were greatest, whereas smaller fish dominated the catch in subsequent months. Likewise, the majority of young of year catch and observations occurred in the Upper Reservoir Reach, with fewer observations in the Canyon Reach. Catch rates in the deeper water habitat, as measured by the gill netting, increased during July and August, suggesting a shift in habitat use by larger fish. These results suggest that the relative abundance of larger, mature fish increases in the near-shore habitats during the peak spawning periods, especially in the Upper Reservoir and Canyon reaches. Similar to the findings reported for mountain whitefish above, seasonal changes were noted in the distribution and relative abundance of smallmouth bass.

6.1.3. Spatial and Temporal Patterns

Results to date suggest that the number of study sites investigated and the variety of capture methods being used will provide sufficient fish information to evaluate general spatial and temporal patterns of fish use across the Project for many of the species of interest. Based on the current study design, RSP objectives 1 and 3 will likely be attained, because substantial numbers of target species are being captured and a wide array of habitat conditions are represented with existing study sites. However, under the current work plan, it appears that some habitat conditions and life history stages may be under-represented in the reservoir. For example, the ability to effectively deploy gill nets in shallow to moderate depths with moderate currents is limited. This was especially true in periods of higher discharge, and as such these areas were avoided for establishment of the monthly sample sites. Field staff attempted to establish the moderate depth sets in the Upper Reservoir Reach in swift currents near the confluence with Sweet Creek, in the mid-channel area near the Box Canyon USGS gage, and in moderate depths with moderate current and diverse hydraulics along the canyon walls of the Project. The large surface areas of the nets were subjected to significant force and were quickly transported downstream. Yet these same areas are purported to be local angling “hotspots” for a variety of species, especially as Project inflow taper off throughout the spring and summer. The use of biotelemetry to monitor movement of target species should provide additional information on use of these habitats. Likewise, the shallow, near-shore habitats associated with gently sloping bottom profiles may also be under-represented with the current work plan, because they are inaccessible by boat electrofishing. Increased sampling efforts using backpack electrofishing will provide information on near-shore shallows. However, the current study plan sampling methods cover a broad range of habitats within the reservoir, and the chances of missing a significant portion of abundant life stages are likely not high.

6.2. Tagging Objectives and Post-Tagging Survival

The number of native salmonids of sufficient size to accept the variety of telemetry tags used in this study was low. Consequently, only nine native salmonids were equipped with transmitters between April and September 2007. This is substantially lower than the RSP objective of 150 tagged native salmonids. The 2007 tagging results to date suggest that the first part of assumption 1 from the RSP for biotelemetry (i.e., that adequate numbers of native salmonids are available for tagging) is not valid. However, there is a possibility that capture rates of suitably sized native salmonids may increase substantially over the remaining fall and winter field periods and more native salmonids will be tagged. Nonetheless, it is considered unlikely that the RSP objectives for this study component will be achieved. A secondary objective of the RSP, to tag 20 smallmouth bass with 10 radio tags and 10 CART tags, was met because there was a large number of bass in the reservoir.

The available data suggest the post-tagging mortality of mountain whitefish was higher than for other salmonid species. For all native salmonids tagged, of the nine fish released, four fish either died or were suspected of dying shortly after release. In part, this high post-release mortality was likely due to the low number of fish available for tagging, such that some fish with marginal suitability were tagged. Potentially, if more of these species were available for capture, some of the fish that were tagged would have been rejected in favor of either larger or healthier fish. Also, if there were more fish available, the capture and tagging effort could have been restricted to periods when environmental conditions for capture and tagging were optimal (e.g., during periods of low water temperature). A relationship between higher water temperatures and high post-tagging mortality was not evident, but this may have been due to the small number of fish tagged. Given the low thermal tolerance of salmonids, capture and tagging of these fish at water temperatures above 15ºC should be avoided. Tagging above this temperature in 2007 for salmonids did not occur unless a temperature refuge was available for release. In the future, reservoir temperatures should be considered the controlling factor.

Post-implantation survival of tagged smallmouth bass was high because fish size was suitable and most fish were in very good condition when tagged and released. Due to the higher thermal tolerance of this species, tag implantations were successful at both high and low reservoir water temperatures. The cause of three of the four mortalities post-release was either known or suspected to be related to angling. Angling pressure will likely continue to result in tag loss. Increased angler awareness may help reduce the overall numbers of tags lost due to angling mortality.

6.3. Native Salmonid Movement

Because of the low number of native salmonids tagged, statistical correlations of movement data and environmental variable data could not be conducted, and interpretation of the data collected was limited to a general descriptive analysis of the movement of one or two individual fish. Consequently, RSP objectives 4 and 5 (identifying overall movement patterns associated with the life history of native salmonids and their movement response to changes in environmental variables and existing Project operations) were not fully achieved and will not be met unless substantially more native salmonids are successfully tagged. Study design changes to meet objective 5 are discussed in Section 7.

Overall, the movement of native salmonids in the Upper Reservoir and Tailrace reaches appeared to be affected primarily by reservoir water temperature. When water temperature in the Pend Oreille River exceeded 18ºC, use of cold water refugia in the reservoir by the two tagged westslope cutthroat trout (Fish 24 and 181) was confirmed. When water temperatures decreased to below 21ºC in late August, Fish 24 left the refugia. This latter movement, however, also occurred during a large reduction in reservoir water level, conducted as part of sampling for the Aquatic Habitat Model (Study 7), which was substantially greater both in magnitude and duration compared to reductions associated with existing Project operations. Within the Tailrace Reach, a tagged bull trout (Fish 184) and mountain whitefish (Fish 179) left the tailrace area when tailrace water temperatures approached 20ºC. Although some fish were occasionally detected simultaneously by both the tributary and reservoir antennas at Sweet or Sullivan Creeks, no native salmonids in Boundary Reservoir or its tailrace were observed to move into tributaries.

Within the reservoir, the limited data suggest that, in addition to the Sweet Creek delta's importance as a thermal refuge, the general area of the reservoir near Sweet Creek may provide other important habitat types for native salmonids, such as feeding, holding, or spawning habitat. Three mountain whitefish and a hybrid char (unsuccessful tag recipients, the latter of which was thought to be a bull trout at time of capture) also were captured near Sweet Creek. This may suggest moderate to high use of the general area by native salmonids compared to other areas within the reservoir, but this observation is tempered by the limited amount of tagging data.

6.4. Smallmouth Bass and Northern Pike Movement

Objectives directed specifically at analyzing movements of smallmouth bass and northern pike relative to existing Project operations were not a requirement of this study. However, sufficient numbers of smallmouth bass were tagged, thereby allowing possible correlations of movement data relative to the selected environmental variables. The intent was two-fold: to test the statistical analysis techniques selected, and to determine if movements of these species could be correlated with environmental variables influenced by existing Project operations.

The analysis indicated that the distance of movement of smallmouth bass could not be explained at a statistically significant level by flow changes, existing Project operations, or reservoir temperature. Factors that may have limited this analysis were the low number of smallmouth bass tagged, the distribution of the fish over the entire reservoir, and the different release times (i.e., protracted releases over several months).

Correlations between fish position and depth at the end of the smallmouth bass spawning season indicated a relationship between spawn timing and upstream fish movement, but depth and spawn timing were not correlated. The end of the spawning period, assumed to be occur by June 30, also corresponded to the descending limb of the hydrograph, reduced water velocities, and increasing reservoir temperature. The correlation evidence and general inspection of the movement data suggest that post-spawning smallmouth bass may move. However, some of the smallmouth bass either remained near their release locations or did not move after the spawning season. Because male smallmouth bass remain on the nest to guard the eggs after the female leaves (Wydoski and Whitney 2003), some of the fish that did not move upstream may have been males. For 2008, the sex of smallmouth bass should be identified when tags are inserted if it can be accomplished without added stress to the subject fish.

Movement of the one tagged northern pike was limited to descriptive analysis. The upstream movements of this fish may have been partly influenced by unusually large drawdown events in late August and early September. The pike was often located in shallow habitat across from the Metaline Launch that consisted mainly of inundated terrestrial vegetation. However, it was not present in this area during and following the two large drawdown events that generally dewatered much of this region. Telemetry tracking during the winter should indicate where this northern pike overwinters in the reservoir.

6.5. Fish Use of Cold Water Refugia

6.5.1. Passive and Active Sampling

Salmonids were observed congregating around the mouths of several tributaries. One of the key assumptions in developing the sampling program was that native salmonids use thermal refugia near the mouths of the tributaries. Based on angling, snorkeling, and anecdotal observations, this assumption was verified for non-native salmonids at the mouths of Sweet, Slate, Pewee, and Flume creeks, and, to a lesser degree, Sullivan Creek.

Concentrations were also observed at the mouths of Lime Creek, Wolf Creek, and near an unnamed tributary on the east side of the reservoir approximately 0.25 mile south of Boundary Dam. Although these concentrations may provide a high likelihood of capturing target species, field staff discontinued the extra gill netting at the deltas due to concern for undue stress during periods of high water temperatures.

Rainbow trout (often large carry-over triploids rainbow trout) were the primary species of salmonids observed at the tributary mouths during July and August when temperatures were often over 20°C. During snorkel surveys, fish were observed near the tributary mouth areas during the summer months, but due to night sampling limitations, snorkel counts were generally lower than the number of fish observed from the boat deck. However, overall regular snorkeling survey sampling, in conjunction with anecdotal observations and angling surveys, was able to confirm the increased use of tributary confluences in these areas by salmonids during periods of high reservoir water temperatures, thus contributing to addressing objectives 3, 4, and 7.

6.5.2. Biotelemetry

Use of cold water refugia by native salmonids was confirmed through telemetry data from two tagged westslope cutthroat trout (Fish 24 and 181). These fish were detected within a known cold water refuge at the confluence of Sweet Creek and Boundary Reservoir. Both fish exhibited a very high fidelity to this cold water refuge during the period when reservoir temperatures exceeded 20°C. Intensive tracking over two 24-hour periods indicated that Fish 24 altered its position to remain within the Sweet Creek cold water plume. Large aggregations of triploid trout were also recorded within the cold water refuge and included a CART-tagged carry-over triploid trout for which sensor data were recorded concurrently with the sensor data from Fish 24 (see Study 13, Recreational Fishery Study [SCL 2008c]). Based on observed fish locations and spot temperature measurements, the areal extent of the refuge appeared restricted to the plume of cooler water at the confluence of Sweet Creek and several adjacent shallow depressions. The close proximity of the fish confined to these areas suggested the refuge area was relatively small. The intensive use of this region indicates the habitat conditions are very desirable and likely important to trout that may be in the reservoir during the warm water period.

6.6. Tributary and Tributary Delta use by Native Salmonids, Smallmouth Bass, and Northern Pike

6.6.1. Passive and Active Sampling

Evaluating the seasonal changes in distribution and relative abundance of native salmonids, as well as determining the magnitude and periodicity of movement of adfluvial fish migration behavior, is the focus of RSP objective 2. Sampling confirmed observations of native salmonids in tributary channels. Cutthroat trout were observed in Sullivan, Sweet, Sand, and Slate creeks and mountain whitefish were observed in Sullivan and Sweet creeks. One char believed to be a bull trout was observed in Sullivan Creek during a snorkel survey in September.

An increase in the number of downstream moving yearling mountain whitefish occurred in Sullivan Creek and Sweet Creek, as well as an increase in young of year and yearling cutthroat trout in Slate and Sweet Creek, suggesting that some movement from the tributaries to the reservoir is occurring.

Because no large fish were observed moving upstream into tributaries, it is unclear at this time if the fish moving downstream are part of an adfluvial stock that depends on the stream for spawning and early rearing or excess production from resident fish in the tributaries. However, visibility and maneuverability during April and May sampling were limited by high stream discharge and turbid flows during the sampling events. In addition the sample period has yet to cover the late fall and early winter period when mountain whitefish may be expected to spawn. Adult mountain whitefish were captured at the mouth of Sullivan Creek with both gill net and boat electrofishing gear. Operations by Pend Oreille PUD often result in high discharge and poor visibility in Sullivan Creek in the fall. Moreover, the chance of encountering adfluvial fish is also limited by the general lack of adult holding waters and limited spawning habitat in the tributary reaches that are currently being investigated. This is especially evident in Sweet Sullivan creeks, both sites in which juvenile salmonids were captured in the downstream migrant traps. Adfluvial fish, ascending these channels that have not been radio tagged may simply pass beyond the designated sample reach without being detected in the monthly survey. While objective 2 is being met for radio-tagged fish (see Section 6.6.2), modification to the current tributary sampling program may be warranted to increase the probability of encountering native salmonids that may ascend the streams to spawn.

6.6.2. Biotelemetry

Telemetry data recorded at the three tributaries monitored, Slate, Sullivan, and Sweet creeks, indicated the tributary deltas were used by smallmouth bass in June when reservoir levels are high and the deltas at the confluence of each creek are fully inundated. Twelve smallmouth bass were detected simultaneously on both tributary and reservoir antennas during this period. In addition, one cutthroat trout (Fish 181) was detected on both tributary and reservoir antennas at Sweet Creek between June 2 and 12 and one cutthroat trout (Fish 24) was detected between July 5 and August 1. None of the radio- or CART-tagged fish were observed to pass upstream beyond the mainstem receiver, such that it was detected solely on the tributary antenna.

During periods of high reservoir temperatures, use of the stream confluence as a thermal refuge was confirmed, but substantial upstream movement into the tributary to avoid high reservoir temperatures was not detected. In the case of Slate Creek and Sweet Creek, the first portion of the lower reach of each stream consisted of shallow water depth and minimal overhead cover which may have discouraged larger fish movement due to lack of overall protective cover by water depth or debris (Hickman and Raleigh 1982). Sullivan Creek, the largest of the three, streams appeared to have greater overall stream depth, which would increase the likelihood that passage conditions would not restrict upstream migration during low tributary flow and high reservoir temperature. However, upstream movement was not detected into Sullivan Creek.

Under the current study design, RPS objective 2 was achieved and the ability of the telemetry program to detect potential movement into the tributaries was confirmed. Potentially, upstream movement may be detected into these tributaries over the winter and spring if these systems are used for spawning season by mountain whitefish or westslope cutthroat trout.

6.7. HSC Data Collection and Supplemental Information

6.7.1. Electrofishing

Electrofishing was considered in the RSP to be a secondary method to collect HSC field data for some life stages of target species. This is partly because electrofishing has a limited distribution of sampling area within the available Project area habitat (i.e., depths typically less than 6 to 10 feet deep in near-shore environments). The level of accuracy associated with the identification of fish location as determined by the electrofishing point sampling was sufficient to allow incorporation of the velocity data collected for each fish into the HSC model. At each point, velocity and substrate patterns were generally consistent within a 30-foot radius surrounding the electrofishing unit, which was considered the general extent of the attraction field.

The velocity data were compromised in a few situations by a limited ability to maintain a stationary position in the river with the boat motor during velocity measurements. However, because most of the points were situated near the shoreline, it was generally easy to maintain boat position for velocity measurements. Within the sampling limitation of depth and habitat, this method could approximate meeting objective 6. However, the suitability of meeting this objective will be evaluated in Study 7, where HSC values will be developed.

6.7.2. Biotelemetry

Under the RSP, the use of biotelemetry was considered to be the primary method of obtaining HSC field data for most adult and spawning life stages. Because mobile telemetry tracking could not pinpoint the location of the fish, depth and velocity data were sometimes qualitative rather than quantitative. Also, the quality of the velocity data was compromised by a limited ability to maintain a stationary position in the river with the boat motor during velocity measurements. The result was that velocity measurements taken could not be assumed to represent the mean water column velocity or the water velocity the fish was using at the time of tracking (see Study 7 interim report [SCL 2008a] for details). Therefore, the use of these data to aid in the development of fish HSC curves for the habitat model should be qualified. The suitability of meeting Objective 6 will be evaluated in Study 7, where HSC values will be developed.

6.7.3. Project-Specific Life Histories

In addition to the HSC validation sampling, Study 7 relies on the Passive and Active Sampling study to supplement the literature based provisional periodicity tables constructed for the Project. Results of this study can be particularly useful for further refinement of the spawning timing for index species as well as identifying the spawning, rearing, cold water refugia and over winter habitat of key species.

The total fish length and time of capture data, combined with water temperature data, can be used to estimate the approximate dates of egg deposition, incubation period, and date of emergence. From this, spawn timing of target species can be estimated for modeling purposes.

Currently, few specimens have been captured to further refine the periodicity tables for the major target species. Cutthroat trout and rainbow trout young of the year were captured exclusively in tributary streams. While some mountain whitefish, smallmouth bass, and cyprinid species young of year were captured at monthly electrofishing and fyke netting locations, the sites were not situated specifically to acquire data on new emerged or early fry-rearing habitat. However, some life history data on other common species that are of interest as part of the stranding and trapping analysis are available from both the passive and active study and field portion of the stranding and trapping study, which is part of Study 7 (SCL 2008a). Information on these species' life history stages that may be affected by stranding or trapping is summarized in Study 7.

Study 7 includes additional site-specific information used to develop periodicity on species such as largemouth bass, yellow perch, black crappie and pumpkinseed. Additional study effort using backpack electrofishing in 2008 should specifically target early fry rearing habitats of species of interest. Sampling during the periods when target species fry are anticipated to be recruited to the population would provide an opportunity to accurately estimate the spawn timing and rearing period of the species in question.

To date, surveys have not specifically identified spawning habitats of the targeted species. Additional surveys are scheduled to occur during 2008.

7 VARIANCES FROM FERC-APPROVED STUDY PLAN AND MODIFICATIONS RECOMMENDED TO IMPROVE STUDY DESIGN

7.1. Variances

There were no substantial variances from the Passive and Active Sampling or the Biotelemetry study design outlined in the RSP. Minor variances in the Passive and Active Sampling included a later start date of field activities than planned in the RSP as shown in Table 7.1-1. Delays in the start dates were necessary because the detailed work plans for each of the sampling methods were under refinement during January and early February prior to the commencement of field activities. Weather and site conditions also played a role in the delay of some activities because staff safety must be ensured. The Tailrace Reach sampling effort was not performed in August because tailrace conditions prohibited use of the boat launch.

Table 7.1-1. Variances in Passive and Active Sampling.

Sample Method	Planned Start Date	Actual Start Date
Reservoir		
Gill netting	January	February
Electrofishing	January	March
Mainstem fyke netting	March	April
Tributary fyke netting	March	May
Tributary snorkeling	March	No Change
Tailrace		
Gill netting	April	No Change
Electrofishing	January	March
Snorkeling	January	February
Fyke netting	April	No Change

Proposed variances to the study plan relating to the Passive and Active Sampling portion of Study 9 are:

1. <u>Eliminate Flume Creek from snorkel survey (March through June and October to November).</u> A primary goal of snorkel surveys is to assess which species may be utilizing tributary deltas and potential adfluvial species relationships. A series of steep cascade/waterfalls at the mouth of Flume Creek limits access to upstream habitat by adfluvial fish. Fyke netting, originally planned for this stream, was eliminated at the request of the RPs; therefore, continued sampling of the stream on the same regular basis as other potential adfluvial access streams is not necessary to examine Project-related actions. However, the mouth of Flume Creek may be used as a thermal refuge during warm water periods, and sampling should continue during July through September.
2. <u>Add summer surveys of the tributary delta areas of Linton and Pocahontas creeks to the list of tributary survey streams.</u> During July and August 2007, when reservoir water temperatures exceeded approximately 20ºC, salmonids were observed at the mouth of Linton and Pocahontas creeks apparently utilizing cool water entering the reservoir from tributaries. Surveys of the tributary deltas of these creeks will provide information on the distribution of salmonids during summer months and will complement analyses of the tributary deltas being conducted under Study 8. Surveys would occur monthly during July, August, and September.
3. <u>Eliminate vertical gill net sampling from the Canyon Reach of Boundary Reservoir.</u> Vertical gill net sampling is used as a method of assessing potential fish use of the offshore deep pelagic habitat. These four separate-panel 100-foot-long nets are currently used only in the deep water areas of the Canyon and Forebay reaches in water over 100 feet deep. Significant effort has been expended to sample these areas with gill nets. Overall net sets have included over 1,066 hours per 1,000 square feet of net. The set time equals 33 percent of all gill net effort. However, despite this level of effort, only 18 fish have been captured. The average overall catch rate is 0.016 fish per 1,000

square feet per hour, about 2 percent of the catch of other gill net types. No target species have been captured with the vertical nets. These results are similar to the general results from sampling with vertical gillnets in the Boundary Reservoir by McLellan and O'Connor (2001) who also caught few fish in this habitat. The effort to date confirms that there is little use of this deep offshore pelagic area of Boundary Reservoir by native or non-native fish resources. Continued effort with this type of sampling for regular distribution and abundance sampling in the Canyon Reach would not supply substantial additional useful data, and therefore, this portion of gill netting is recommended to be discontinued. However, vertical gillnetting is proposed to be continued in the Forebay Reach at the one station near the dam to provide additional information on fish presence in support of Study 12.

Proposed variances to the RSP related to the Biotelemetry portion of Study 9 are:

1. <u>Conduct mobile biotelemetry monitoring sessions twice per month instead of once per month in February and March 2008.</u> The current study plan includes one monitoring session per month for November through March. Effort was originally reduced relative to other periods because of the assumption that fish movement during the cold water periods would be low. Additional biotelemetry sessions are proposed during mid- to late winter to collect data on fish distribution during this period and help identify overwintering habitats. Currently, many of the fixed telemetry stations can operate for 30 days or more without requiring battery changes, although cold weather may reduce the length of battery life. One of the advantages of more frequent sampling would be to allow more frequent checking and changing of batteries during this period. However, accessibility during cold weather periods may prevent increased survey frequency and some sites may not be accessible until the weather warms. .

2. <u>Move the Pewee Falls fixed monitoring receiver station to the region across from the Metaline Falls boat launch.</u> The current Pewee Falls station location is very near the Canyon Reach opening receiver station (Figure 4.2-1). It was found that fish detected at the Canyon Reach opening receiver station (R4) were usually detected nearly simultaneously at the Pewee Falls (R5) receiver, likely because of their close proximity. The result was that no additional information was gained on fish presence or location by the Pewee Falls station that was not obtained by the receiver at the Canyon Reach opening. Thus, essentially the same information would be obtained by having just one of these two receivers in the Forebay Reach. The Canyon Reach opening station is strategically located to increase the chance that fish passing downstream into the Forebay Reach or upstream into the Canyon Reach would be detected. Therefore, this receiver should remain. The wide river region in the vicinity of the Metaline Falls Launch appeared to have moderate use by some of the tagged fish. The main river channel is nearest the east bank in this wide area so fish passing through this area would have a high chance of being detected by a receiver on the east bank. There are currently no fixed receiver stations that can monitor fish in this region. Moving the Pewee Falls receiver to this region would aid in monitoring upstream and downstream movement in the Upper Reservoir Reach as well as fish use within this area.

3. Eliminate collection of velocity data as part of the biotelemetry HSC methodology. As discussed earlier, the velocity measurement data taken during the HSC data are not of sufficient quality for HSC data development. Due to limited accuracy [+/- 10 m (33 feet)] associated with fish locations identified by radio telemetry, the likelihood that fish may be in a much different velocity (e.g., near the bottom) in deep and fast water areas, and difficulty in getting stationary positions to measure velocity during tracking, water velocity data recorded at these locations are not suitable for HSC curve development. Depth measurements however, do supply useful information for HSC curve development (see Study 7 [SCL 2008a]). Elimination of the velocity data collection requirement will increase the amount of time available for mobile tracking by up to 1 hour per day.

4. Increase monitoring in thermal refugia. The 2008 plan includes adding recording receivers near the mouths of Sweet, Slate, and Sullivan creeks. The receivers would record depth and temperature of fish having CART or similar tags in the vicinity of these creeks. The installation of receivers depends on the successful tagging of native salmonids with depth-temperature tags during the spring 2008 or survival of those that were tagged in 2007. Receivers would be in place and operate during the warm reservoir temperature period of July and August, when salmonids have been observed utilizing areas of thermal refugia. Continuous temperature and depth data recorded from tagged fish within a thermal refugia would be compared to hourly and daily Project operations. The extent of analysis would depend on the number of tagged fish that remain in areas of thermal refugia. At a minimum, however, fish behavior (i.e., change in use of depth and water temperature) relative to existing Project operations and main river flow will be assessed. The addition of the continuous recorders will allow the tracking of individual fish over a range of flow, operation, and temperature.

5. Capture and radio-tag cutthroat trout in Sullivan, Slate, and Sweet creeks. RPs (T. Shuda, USFS, pers. comm. with A. Solonsky, November 27, 2007) have expressed concern that low numbers of radio- or CART-tagged fish during the 2007 field season limit the ability to understand the role of tributaries, particularly Sullivan Creek, in the production of native salmonids in Boundary Reservoir. Consequently, they have requested that fish also be captured and radio-tagged in tributaries and their downstream and reservoir movements monitored.

   SCL proposes to honor this request by tagging up to 25 native salmonids (cutthroat trout, mountain whitefish, or bull trout) captured in Slate, Sweet, or Sullivan creeks with Lotek NTC-3-2 or NTC-4-2L Nanotags. Respectively, these tags weigh 1.1 grams and 2.1 grams and have an 80- or 163- day life span at a 5- second burst interval. Minimum fish weights to accommodate these surgically implanted tags would be 44 grams for the NTC-3-2 and 84 grams for the NTC-4-2L. Surgical procedures would follow those used during 2007. In Sullivan Creek, 10 cutthroat trout and 5 mountain whitefish would be targeted for tagging. In Slate and Sweet Creeks, five cutthroat trout would be targeted for tagging in each creek. If bull trout are captured, then they would be substituted for one or more of the cutthroat trout. If no suitably-sized whitefish are captured, these tags would be used on cutthroat trout.

   One electrofishing survey targeted for capture and tagging fish will occur in each of the three tributaries. Capture and tagging surveys would occur sometime during

April or May, depending upon flow and water clarity conditions that affect the efficiency of this capture technique. Capture of subject fish would occur using backpack electrofishing techniques beginning just downstream of the lowermost passage barrier located in the tributary and working downstream (i.e., below Mill Pond Dam at RM 3.25 in Sullivan Creek, RM 0.75 in Slate Creek, and RM 0.5 in Sweet Creek). All electrofishing and tagging would occur downstream of the lowermost passage barrier on the stream. Fish would be tagged at their capture location and released following recovery from surgery in a nearby pool or backwater. Downstream movement of fish past antennas located at the mouth of the tributary in less than 5 days after tag implantation would be considered suspect and would not be analyzed. Fish requiring more than 5 days to exit the tributary would be considered behaving independent of the tagging procedure.

All tracking of tagged fish movements would occur using the existing fixed stations at the mouth of selected tributaries and other strategic locations in the reservoir plus the mobile tracking occurring in the reservoir under the existing schedule. If all tagged fish do not out-migrate, one foot survey would occur at each stream in which radio-tagged fish are released and still assumed to be present. These surveys would occur during September 2008.

7.2. Recommended Modifications

The following are recommendations for refining sampling efforts during 2008. These recommendations are not considered variances from the FERC-approved study plan.

7.2.1. Fish Distribution and Abundance 2008 Sampling Recommendations

Items identified for additional effort in the current work plan include:

1. Modify tributary and delta snorkeling survey protocols. The current snorkel survey methods were intended to determine seasonal changes in the relative abundance of native salmonids and other fishes in the lower part of the streams and associated deltas in selected tributaries to Boundary Reservoir. However, based on 2007 survey results, a better understanding of potential use of tributaries and deltas as thermal refuge for native salmonids present in the reservoir is desired. Issues associated with the use of the delta habitats and tributary channels upstream of the reservoir as thermal refuge can be addressed through modifications of the current snorkeling study.

   It is recommended that snorkel surveys include reach demarcations that divide the survey area into four distinct zones: mainstem reservoir along the delta foreset, lacustrine habitat areas of the delta when inundated, riverine habitat areas of the delta when reservoir water surface elevations are low, and the tributary channel upstream of the reservoir high water mark (Appendix 2, Figure A.2-2). These four zones correspond to those used in the tributary delta habitat portion of Study 8. The proportion of lacustrine versus riverine habitat within the delta fluctuates in response to changes in reservoir water surface elevations. The foreset zone remains the same but the level of inundation changes in response to fluctuations in reservoir water surface elevations. The four distinct zones would be used to separate fish observations within the delta region.

The reservoir reach starts on the delta foreset and extends out into the reservoir. The elevation of the reservoir pool level during the survey will affect survey efficiency; therefore, visibility and reservoir pool levels will be recorded. The same length of reservoir shoreline would be sampled in each survey. It is likely that this zone cannot be surveyed effectively during certain months. The delta reach starts at the delta foreset and extends upstream to the start of the channel reach (Appendix 2, Figure A.2-2). Surveys would record where the reservoir pool level intersects the delta as well as record fish numbers in the lacustrine habitat separate from the number of fish in riverine habitat of the delta. The "channel" reach starts at the upstream limit of the reservoir fluctuation zone, and the same starting point would be used for each survey. Fish would be recorded by channel unit or by 100-ft sub-reach. This method would allow comparison of the same channel units or sub-reaches over time. This approach may aid in determining if fish hold at different locations in the deltas and tributary mouths.

Another important modification to further determine seasonal changes would include a tally of fish into more refined size classes. The total length of each fish would be estimated to the nearest centimeter, rather than grouping into one of four size classes as conducted in 2007. This refinement in conjunction with the tally by distinct zones and channel units would provide for a better determination of seasonal changes in fish distribution and abundance. When presenting survey results, counts of young-of-year fish will be tallied separately. Counts of young-of-year fish can vary widely, even day to day, and can overwhelm counts of adult and subadult fish.

It is also recommended that all counts within the lacustrine delta and mainstem reservoir along the foreset zones be conducted from the boat deck platform at night using a high-powered spotlight when possible. Studies conducted during 2007 revealed that night time snorkel counts were typically less effective than counts made during the day from the boats, owing largely to poor underwater visibility associated with reflections caused by turbidity. Shallow nearshore areas inaccessible to the survey boat would still require snorkeling observations. If nighttime surveys from the boat deck in the delta are determined ineffective (or if no or few fish are observed as compared to anecdotal daytime observations), then daytime surveys would be conducted to supplement or replace night surveys.

2. Survey tributary delta areas even if no surface flow is evident. During late summer 2007, surface flow in Sand and Pocahontas creeks dropped and no surface flow was evident in the tributary delta areas. When surface flow was no longer evident, biological surveys were discontinued. Cool subsurface tributary flow may be passing through the delta sediment deposits and entering the reservoir. The inflow of cool water at the delta foreset may attract salmonids. Surveys will be conducted within the mainstem reservoir along the delta foreset and in the tributary channel upstream of the reservoir high water mark if surface flow in that reach is observed. These surveys

will provide information on the distribution of salmonids during summer months and will complement analyses of the tributary deltas being conducted under Study 8.

3. If environmental conditions reduce the effectiveness of snorkel survey, backpack electrofishing will be used instead. Turbid water during early spring and late summer and low flow conditions reduced snorkel survey effectiveness in some tributary reaches. Provided survey procedures comply with conditions of the state and federal collecting permits, electrofishing will be used instead of snorkeling to census fish distribution in tributary delta reaches.

4. Suspend biological surveys of the tributaries and deltas if sampling effectiveness is compromised. Tributary and delta snorkel surveys conducted during March and April 2007 resulted in very few fish observations because of, in part, high stream discharge and turbid water conditions. Comparison of the March and April results with the remainder of the data is difficult because of large differences in sampling efficiency. Continued surveys of the delta and tributary reaches during these months would provide limited information for examining Project-related actions. If snorkel and electrofishing surveys are ineffective, the surveys will be suspended pending an improvement in environmental conditions. Although site-specific conditions will dictate effectiveness, it is assumed that underwater visibility of less than 3 feet will cause the surveys to be temporarily suspended.

5. Establish shoreline margin study sites for backpack electrofishing. Young of year and yearling fish are vulnerable to capture in near-shore sample sites with electrofishing and fyke netting. Currently, fyke netting is targeted for backwater and slough channels and has not included near-shore areas with moderate velocities or cobble substrates (except in the tailrace). Boat electrofishing is effective in shallows along steep and moderate bank profiles, but less effective in gently sloping or flat near-shore profiles.

   To effectively sample near shore fry rearing habitats and increase the number of young of year fish captured for developing periodicity tables, additional near-shore study sites will be established and incorporated into the monthly work plan as part of Study 9. The sites would be sampled with the use of backpack electrofishing units to effectively sample channel margin habitat. The sites will be distributed throughout the reservoir to ensure that all reaches are represented, but emphasize the Upper Reservoir Reach.

6. Conduct HSC/HSI data collection. Modifications to HSC/HSI data collection will be addressed in the Aquatic Habitat Model Study (Study 7).

7.2.2. Biotelemetry 2008 Recommendations

The following recommendations suggested for the 2008 Biotelemetry program were developed to increase the total amount of telemetry data recorded to allow statistical analysis of movement data in relation to species life history movement patterns and moderate- to large-scale changes in environmental variables that occur monthly and seasonally. Recommendations are also provided that should allow analysis of the effect of daily operations scenarios on fish movement within thermal refuge during high reservoir water temperatures and possibly during spawning if sufficient numbers of tagged fish aggregate at these locations. Additionally, recommendations are included to obtain more detections of CART-tagged fish movement into the Forebay Reach deep water areas from the Canyon Reach that may be missed during other sampling. Finally, recommendations are provided to modify the type and amount of HSC data collected in 2008.

1. <u>Conduct targeted native salmonid collection and tagging.</u> Current sampling methods have collected few of the target species. Without tagged target species, none of the study objectives can be met. Over the fall, winter, and spring periods, more target species may be captured during regular sampling. However, to enhance the possibility of collecting additional target fish, more targeted sampling will be performed. To increase the number of tagged native salmonids, one or two dedicated tagging sessions will be conducted. These sessions would identify high use salmonid habitat (based on past sampling results) and these would be sampled repetitively. These targeted sessions were implemented in October and November 2007 and will be repeated in spring 2008.
2. <u>Deploy all radio and CART tags by July 1, 2008.</u> Based on 2007 data collection, tagging during the warmer months may increase potential harm to native salmonids. In 2008, tagging will end in July because of warm water temperature. To reduce stress and mortality and ensure as much data can be collected as possible, all available tags should be deployed as early in 2008 as possible to maximize the amount of telemetry data collected prior to the data collection cut-off date.
3. <u>Extend biotelemetry monitoring sessions in Boundary Reservoir by one day.</u> The current monitoring plan for mobile tracking allocates two days to replace batteries and track radio- and CART-tagged fish on Boundary Reservoir. In some cases (e.g., during adverse weather and boat launching conditions), coverage of the reservoir over this time period has not been adequate to conduct sufficient coverage of all regions as may be required to reduce the chance of missing tagged fish. Adverse conditions also result in increased time to do normal monitoring. Additionally, if the number of deployed tags is increased, more time would be needed to locate tags.

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Appendix 1. Biotelemetry Methods Details

BIOTELEMETRY MONITIORING—DETAILED PROCEDURES

Telemetry Equipment Details

All radio transmitters ordered were configured to transmit on a single frequency (151.400 MHz) and programmed with the 2000 codeset that allowed up to 212 individual tag codes. The rationale behind the placing all radio transmitters on a single frequency was to increase the probability of detection during mobile tracking and maximizing the number of detections at the fixed station locations by eliminating the need to switch among frequencies. Configured in this manner, the potential for increased signal collision was increased in the event that more that five tags remained within range of a fixed receiver. However, due to the low number of total tags to be deployed and the staggered tag deployment over time, the likelihood of tag collisions was considered low. This likelihood was furthered reduced by offsetting the program burst signal interval. For the NTC-6-2 tags, (the majority of the tags used), 1/3 of these tags were programmed with a burst intervals of 4.8 s, another 1/3 programmed at 5.0 s, and the remaining 1/3 programmed with burst intervals of 5.2 s. Total life expectancy of the NTC-6-2 ranged from 408 to 431 days depending on the programmed burst interval.

The radio transmissions of the CART tags were also programmed with Codeset 2000 and broadcast on 151.400 MHz at a burst interval of 9.5 second. The CART tag acoustic signal was broadcast on 200 kHz. Depth and pressure data recorded by the tag was encoded in the acoustic signal and could only be received and decoded by the acoustic telemetry hydrophones and receiver used during mobile tracking. The CART tag temperature sensor range was from -6 to +34ºC (accuracy +/- 0.8ºC) and the depth sensor pressure sensor range was from 0 to 50 psi (accuracy +/- 1 psi), which corresponded to depths between 0 and 35 m (accuracy +/- 0.7 m).

Radio transmissions used less energy than acoustic transmissions; therefore, to extend tag life to approximately one year, the CART tags were programmed to broadcast two radio signals for every acoustic signal at a burst interval of 9.5s between radio signals and 28.5s between acoustic signals. Based on anticipated use of the CART tag sensor data to support the HSC data collected during mobile tracking, depth data was identified as a more important parameter. To increase the amount of depth data obtained, the CART tags were programmed to transmitted pressure and temperature data at a 3:1 ratio. Due to their larger size, the CART tags were labeled with a return mail address in case tags were recovered by angler. Table A.1-1 summarizes the specifications of the radio and CART tags used during the 2007 Biotelemetry program.

Table A.1-1. Parameters and specifications of the radio and CART tags used during the 2007 Biotelemetry study.

Transmitter Model	Required Parameter	Specification
Nanotag NTC 6-2	Codeset	2000
	Operating Frequency(s)	151.400 MHz (radio)
	Burst Interval	4.8s, 5.0s ,5.2s (equal distribution among tags)
	Operation Life Range	408-431 days
	Label Information	Code and frequency only
Nanotag NTC 6-1	Codeset	2000
	Operating Frequency(s)	151.400 MHz (radio)
	Burst Interval Operational Life	10s
	Label Information	Code and frequency only
MAP CART Model # CH-TP11-18		
	Radio to acoustic transmission ratio	2:1
	Burst Interval (radio)	9.5s (radio - radio) 19s (radio-acoustic-radio)
	Burst Interval (acoustic)	28.5s (acoustic - acoustic)
	Operational Life	375 days
Acoustic Parameters	Operating Frequency	55 unique codes on 200kHz operational freq
	Pressure to Temperature data transmit ratio	3:1 Pressure to Temperature
	Temperature Range	-6 to +34ºC (+/-0.8ºC)
	Pressure Range	0-50 psi/ 0-35m (+/- 1 psi or 0.7 m)
Radio Parameters	Codeset	2000
	Operating Frequency	151.400 MHz
	Label Information	code & frequency plus additional information to facilitate tag return

The Lotek SRX_400 radio receiver/datalogger, was selected for deployment at the shore-based stations and for use during boat-based mobile tracking. The SRX_400 receiver has an extensive track record of reliability and use through the Columbia River Basin. For the purpose of this study, the receivers were ordered with W7 firmware and 500kb of non-volatile memory. This amount of memory was assumed to be sufficient based on anticipated total tags deployed and the estimated amount of data accumulation between download sessions. The configuration options of the W7 firmware were sufficiently flexible to allow optimization of signal reception power to maximize valid detections while minimizing the logging of false signals and error codes. The continuous record time-out feature allowed data recorded for each tag code logged over a period of up to one hour to be condensed into a single record.

In both fixed station and mobile tracking configurations, a four-element Lindsay antenna (Gain 8 dBi) was used to detect coded radio signals. The four element antenna was selected for its intermediate detection beam width that would allow relatively accurate positioning of fish while mobile tracking and possessed sufficient gain to detect signals over a long distance. Stock lengths of Beldon 9311 coaxial cable of 20 feet or less were used to connect the receiver and the antenna.

Acoustic telemetry equipment purchased consisted of a MAP™600 RT two-port receiver and two LHP 3DF hydrophones. The hydrophones were connected to the receiver with two 30 foot length of marine-grade cable. The primary advantage of the Lotek MAP platform was that the receiver and coded acoustic tag operate on CDMA (Coded Division Multiple Access) acoustic signal that allows simultaneous reception of multiple tags signals without signal collisions. A field laptop was used to operate the receiver through the Maphost™ software user interface which allowed the user to initial logger, capture recorded data, and configure the receiver. The Maphost software also provided a graphical display to allow directional tracking based the signal strength reception at each hydrophone. In addition of have the option of directly saving all data to a portable field computer, all data recorded by the receiver was stored directly on to a flash memory card, as a backup, from which data could be retrieved using the BioMap™ software.

LOCATION AND DEPLOYMENT AND DETECTION EQUIPMENT

Station Site Selection—Station Characteristic Details

The Redbird Creek station, designated Station C1, is located in Canada on the left downstream bank near PRM 13.4. The station is located in a relatively secure location with no road or foot access. Boat travel and angling use within the Canadian portion of the Pend d’Oreille River is low compared to the U.S. portion of the river. Background noise at the site was low, allowing relatively high receiver gain settings. The antenna was positioned at a bearing of 80º with a clear line of site across a wide, shallow section of river near the old Remax mine site.

The station near the International Border (R1) is located on the US side on the right downstream bank near the mouth of Lemond Creek at PRM 16.0. This site experiences very low public use and may be under observation by border surveillance equipment. The station antenna was positioned at bearing of 210º, angled upstream toward the USGS Gage Station. The station location had low background noise levels that allowed a relatively high receiver gain setting. During the freshet period, water velocity this reach of river was very high (i.e., estimated at nearly 10 feet/second). As a result, radio tagged fish at depth could potentially move rapidly through the reception field of this station either without being detected or registering very few verified coded signals.

The Tailrace station (R2) is situated on the left downstream bank near the top of the tailrace boat launch road at PRM 16.6. The station is located on SCL property and is secure. The antenna was positioned at bearing 165ºand was directed upstream towards Boundary Dam and left of the transformer bays. Background noise was high due to overhead wires and the transformer bays. The amount of noise varies based on the amount of electrical generation by the power plant.

Consequently, gain at this station was reduced to optimize signal reception and eliminate error code and false tag signals produced by electrical interference.

The Boundary Forebay station (R3) is located near the left downstream spillway at PRM 17.0 on SCL property. The station antenna was positioned at a bearing of 172º, directed upstream and slightly left of the intake canal trash racks. Noise at this location was initially rated as moderate, but increase substantially after placement of the HTI trailer containing the acoustic monitoring equipment. A reduction in receiver gain failed to reduce the number of logged error coded and false tag signals, so the R3 station was moved closer towards the intake canal and away from the HTI trailer. The aspect of the antenna remained unchanged.

Station R4 is situated on the left downstream bank near the entrance to the Canyon Reservoir Reach at PRM 18.0. During low reservoir levels, access to the station requires climbing a 7-foot-high vertical bank. The site is accessible only by boat and the station is relatively well hidden. The antenna was positioned on a bearing of 35º and was directed downstream and across the canyon opening toward the opposite bank. The site had low background noise and higher receiver gain settings were selected to maximize signal reception.

Station R5 at Pewee Falls was originally intended to be located near the base of the falls. Upon inspection of the site during installation, rock fall hazards and steep, unstable slope prevented access and deployment of the station near the falls. Consequently, the best location available was relatively close to Station R4 (i.e. ~1,300 feet separation), with the antenna positioned on a bearing of 270º and directed toward the falls. Access to Station R5 was steep and required the installation of barrier ropes and climb-assist ropes to improve access and safety of personnel servicing the site. Similar to Station R4, the R5 Station was a low noise environment.

The Slate Creek station (R6) is a dual-antenna station situated near the mouth of Slate Creek at PRM 22.2. Although remote, station security is a concern due to high use of the area by anglers during the summer. Due to the steep slopes around the mouth of the creek, only a single location was deemed suitable as a potential monitoring location. Access to this site is steep; however, the station was successfully installed and climbing assist ropes were installed to improve accessible and safety. Both reservoir and upstream antenna, positioned on bearings of 245º and 165º, respectively, had sight lines that were free of vegetation. Background noise level at the site was low.

Station R7 is located immediately downstream of Metaline Falls on an island located at PRM 26.6. Security of this site is a concern due to the proximately of the town of Metaline Falls and because the islands tend to attract visitors. Access to the site is moderately difficult and potential fall hazards required the installation of access and safety ropes. The station antenna was positioned on a bearing of 31º directed downstream. Background noise at the station was low.

Based on an reconnaissance survey at the mouth of the Sullivan Creek determined that, given the potential for flooding during high water level and extensive amount of thick vegetation, and combined with the requirement monitor upstream fish movement into Sullivan Creek, a shorebased station located immediately adjacent to the river was not feasible. A suitable site was eventually located near PRM 26.9 along the edge south facing slope overlooking the alluvial fan of Sullivan Creek. This site, designated Station R8, is accessible by road and then by foot on an existing foot path. Site security is a concern due to the proximity of residences and evidence of public use. A dual-antenna station, the antenna directed upstream toward Sullivan Creek was positioned on a bearing of 159º, while the antenna directed towards the reservoir was positioned on a bearing of 259º. A large powerline adjacent to the site produced background noise that varied throughout the day in relation to power demand. The gain settings of both antennas were reduced to improve reception of valid tag signals and reduce error codes and false tag signals. Vegetation and tree branches were removed to improve the sight lines of both antennas.

Station R9 is located across from Pocahontas Creek on the left downstream bank of the Pend Oreille River near PRM 29.5. Initial thought to be free of hazards, poison ivy was eventually identified as a hazard at the site. Risk to the station from vandalism is low based on the remote location (site is only readily accessed by boat). The station antenna was directed downstream on a bearing on 28º towards the mouth of Pocahontas Creek. The site had relatively low noise and higher receiver gain settings were used to maximize signal reception.

A dual-antenna station, designated Station R10, was installed at the mouth of Sweet Creek near PRM 30.9. The antennas directed toward Sweet Creek and upstream and across the mainstem Pend Oreille River were positioned on bearings of 300º and 192º, respectively. Although exposed and very visible from the river, the station is located on private property, which is expected to prevent vandalism and tampering. Due to the present of nearby residences, background noise has been variable and periodic modification of the receiver gain setting is required to maximize signal reception and minimized false tag signals and error codes.

The Box Canyon station (R11) is located near the tailrace on the right downstream bank near PRM 34.1, approximately directly across from the end of the Box Canyon Launch. The site is only accessible by boat is relatively secure. Originally, the station antenna was to be angled upstream toward Box Canyon Dam in order to detect fish in the vicinity of the generation discharge. A background noise check confirmed that the switchyard and associated power lines produced large amounts of background noise that varied based on power demand. To compensate for the high levels of background noise, the station antenna was directed downstream on a bearing of 240º. A lower gain setting was also required to maximize reception of valid signals and reduce error codes and false tag signals.

Station Installation Procedures

The details of the box used for installation, antennae and other mounting characteristics, markings used, and boat used for the installation activities are presented below.

The station box was approximately 48 inches long x 24 inches wide x 28 inches deep and was large enough to house two 12-volt deep cycle batteries (connected in parallel) and the receiver (Figure A.1-1). The box also featured recessed locks that were resistant to cutting and prying. High quality commercial grade identically-keyed locks were used to secure the box. The aluminum conduit and antenna cable access the box through a ½-inch hole drilled through the bottom of the box. Once attached, the end of the conduit was then extended to the antenna mount and attached the outside of the tree with C-brackets and wood screws. The antenna mount consisted of a 4-foot length of 2-inch diameter ABS pipe attached to a 2-foot length of a 2-inch by 8-inch board. Two lag-bolted C-brackets and one threaded U-bracket were used to attach the pipe to the board.

Typically, for ease of installation and antenna alignment, the antenna was attached to the mount prior to installing the mount in the tree. For security, antenna mounts were located high enough to be out of reach from an average-sized person standing on top of the weather-proof box. Once the mount was aligned and positioned, four 5-inch long lag bolts were drilled through the 2-inch by 8-inch board and into the tree to secure the mount in place. A single lag bolt was then drilled through the center of the pipe and into the tree to prevent rotation of the pipe once the antenna was attached. Additional support was provided by rope attached at the distal end of the ABS pipe and a higher point on the tree. The antenna cable was the then connected to the antenna and the end of the conduit secured with the open end angled down to prevent rain and snow from entering the end of the conduit and draining into the box. A label with a description of the purpose of the equipment as well as contact information was attached to the box. At stations with open public access, the high-visibility orange and red painted boxes were spray painted with camouflage paint, as was the aluminum conduit, metal cable, and expose portions of the antenna mount. The antenna, however, were not painted. Natural vegetation, grasses and logs were also used to conceal the box from sight (Figure A.1-2).

Stations R3 and R10 required metal masts (2-inch diameter galvanized metal electrical conduit) to mount the antennas. A combination of wooden braces, metal U-brackets, and tensioned guide wires were used to support the mast (Figure A.1-3).

A Valco river boat with a 150 horsepower Yamaha jet-drive outboard engine was used to mobilize equipment and personnel during the installation. The same boat was also used for bi-monthly servicing and mobile radio and acoustic tracking (Figure A.1-4).

Figure A.1-1. Standard field radio receiver box and equipment.

Figure A.1-2. Complete single antenna receiver station at wooded site.

Figure A.1-3. Dual antenna receiver station arrangement in unwooded Sweet Creek site.

Figure A.1-4. Field tracking and receiver access boat with tracking equipment.

Station Installation QA/QC Measures

Prior to installation of the station, the background noise of the location was assessed. If the noise level was excessively high to the point where reception was compromised, a new station location or antenna direction was chosen. The potential for increases in the background noise, particularly near power lines and hydroelectric facilities, was also considered when positioning a station. Prior to installation, the antenna and antenna cable were tested to confirm they were fully functional.

After installation, the receiver gain was optimized and a two-point range test using a test tag was conducted. Optimizing the receiver gain involved increasing the gain until error codes were recorded. Once this point was reached, the gain was reduced by 5 to 10 dB until error codes were not recorded. A test tag (NTC-6-2) was activated and deployed at a depth of 7 feet at locations adjacent the near shore and far shore in the direction of the antenna. Two-point range tests were conducted at all boat access stations. At the Boundary Forebay station (R3) and the Sullivan Creek Station, where use of a boat was not possible, range testing relied on single point tests and inspection of the initially recorded data to confirm that deployed tags were readily detected.

At dual-antenna stations, the tributary antenna was tested by positioning the test tag at several locations upstream in the tributary thalweg (generally <3 foot depth). Maximum reception range within the tributary was difficult to determine and was usually limited by vegetation growth and other physical barriers. Identification of movements of radio tagged fish into the tributary was accomplished by reducing the gain of the tributary antenna by 15 to 20 dB relative to the reservoir antenna. In this way, movement into the tributary could be confirmed by initially detecting the fish on the reservoir antenna, followed by concurrent detections on both the reservoir and tributary antenna, followed by stronger signal reception by the tributary antenna relative to the reservoir antenna, and finally by detection only on the tributary antenna.

At installation, basic operations and functionality of the station were verified and recorded in a service log. Data recorded in the installation logs included the following:

- Site name, date of service, arrival and departure from site, crew personnel
- Site UTM
- Battery identification number and voltage
- Antenna gain setting and bearing
- Programmed frequencies and scan duration
- GPS time/ SRX_400 time synchronization and correction
- Antenna signal reception confirmation with test-tag or detection of a deployed tag
- Logger initialization confirmation
- Logging status
- Receiver power confirmation
- Station security confirmation
- Other changes to receiver settings or station status

All installation logs were recorded on water-resistant paper and field notebook. At the end of each session, the service logs and note book were photocopied and the original stored in a fire-resistant cabinet.

FISH COLLECTION AND TAGGING: SURGICAL IMPLANTATION PROCEDURE

The following surgical implantation procedure was used. A surgical record and tag deployment datasheet was used to document the tagging and release process. Field crews were instructed to ensure that data were provided for all fields and to provide the tag release information in a timely manner to the Biotelemetry study lead. The fields on the datasheet included:

- The fish sample number
- Capture site
- Water temperature at capture
- Species
- Fork Length measured to nearest millimeter
- Weight measure to nearest gram
- Date of surgery
- Initials of the surgeon
- Start and end time of anesthetic bath

- Start and end time of surgery
- Verification that the radio tag is functional
- Tag frequency in MHz, tag type, radio and acoustic transmission codes
- External streamer tag number and color
- Whether or not the fish was released with tags
- Release location, date and time
- Comments on health and post-surgery condition

An anesthetic bath was used. A radio or CART was then activated and tested with an SRX_400 receiver to verify activation. Once activation was confirmed, the tag and all surgical instruments were place in a 10 percent germaphene disinfectant solution for 5 to 10 minutes and then transferred to a rinse tray filled with distilled water. The fish was then weighed and measured (fork length) and then placed ventral side up in a foam lined surgery tray or trough lined with a surgical drape. A gauss pad saturated with either Betadine or germaphene was used to clean the location of the incision and the area around it. Depending on the size of the fish, the start of the incision location was approximately 4 to 6 cm anterior of the cloacal vent, slightly off the midline, and approximately 1 to 3 cm in length depending on the size of the tag to be inserted. A cannula was then inserted through the incision and pushed through the abdominal wall on the ventral surface and slightly to one side of the pelvic girdle. The tag antenna was then inserted through the cannula and the cannula then removed. The tip of the tag was then inserted in the incision and, through a combination of pulling the antenna and pushing on the tag, that tag was inserted within the body cavity of the fish. The incision was then closed with two to three stitches using Ethicon monofilament 2-0 sutures. An external red polystreamer tag was then applied at the base of the dorsal fin near the posterior edge.

After the surgery, fish was placed either in a recovery tank or a fish sock until fully recovered. Fish were then held from 2 to 4 hours and the health of the fish re-assessed. If the fish appeared healthy and vigorous, the fish was released; if the fish was lethargic and in poor shape, the tags were removed and the fish sacrificed for life history data. Photographs were taken of tagged fish prior to and after surgery.

SHORE-BASED STATION SERVICING AND DATA DOWNLOAD PROCEDURE

The following provides the details of the schedule followed and procedures used to service each shore based station. Tables A.1-2 and A.1-3 provide the detail of the schedule for the U.S. and Canadian stations respectively.

Table A.1-2. Downloading and servicing schedule for Stations R1 to R11 in the U.S. portion of the Boundary study area, March to September 2007.

Service period		Session	Comments
21-Mar-07	29-Mar-07	Installation	
12-Apr-07	13-Apr-07	1	R1-R3, not serviced or tracked, boat failure
24-Apr-07	26-Apr-07	2	Service and tracking completed
7-May-07	8-May-07	3	R1 & R9-11 not serviced in lieu of testing acoustic receiver
23-May-07	25-May-07	4	Service and tracking completed
6-Jun-07	8-Jun-07	5	Service and tracking completed
18-Jun-07	20-Jun-07	6	Service and tracking completed Station 6 data lost, logger stalled
4-Jul-07	6-Jul-07	7	Service and tracking completed
17-Jul-07	19-Jul-07	8	Service and tracking completed
31-Jul-07	2-Aug-07	9	Service and tracking completed Station 7 data lost -power failure
14-Jul-07	16-Aug-07	10	Service and tracking completed
28-Aug-07	30-Aug-07	11	Service and tracking completed
14-Sep-07	14-Sep-07	12	Land access stations only - low water
25-Sep-07	27-Sep-07	13	Service and tracking completed

Table A.1-3. Downloading and servicing schedule for Station C1 in the Canadian portion of the Boundary study area, March to September 2007.

Service period	Session	Comments
2-Apr-07	installation	
16-Apr-07	1	
23-Apr-07	2	
14-May-07	3	data lost
4-Jun-07	4	
25-Jun-07	5	
9-Jul-07	6	
10-Aug-07	7	
14-Sep-07	8	Inaccessible due to low water and forest fire

During each service, the station batteries were exchanged and the station receiver data downloaded to a portable field computer. The battery identification numbers and voltage of the old and new batteries were recorded to monitor the status of the batteries and determine whether a battery, due to age and use, could no longer maintain a sufficient charge for the duration of the deployment. Color coded terminal markers were used to clearly identify battery polarity. When disconnecting the power cables between the batteries, care was taken to avoid accidentally shorting the battery terminals during the battery exchange. Prior to reconnecting the receiver power cable, the polarity of the power cable leads was confirmed. During the first two download session, it was noted by field staff that the single antenna stations would remain powered for more than 30 days between battery exchanges. The dual-antenna stations, however, used substantially more power and required new batteries every two weeks.

Data from the receiver was downloaded via a serial cable to a laptop computer. The data file was then viewed in Excel and the start and end date recorded. The download was determined to be successful if the end date corresponded to the time of download. If this was not the case, the download was re-initiated. Once successful download of the data was confirmed, the receiver was re-initialized.

The recorded telemetry data were reviewed in Excel and tag codes identified were recorded in the service log. The number of error codes and false tag signal provided a measure of station performance in terms of whether the current gain setting was appropriate for the ambient noise levels that occurred during the monitoring period. Error codes could be produced by increases in ambient noise (e.g., increase power generation at specific times of the day) or by tag code collisions, when two or more coded tags with overlapping signals were within range of the receiver. The other main source of noise was electric interference from unshielded outboard boat motors. This type of noise tended to occur for brief periods, but on a relatively frequent basis, especially during the summer for stations adjacent to popular fishing locations.

If the station data contained substantial numbers of error codes, the receiver gain setting was reduced by 5 to 10 dB in an attempt to reduce the number error codes and signal collisions. Typically, corrections were required during the first two or three service sessions after installation. Most of the stations were in positioned in low-noise locations and were able to function properly at relatively high gain levels.

To determine tributary use by tagged fish at the three dual-antenna stations located at tributary confluences (i.e., Slate Creek, Sullivan Creek, and Sweet Creek), the tributary antenna was set to a lower gain (e.g., 10 -20 dB lower) than the reservoir antenna. This gain differential allowed easier confirmation of upstream movements into the tributary by radio tagged fish.

Service logs were completed for each service session; the data recorded in the service log included the following:

- Site name, date of service, arrival and departure from site, crew personnel
- Pre- and post -service battery identification number and voltage
- Pre- and post –service antenna gain setting and bearing
- Pre- and post – service programmed frequencies and scan duration
- Pre-service logger status/power status
- Data download status, file name, file location, file size, and file content confirmation
- A list of logged tag codes
- GPS time/ SRX_400 time synchronization and correction
- Antenna signal reception confirmation with test-tag or detection of a deployed tag
- Logger re-initialization confirmation
- Post-service logging status
- Post-service receiver power status confirmation
- Post-service station security status
- Other changes to receiver settings or station status

All service logs were recorded on water-resistant paper and field notebooks. At the end of each session, the service logs and note book were photocopied and the original stored in a fire-resistant cabinet. On a daily basis, a copy of the data downloaded from the stations was transferred to a flash-memory portable storage. At the end of the session, all data were transferred to an office server. Once on the server, all data files were included in the regular offsite remote server backup process.

HSC DATA COLLECTION—DETAILED PROCEDURE

The following are the detailed procedure was used to obtain habitat characteristics for radio and CART tagged target species during field tracking phase of the Biotelemetry study.

1. Water temperature (+/- 0.1ºC) was measured at the estimated fish location. Water temperature in the main river or reservoir also was recorded. It was assumed that as reservoir temperatures increased during the summer, fish use of cold-water refugia at tributary mouths would increase and substantial differences in water temperature between the fish location and the reservoir temperature would be recorded.
2. Distance was measured from the estimated fish location to the nearest river bank with a laser range finder (+/- 1 m). Based on the mobile tracking in April 2007, most fish were assume to be closer to the river bank rather than within mid-channel region of the river or reservoir. For fish in the reservoir, distances to shore were estimated from airphotos when in excess of the 400-meter range of the laser range finder.
3. Water depth was measured with an onboard Lowrance X45 depth sounder (+/- 0.1 m). Due to uncertainty of the precise location of the fish (i.e., within an estimated 10 m radius), additional depth measurements were recorded at two positions located 5 m, perpendicular to the closest river bank, on either side of the estimated fish location. These two additional depth measurements described the maximum and minimum depth range the fish potentially occupied.
4. Concurrent with the three depth measurements, water velocity was recorded with a Marsh McBirney Flow-mate velocity meter (+/- 0.1 m per second [m/s]) set to average over a 10-second interval. Based on the April 2007 mobile tracking surveys, most fish were located in relatively high velocity areas and/or in deep water where mid-column velocity measurements were not feasible. During development of the HSC collection procedures, the assumption was made that fish will generally occupy the upper portion of the water column; therefore, all velocity measurements were taken at a depth of 2m below the water surface. When depths were shallow (less than about 3.3 m), velocity were taken at 0.6 of the total depth. When recording velocity data, the boat was held in position with the engine. A fixed point on the nearest river bank was used to gauge movement of the boat. Once the boat was near motionless relative to the fixed point, a depth and velocity reading were taken
5. Substrate at each fish location was classified as either “hard” or “soft” based on the gray line density readings produced by the Lowrance X45 sounder. In shallow water areas, the substrate associated with the depth sounder reading were verified either visually or with an underwater Aqua-Vu camera, and the dominant and sub-dominant substrate composition based on the criteria listed below.

Substrate types (e.g., 27.6 = sand 60% dominant, large cobble sub-dominant) include the following:

- Silt, clay, or organics
- Sand
- Small gravel (0.25 to 1.25 cm)
- Medium gravel (1.25 to 3.75 cm)
- Large gravel (3.75 to 7.5 cm)
- Small cobble (7.5 to 15 cm)
- Large cobble (15 to 30 cm)
- Boulder (greater than 30 cm)
- Bedrock

6. Cover was documented within a 10 m (33 foot) radius of the fish location and the following cover criteria applied:
   - Undercut bank
   - Overhanging vegetation (within 1 m [3.3 feet] of surface)
   - Rootwads
   - Log jams or brush piles
   - Individual logs
   - Aquatic vegetation
   - Short (less than 1 foot) terrestrial grass
   - Tall (greater than 3 feet) dense grass
   - Vegetation beyond the bank-full water's edge
   - Boulder/Bedrock

At fish locations where use of aquatic macrophytes was evident, the depth from the water surface to the surface of the macrophyte beds was recorded (+/- 0.1 m [0.3 feet]).

7. The presence of shear zones relative to the estimated fish location was noted. If a shear zone was evident, the strength of the shear zone, based on differences in estimated water velocity, and distance between the shear zone and fish location, was estimated according the following criteria:
   - N = none
   - L = a gradual change or gradient in velocities over a 1 to 2 m (3 to 7 feet) distance, but without a prominent shear
   - M = an "abrupt" change in velocities of greater than 0.5 m/second (1.6 feet/second) over a distance of 1 to 2 m (3 to 7 feet)
   - H = an "abrupt" change in velocities of greater than 1 m/second (3 feet/second) over a distance of 1 to 2 m (3 to 7 feet)

8. Because the ability of the tracking crew to accurately locate fish varied under different conditions (e.g., fast flows versus slow flows), a confidence ranking of the representative fish location of high (H), moderate (M), or low (L) was estimated based on the opinion of the telemetry equipment operator. The following criteria were applied when choosing a location confidence ranking:
    - High: located less than 5 m (16 feet) from the boat
    - Moderate: located between 5 and 15 m (16 and 49 feet) from the boat
    - Low: located 15 m (49 feet) or greater from the boat.

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Appendix 2. Passive and Active Sampling Results Data

Table A.2-1. Between-month and reach comparisons of gill netting catch (mean catch per unit effort as measured fish per 1000 square feet net set time [hr] in parentheses) in the Boundary Project during March through October, 2007. Catch rate is computed by first calculating the CPUE for each sampling event at each site, and then computing the mean CPUE for each combination of species, reach and month.

Species	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Tailrace																		
Rainbow trout [1]	Not scheduled		Not sampled		6	(0.60)	1	(0.10)	10	(0.82)	no boat access		2	(0.21)	0	(0.00)	19	(0.43)
Smallmouth bass					0	(0.00)	0	(0.00)	6	(0.49)			0	(0.00)	0	(0.00)	6	(0.16)
Largescale sucker					5	(0.50)	0	(0.00)	14	(1.09)			2	(0.35)	2	(0.16)	23	(0.53)
Northern pikeminnow					2	(0.20)	4	(0.33)	7	(0.43)			1	(0.25)	1	(0.08)	15	(0.29)
Peamouth					1	(0.10)	0	(0.00)	0	(0.00)			0	(0.00)	0	(0.00)	1	(0.02)
Walleye					1	(0.10)	0	(0.00)	0	(0.00)			2	(0.35)	0	(0.00)	3	(0.08)
All Species					**15**	**(1.51)**	**5**	**(0.42)**	**37**	**(2.83)**			**7**	**(0.78)**	**3**	**(0.23)**	**67**	**(1.38)**
Forebay																		
Brown trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	0	(0.00)	1	(0.01)
Rainbow trout [1]	1	(0.13)	2	(0.13)	7	(0.34)	0	(0.00)	0	(0.00)	2	(0.08)	0	(0.00)	1	(0.03)	13	(0.08)
Smallmouth bass	0	(0.00)	0	(0.00)	1	(0.05)	1	(0.01)	3	(0.02)	4	(0.13)	2	(0.02)	0	(0.00)	11	(0.04)
Largescale sucker	2	(0.20)	1	(0.05)	1	(0.05)	10	(0.12)	9	(0.23)	16	(0.21)	3	(0.03)	6	(0.31)	48	(0.15)
Longnose sucker	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	2	(0.01)
Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Northern pikeminnow	2	(0.25)	1	(0.04)	8	(0.42)	4	(0.09)	10	(0.17)	5	(0.11)	13	(0.21)	11	(0.44)	54	(0.19)
Peamouth	0	(0.00)	2	(0.11)	3	(0.14)	1	(0.07)	1	(0.06)	4	(0.06)	4	(0.07)	5	(0.27)	20	(0.08)
Tench	0	(0.00)	0	(0.00)	3	(0.14)	1	(0.01)	1	(0.02)	1	(0.01)	1	(0.03)	0	(0.00)	7	(0.02)
Yellow perch	1	(0.13)	0	(0.00)	0	(0.00)	2	(0.02)	28	(0.33)	8	(0.07)	12	(0.14)	6	(0.21)	57	(0.11)
All Species	**6**	**(0.12)**	**6**	**(0.12)**	**24**	**(0.28)**	**19**	**(0.09)**	**53**	**(0.30)**	**41**	**(0.33)**	**36**	**(0.15)**	**29**	**(0.22)**	**214**	**(0.20)**
Canyon																		
Burbot	0	(0.00)	2	(0.12)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	3	(0.01)
Lake trout	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.07)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Rainbow trout [1]	1	(0.15)	2	(0.15)	0	(0.00)	0	(0.00)	2	(0.19)	0	(0.00)	0	(0.00)	0	(0.00)	5	(0.04)
Rainbow trout [2]	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.07)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	5	(0.03)	8	(0.04)	0	(0.00)	13	(0.01)
Largescale sucker	2	(0.43)	1	(0.09)	1	(0.01)	3	(0.08)	2	(0.19)	15	(0.25)	18	(0.16)	5	(0.11)	47	(0.17)

Table A.2-1, continued…

Species	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.12)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Northern pikeminnow	3	(0.29)	9	(0.54)	4	(0.43)	1	(0.01)	7	(0.79)	9	(0.11)	16	(0.24)	9	(0.24)	58	(0.29)
Peamouth	2	(0.22)	4	(0.37)	0	(0.00)	0	(0.00)	0	(0.00)	16	(0.87)	5	(0.06)	4	(0.08)	31	(0.30)
Redside shiner	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.10)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Tench	0	(0.00)	0	(0.00)	1	(0.08)	3	(0.12)	0	(0.00)	5	(0.24)	1	(0.04)	0	(0.00)	10	(0.09)
Yellow perch	0	(0.00)	6	(0.56)	1	(0.01)	0	(0.00)	3	(0.31)	13	(0.11)	7	(0.07)	0	(0.00)	30	(0.12)
All Species	**8**	**(0.13)**	**24**	**(0.31)**	**7**	**(0.11)**	**9**	**(0.06)**	**16**	**(0.30)**	**63**	**(0.76)**	**56**	**(0.18)**	**18**	**(0.10)**	**201**	**(0.24)**
Upper Reservoir																		
Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	1	(0.03)	1	(0.03)	0	(0.00)	3	(0.02)
Burbot	1	(0.03)	0	(0.00)	2	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.01)
Brook trout	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Brown trout	0	(0.00)	0	(0.00)	3	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.00)
Lake trout	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Largemouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	5	(0.04)	6	(0.01)
Rainbow trout [1]	0	(0.00)	1	(0.05)	7	(0.09)	0	(0.00)	2	(0.03)	0	(0.00)	0	(0.00)	2	(0.03)	12	(0.02)
Smallmouth bass	0	(0.00)	0	(0.00)	4	(0.05)	0	(0.00)	2	(0.03)	4	(0.21)	1	(0.03)	12	(0.08)	23	(0.07)
Largescale sucker	2	(0.11)	6	(0.33)	11	(0.14)	3	(0.09)	3	(0.13)	7	(0.24)	2	(0.10)	2	(0.02)	36	(0.15)
Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.06)	1	(0.07)	3	(0.05)	6	(0.03)
Northern pike	0	(0.00)	1	(0.04)	2	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	11	(0.09)	14	(0.01)
Northern pikeminnow	21	(0.69)	3	(0.18)	36	(0.46)	9	(0.48)	13	(0.53)	28	(0.94)	3	(0.09)	19	(0.30)	132	(0.52)
Peamouth	9	(0.38)	2	(0.07)	79	(1.03)	20	(0.76)	9	(0.85)	2	(0.08)	0	(0.00)	0	(0.00)	121	(0.36)
Pumpkinseed	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.12)	1	(0.04)	0	(0.00)	3	(0.05)	7	(0.03)
Tench	0	(0.00)	0	(0.00)	3	(0.04)	0	(0.00)	1	(0.02)	6	(0.20)	4	(0.14)	1	(0.02)	15	(0.07)
Walleye	0	(0.00)	0	(0.00)	2	(0.03)	0	(0.00)	2	(0.03)	0	(0.00)	1	(0.03)	3	(0.06)	8	(0.02)
Yellow perch	0	(0.00)	1	(0.04)	10	(0.12)	7	(0.36)	9	(0.16)	0	(0.00)	0	(0.00)	20	(0.27)	47	(0.10)
All Species	**33**	**(1.06)**	**14**	**(0.71)**	**160**	**(2.07)**	**41**	**(1.13)**	**45**	**(1.93)**	**51**	**(1.79)**	**13**	**(0.43)**	**81**	**(0.71)**	**438**	**(1.24)**

Notes:

1 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids)

2 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries

Table A.2-2. Between-month and set type comparisons of gill netting catch (including mean catch per unit effort as measured by value per 1000 square feet fished per hour) in the Boundary Project during March through October, 2007.

Species	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Shallow																				
Burbot	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Brook trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Brown trout	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	2	(0.01)
Lake trout	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Largemouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	4	(0.03)	5	(0.01)
Rainbow trout [1]	0	(0.00)	1	(0.09)	2	(0.11)	8	(0.26)	1	(0.04)	9	(0.48)	1	(0.05)	0	(0.00)	2	(0.02)	24	(0.13)
Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.07)	0	(0.00)	5	(0.24)	6	(0.29)	0	(0.00)	4	(0.03)	19	(0.10)
Largescale sucker	3	(0.28)	2	(0.18)	7	(0.39)	14	(0.26)	4	(0.11)	12	(0.60)	8	(0.29)	4	(0.20)	11	(0.20)	65	(0.29)
Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.06)	0	(0.00)	2	(0.03)	4	(0.02)
Northern pike	0	(0.00)	0	(0.00)	1	(0.04)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	6	(0.05)	8	(0.01)
Northern pikeminnow	0	(0.00)	21	(0.69)	3	(0.20)	15	(0.26)	4	(0.19)	11	(0.28)	25	(0.86)	11	(0.36)	21	(0.34)	111	(0.45)
Peamouth	0	(0.00)	7	(0.31)	6	(0.30)	22	(0.28)	1	(0.07)	0	(0.00)	2	(0.08)	3	(0.08)	9	(0.19)	50	(0.15)
Pumpkinseed	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.04)	0	(0.00)	0	(0.00)	2	(0.03)	4	(0.01)
Redside shiner	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Tench	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.08)	3	(0.07)	2	(0.03)	7	(0.29)	4	(0.12)	1	(0.02)	20	(0.09)
Walleye	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.11)	3	(0.05)	7	(0.02)
Yellow perch	0	(0.00)	0	(0.00)	7	(0.37)	8	(0.08)	0	(0.00)	6	(0.15)	1	(0.04)	2	(0.05)	20	(0.23)	44	(0.10)
All Species	**3**	**(0.07)**	**31**	**(0.98)**	**26**	**(0.88)**	**80**	**(1.13)**	**14**	**(0.27)**	**49**	**(1.88)**	**53**	**(1.99)**	**26**	**(0.69)**	**85**	**(0.90)**	**367**	**(1.03)**
Moderate Bottom																				
Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.09)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Burbot	0	(0.00)	1	(0.04)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
Brown trout	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
Largemouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	1	(0.00)
Rainbow trout [1]	0	(0.00)	0	(0.00)	0	(0.00)	5	(0.05)	0	(0.00)	1	(0.07)	0	(0.00)	0	(0.00)	0	(0.00)	6	(0.01)
Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	3	(0.17)	0	(0.00)	0	(0.00)	4	(0.04)	8	(0.02)
Largescale sucker	0	(0.00)	4	(0.31)	1	(0.12)	3	(0.09)	1	(0.05)	5	(0.28)	5	(0.15)	1	(0.10)	1	(0.03)	21	(0.15)
Longnose sucker	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	2	(0.01)

Table A.2-2, continued…

	Species	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Moderate Bottom (continued)																					
	Northern pike	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.02)	2	(0.00)
	Northern pikeminnow	4	(0.31)	2	(0.14)	1	(0.09)	19	(0.58)	7	(0.44)	6	(0.29)	5	(0.24)	2	(0.08)	10	(0.28)	56	(0.29)
	Peamouth	0	(0.00)	0	(0.00)	0	(0.00)	26	(0.31)	9	(0.68)	0	(0.00)	1	(0.09)	0	(0.00)	0	(0.00)	36	(0.13)
	Pumpkinseed	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.03)	1	(0.00)
	Tench	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.05)	0	(0.00)	0	(0.00)	4	(0.17)	0	(0.00)	0	(0.00)	6	(0.04)
	Walleye	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.08)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
	Yellow perch	1	(0.10)	1	(0.10)	0	(0.00)	1	(0.01)	7	(0.60)	8	(0.32)	0	(0.00)	1	(0.04)	5	(0.15)	24	(0.13)
	All Species	**5**	**(0.20)**	**8**	**(0.44)**	**2**	**(0.14)**	**61**	**(0.98)**	**25**	**(1.40)**	**25**	**(0.73)**	**15**	**(0.66)**	**5**	**(0.17)**	**24**	**(0.34)**	**170**	**(0.59)**
Deep Bottom																					
	Burbot	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	1	(0.00)
	Rainbow trout [1]	0	(0.00)	0	(0.00)	2	(0.17)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.03)
	Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	3	(0.07)	7	(0.07)	10	(0.08)	0	(0.00)	21	(0.03)
	Largescale sucker	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	11	(0.21)	7	(0.45)	19	(0.21)	18	(0.13)	2	(0.10)	58	(0.14)
	Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Northern pikeminnow	3	(0.17)	0	(0.00)	3	(0.11)	0	(0.00)	3	(0.05)	6	(0.28)	7	(0.07)	18	(0.15)	5	(0.21)	45	(0.12)
	Peamouth	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	6	(0.05)	0	(0.00)	8	(0.02)
	Tench	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.20)	1	(0.02)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	4	(0.02)
	Yellow perch	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	2	(0.04)	24	(0.77)	19	(0.20)	16	(0.16)	1	(0.06)	63	(0.14)
	All Species	**3**	**(0.06)**	**0**	**(0.00)**	**6**	**(0.21)**	**4**	**(0.08)**	**18**	**(0.17)**	**41**	**(0.53)**	**54**	**(0.48)**	**69**	**(0.38)**	**8**	**(0.18)**	**203**	**(0.23)**
Moderate Surface																					
	Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	1	(0.04)	0	(0.00)	2	(0.01)
	Burbot	0	(0.00)	0	(0.00)	2	(0.36)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
	Lake trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
	Rainbow trout [1]	0	(0.00)	1	(0.15)	1	(0.18)	7	(0.27)	0	(0.00)	4	(0.09)	1	(0.02)	2	(0.08)	1	(0.02)	17	(0.10)
	Rainbow trout [2]	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.01)
	Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.03)	4	(0.03)	5	(0.01)
	Largescale sucker	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.16)	5	(0.18)	1	(0.06)	1	(0.04)	10	(0.07)
	Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.06)	0	(0.00)	1	(0.08)	1	(0.01)	3	(0.02)
	Northern pike	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.02)	4	(0.00)

Table A.2-2, continued…

Species	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Moderate Surface (continued)																				
Northern pikeminnow	0	(0.00)	2	(0.22)	6	(1.08)	15	(0.21)	2	(0.19)	13	(0.86)	3	(0.10)	1	(0.07)	4	(0.11)	46	(0.30)
Peamouth	0	(0.00)	4	(0.39)	0	(0.00)	35	(0.38)	11	(0.44)	9	(0.99)	16	(1.22)	0	(0.00)	0	(0.00)	75	(0.53)
Pumpkinseed	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.10)	1	(0.07)	0	(0.00)	0	(0.00)	2	(0.03)
Tench	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.09)	0	(0.00)	2	(0.01)
Walleye	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	2	(0.01)
Yellow perch	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	2	(0.08)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.02)
All Species	**0**	**(0.00)**	**7**	**(0.25)**	**9**	**(0.54)**	**60**	**(0.77)**	**15**	**(0.74)**	**33**	**(2.00)**	**27**	**(1.41)**	**10**	**(0.42)**	**14**	**(0.19)**	**175**	**(0.75)**
Deep Vertical																				
Burbot	1	(0.092)	0	(0.000)	0	(0.000)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Rainbow trout [1]	1	(0.083)	0	(0.000)	0	(0.000)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Largescale sucker	0	(0.000)	0	(0.000)	0	(0.000)	0	(0.00)	0	(0.00)	1	(0.12)	1	(0.03)	1	(0.03)	0	(0.00)	3	(0.03)
Northern pikeminnow	0	(0.000)	1	(0.625)	0	(0.000)	1	(0.37)	2	(0.16)	1	(0.10)	2	(0.03)	1	(0.03)	0	(0.00)	8	(0.11)
Peamouth	0	(0.000)	0	(0.000)	1	(0.375)	0	(0.00)	0	(0.00)	1	(0.12)	2	(0.05)	0	(0.00)	0	(0.00)	4	(0.06)
Yellow perch	0	(0.000)	0	(0.000)	0	(0.000)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	1	(0.01)
All Species	**2**	**(0.01)**	**1**	**(0.02)**	**1**	**(0.02)**	**1**	**(0.02)**	**2**	**(0.01)**	**3**	**(0.04)**	**6**	**(0.03)**	**2**	**(0.00)**	**0**	**(0.00)**	**18**	**(0.02)**

Notes:

1 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids)

2 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries

Table A.2-3. Between-month and reach comparisons of electrofishing catch (mean catch per unit effort as measured by fish per electrofishing run time [minute] in parentheses) in the Boundary Project during March through October, 2007. Catch rate is computed by first calculating the CPUE for each sampling event at each site, and then computing the mean CPUE for each combination of species, reach and month.

	Species	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Tailrace																			
	Black crappie	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Brook trout	2	(0.05)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.01)
	Brown trout	2	(0.04)	1	(0.02)	1	(0.03)	2	(0.05)	0	(0.00)	2	(0.04)	3	(0.03)	2	(0.05)	13	(0.03)
	Bull trout [1]	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Cutthroat trout[2]	0	(0.00)	1	(0.03)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
	Kokanee	0	(0.00)	1	(0.02)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
	Lake trout	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Largescale sucker	54	(1.17)	88	(1.67)	121	(3.43)	59	(1.27)	1	(0.08)	24	(0.50)	111	(1.24)	92	(1.96)	550	(1.51)
	Longnose sucker	0	(0.00)	0	(0.00)	1	(0.03)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
	Mountain whitefish	0	(0.00)	0	(0.00)	1	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.07)	4	(0.01)
	Northern pikeminnow	0	(0.00)	11	(0.21)	14	(0.37)	27	(0.53)	0	(0.00)	4	(0.08)	3	(0.03)	2	(0.04)	61	(0.16)
	Peamouth	0	(0.00)	15	(0.28)	4	(0.10)	6	(0.12)	0	(0.00)	0	(0.00)	7	(0.07)	5	(0.11)	37	(0.09)
	Pumpkinseed	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Rainbow trout [3]	39	(1.03)	64	(1.21)	29	(0.75)	60	(1.32)	0	(0.00)	5	(0.11)	10	(0.11)	0	(0.00)	207	(0.62)
	Rainbow trout [4]	5	(0.12)	0	(0.00)	2	(0.05)	2	(0.05)	0	(0.00)	0	(0.00)	1	(0.01)	2	(0.05)	12	(0.04)
	Smallmouth bass	0	(0.00)	19	(0.35)	59	(1.58)	50	(1.02)	2	(0.18)	34	(0.73)	34	(0.35)	26	(0.50)	224	(0.59)
	Sucker sp	1	(0.03)	16	(0.30)	4	(0.09)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	21	(0.06)
	Walleye	1	(0.03)	7	(0.13)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	8	(0.02)
	Yellow perch	0	(0.00)	3	(0.05)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.03)	5	(0.01)
	All Species	**105**	**(2.50)**	**229**	**(4.32)**	**238**	**(6.52)**	**209**	**(4.42)**	**3**	**(0.25)**	**69**	**(1.47)**	**169**	**(1.83)**	**133**	**(2.81)**	**1155**	**(3.21)**
Forebay																			
	Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	1	(0.01)	2	(0.00)
	Brown trout	0	(0.00)	0	(0.00)	1	(0.03)	1	(0.02)	0	(0.00)	1	(0.02)	1	(0.02)	1	(0.02)	5	(0.01)
	Cutthroat trout[2]	1	(0.02)	0	(0.00)	1	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.03)	4	(0.01)
	Lake trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.01)
	Largemouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.03)	2	(0.03)	0	(0.00)	4	(0.01)
	Largescale sucker	4	(0.06)	7	(0.14)	6	(0.15)	20	(0.36)	147	(3.20)	407	(7.81)	49	(0.78)	351	(5.17)	991	(2.03)
	Longnose sucker	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)

Table A.2-3, continued…

	Species	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
	Mountain whitefish	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.07)	0	(0.00)	1	(0.02)	1	(0.02)	0	(0.00)	6	(0.01)
	Northern pikeminnow	1	(0.01)	0	(0.00)	1	(0.03)	0	(0.00)	2	(0.04)	6	(0.15)	6	(0.11)	4	(0.06)	20	(0.05)
	Peamouth	4	(0.06)	5	(0.10)	2	(0.05)	9	(0.16)	0	(0.00)	1	(0.02)	0	(0.00)	1	(0.01)	22	(0.05)
	Pumpkinseed	0	(0.00)	4	(0.10)	0	(0.00)	0	(0.00)	1	(0.02)	17	(0.36)	2	(0.03)	0	(0.00)	24	(0.06)
	Rainbow trout [3]	60	(0.88)	37	(0.77)	32	(0.80)	17	(0.31)	27	(0.52)	7	(0.12)	5	(0.08)	10	(0.16)	195	(0.47)
	Rainbow trout [5]	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	2	(0.04)	1	(0.02)	0	(0.00)	0	(0.00)	4	(0.01)
	Smallmouth bass	1	(0.02)	9	(0.21)	16	(0.42)	39	(0.73)	6	(0.12)	30	(0.60)	4	(0.06)	18	(0.27)	123	(0.29)
	Sucker sp	87	(1.62)	121	(2.89)	302	(8.00)	190	(3.36)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	701	(2.05)
	Walleye	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	1	(0.00)
	Yellow perch	34	(0.52)	32	(0.65)	9	(0.23)	46	(0.87)	3	(0.06)	27	(0.48)	0	(0.00)	3	(0.04)	154	(0.35)
	All Species	**192**	**(3.20)**	**215**	**(4.85)**	**371**	**(9.74)**	**327**	**(5.90)**	**191**	**(4.07)**	**502**	**(7.25)**	**70**	**(1.12)**	**392**	**(5.79)**	**2260**	**(5.24)**
Canyon																			
	Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	1	(0.01)	1	(0.01)	3	(0.03)	6	(0.01)
	Brook trout	1	(0.01)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
	Brown bullhead	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
	Brown trout	2	(0.02)	2	(0.03)	0	(0.00)	1	(0.01)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	6	(0.01)
	Cutthroat trout[2]	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Lake trout	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
	Lake whitefish	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.00)
	Largescale sucker	10	(0.14)	17	(0.26)	18	(0.29)	37	(0.53)	21	(0.21)	66	(0.89)	34	(0.34)	202	(1.84)	405	(0.57)
	Longnose sucker	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	2	(0.00)
	Mountain whitefish	1	(0.01)	1	(0.02)	2	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.01)
	Northern pikeminnow	14	(0.19)	4	(0.08)	1	(0.01)	1	(0.01)	5	(0.05)	7	(0.10)	11	(0.12)	17	(0.18)	60	(0.09)
	Peamouth	13	(0.16)	10	(0.14)	31	(0.46)	21	(0.28)	0	(0.00)	2	(0.03)	11	(0.10)	27	(0.23)	115	(0.17)
	Pumpkinseed	13	(0.18)	10	(0.14)	0	(0.00)	3	(0.04)	6	(0.06)	9	(0.12)	5	(0.04)	2	(0.02)	48	(0.07)
	Rainbow trout [3]	33	(0.47)	39	(0.61)	12	(0.24)	9	(0.13)	10	(0.11)	5	(0.06)	1	(0.01)	3	(0.04)	112	(0.20)
	Rainbow trout [5]	4	(0.06)	0	(0.00)	0	(0.00)	1	(0.02)	3	(0.03)	1	(0.01)	0	(0.00)	1	(0.02)	10	(0.02)
	Smallmouth bass	2	(0.03)	42	(0.73)	54	(0.84)	56	(0.81)	23	(0.26)	78	(1.11)	16	(0.17)	56	(0.54)	327	(0.56)
	Sucker sp	69	(0.88)	47	(0.64)	178	(2.59)	122	(1.54)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	416	(0.71)
	Tench	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	2	(0.00)
	Yellow perch	125	(1.64)	29	(0.41)	1	(0.01)	29	(0.39)	19	(0.20)	6	(0.08)	10	(0.09)	3	(0.02)	222	(0.35)
	All Species	**287**	**(3.79)**	**203**	**(3.08)**	**298**	**(4.48)**	**286**	**(3.86)**	**89**	**(0.94)**	**176**	**(2.43)**	**89**	**(0.88)**	**316**	**(2.92)**	**1744**	**(2.79)**

Table A.2-3, continued…

	Species	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Upper Reservoir																			
	Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.02)	7	(0.08)	63	(0.65)	1	(0.01)	73	(0.09)
	Brown bullhead	2	(0.02)	4	(0.05)	3	(0.05)	9	(0.11)	2	(0.02)	1	(0.01)	1	(0.01)	2	(0.02)	24	(0.04)
	Brown trout	5	(0.06)	1	(0.01)	1	(0.01)	3	(0.03)	4	(0.03)	4	(0.06)	0	(0.00)	2	(0.01)	20	(0.03)
	Burbot	2	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	2	(0.02)	5	(0.01)
	Char hybrid [6]	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Cutthroat trout[2]	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	2	(0.01)	0	(0.00)	1	(0.01)	0	(0.00)	4	(0.00)
	Kokanee	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Largemouth bass	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.04)	2	(0.02)	20	(0.15)	26	(0.03)
	Largescale sucker	122	(1.36)	44	(0.62)	97	(1.51)	117	(1.34)	58	(0.52)	49	(0.62)	60	(0.54)	122	(0.94)	669	(0.93)
	Longnose sucker	0	(0.00)	0	(0.00)	7	(0.11)	11	(0.12)	0	(0.00)	4	(0.06)	2	(0.02)	4	(0.03)	28	(0.04)
	Mountain whitefish	4	(0.04)	4	(0.05)	9	(0.12)	52	(0.56)	13	(0.09)	4	(0.06)	1	(0.01)	2	(0.01)	89	(0.12)
	Northern pike	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	1	(0.00)
	Northern pikeminnow	11	(0.13)	20	(0.30)	12	(0.18)	14	(0.18)	24	(0.23)	12	(0.14)	74	(0.66)	27	(0.23)	194	(0.26)
	Peamouth	18	(0.21)	96	(0.99)	34	(0.52)	64	(0.77)	8	(0.07)	10	(0.11)	60	(0.56)	100	(0.76)	390	(0.50)
	Pumpkinseed	2	(0.02)	0	(0.00)	2	(0.03)	2	(0.02)	1	(0.01)	15	(0.18)	69	(0.71)	21	(0.16)	112	(0.14)
	Rainbow trout [3]	8	(0.11)	81	(1.08)	19	(0.30)	10	(0.13)	32	(0.27)	9	(0.13)	2	(0.02)	17	(0.13)	178	(0.27)
	Rainbow trout [5]	3	(0.04)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	1	(0.01)	6	(0.01)
	Redside shiner	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.02)	1	(0.01)	1	(0.01)	1	(0.01)	0	(0.00)	4	(0.01)
	Sculpin sp	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	1	(0.00)
	Smallmouth bass	6	(0.07)	17	(0.26)	25	(0.41)	41	(0.51)	38	(0.34)	20	(0.24)	73	(0.58)	70	(0.59)	290	(0.38)
	Sucker sp	124	(1.40)	255	(3.82)	13	(0.20)	144	(1.72)	6	(0.05)	38	(0.56)	0	(0.00)	1	(0.01)	581	(0.96)
	Tench	4	(0.04)	1	(0.01)	1	(0.01)	4	(0.05)	1	(0.01)	7	(0.08)	2	(0.02)	3	(0.02)	23	(0.03)
	Walleye	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
	Yellow perch	55	(0.72)	29	(0.40)	32	(0.51)	87	(0.96)	55	(0.56)	40	(0.49)	16	(0.17)	160	(1.29)	474	(0.64)
	All Species	**367**	**(5.13)**	**556**	**(7.63)**	**256**	**(3.98)**	**559**	**(6.50)**	**247**	**(2.26)**	**226**	**(2.88)**	**428**	**(4.00)**	**556**	**(4.38)**	**3195**	**(4.59)**

Notes:

1 Genetic analysis completed by the USFWS in November 2007 (P DeHaan, USFWS, personal communication, Nov 14, 2007) identified specimen as bull trout
2 Exhibited characteristics indicative of the westslope variety
3 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids)
4 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout
5 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries
6 Genetic analysis completed by the USFWS in November 2007 identified specimen as bull trout / brook trout hybrid

Mountain whitefish

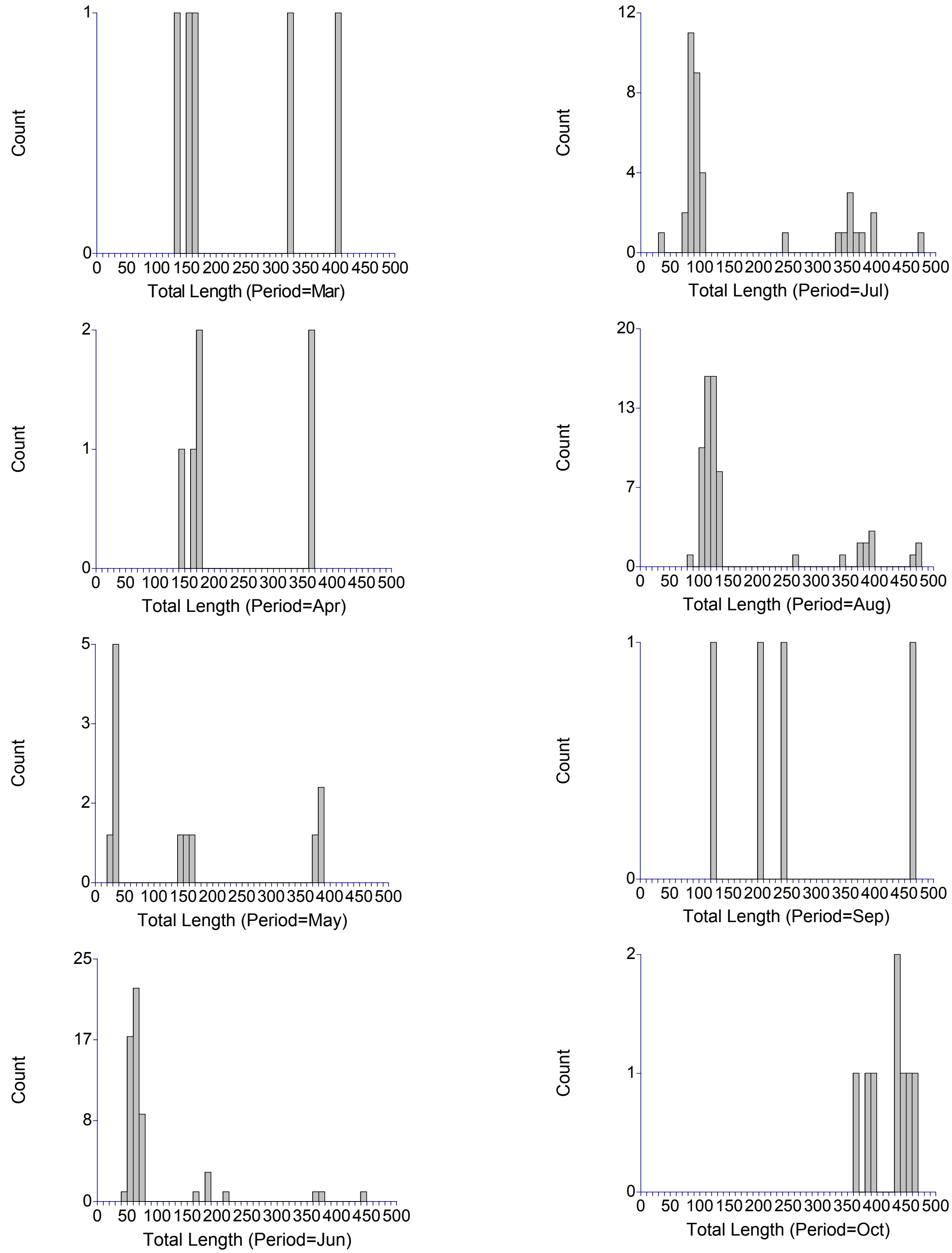


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (1 of 6**)**

Smallmouth Bass

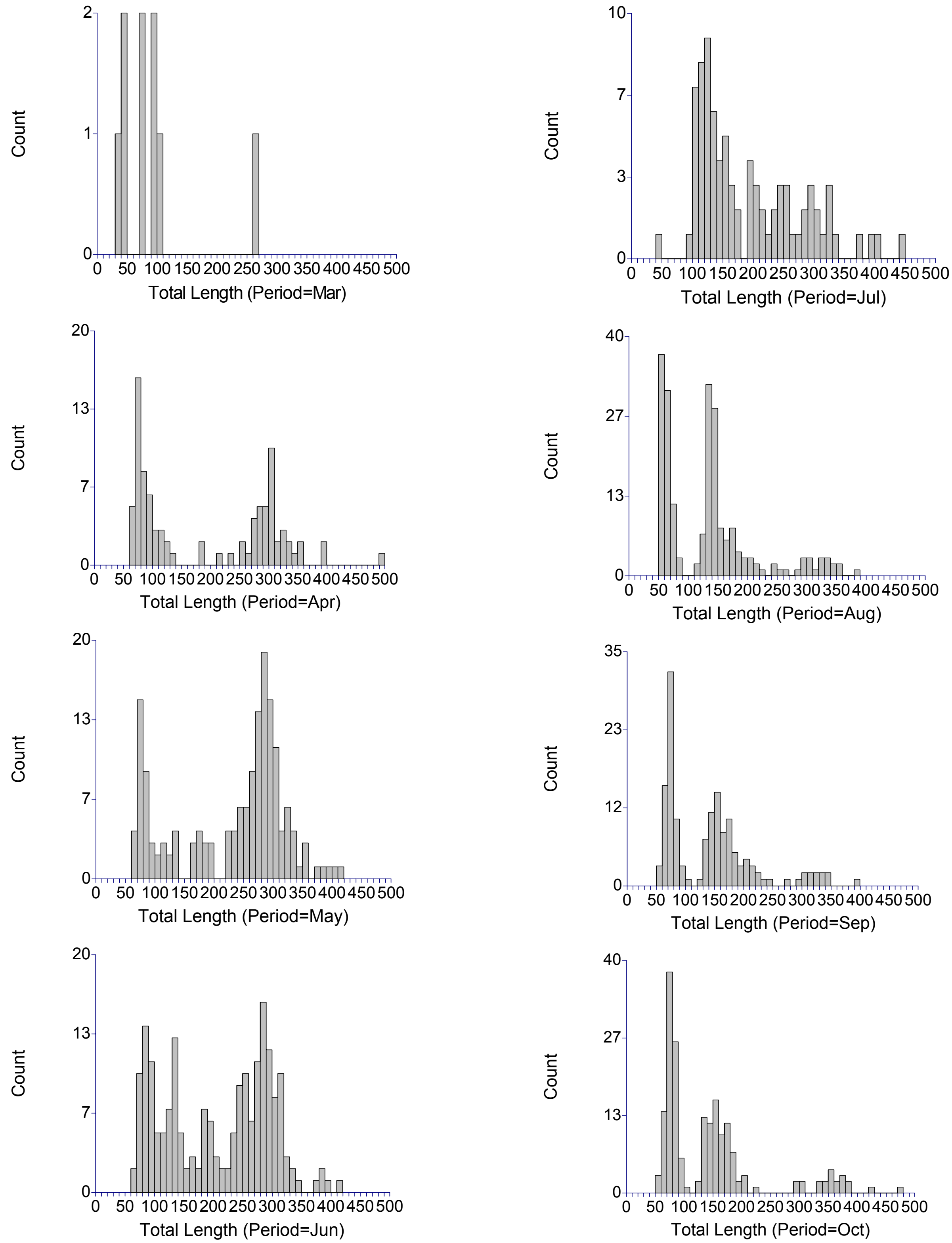


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (2 of 6)

Cutthroat Trout

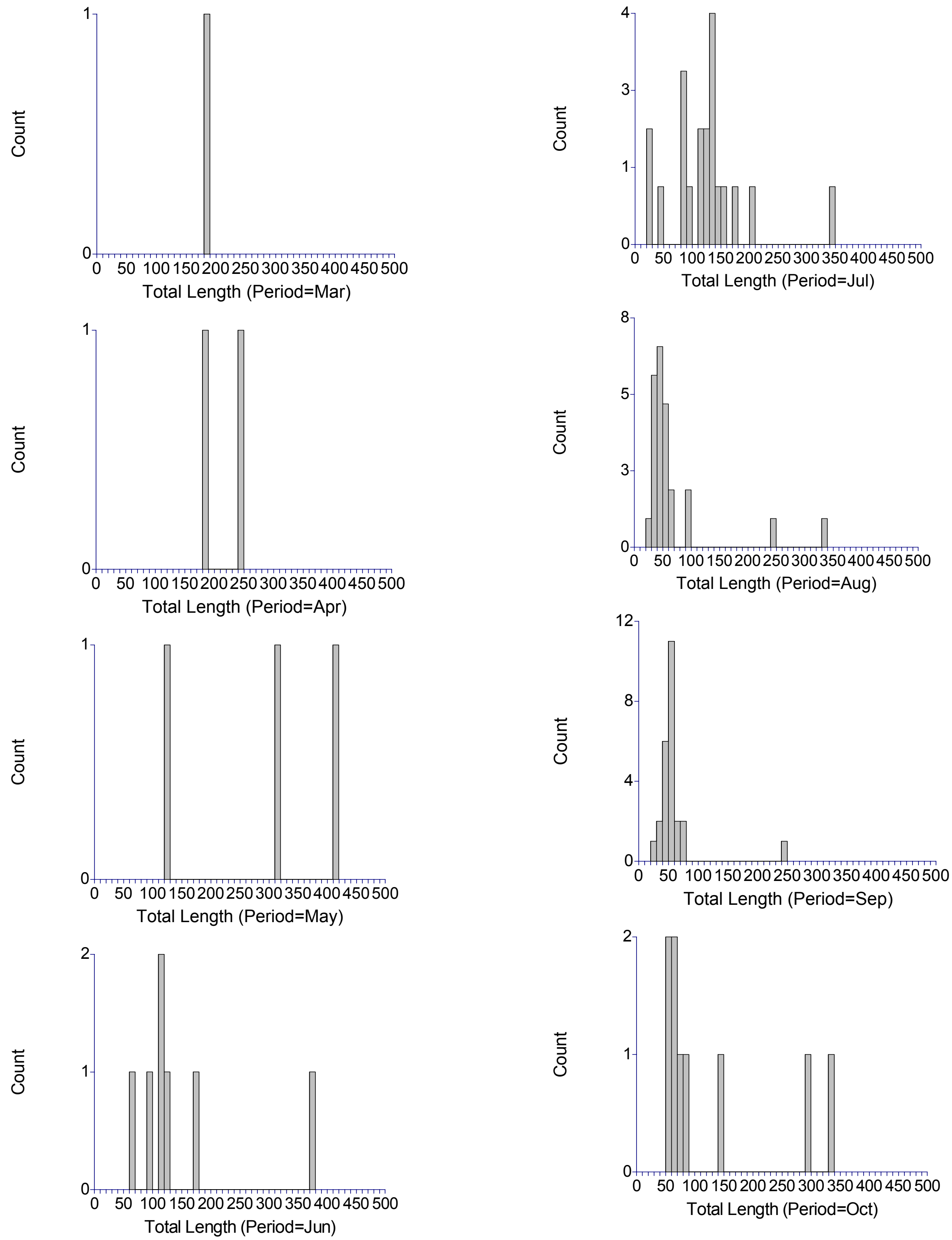


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (3 of 6)

Peamouth

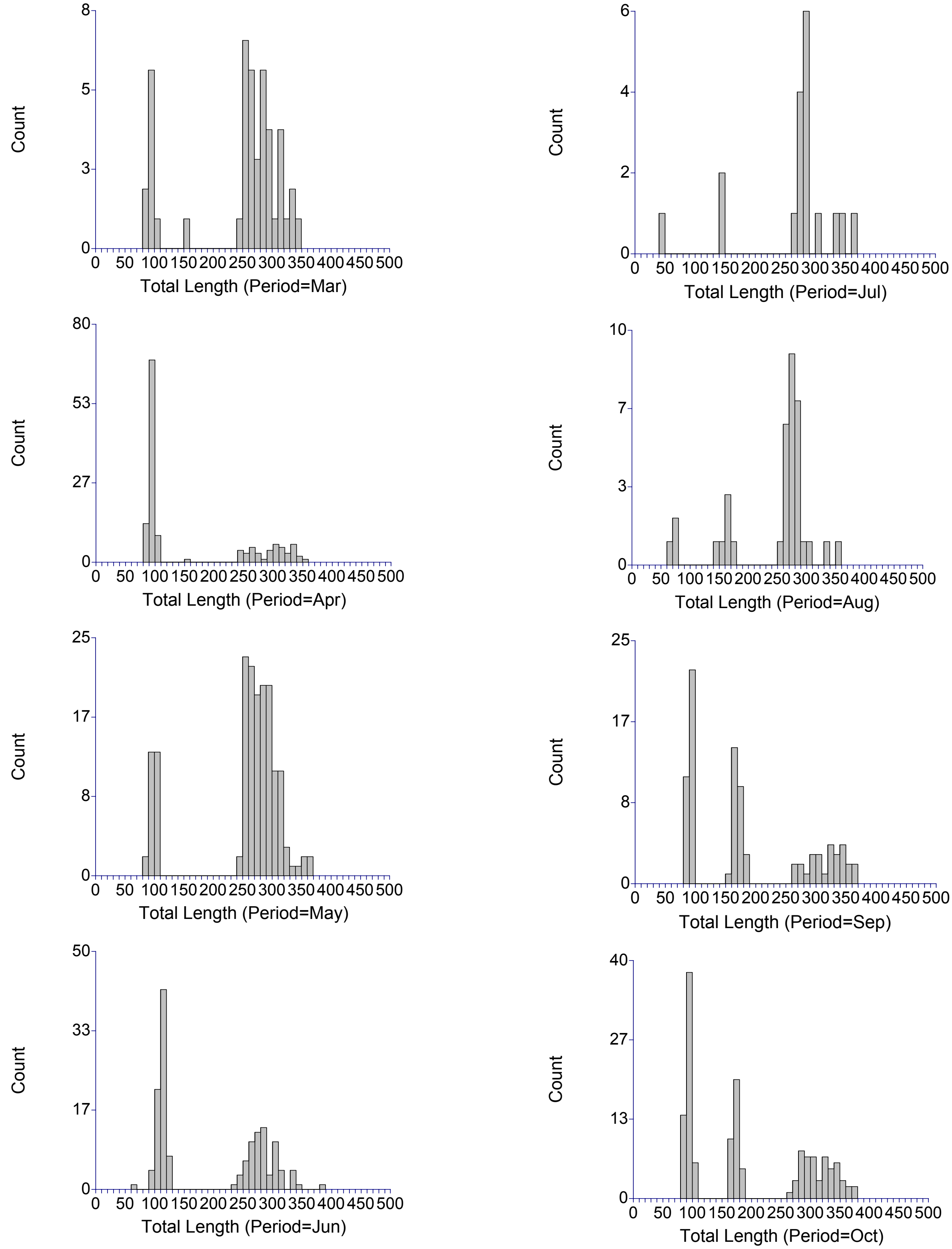


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (4 of 6)

Northern pikeminnow

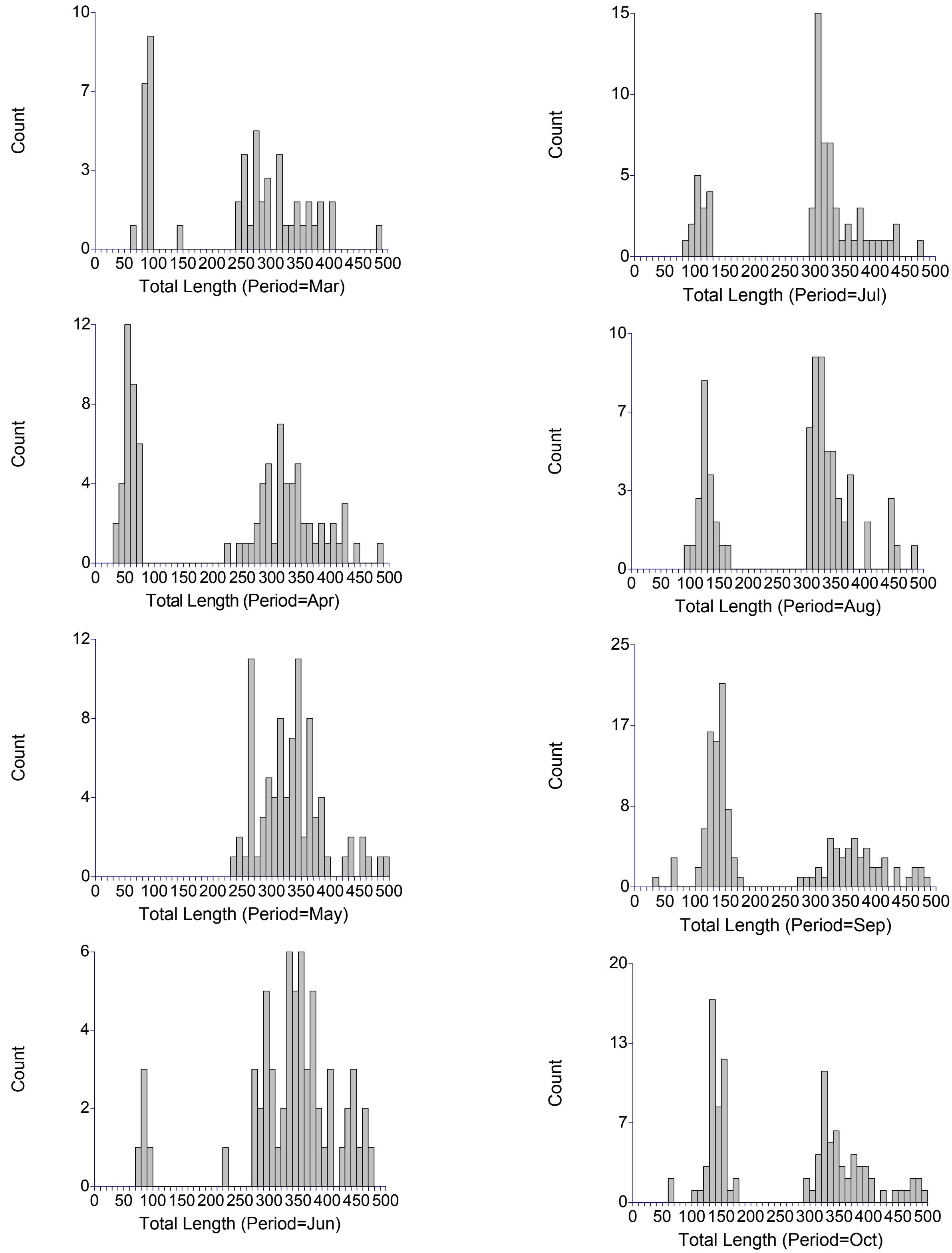


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (5 of 6)

Rainbow trout all reaches and tributaries combined

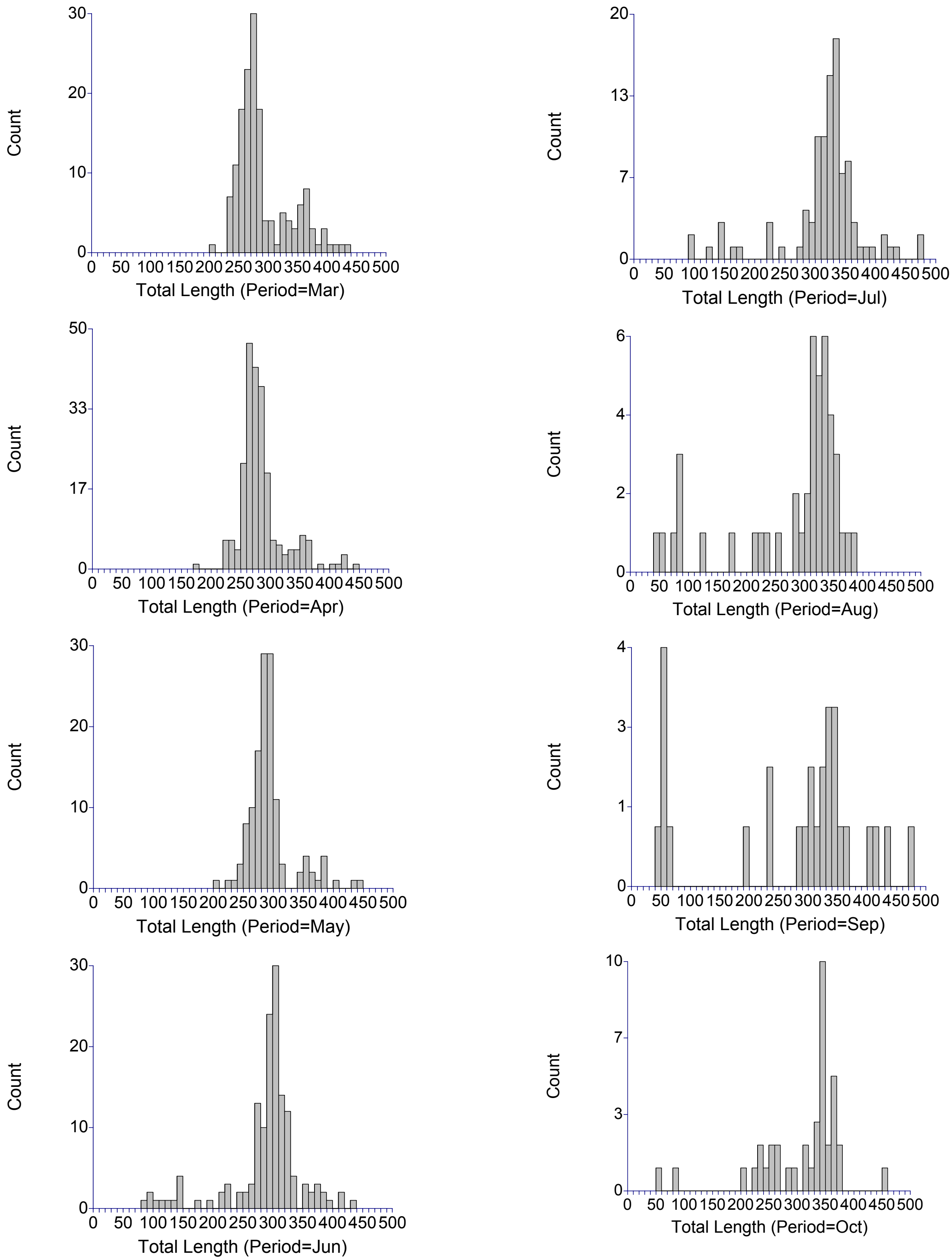


Figure A.2-1. Monthly length frequency distribution of mountain whitefish, cutthroat trout, smallmouth bass, peamouth, northern pikeminnow, and rainbow trout of fish captured within the Boundary Project during March through October, 2007. (6 of 6)

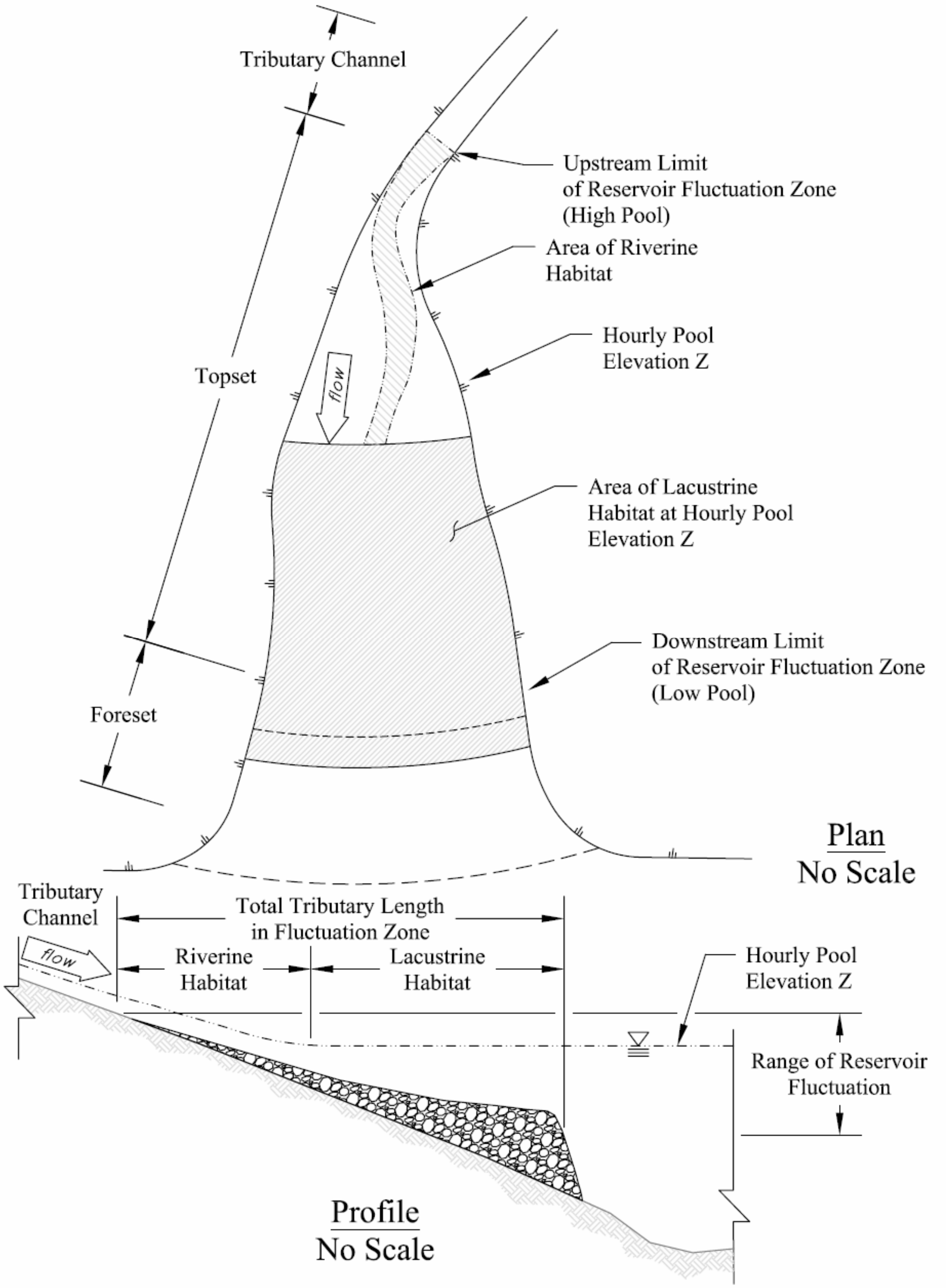


Figure A.2-2. Conceptual model of tributary delta habitat, example of high and low flow conditions.

Table A.2-4. Between-month and reach comparisons of fyke netting catch (mean catch per unit effort as measured by fish per fyke net set time [hr])[1] in the Boundary Project during April through October 2007. Catch rate is computed by first calculating the CPUE for each sampling event at each site, and then computing the mean CPUE for each combination of species, reach and month.

Species	Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Tailrace																
Smallmouth bass	No sample		0	(0.00)	1	(0.04)	0	(0.00)	1	(0.04)	1	(0.03)	0	(0.00)	3	(0.03)
Pumpkinseed			0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
All Species			**0**	**(0.00)**	**1**	**(0.04)**	**1**	**(0.04)**	**1**	**(0.04)**	**1**	**(0.03)**	**0**	**(0.00)**	**4**	**(0.04)**
Forebay																
Rainbow trout [2]	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	1	(0.01)
Largescale sucker	23	(0.96)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	23	(0.32)
Northern pikeminnow	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Pumpkinseed	2	(0.08)	0	(0.00)	27	(1.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	29	(0.36)
Tench	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Yellow perch	17	(0.71)	0	(0.00)	42	(1.56)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	59	(0.75)
All Species	**42**	**(1.75)**	**0**	**(0.00)**	**71**	**(2.63)**	**0**	**(0.00)**	**1**	**(0.04)**	**0**	**(0.00)**	**0**	**(0.00)**	**114**	**(1.47)**
Canyon																
Brown bullhead	0	(0.00)	0	(0.00)	2	(0.07)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
Rainbow trout [2]	0	(0.00)	5	(0.20)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	6	(0.04)
Rainbow trout [3]	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	6	(0.25)	2	(0.08)	0	(0.00)	8	(0.05)
Largescale sucker	4	(0.17)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.03)
Longnose sucker	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)
Pumpkinseed	2	(0.08)	0	(0.00)	5	(0.18)	2	(0.07)	3	(0.13)	1	(0.04)	0	(0.00)	13	(0.08)
Tench	0	(0.00)	0	(0.00)	4	(0.15)	30	(1.06)	0	(0.00)	1	(0.04)	0	(0.00)	35	(0.21)
Yellow perch	0	(0.00)	2	(0.08)	20	(0.73)	8	(0.28)	15	(0.63)	0	(0.00)	0	(0.00)	45	(0.29)
All Species	**6**	**(0.25)**	**8**	**(0.32)**	**31**	**(1.14)**	**41**	**(1.45)**	**25**	**(1.04)**	**4**	**(0.15)**	**0**	**(0.00)**	**115**	**(0.73)**
Upper Reservoir																
Black crappie	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	9	(0.46)	39	(0.80)	48	(0.19)
Brown bullhead	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	8	(0.41)	0	(0.00)	8	(0.04)
Burbot	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	1	(0.00)
Largemouth bass	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	2	(0.01)

Table A.2-4, continued…

Species	Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
Upper Reservoir																
Smallmouth bass	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.07)	28	(1.17)	3	(0.15)	5	(0.10)	39	(0.15)
Largescale sucker	232	(4.89)	0	(0.00)	0	(0.00)	2	(0.03)	6	(0.25)	8	(0.41)	4	(0.03)	252	(0.96)
Longnose sucker	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	2	(0.10)	0	(0.00)	3	(0.01)
Northern pike	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Northern pikeminnow	30	(0.59)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.04)	0	(0.00)	10	(0.20)	41	(0.15)
Peamouth	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.05)	0	(0.00)	1	(0.00)
Pumpkinseed	5	(0.10)	4	(0.08)	1	(0.05)	8	(0.18)	14	(0.58)	31	(1.59)	31	(0.62)	94	(0.38)
Sucker sp	2	(0.04)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)
Tench	4	(0.08)	0	(0.00)	0	(0.00)	67	(0.96)	9	(0.38)	17	(0.87)	5	(0.09)	102	(0.32)
Yellow perch	231	(4.90)	0	(0.00)	5	(0.25)	2	(0.03)	61	(2.54)	24	(1.23)	5	(0.10)	328	(1.28)
All Species	**506**	**(10.65)**	**4**	**(0.08)**	**6**	**(0.30)**	**83**	**(1.28)**	**119**	**(4.96)**	**105**	**(5.38)**	**99**	**(1.95)**	**922**	**(3.51)**
Sand Creek																
Cutthroat trout [4]			0	(0.00)	2	(0.01)									2	(0.01)
Brown trout			0	(0.00)	1	(0.01)									1	(0.00)
Rainbow trout [2]			2	(0.03)	0	(0.00)									2	(0.01)
Rainbow trout [3]			0	(0.00)	5	(0.03)									5	(0.02)
All Species			**2**	**(0.03)**	**8**	**(0.06)**									**10**	**(0.05)**
Slate Creek																
Cutthroat trout [4]				(0.00)	1	(0.01)	12	(0.08)	4	(0.03)	14	(0.07)	3	(0.02)	34	(0.05)
Rainbow trout [3]			0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	1	(0.00)
All Species			**0**	**(0.00)**	**1**	**(0.01)**	**12**	**(0.08)**	**5**	**(0.03)**	**14**	**(0.07)**	**3**	**(0.02)**	**35**	**(0.04)**
Sullivan Creek																
Burbot			0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	1	(0.00)
Cutthroat trout [4]			0	(0.00)	0	(0.00)	0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	1	(0.00)
Brown trout			0	(0.00)	0	(0.00)	1	(0.02)	4	(0.03)	0	(0.00)	0	(0.00)	5	(0.01)
Rainbow trout [2]			0	(0.00)	0	(0.00)	0	(0.00)	7	(0.05)	0	(0.00)	2	(0.01)	9	(0.01)
Largescale sucker				(0.00)	0	(0.00)	4	(0.09)	1	(0.01)	1	(0.01)	0	(0.00)	6	(0.02)
Longnose dace			0	(0.00)	3	(0.02)	9	(0.16)	3	(0.02)	2	(0.01)	1	(0.01)	18	(0.04)
Mountain whitefish				(0.00)	0	(0.00)	0	(0.00)	48	(0.33)	1	(0.01)	0	(0.00)	49	(0.07)
Northern pikeminnow				(0.00)	0	(0.00)	1	(0.02)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)
Redside shiner			0	(0.00)	4	(0.03)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.01)
Sculpin sp			0	(0.00)	4	(0.03)	3	(0.02)	5	(0.03)	5	(0.03)	1	(0.01)	18	(0.02)
Sucker sp			0	(0.00)	1	(0.01)	0	(0.00)	4	(0.03)	1	(0.01)	0	(0.00)	6	(0.01)
Tench			0	(0.00)	1	(0.01)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)

Table A.2-4, continued…

	Species	Apr		May		Jun		Jul		Aug		Sep		Oct		Total	
	All Species			**0**	**(0.00)**	**13**	**(0.09)**	**18**	**(0.31)**	**74**	**(0.51)**	**10**	**(0.07)**	**4**	**(0.03)**	**119**	**(0.20)**
Sweet Creek																	
	Cutthroat trout [4]				(0.00)	0	(0.00)	3	(0.02)	19	(0.13)	10	(0.05)	3	(0.04)	35	(0.06)
	Brown trout			0	(0.00)	0	(0.00)	0	(0.00)	6	(0.04)	0	(0.00)	0	(0.00)	6	(0.01)
	Rainbow trout [2]			0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)	6	(0.04)	0	(0.00)	8	(0.02)
	Rainbow trout [3]			0	(0.00)	0	(0.00)	0	(0.00)	2	(0.01)	0	(0.00)	0	(0.00)	2	(0.00)
	Mountain whitefish				(0.00)	0	(0.00)	23	(0.16)	1	(0.01)	0	(0.00)	0	(0.00)	24	(0.05)
	Sculpin sp			0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.00)	0	(0.00)	1	(0.00)
	All Species			**0**	**(0.00)**	**0**	**(0.00)**	**26**	**(0.18)**	**30**	**(0.20)**	**17**	**(0.10)**	**3**	**(0.04)**	**76**	**(0.15)**

Notes:

1 For tributary fyke nets: mean catch per unit effort measured by fish per percent total tributary flow per set time (hr).

2 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids).

3 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries.

4 Exhibited characteristics indicative of the westslope variety.

Tributary fyke nets were first available in May; No tributary fyke net sampling conducted in April.

Sand Creek fyke netting was discontinued in July, as streamflow infiltrated the channel.

Table A.2-5. Between-month comparisons of day and night snorkel observations in the Tailrace Reach of the Boundary Project during March through October 2007.

Day Period	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Tailrace Total	**48**	**181**	**161**	**111**	**92**	**203**	**127**	**121**	**1044**
Day	***0***	***70***	***72***	***54***	***48***	***80***	***70***	***60***	***454***
Largescale sucker		62	23	33	6	9	54	49	**236**
Smallmouth bass			6	6	31	68	1		**112**
Rainbow trout [1]		5	20	5	6	3	12	6	**57**
Northern pikeminnow		1	12	2	3			5	**23**
Yellow perch		2	10	6	1				**19**
Rainbow trout[2]				1			2		**3**
Mountain whitefish			1						**1**
Brook trout							1		**1**
Pumpkinseed					1				**1**
Walleye				1					**1**
Night	***48***	***111***	***89***	***57***	***44***	***123***	***57***	***61***	***590***
Largescale sucker	4	92	43	28	6	9	44	47	**273**
Smallmouth bass		1	3	3	30	110	1		**148**
Rainbow trout [1]	38	9	14	6	5	4	11	9	**96**
Northern pikeminnow	2	2	19	5	1			1	**30**
Yellow perch	1	3	7	12	1				**24**
Mountain whitefish	3	1	1					2	**7**
Unidentified trout		2	2						**4**
Cutthroat trout[3]								2	**2**
Rainbow trout[2]				2					**2**
Walleye		1		1					**2**
Brook trout							1		**1**
Pumpkinseed					1				**1**

Notes:

1 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids)

2 Exhibited characteristics indicative of naturally reared, non-hatchery rainbow trout captured below Boundary Dam that may be descendants of redband trout

3 Exhibited characteristics indicative of the westslope cutthroat trout variety

Table A.2-6. Between-month and reach comparisons of night snorkel observations in the tributaries of the Boundary Reservoir during March through October 2007.

Tributary	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Tributaries Total	**15**	**22**	**56**	**147**	**231**	**251**	**278**	**51**	**1051**
Sullivan	**7**	**0**	**9**	**27**	**42**	**96**	**194**	**17**	**392**
Inundated Delta			***3***	***11***	***17***	***74***	***157***	***2***	***264***
Sucker sp				4	4	65	150		**223**
Largescale sucker			3	5	12			2	**22**
Rainbow trout [1]						6(6)	4(4)		**10(10)**
Smallmouth bass				1		2	2		**5**
Cutthroat trout[2]						1(1)	1(1)		**2(2)**
Peamouth				1	1				**2**
Channel	***7***	***0***	***6***	***16***	***25***	***22***	***37***	***15***	***128***
Rainbow trout [3]				4(0)	14(1)	8(0)	23(5)	2(2)	**51(8)**
Rainbow trout [1]			6 (6)	10(4)	1(1)	4(4)			**21(15)**
Cutthroat trout[2]				2(2)	3(0)	3(1)	6(2)	6(0)	**20(5)**
Brown trout	2(0)					5(1)	5(3)	3(1)	**15(15)**
Unidentified trout	5 (1)				5(0)				**10**
Largescale sucker					2	1	1	4	**8**
Brook trout						1(1)	1(1)		**2(2)**
Unidentified char [4]							1(1)		**1(1)**
Flume	**0**	**4**	**0**	**19**	**92**	**69**	**18**	**8**	**210**
Inundated Delta	***0***	***0***	***0***	***6***	***73***	***53***	***7***	***1***	***140***
Smallmouth bass				6	36	29	7	1	**79**
Rainbow trout [1]					27(27)	20(20)			**47(47)**
Largescale sucker					8	4			**12**
Lake trout					2(2)				**2(2)**
Channel	***0***	***4***	***0***	***13***	***19***	***16***	***11***	***7***	***70***
Brook trout		4(0)		13(3)	18(5)	14(8)	9(4)	7(4)	**65(24)**
Rainbow trout [1]					1(1)	2(2)			**3(3)**
Rainbow trout [3]							2(0)		**2(0)**
Sand	**1**	**2**	**9**	**16**					**28**
Inundated Delta	***0***	***0***	***0***	***0***					***0***
Channel	***1***	***2***	***9***	***16***					***28***
Cutthroat trout[2]	1(0)	1(0)	2(0)	16(0)	Did not sample during July through October; no direct river connection				**20(0)**
Unidentified trout			5(1)						**5(1)**
Rainbow trout [1]			2(2)						**2(2)**
Rainbow trout [3]		1(0)							**1**
Slate	**7**	**16**	**32**	**67**	**87**	**67**	**56**	**21**	**353**
Inundated Delta	***0***	***0***	***13***	***18***	***20***	***19***	***5***	***2***	***77***

Table A.2-6, continued…

Tributary	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Smallmouth bass				14	16	5		1	**36**
Rainbow trout [1]				2(2)	3(3)	14(14)	3(3)	1(1)	**23(23)**
Sucker sp			12						**12**
Largescale sucker				1			2		**3**
Northern pikeminnow			1	1	1				**3**
Channel	***7***	***16***	***19***	***49***	***67***	***48***	***51***	***19***	***276***
Cutthroat trout[2]	7(2)	15(7)	16(3)	44(2)	61(5)	47(6)	46(4)	18(3)	**254(32)**
Brook trout			1(0)	5(1)	6(1)		4(0)	1(0)	**17(2)**
Brown trout						1(1)	1(1)		**2(2)**
Northern pikeminnow			2						**2**
Peamouth		1							**1**
Sweet	**0**	**0**	**6**	**18**	**10**	**19**	**10**	**5**	**68**
Inundated Delta	***0***	***0***	***0***	***4***				***0***	***4***
Cutthroat trout[2]				1(1)					**1(1)**
Brown trout				1(1)					**1(1)**
Largescale sucker				1					**1**
Rainbow trout [1]				1(1)	48[5](48)	37[5](37)	8[5](8)	0	**1(1)**
Smallmouth bass					11[5]	6[5]			
Channel	***0***	***0***	***6***	***14***	***10***	***19***	***10***	***5***	***64***
Cutthroat trout[2]				12(2)		5(0)	3(0)	3(0)	**23(2)**
Rainbow trout [3]					1(0)	8(0)	6(0)		**15(0)**
Rainbow trout [1]					8(2)	6(0)			**14(2)**
Brown trout				2(1)	1(1)		1(0)	2(0)	**6(2)**
Unidentified trout			6(6)						**6(0)**

Notes:

1 Exhibited characteristics indicative of hatchery reared rainbow trout (triploids)
2 Exhibited characteristics indicative of the westslope cutthroat trout variety
3 Exhibited characteristics indicative of naturally reared rainbow trout in Boundary Reservoir and tributaries
4 Specimen observed in Sullivan Creek during snorkel survey with characteristics indicative of a bull trout, but not confirmed through capture
5 Observed from the boat deck in the inundated delta at the stream mouth and not included in the total snorkel observation counts

Numbers in parentheses represent the number of salmonids observed that month within the tributary study reach that were estimated to exceed 250 mm TL.

Observations listed under Inundated Delta were observed within the mainstem reservoir pool adjacent or in the stream mouth immediately adjacent to the reservoir.

Observations listed under Channel were observed within study stream upstream of the mainstem reservoir pool at the time of survey.

Very Poor Visibility in Tributary

Moderate Visibility in Tributary

Table A.2-7. Anchor tag deployment information on sport fishes during the March through October 2007 fish sampling program on the Boundary Project.

Species Code	Total Length (mm)	Tag No.	Method	Date	Capture Site	Project Reach
Burbot	482	74094	GN	15-Apr-07	C5GN	Canyon
Burbot	599	74574	GN	16-May-07	UR1GN	Upper Reservoir
Brook trout	269	74980	GN	6-Jun-07	UR5GN	Upper Reservoir
Brown trout	430	74077	EF	27-Apr-07	C2E	Canyon
Brown trout	403	74079	EF	27-Apr-07	C2E	Canyon
Brown trout	320	74091	EF	25-Apr-07	UR4E	Upper Reservoir
Brown trout	309	74557	EF	28-Apr-07	T3En	Tailrace
Brown trout	509	74836	EF	28-Jul-07	UR5E	Upper Reservoir
Brown trout	540	74837	EF	28-Jul-07	UR9E	Upper Reservoir
Brown trout	374	74845	EF	21-Aug-07	F2E	Forebay
Brown trout	441	74877	EF	18-Oct-07	UR6E	Upper Reservoir
Brown trout	326	74880	EF	18-Oct-07	UR1E	Upper Reservoir
Brown trout	497	74882	GN	23-Oct-07	Sweet delta	Upper Reservoir
Brown trout	545	74899	EF	16-Oct-07	F4E	Forebay
Brown trout	387	74940	EF	20-Jun-07	UR6E	Upper Reservoir
Brown trout	446	74949	EF	21-Jun-07	T1En	Tailrace
Brown trout	423	74950	EF	21-Jun-07	T1En	Tailrace
Brown trout	379	74982	GN	12-Jun-07	Beast delta	Forebay
Brown trout	531	orange 6224	EF	10-Mar-07	UR7E	Upper Reservoir
Brown trout	495	orange 6860	EF	9-Mar-07	UR2E	Upper Reservoir
Brown trout	338	yellow 6111	EF	11-Mar-07	C3E	Canyon
Largemouth bass	336	74879	EF	18-Oct-07	UR8E	Upper Reservoir
Largemouth bass	372	74886	GN	23-Oct-07	UR4GN	Upper Reservoir
Largemouth bass	387	74897	GN	23-Oct-07	UR3GNA	Upper Reservoir
Lake trout	449	74023	GN	16-May-07	UR2GN	Upper Reservoir
Lake trout	435	74976	GN	4-Jun-07	C5GN	Canyon
Lake trout	616	74979	GN	6-Jun-07	Sand Delta	Upper Reservoir
Lake trout	486	74984	AN	14-Jun-07	Slate delta AN	Canyon
Northern pike	468	74022	GN	16-May-07	UR4GN	Upper Reservoir
Northern pike	499	74025	GN	16-May-07	UR1GN	Upper Reservoir
Northern pike	786	74100	GN	13-Apr-07	UR2GN	Upper Reservoir
Northern pike	615	74544	GN	23-Oct-07	UR4GN	Upper Reservoir
Northern pike	725	74888	GN	23-Oct-07	UR3GNA	Upper Reservoir
Northern pike	670	74889	GN	23-Oct-07	UR3GNA	Upper Reservoir
Northern pike	673	74890	GN	23-Oct-07	UR3GNA	Upper Reservoir
Northern pike	636	74896	GN	23-Oct-07	UR3GNA	Upper Reservoir
Rainbow trout	275	74056	GN	20-May-07	F3GN	Forebay
Rainbow trout	281	74057	GN	20-May-07	F3GN	Forebay
Rainbow trout	277	74058	GN	20-May-07	F3GN	Forebay
Rainbow trout	274	74059	GN	20-May-07	F3GN	Forebay

Table A.2-7, continued…

Species Code	Total Length (mm)	Tag No.	Method	Date	Capture Site	Project Reach
Rainbow trout	289	74060	GN	20-May-07	F3GN	Forebay
Rainbow trout	295	74061	GN	20-May-07	F3GN	Forebay
Rainbow trout	310	74062	GN	20-May-07	Beast delta	Forebay
Rainbow trout	263	74098	GN	13-Apr-07	Wolf Delta	Upper Reservoir
Rainbow trout	599	74981	GN	6-Jun-07	Sweet delta	Upper Reservoir
Smallmouth Bass	303	74001	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	289	74002	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	259	74003	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	330	74004	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	304	74005	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	272	74006	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	392	74007	EF	27-Apr-07	C3E	Canyon
Smallmouth Bass	290	74008	EF	28-Apr-07	C6E	Canyon
Smallmouth Bass	292	74009	EF	28-Apr-07	C6E	Canyon
Smallmouth Bass	310	74010	EF	28-Apr-07	T3Ed	Tailrace
Smallmouth Bass	355	74012	EF	28-Apr-07	T3Ed	Tailrace
Smallmouth Bass	276	74013	EF	28-Apr-07	T3Ed	Tailrace
Smallmouth Bass	271	74019	GN	16-May-07	UR2GN	Upper Reservoir
Smallmouth Bass	358	74021	GN	16-May-07	UR4GN	Upper Reservoir
Smallmouth Bass	331	74026	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	305	74027	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	319	74028	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	287	74029	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	279	74030	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	294	74031	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	294	74032	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	301	74033	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	289	74034	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	296	74035	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	297	74036	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	276	74037	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	293	74038	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	271	74039	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	259	74040	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	279	74041	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	275	74042	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	285	74045	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	322	74046	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	330	74047	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	290	74048	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	255	74050	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	339	74054	GN	18-May-07	UR4GN	Upper Reservoir
Smallmouth Bass	309	74056	AN	20-May-07	Beast delta	Forebay
Smallmouth Bass	289	74064	GN	20-May-07	F2GN	Forebay
Smallmouth Bass	359	74066	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	289	74067	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	334	74068	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	293	74069	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	282	74070	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	274	74071	EF	21-May-07	T3En	Tailrace

Table A.2-7, continued…

Species Code	Total Length (mm)	Tag No.	Method	Date	Capture Site	Project Reach
Smallmouth Bass	301	74072	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	342	74073	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	301	74074	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	314	74075	EF	21-May-07	T3En	Tailrace
Smallmouth Bass	344	74078	EF	27-Apr-07	C2E	Canyon
Smallmouth Bass	295	74080	EF	27-Apr-07	C2E	Canyon
Smallmouth Bass	305	74081	EF	27-Apr-07	C2E	Canyon
Smallmouth Bass	251	74082	EF	27-Apr-07	C1E	Canyon
Smallmouth Bass	286	74083	EF	27-Apr-07	C1E	Canyon
Smallmouth Bass	297	74084	EF	26-Apr-07	F4E	Forebay
Smallmouth Bass	307	74085	EF	26-Apr-07	F4E	Forebay
Smallmouth Bass	304	74087	EF	26-Apr-07	F4E	Forebay
Smallmouth Bass	304	74088	EF	26-Apr-07	F4E	Forebay
Smallmouth Bass	317	74089	EF	26-Apr-07	F4E	Forebay
Smallmouth Bass	352	74093	EF	24-Apr-07	UR2E	Upper Reservoir
Smallmouth Bass	306	74096	EF	27-Apr-07	C2E	Canyon
Smallmouth Bass	301	74500	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	383	74545	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	370	74547	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	380	74549	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	301	74551	EF	28-Apr-07	T3En	Tailrace
Smallmouth Bass	334	74553	EF	28-Apr-07	T3En	Tailrace
Smallmouth Bass	287	74554	EF	28-Apr-07	T3En	Tailrace
Smallmouth Bass	309	74555	EF	28-Apr-07	T3En	Tailrace
Smallmouth Bass	298	74556	EF	28-Apr-07	T3En	Tailrace
Smallmouth Bass	330	74558	EF	28-Apr-07	T4En	Tailrace
Smallmouth Bass	321	74559	EF	28-Apr-07	T4En	Tailrace
Smallmouth Bass	335	74560	EF	28-Apr-07	T4En	Tailrace
Smallmouth Bass	262	74561	EF	28-Apr-07	T4En	Tailrace
Smallmouth Bass	276	74562	EF	28-Apr-07	T4En	Tailrace
Smallmouth Bass	276	74563	EF	29-Apr-07	T2En	Tailrace
Smallmouth Bass	292	74564	EF	29-Apr-07	T2En	Tailrace
Smallmouth Bass	494	74565	EF	29-Apr-07	T2En	Tailrace
Smallmouth Bass	315	74570	EF	29-Apr-07	T1En	Tailrace
Smallmouth Bass	289	74572	EF	29-Apr-07	T1En	Tailrace
Smallmouth Bass	318	74573	GN	16-May-07	Wolf Delta	Upper Reservoir
Smallmouth Bass	274	74575	GN	16-May-07	UR1GN	Upper Reservoir
Smallmouth Bass	284	74576	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	373	74577	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	282	74578	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	286	74579	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	295	74580	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	256	74581	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	282	74582	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	280	74583	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	266	74584	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	250	74585	EF	22-May-07	T1En	Tailrace
Smallmouth Bass	358	74586	EF	22-May-07	T2En	Tailrace
Smallmouth Bass	270	74587	EF	22-May-07	T2En	Tailrace
Smallmouth Bass	286	74588	EF	22-May-07	T2En	Tailrace

Table A.2-7, continued…

Species Code	Total Length (mm)	Tag No.	Method	Date	Capture Site	Project Reach
Smallmouth Bass	382	74589	EF	22-May-07	T2En	Tailrace
Smallmouth Bass	266	74590	EF	22-May-07	T2En	Tailrace
Smallmouth Bass	267	74592	EF	22-May-07	T2En	Tailrace
Smallmouth Bass	284	74594	EF	22-May-07	C2E	Canyon
Smallmouth Bass	296	74595	EF	22-May-07	C2E	Canyon
Smallmouth Bass	305	74597	EF	22-May-07	C3E	Canyon
Smallmouth Bass	281	74598	EF	22-May-07	C3E	Canyon
Smallmouth Bass	285	74599	EF	22-May-07	C3E	Canyon
Smallmouth Bass	265	74600	EF	22-May-07	C3E	Canyon
Smallmouth Bass	321	74826	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	299	74827	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	335	74828	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	278	74829	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	298	74830	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	322	74831	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	295	74832	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	253	74833	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	259	74834	EF	27-Jul-07	UR1E	Upper Reservoir
Smallmouth Bass	394	74835	EF	27-Jul-07	UR2E	Upper Reservoir
Smallmouth Bass	322	74839	GN	11-Aug-07	F5GN	Forebay
Smallmouth Bass	324	74840	GN	13-Aug-07	C3GN	Canyon
Smallmouth Bass	331	74843	EF	21-Aug-07	F1E	Forebay
Smallmouth Bass	346	74844	EF	21-Aug-07	F1E	Forebay
Smallmouth Bass	323	74848	EF	21-Sep-07	F1E	Forebay
Smallmouth Bass	348	74849	GN	26-Sep-07	UR3GNA	Upper Reservoir
Smallmouth Bass	398	74850	GN	1-Oct-07	C1GN	Canyon
Smallmouth Bass	480	74876	EF	18-Oct-07	UR6E	Upper Reservoir
Smallmouth Bass	369	74878	EF	18-Oct-07	UR7E	Upper Reservoir
Smallmouth Bass	373	74881	EF	18-Oct-07	UR4E	Upper Reservoir
Smallmouth Bass	353	74883	GN	23-Oct-07	UR4GN	Upper Reservoir
Smallmouth Bass	353	74884	GN	23-Oct-07	UR4GN	Upper Reservoir
Smallmouth Bass	338	74885	GN	23-Oct-07	UR4GN	Upper Reservoir
Smallmouth Bass	342	74887	GN	23-Oct-07	UR4GN	Upper Reservoir
Smallmouth Bass	334	74891	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	356	74892	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	383	74893	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	379	74894	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	426	74895	GN	23-Oct-07	UR3GNA	Upper Reservoir
Smallmouth Bass	252	74926	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	281	74927	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	320	74928	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	304	74929	EF	19-Jun-07	UR2E	Upper Reservoir
Smallmouth Bass	414	74930	EF	19-Jun-07	UR2E	Upper Reservoir
Smallmouth Bass	342	74931	EF	19-Jun-07	UR2E	Upper Reservoir
Smallmouth Bass	305	74932	EF	19-Jun-07	UR2E	Upper Reservoir
Smallmouth Bass	320	74933	EF	19-Jun-07	UR3E	Upper Reservoir
Smallmouth Bass	287	74934	EF	19-Jun-07	UR3E	Upper Reservoir
Smallmouth Bass	325	74935	EF	19-Jun-07	UR3E	Upper Reservoir
Smallmouth Bass	259	74936	EF	19-Jun-07	UR3E	Upper Reservoir
Smallmouth Bass	381	74937	EF	19-Jun-07	UR4E	Upper Reservoir

Table A.2-7, continued…

Species Code	Total Length (mm)	Tag No.	Method	Date	Capture Site	Project Reach
Smallmouth Bass	292	74938	EF	19-Jun-07	UR4E	Upper Reservoir
Smallmouth Bass	387	74939	EF	19-Jun-07	UR4E	Upper Reservoir
Smallmouth Bass	317	74941	EF	20-Jun-07	UR6E	Upper Reservoir
Smallmouth Bass	299	74943	EF	20-Jun-07	UR7E	Upper Reservoir
Smallmouth Bass	272	74944	EF	20-Jun-07	UR7E	Upper Reservoir
Smallmouth Bass	307	74945	EF	20-Jun-07	F4E	Forebay
Smallmouth Bass	253	74946	EF	20-Jun-07	F4E	Forebay
Smallmouth Bass	291	74948	EF	20-Jun-07	F2E	Forebay
Smallmouth Bass	285	74986	GN	14-Jun-07	F4GN	Forebay
Smallmouth Bass	310	74987	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	287	74988	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	289	74989	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	260	74990	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	315	74991	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	291	74992	EF	18-Jun-07	C3E	Canyon
Smallmouth Bass	263	74993	EF	18-Jun-07	C4E	Canyon
Smallmouth Bass	254	74994	EF	18-Jun-07	C4E	Canyon
Smallmouth Bass	289	74995	EF	19-Jun-07	C5E	Canyon
Smallmouth Bass	281	74996	EF	19-Jun-07	C7E	Canyon
Smallmouth Bass	334	74997	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	332	74998	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	295	74999	EF	19-Jun-07	UR1E	Upper Reservoir
Smallmouth Bass	282	94942	EF	20-Jun-07	UR6E	Upper Reservoir
Walleye	561	74014	EF	28-Apr-07	T3Ed	Tailrace
Walleye	332	74092	EF	24-Apr-07	UR2E	Upper Reservoir
Walleye	515	74475	GN	23-Oct-07	Sweet delta	Upper Reservoir
Walleye	505	74552	EF	28-Apr-07	T3En	Tailrace
Walleye	640	74566	EF	29-Apr-07	T1En	Tailrace
Walleye	598	74567	EF	29-Apr-07	T1En	Tailrace
Walleye	469	74568	EF	29-Apr-07	T1En	Tailrace
Walleye	505	74569	EF	29-Apr-07	T1En	Tailrace
Walleye	500	74571	EF	29-Apr-07	T1En	Tailrace
Walleye	463	74951	GN	5-Jul-07	UR1GN	Upper Reservoir
Walleye	562	74952	GN	5-Jul-07	UR1GN	Upper Reservoir
Walleye	494	74972	GN	23-Oct-07	UR2GN	Upper Reservoir
Walleye	492	74973	GN	23-Oct-07	UR2GN	Upper Reservoir
Walleye	546	74974	GN	23-Oct-07	UR2GN	Upper Reservoir

Appendix 3. Biotelemetry Results Data

Table A.3-1. Deployed radio and CART tags and status and fate of fish during Biotelemetry monitoring, April to September 2007.

Release information						Station Detections: Time and Location of last detection		Mobile Tracking: Time and Location of last detection		Condition Status and Fate of Fish	
Species	Tag Type	Radio tag code	Acoustic tag code	Release Site Reach	Release Date	Date & time	PRM	Date & time	PRM	Status	Evidence Code[2]
smallmouth bass	CH-TP11-18	14	1100	canyon	23-May-07	23-May-07 04:49	18	n/a[1]	n/a[1]	Suspect	5
smallmouth bass	CH-TP11-18	15	1200	upper reservoir	24-May-07	31-Jul-07 16:36	30.9	26-Sep-07 13:58	31.5	Alive	0
smallmouth bass	CH-TP11-18	16	1300	upper reservoir	24-May-07	n/a[1]	n/a[1]	n/a[1]	n/a[1]	Dead	7
smallmouth bass	CH-TP11-18	17	1400	canyon	23-May-07	26-Sep-07 05:47	30.9	26-Sep-07 13:11	31.1	Alive	0
smallmouth bass	CH-TP11-18	21	1800	upper reservoir	24-May-07	13-Sep-07 14:52	29.6	26-Sep-07 16:35	28.9	Alive	0
smallmouth bass	CH-TP11-18	22	1900	upper reservoir	24-May-07	3-Jun-07 09:48	29.6	25-May-07 12:33	27.7	Dead	3
smallmouth bass	CH-TP11-18	23	2000	upper reservoir	24-May-07	8-Sep-07 17:13	29.6	30-Aug-07 13:50	28.6	Alive	0
cutthroat trout	CH-TP11-18	24	2100	upper reservoir	24-May-07	18-Sep-07 10:57	30.9	30-Aug-07 17:00	32	Alive	0
smallmouth bass	CH-TP11-18	26	2300	forebay	10-Sep-07	10-Sep-07 16:48	17.9	n/a[1]	n/a[1]	Alive	0
smallmouth bass	CH-TP11-18	27	2400	forebay	14-Jun-07	14-Jul-07 13:33	18	19-Jun-07 18:00	18	Alive	0
smallmouth bass	CH-TP11-18	29	2600	forebay	10-Sep-07	14-Sep-07 22:28	18	25-Sep-07 18:11	17.5	Alive	0
smallmouth bass	CH-TP11-18	42	3900	forebay	10-Sep-07	24-Sep-07 20:11	18	25-Sep-07 17:11	17.8	Alive	0
cutthroat trout	CH-TP11-18	59	5600	tailrace	22-Jun-07	27-Sep-07 09:37	16.5	27-Sep-07 11:03	16.6	Suspect	4
smallmouth bass	CH-TP11-18	72	6900	upper reservoir	30-Aug-07	30-Aug-07 16:47	29.6	n/a[1]	n/a[1]	Alive	0
smallmouth bass	NTC-6-1	97		upper reservoir	05-May-07	n/a[1]	n/a[1]	26-Sep-07 16:55	28.1	Alive	0
smallmouth bass	NTC-6-2	98		upper reservoir	05-May-07	18-Aug-07 12:50	26.9	30-Aug-07 13:50	27.7	Alive	0
smallmouth bass	NTC-6-2	99		upper reservoir	05-May-07	25-Sep-07 12:44	26.6	18-Jul-07 13:12	34.1	Dead	7
smallmouth bass	NTC-6-2	101		upper reservoir	05-May-07	26-Sep-07 09:54	34.1	26-Sep-07 12:10	34.2	Alive	0
smallmouth bass	NTC-6-2	102		upper reservoir	05-May-07	13-Sep-07 07:50	26.6	18-Jul-07 17:48	28.6	Alive	0
smallmouth bass	NTC-6-2	103		upper reservoir	05-May-07	17-Jul-07 09:51	18	4-Jul-07 17:42	18	Alive	0
smallmouth bass	NTC-6-2	105		upper reservoir	05-May-07	26-Sep-07 08:24	29.6	26-Sep-07 15:05	29.4	Alive	0
smallmouth bass	NTC-6-2	106		upper reservoir	05-May-07	26-Sep-07 08:24	29.6	26-Sep-07 15:20	29.1	Alive	0
smallmouth bass	NTC-6-2	107		upper reservoir	05-May-07	28-May-07 06:59	29.6	26-Sep-07 16:44	28	Alive	0
char hybrid [3]	NTC-6-2	157		upper reservoir	26-Apr-07	n/a[1]	n/a[1]	26-Apr-07 15:24	31.4	Dead	4
northern pike	NTC-6-2	158		upper reservoir	30-Apr-07	26-Sep-07 08:24	29.6	30-Aug-07 13:50	28.6	Alive	0
mountain whitefish	NTC-6-2	159		upper reservoir	26-Apr-07	28-Apr-07 21:25	26.6	14-Aug-07 14:25	22.6	Suspect	6
mountain whitefish	NTC-6-2	160		upper reservoir	22-Jun-07	n/a[1]	n/a[1]	n/a[1]	n/a[1]	Suspect	5
cutthroat trout	NTC-6-2	176		tailrace	23-Sep-07	24-Sep-07 18:55	16	n/a[1]	n/a[1]	Alive	0
mountain whitefish	NTC-6-2	179		tailrace	22-May-07	25-Sep-07 00:29	16.5	8-Jun-07 10:46	16.6	Alive	0
cutthroat trout	NTC-6-1	181		upper reservoir	17-May-07	6-Aug-07 16:43	30.9	1-Aug-07 12:49	31.1	Alive	0
bull trout	NTC-6-1	184		tailrace	22-Jun-07	5-Jul-07 23:49	14	n/a[1]	n/a[1]	Alive	0

Notes:

[1] No detections or unreliable detection by fixed stations and mobile tracking.

[2] Evidence code — Evidence description
- 0 alive, movement recorded
- 1 tag recovered from river, above high water mark
- 2 tag recovered from river, below high water mark
- 3 tag not recovered, stationary, above high water mark
- 4 tag not recovered, stationary, below high water mark
- 5 location unknown, no or very few valid detections
- 6 continual downstream movement
- 7 tag returned by angler

[3] Field identified as a bull trout; genetic analysis indicated it was a F1 char hybrid

Table A.3-2. Tag implantation, surgery, and release information of native salmonids, smallmouth bass, and northern pike captured and radio tagged as part of the Biotelemetry monitoring, April to September, 2007.

Sample Number	Capture Site Reach	Capture Site	PRM Capture	Water Temp (ºC)	Species	Fork Length (mm)	Total Length (mm)	Weight (g)	Date of Surgery	Surgeon Initials	Radio tag tested (Y/N)	Tag Type	Radio Tag Frequency (MHz)	Radio Tag Code	Acoustic Tag Code	Streamer Tag No.	Tag Color	Fish Released with Tags? (Y/N)	Release Date	Release Time	Release Location	Release Site Reach	Comments/External Condition	PRM Release
91085	upper reservoir	UR6E, dwnstrm of Wolf Cr.	30.2	9	mountain whitefish	346		398	25-Apr-07	RM	y	NTC-6-2	151.4	159		26	red	Yes	26-Apr-07	13:35	Sand Cr delta	upper reservoir	recuperating @ 6.5°C	31.7
91086	upper reservoir	UR3E, upstrm of Sand Cr.	31.7	9	char hybrid [1]	318		347	25-Apr-07	RM	y	NTC-6-2	151.4	157		27	red	Yes	26-Apr-07	13:45	Sand Cr delta	upper reservoir	recuperating @ 6.5°C	31.7
91087	tailrace	T1E		8.7	brook trout [1]	235		118	29-Apr-07	RM	y	NTC-6-1	151.4	181		100	red	No					sacrificed, tag removed, held in 11C temperature of Sweet for 24 hrs.	
91088	upper reservoir	FYKE1, opposite bank from Metaline launch	27	9	northern pike	465		823	29-Apr-07	TL	y	NTC-6-2	151.4	158		28	red	Yes	30-Apr-07	3:00	Linton Cr delta	upper reservoir	suture healed well	28.5
91089	upper reservoir	Wolf GN	30.4	11.5	cutthroat trout	312		295	16-May-07	RM	y	NTC-6-1	151.4	181		29	red	Yes	17-May-07	1:00	Wolf Cr delta	upper reservoir	737-021 DNA	30.4
91090	tailrace	T1E	16.7	14	mountain whitefish	341		375	22-May-07	TL	y	NTC-6-2	151.4	179		30	red	Yes	22-May-07	4:00	tailrace	tailrace	recovered well	16.7
91091	canyon	C1E	26.3	13.5	smallmouth bass	328		526	23-May-07	RM	y	CH-TP11-18	151.4	17	1400	31	red	Yes	23-May-07	18:30	Flume Cr delta	canyon	very active	25.8
91092	canyon	C3E	25.2	13.5	smallmouth bass	325		571	23-May-07	RM	y	CH-TP11-18	151.4	14	1100	36	red	Yes	23-May-07	18:30	Flume Cr delta	canyon		25.8
91093	upper reservoir	UR4E	31.4	14	smallmouth bass	300		538	24-May-07	RM	y	CH-TP11-18	151.4	23	2000	38	red	Yes	24-May-07	18:25	UR4E,below high school	upper reservoir		31.4
91094	upper reservoir	UR2E	33.1	14	smallmouth bass	388		1058	24-May-07	TL	y	CH-TP11-18	151.4	16	1300	41	red	Yes	24-May-07	18:30	UR2E,across from Box Canyon motel	upper reservoir		33.1
91095	upper reservoir	UR8E	28.8	14	smallmouth bass	308		480	24-May-07	RM	y	CH-TP11-18	151.4	15	1200	42	red	Yes	24-May-07	18:35	UR6E, gravel islands	upper reservoir		30.2
91096	upper reservoir	UR1E	33.6	14	smallmouth bass	303		587	24-May-07	RM	y	CH-TP11-18	151.4	21	1800	44	red	Yes	24-May-07	18:40	UR1E, near USGS gaging tower	upper reservoir		33.6
91097	upper reservoir	UR6E	30.2	14	smallmouth bass	307		446	24-May-07	TL	y	CH-TP11-18	151.4	22	1900	43	red	Yes	24-May-07	18:00	Linton Cr, at Metaline park	upper reservoir		28.5
91098	upper reservoir	UR3E	31.7	14	cutthroat trout	395		689	24-May-07	TL	y	CH-TP11-18	151.4	24	2100	46	red	Yes	24-May-07	18:30	UR3E, just upstream of Sand Cr	upper reservoir		31.8
91099	upper reservoir	UR1E		14	mountain whitefish	357		512	24-May-07	RM	y	CH-TP11-18	151.4	27	2400	48	red	No					did not survive, tag removed	
91100	upper reservoir	UR1E		14	mountain whitefish	367		629	24-May-07	RM	y	CH-TP11-18	151.4	28	2500	49	red	No					did not survive, tag removed	
91105	forebay	Peewee Cr delta	17.9	13.7	smallmouth bass	363		864	14-Jun-07	RM	y	CH-TP11-18	151.4	27	2400	65	red	Yes	14-Jun-07	23:30	Peewee Cr	forebay	T309-523	17.9
91108	upper reservoir	UR7E,dwnstrm of Wolf Cr. left bank side		16	mountain whitefish	364		518	21-Jun-07	TL	y	CH-TP11-18	151.4	33	3000	69	red	No					sacrificed, tag removed, held in 11C temperature of Sweet for 24 hrs.	

Table A.3-2, continued...

Sample Number	Capture Site Reach	Capture Site	PRM Capture	Water Temp (ºC)	Species	Fork Length (mm)	Total Length (mm)	Weight (g)	Date of Surgery	Surgeon Initials	Radio tag tested (Y/N)	Tag Type	Radio Tag Frequency (MHz)	Radio Tag Code	Acoustic Tag Code	Streamer Tag No.	Tag Color	Fish Released with Tags? (Y/N)	Release Date	Release Time	Release Location	Release Site Reach	Comments/External Condition	PRM Release
91109	upper reservoir	UR7E,dwnstrm of Wolf Cr. left bank side	30.4	16	mountain whitefish	352		384	21-Jun-07	TL	y	NTC-6-2	151.4	160		71	red	Yes	22-Jun-07	2:15	Sweet Cr delta	upper reservoir	held in 11°C temp. overnight	30.9
91114	tailrace	Tailrace	16.5	15.5	cutthroat trout	357		499	22-Jun-07	DF	y	CH-TP11-18	151.4	59	5600	86	red	Yes	22-Jun-07	17:15	tailrace	tailrace	elected to release with cart tag	16.5
91115	tailrace	Tailrace	16.5	15.5	bull trout[2]	273		180	22-Jun-07	DF	y	NTC-6-1	151.4	184		87	red	Yes	22-Jun-07	17:15	tailrace	tailrace	lively at release	16.5
920002	upper reservoir	Above Met Falls	28.7	9.1	smallmouth bass		460	1619	5-May-07	DF	y	NTC-6-2	151.4	97		105	red	Yes	5-May-07	15:40	across from Met Fall Launch	upper reservoir	skin tearing, suturing difficult	28.1
920003	upper reservoir	Above Met Falls	28.7	9.1	smallmouth bass		410	1216	5-May-07	DF	y	NTC-6-2	151.4	98		107	red	Yes	5-May-07	15:40	across from Met Fall Launch	upper reservoir		28.1
920007	canyon	Canyon Reach	19.9	9.1	smallmouth bass		320	431	5-May-07	PG	y	NTC-6-2	151.4	99		112	red	Yes	5-May-07	17:39	just u/s of falls	upper reservoir	sitting for unknown length of time in live well; sitting in chlorinated water for long time at bar; this fish recovered and was released	26.9
920006	canyon	Canyon Reach		9.1	smallmouth bass		302	358	5-May-07	PG	y	NTC-6-2	151.4	100		110	red	No				upper reservoir	weak and small, sitting for unknown length of time in live well; sitting in chlorinated water for long time at bar; still not recovered fully after 2 hrs in fresh water; not released	26.9
920009	canyon	Canyon Reach	19.9	9.1	smallmouth bass		415	1093	5-May-07	PG	y	NTC-6-2	151.4	101		114	red	Yes	5-May-07	17:39	just u/s of falls	upper reservoir		26.9
920008	canyon	Canyon Reach	19.9	9.1	smallmouth bass		394	848	5-May-07	PG	y	NTC-6-2	151.4	102		113	red	Yes	5-May-07	17:39	just u/s of falls	upper reservoir		26.9
920010	canyon	Canyon Reach	19.9	9.1	smallmouth bass		427	1207	5-May-07	PG	y	NTC-6-2	151.4	103		118	red	Yes	5-May-07	17:39	just u/s of falls	upper reservoir		26.9
920004	upper reservoir	Above Met Falls	28.7	9.1	smallmouth bass		382	816	5-May-07	DF	y	NTC-6-2	151.4	105		109	red	Yes	5-May-07	15:40	across from Met Fall Launch	upper reservoir		28.1
920001	upper reservoir	Above Met Falls	28.7	9.1	smallmouth bass		490	1801	5-May-07	DF	y	NTC-6-2	151.4	106		103	red	Yes	5-May-07	15:40	across from Met Fall Launch	upper reservoir	red eyes, good condition, streamer tag put through rear dorsal; front dorsal too tough to fully penetrate without breaking tag	28.1
920005	upper reservoir	Above Met Falls	28.7	9.1	smallmouth bass		385	975	5-May-07	DF	y	NTC-6-2	151.4	107		108	red	Yes	5-May-07	15:40	across from Met Fall Launch	upper reservoir		28.1
91121	upper reservoir	UR7E	30	20.6	smallmouth bass	348		617	30-Aug-07	EC	y	CH-TP11-18	151.4	72	6900	119	red	Yes	30-Aug-07	22:00	UR7E, upper cell	upper reservoir	replacement tag for previously returned CART tag (16-1300); released healthy	30
91123	forebay	island in forebay	17.7	20	smallmouth bass	315		470	10-Sep-07	RM	y	CH-TP11-18	151.4	29	2600	122	red	Yes	10-Sep-07	21:00	forebay island	forebay		17.7
91124	forebay	near rb trib upstrm of log boom	17.1	20	smallmouth bass	334		542	10-Sep-07	RM	y	CH-TP11-18	151.4	42	3900	123	red	Yes	10-Sep-07	21:00	forebay island	forebay	recapture floy #74843	17.7

Table A.3-2, continued...

Sample Number	Capture Site Reach	Capture Site	PRM Capture	Water Temp (ºC)	Species	Fork Length (mm)	Total Length (mm)	Weight (g)	Date of Surgery	Surgeon Initials	Radio tag tested (Y/N)	Tag Type	Radio Tag Frequency (MHz)	Radio Tag Code	Acoustic Tag Code	Streamer Tag No.	Tag Color	Fish Rel with tags (Y/N)	Release Date	Release Time	Release Location	Release Site Reach	Comments/External Condition	PRM Release
91125	forebay	rb across from island	17.7	20	smallmouth bass	332		532	10-Sep-07	RM	y	CH-TP11-18	151.4	26	2300	121	red	Yes	10-Sep-07	21:00	forebay island	forebay		17.7
91128	tailrace	TR2E	16.3	16.6	cutthroat trout	308		292	23-Sep-07	RM	y	NTC-6-2	151.4	176		251	red	Yes	23-Sep-07	3:30	tailrace	tailrace	released healthy	16.3
91129	upper reservoir	below Box Canyon dam near gaging station	33.6	15	mountain whitefish	391		679	26-Sep-07	RM	y	CH-TP11-18	151.4	25	2200	154	red	Yes	27-Sep-07	3:30	below Box Canyon dam near gaging station	upper reservoir	released healthy	33.6

Notes:

1 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov. 14, 2007) identified specimen originally field-identified as bull trout as char hybrid and brook trout, as indicated.

2 Genetic analysis completed by the USFWS in November 2007 (P. DeHaan, USFWS, personal communication, Nov. 14, 2007) identified specimen as bull trout.

Table A.3-3. CART tag data for index species recorded during biotelemetry mobile tracking 26 April to 27 September 2007

Index	Species	Tag Type	Radio Code	Date	Time	PRM	Water Temp Reservoir (°C)	Water Temp at fish (°C)	Tag Temp 1 (°C)	Tag Temp 2 (°C)	Tag Temp 3 (°C)	Tag Depth 1 (ft)	Tag Depth 2 (ft)	Tag Depth 3 (ft)	Tag Depth 4 (ft)	Tag Depth 5 (ft)	Tag Depth 6 (ft)
55	smallmouth bass	CART	17	6/6/07	14:37	25.9	16.4	16.4	16.4	16.4	16.4	11.3	11.3	6.8	9.0		
67	cutthroat trout	CART	24	6/7/07	11:58	32	16.4	16.4	16.4	16.4		4.5	4.5	6.8	6.8	6.8	4.5
68	smallmouth bass	CART	15	6/7/07	13:28	31.7	16.4	16.4	16.4	16.4		9.0	9.0	9.0	9.0	9.0	9.0
71	smallmouth bass	CART	21	6/7/07	16:01	29.4	16.4	16.4				6.8	6.8				
72	smallmouth bass	CART	23	6/7/07	16:21	29.7	16.4	16.4	16.4	16.4	16.4	6.8	6.8	6.8	6.8	6.8	6.8
80	smallmouth bass	CART	22	6/7/07	17:28	27.5	16.4	16.4									
89	cutthroat trout	CART	24	6/18/07	17:34	31.9	15.4	14.8	14.8	14.8	14.8	13.5	6.8	6.8	6.8	4.5	6.8
100	smallmouth bass	CART	27	6/19/07	18:00	18.0	15.7	15.7	14.8	14.8	14.8	13.5	13.5	13.5	13.5	13.5	13.5
103	smallmouth bass	CART	21	6/20/07	12:58	29.5	16.5	16.5	15.6	15.6	15.6	6.8	6.8	6.8	6.8	6.8	6.8
125	cutthroat trout	CART	24	7/5/07	13:11	31.7	20.8	20.8	20.4	20.4	20.4	9.0	9.0	9.0	9.0		
131	smallmouth bass	CART	23	7/5/07	16:00	29.4	20.0		20.4	20.4	20.4	18.1	15.8	15.8	15.8	18.1	
132	smallmouth bass	CART	21	7/5/07	16:20	29.4	20.0		20.4	20.4	20.4	18.1	18.1	18.1	18.1	18.1	18.1
193	smallmouth bass	CART	21	8/1/07	13:58	29.1	24.3		24.4	24.4	24.4	27.1	24.9	24.9	24.9	22.6	24.9
194	smallmouth bass	CART	23	8/1/07	13:58	27.7	24.3		24.4								
217	smallmouth bass	CART	17	8/15/07	13:50	31.4	22.1	22.0	22.0	22.0	22.0	11.3	9.0	11.3	13.5	6.8	15.8
219	cutthroat trout	CART	24	8/15/07	14:30	31.0	22.1		18.0	18.0	18.0	6.8	6.8	6.8	6.8	6.8	6.8
240	cutthroat trout	CART	24	8/29/07	11:33	33.1	20.3	21.2	21.2	21.2	21.2	9.0	6.8	4.5	6.8	4.5	6.8
241	smallmouth bass	CART	15	8/29/07	12:36	31.6	20.1		21.2			15.8	15.8	18.1	18.1		
242	smallmouth bass	CART	17	8/29/07	12:40	31.5	20.1		20.4	20.4	20.4	11.3	11.3	11.3	11.3	11.3	9.0
269	smallmouth bass	CART	17	9/26/07	13:11	31.1	15.4	15.6	15.6	15.6		6.8	9.0	6.8	6.8	6.8	4.5
270	smallmouth bass	CART	15	9/26/07	13:58	31.5	15.2	16.4	16.4			13.5	13.5	13.5			

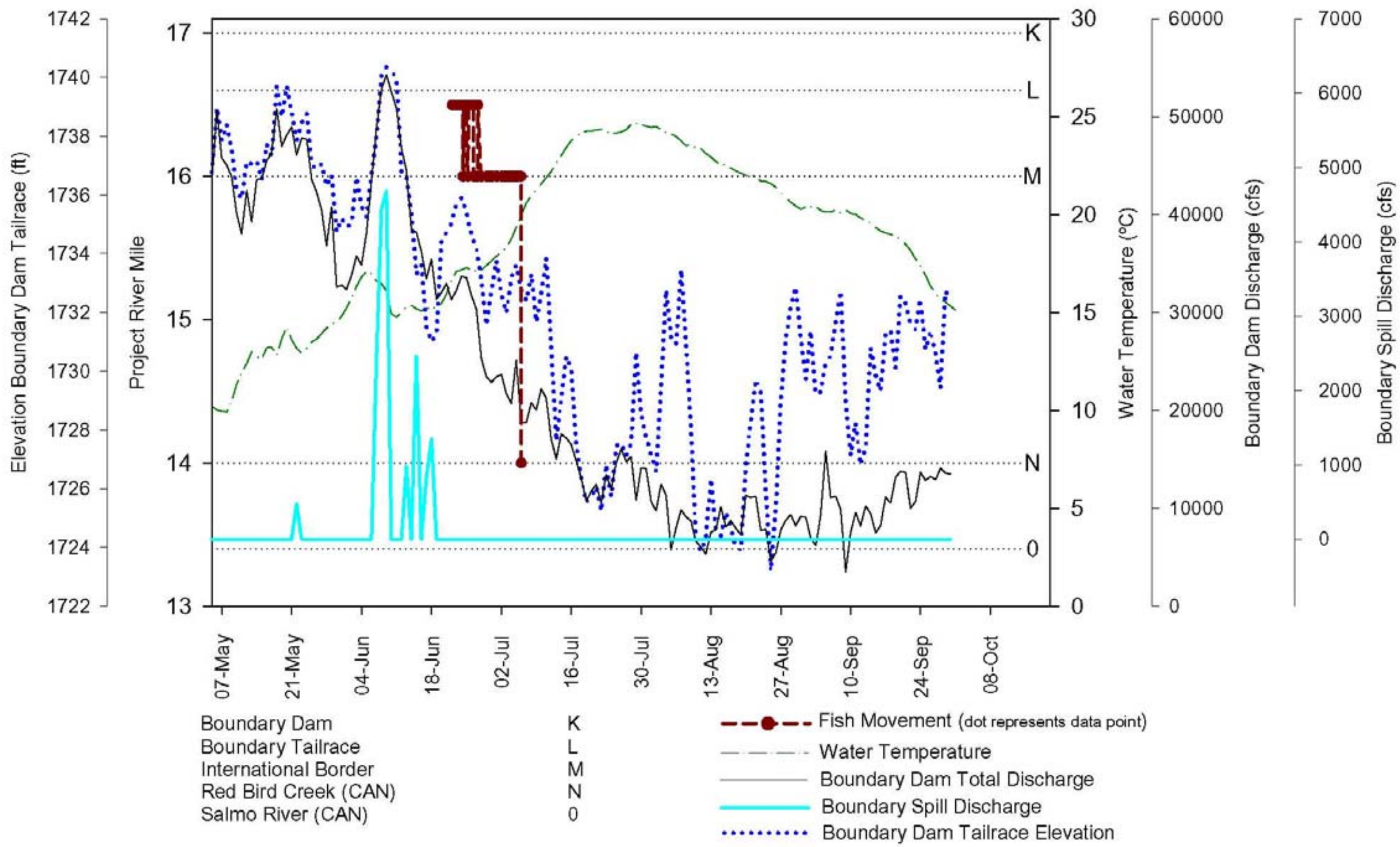


Figure A.3-1 Movement data of a radio-tagged (Fish 184) bull trout (*Salvelinus confluentus*) in the Boundary Tailrace Reach in relation to daily average water temperature, daily average total Boundary discharge, Boundary spill discharge, and daily average water level elevation as measured at Boundary tailrace, 5 May to 30 September 2007.

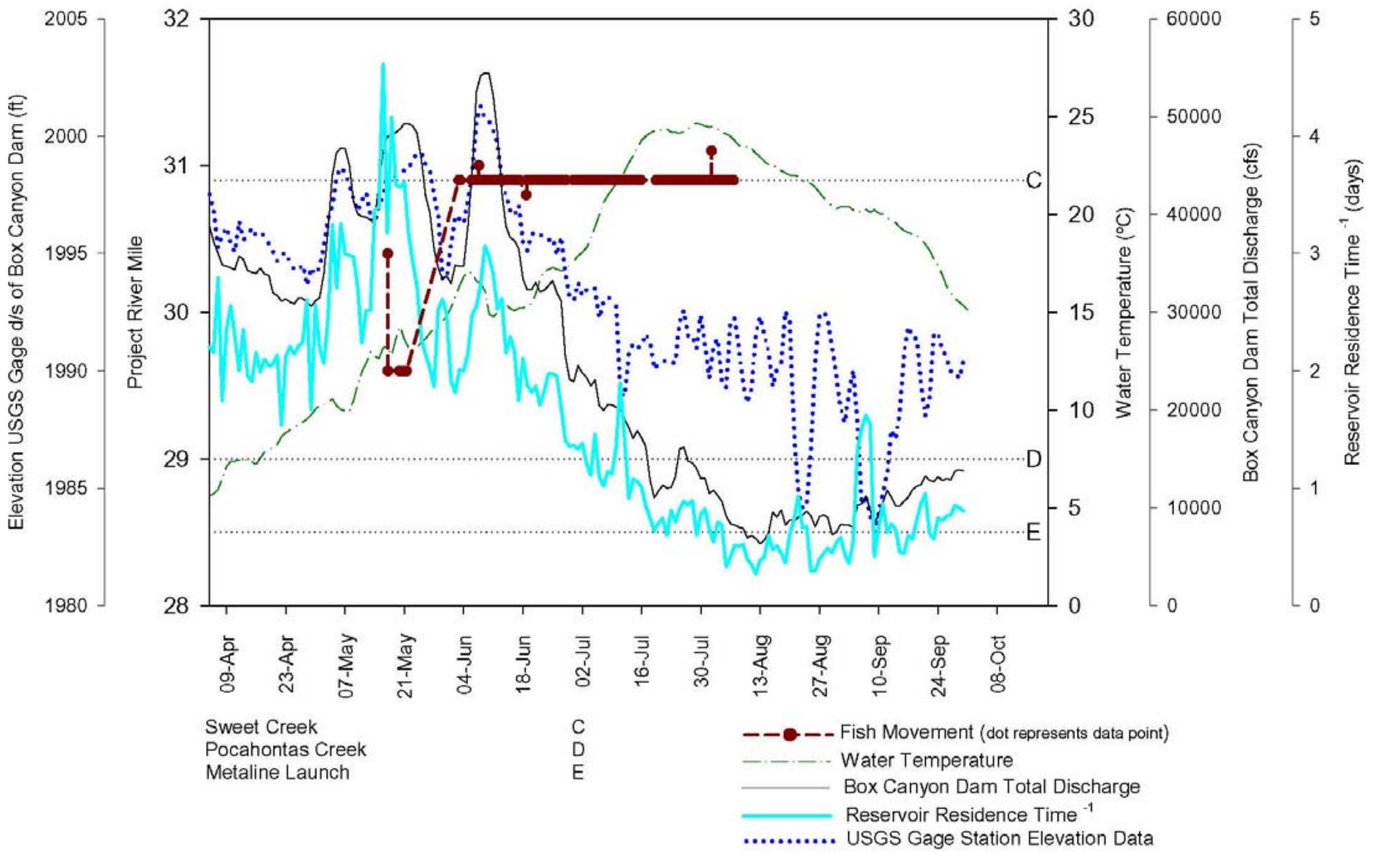


Figure A.3-2 Movement data of a radio-tagged (Fish 181) westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 April to 30 September 2007.

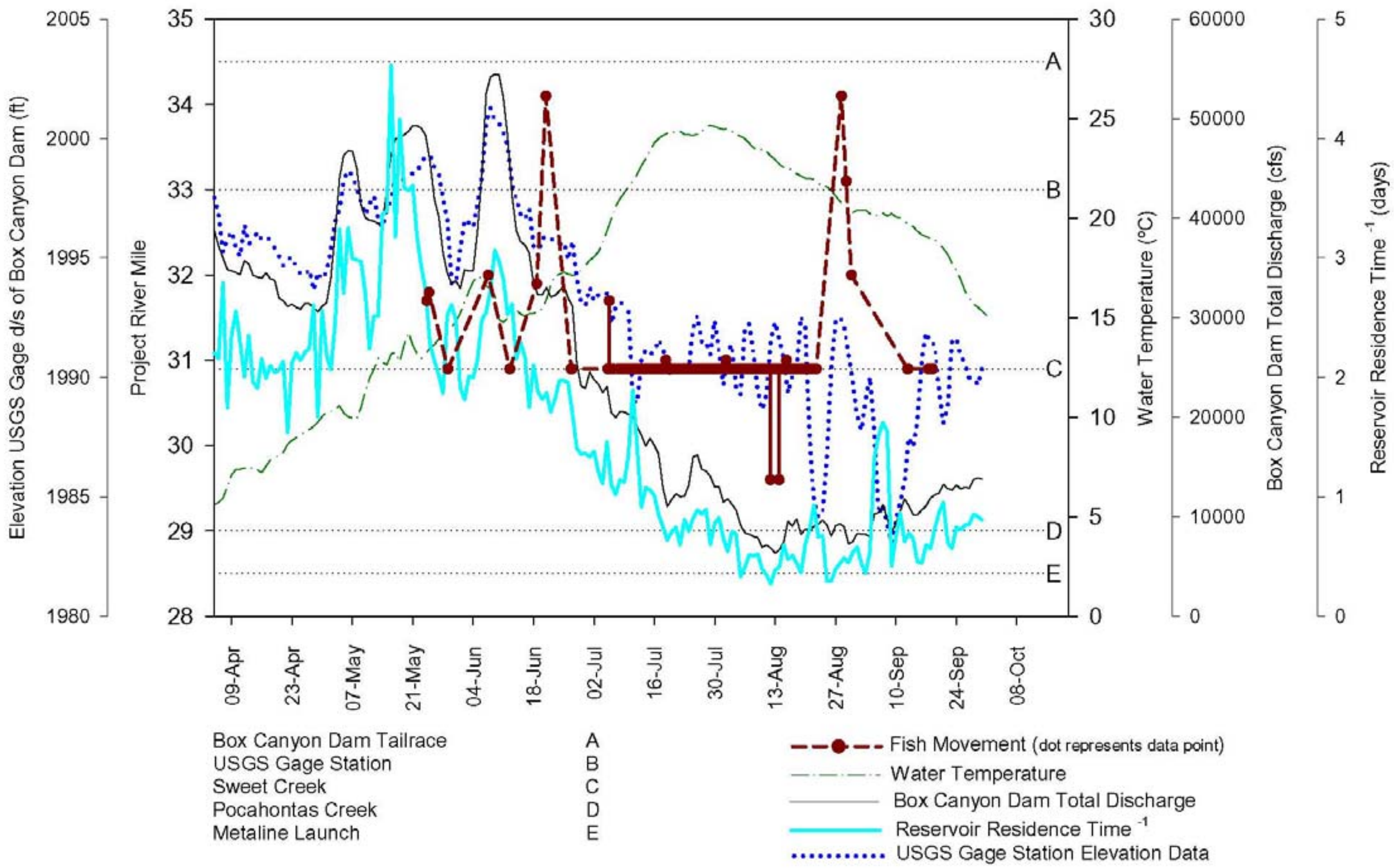


Figure A.3-3 Movement data of a radio-tagged (Fish 24) westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 April to 30 September 2007.

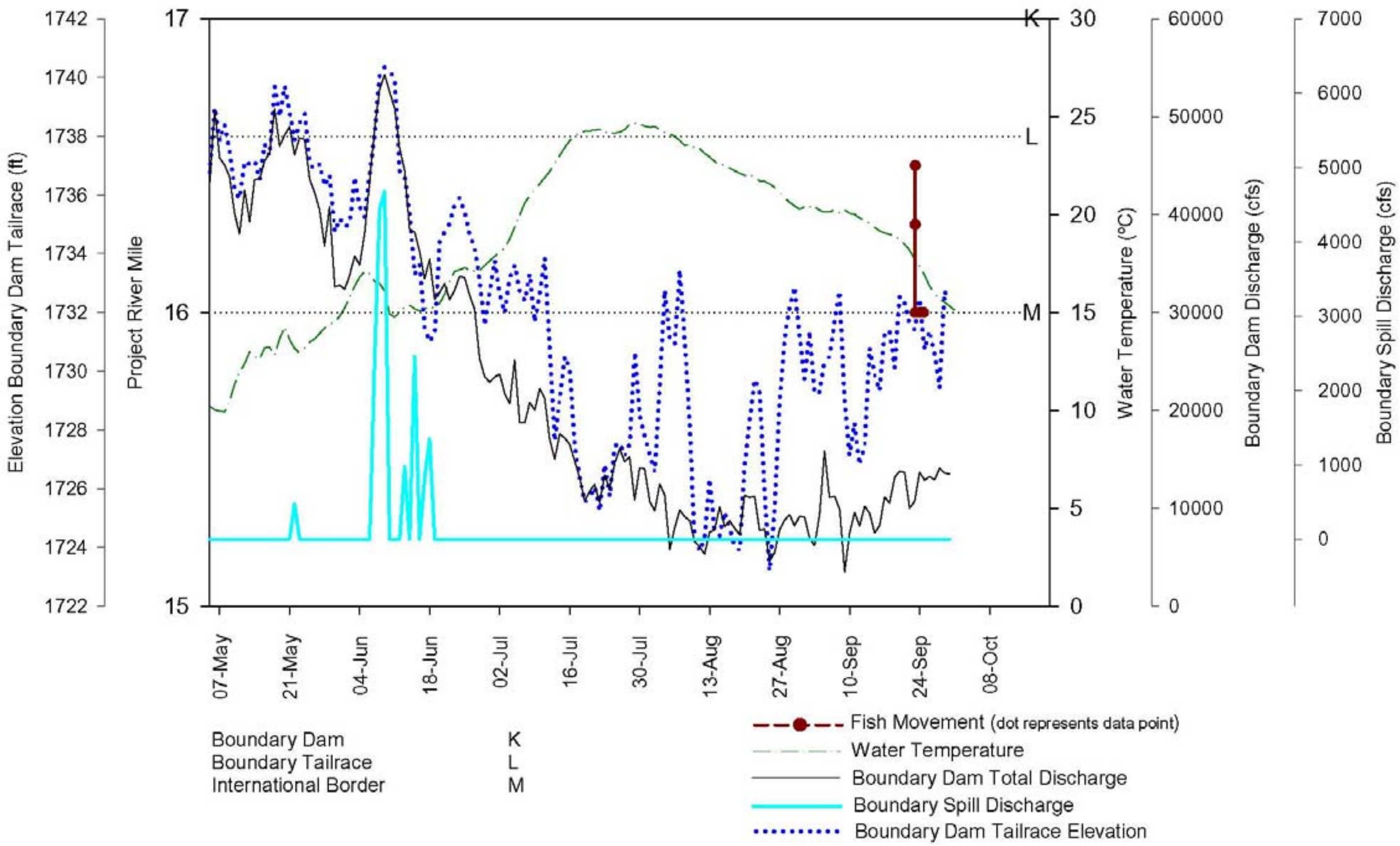


Figure A.3-4 Movement data of a radio-tagged (Fish 176) westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the Boundary Tailrace Reach in relation to daily average water temperature, daily average total Boundary discharge, Boundary spill discharge, and daily average water level elevation as measured at Boundary tailrace, 5 May to 30 September 2007.

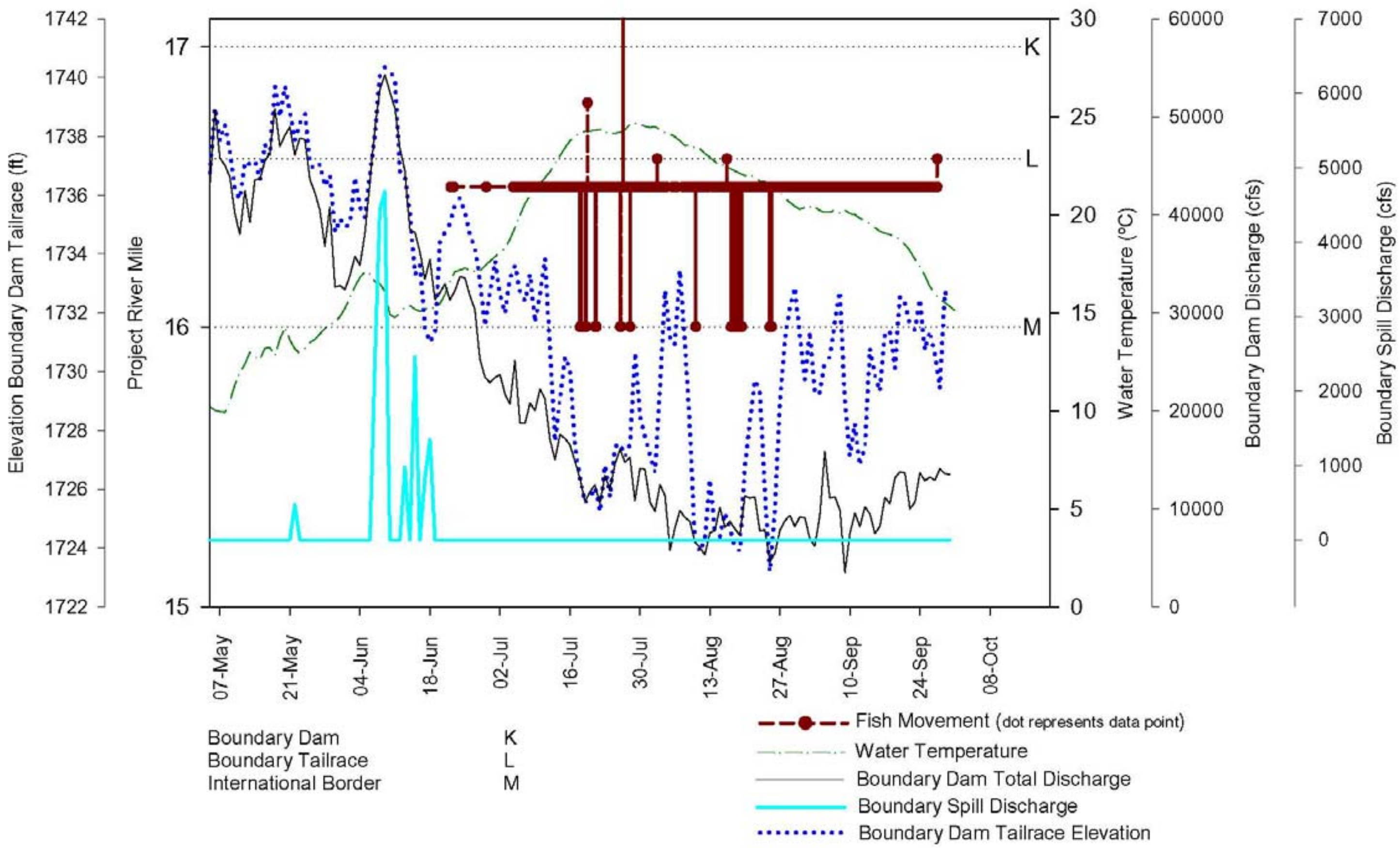


Figure A.3-5 Movement data of a radio-tagged (Fish 59) westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the Boundary Tailrace Reach in relation to daily average water temperature, daily average total Boundary discharge, Boundary spill discharge, and daily average water level elevation as measured at Boundary tailrace, 5 May to 30 September 2007.

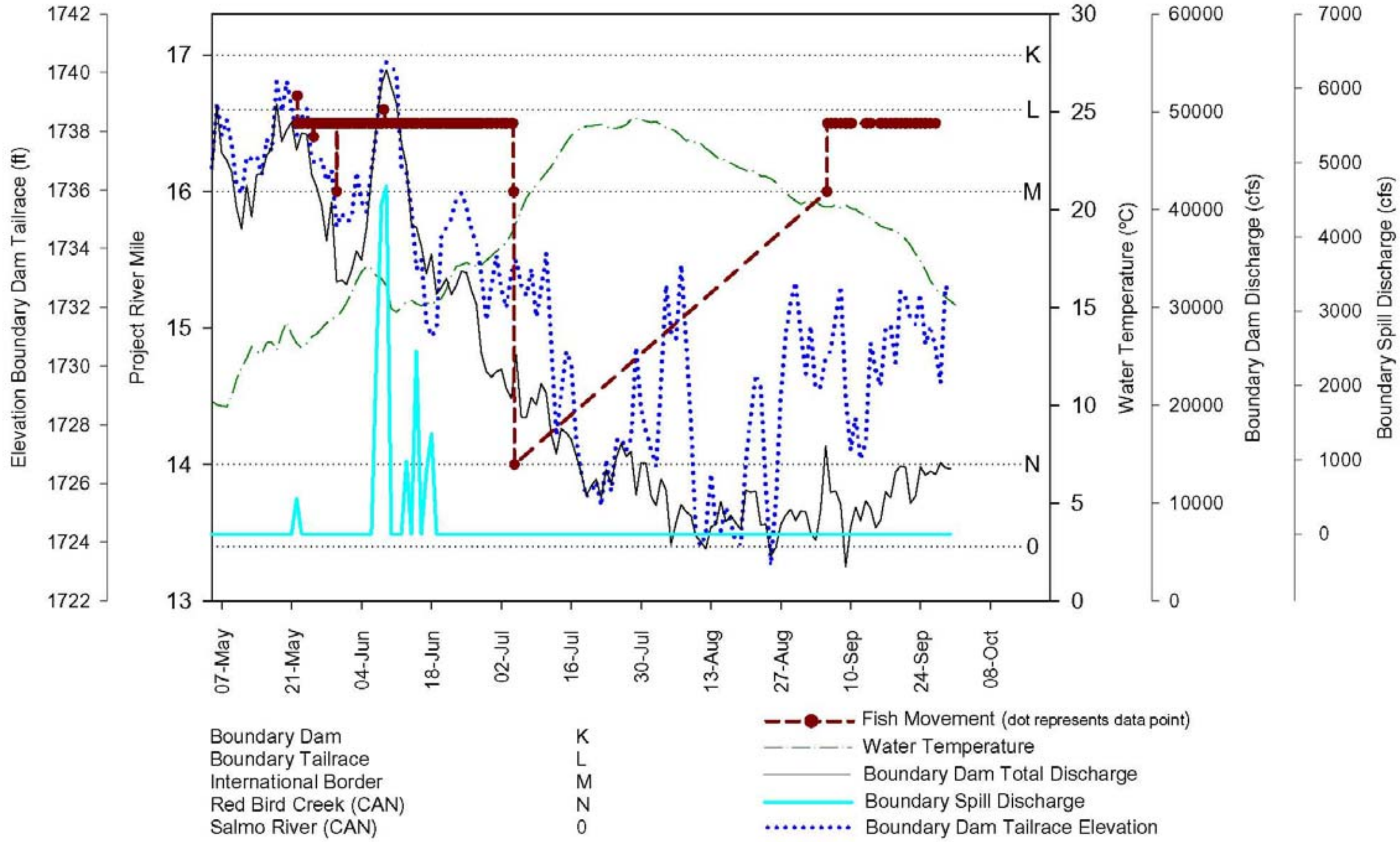


Figure A.3-6 Movement data of a radio-tagged (Fish 179) mountain whitefish (*Prosopium williamsoni*) in the Boundary Tailrace Reach in relation to daily average water temperature, daily average total Boundary discharge, Boundary spill discharge, and daily average water level elevation as measured at Boundary tailrace, 5 May to 30 September 2007.

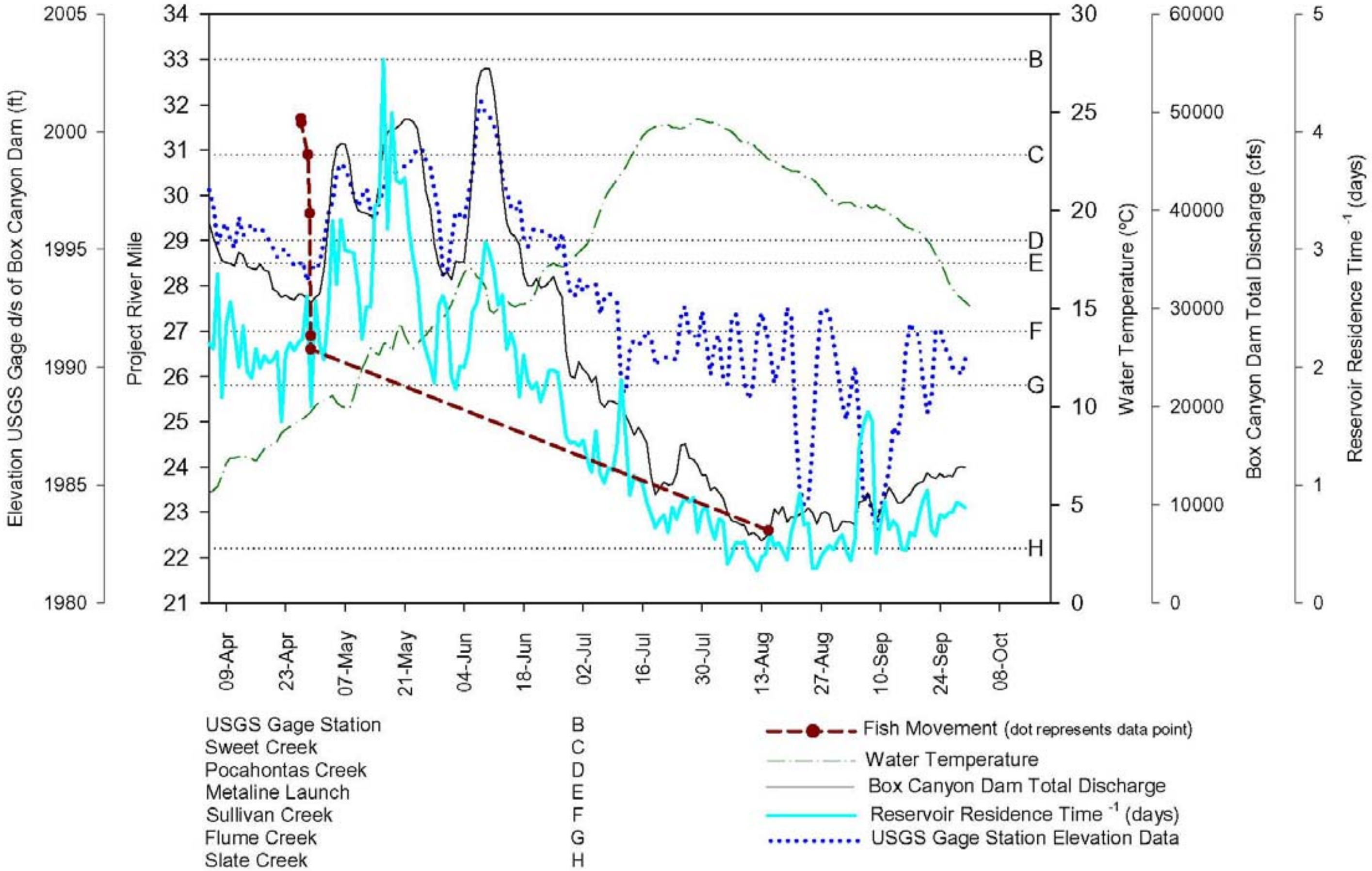


Figure A.3-7 Movement data of a radio-tagged (Fish 159) mountain whitefish (*Prosopium williamsoni*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 April to 30 September 2007.

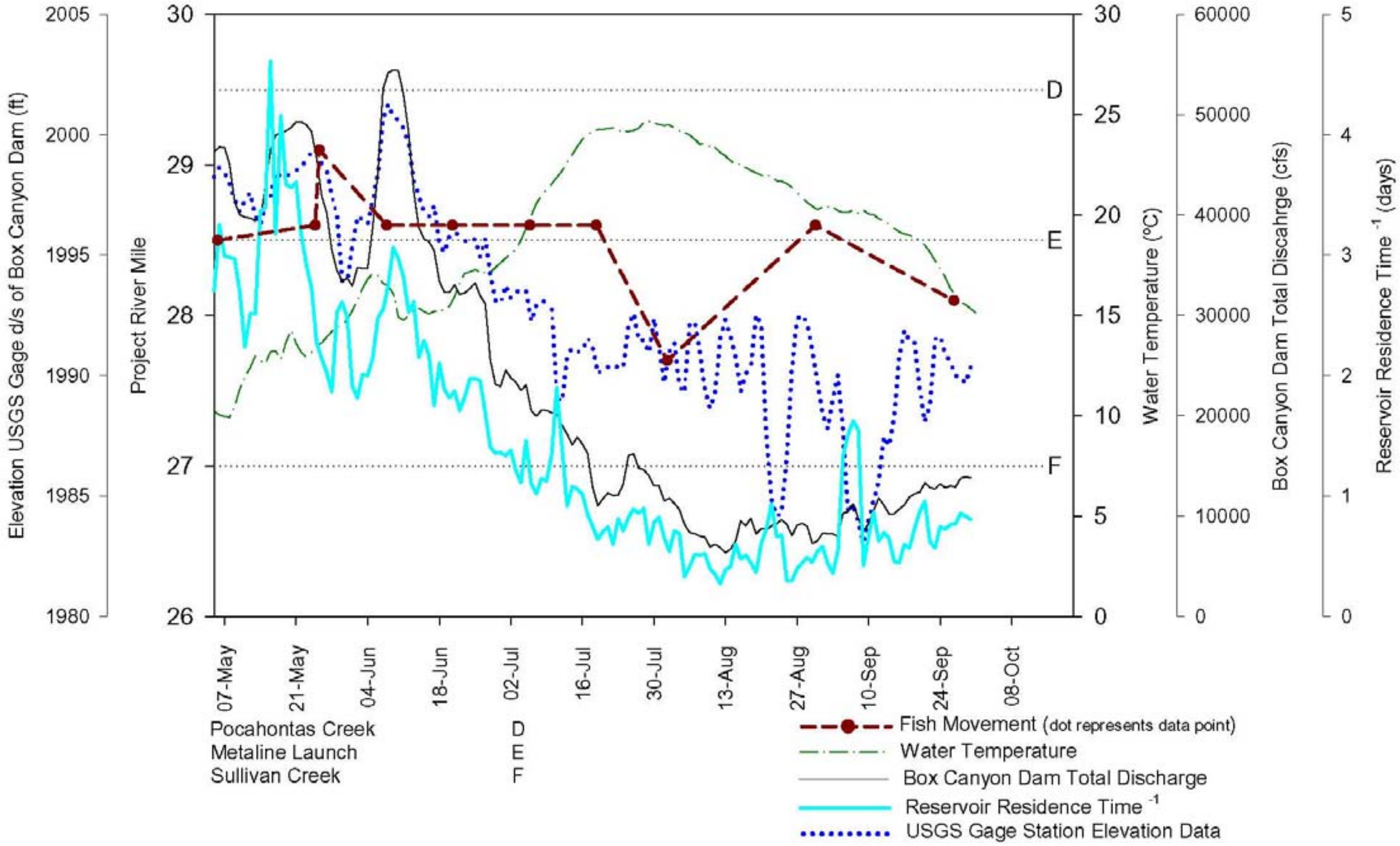


Figure A.3-8 Movement data of a radio-tagged (Fish 97) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

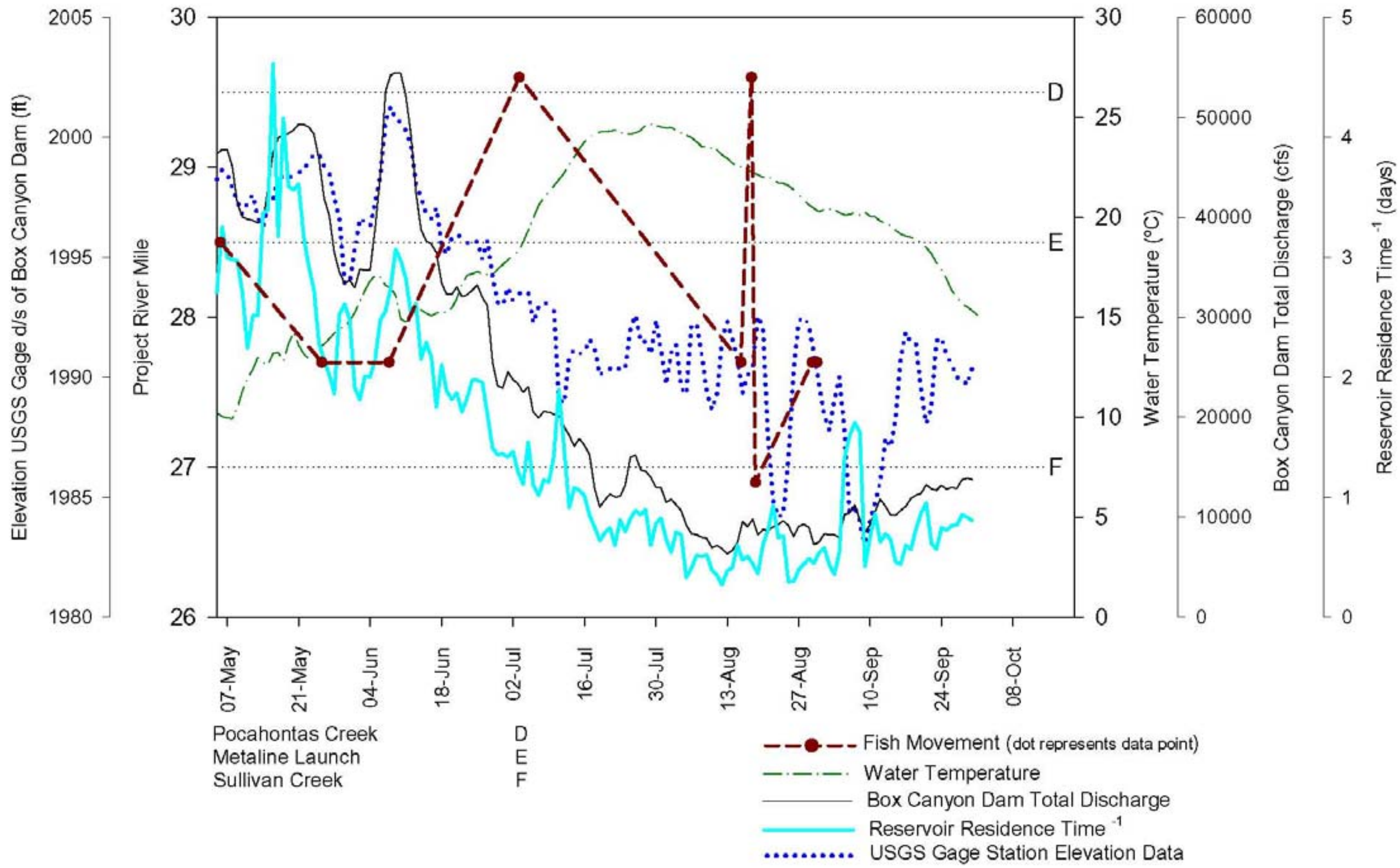


Figure A.3-9 Movement data of a radio-tagged (Fish 98) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

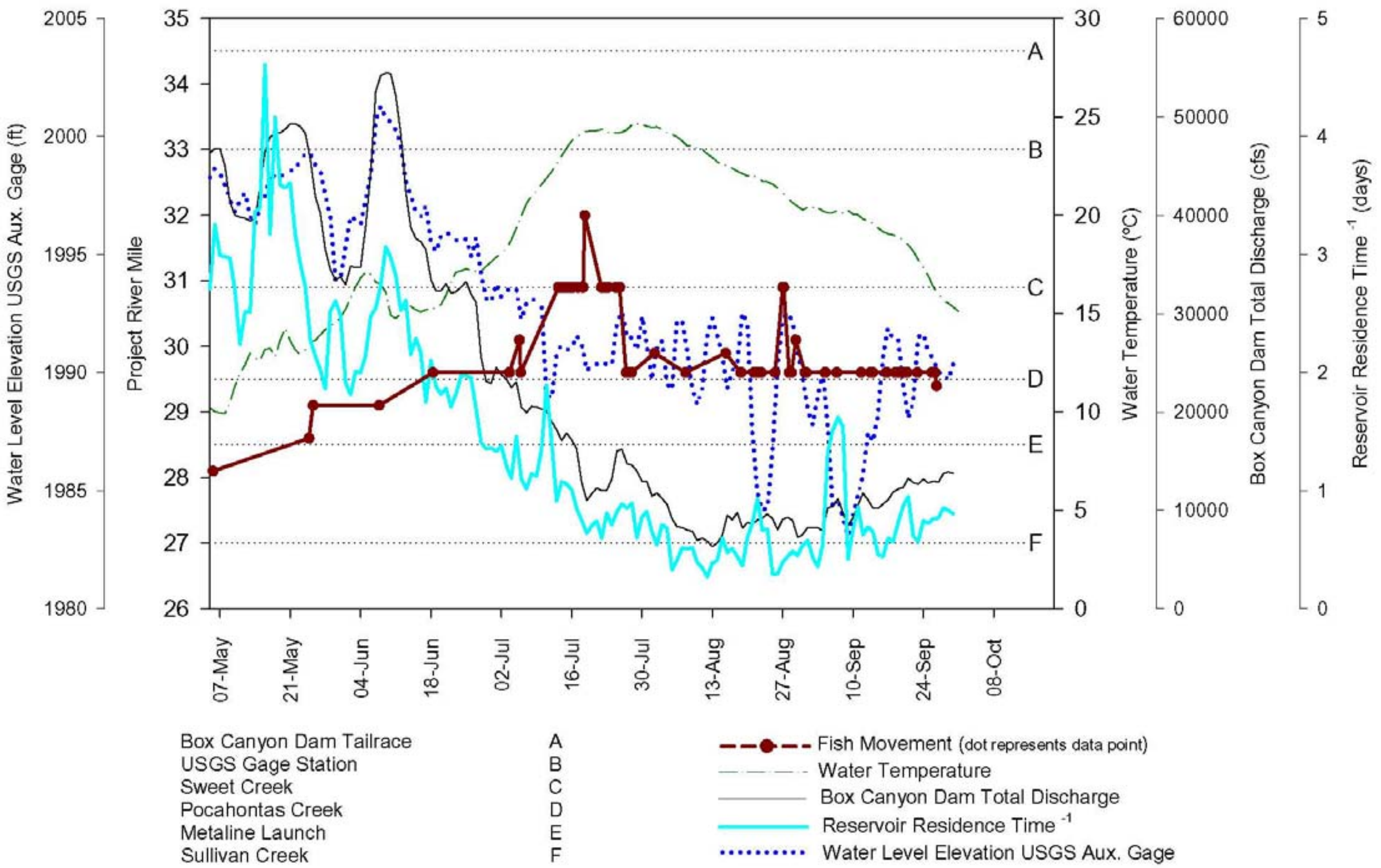


Figure A.3-10 Movement data of a radio-tagged (Fish 105) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

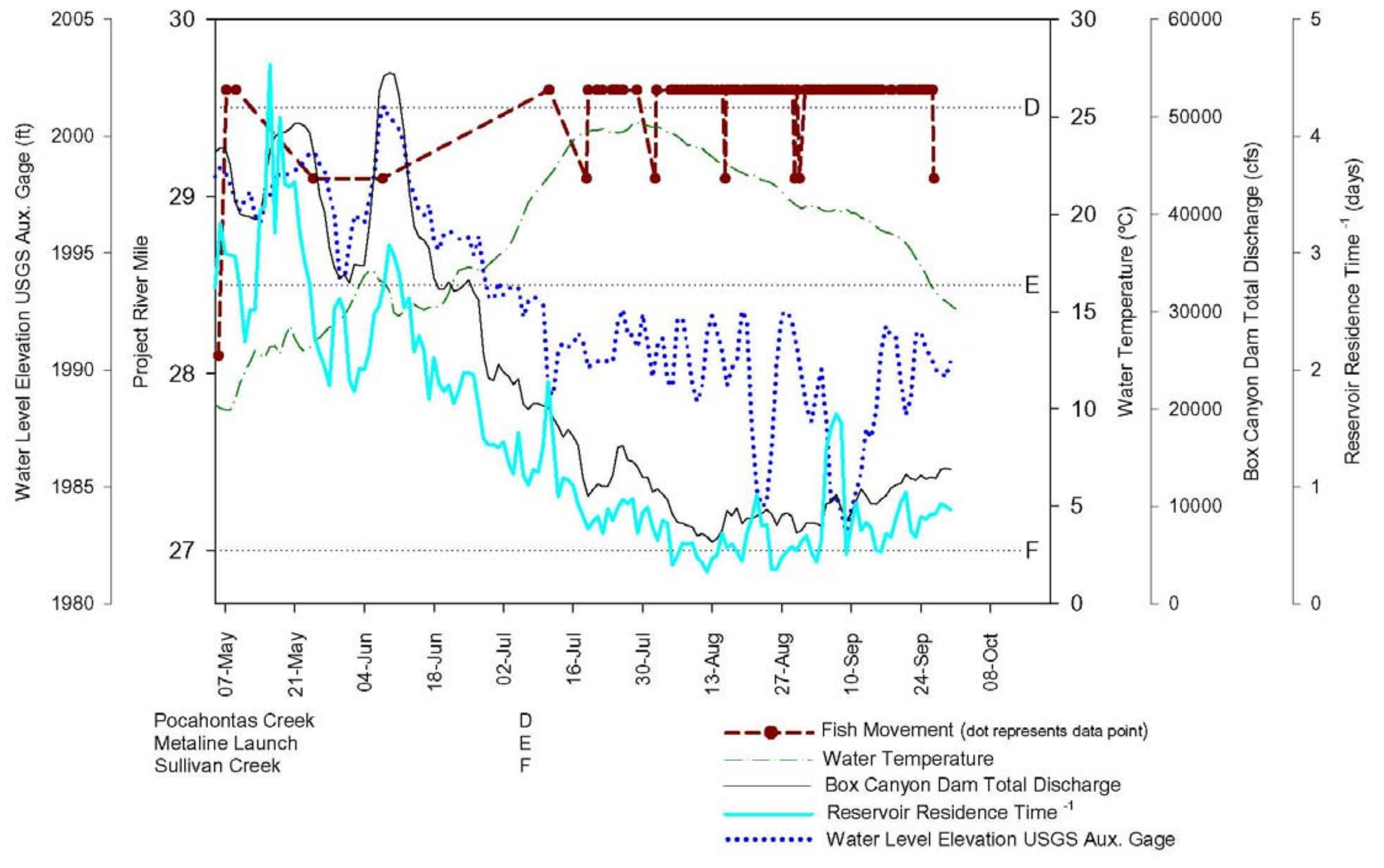


Figure A.3-11 Movement data of a radio-tagged (Fish 106) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity) and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

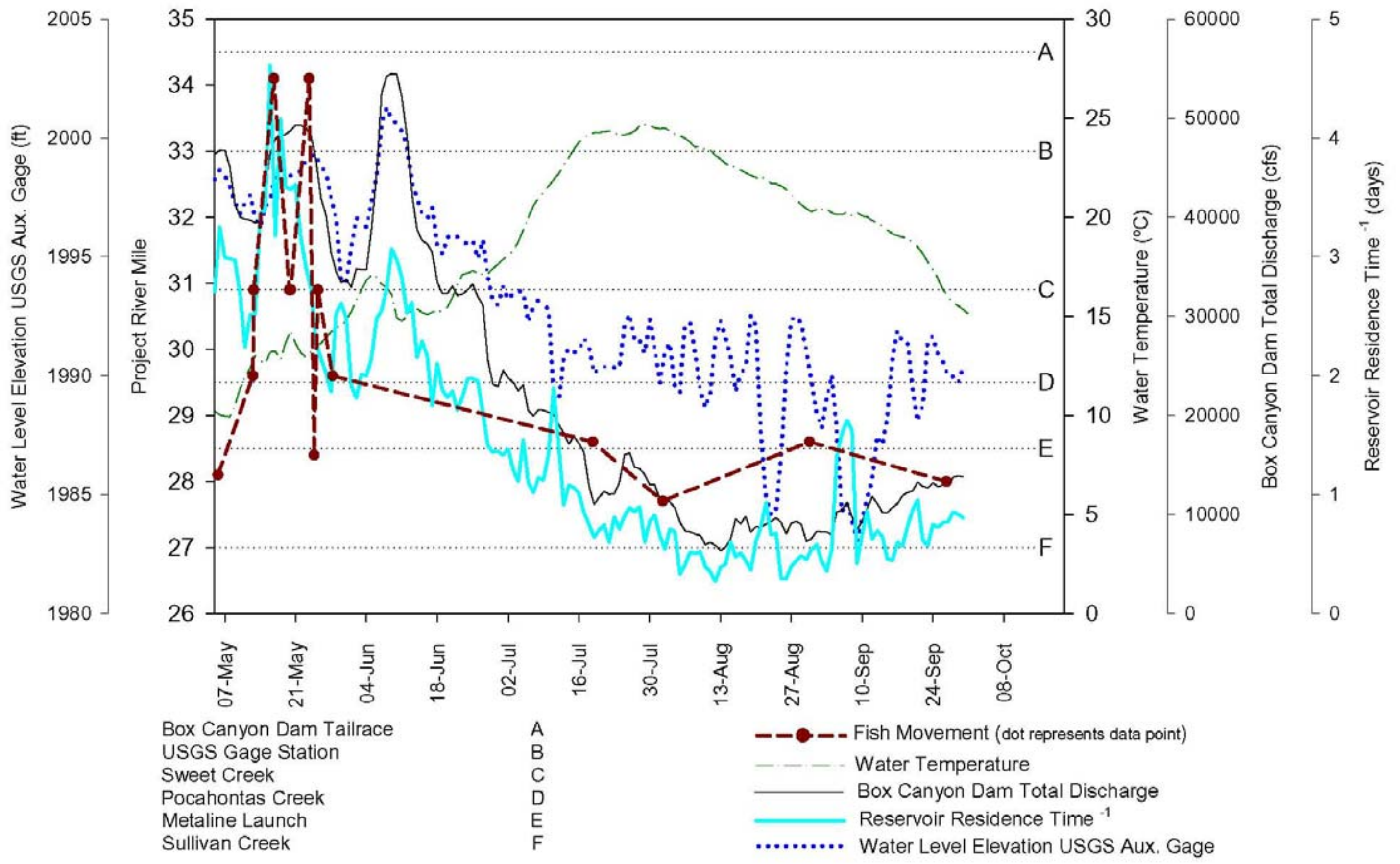


Figure A.3-12 Movement data of a radio-tagged (Fish 107) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

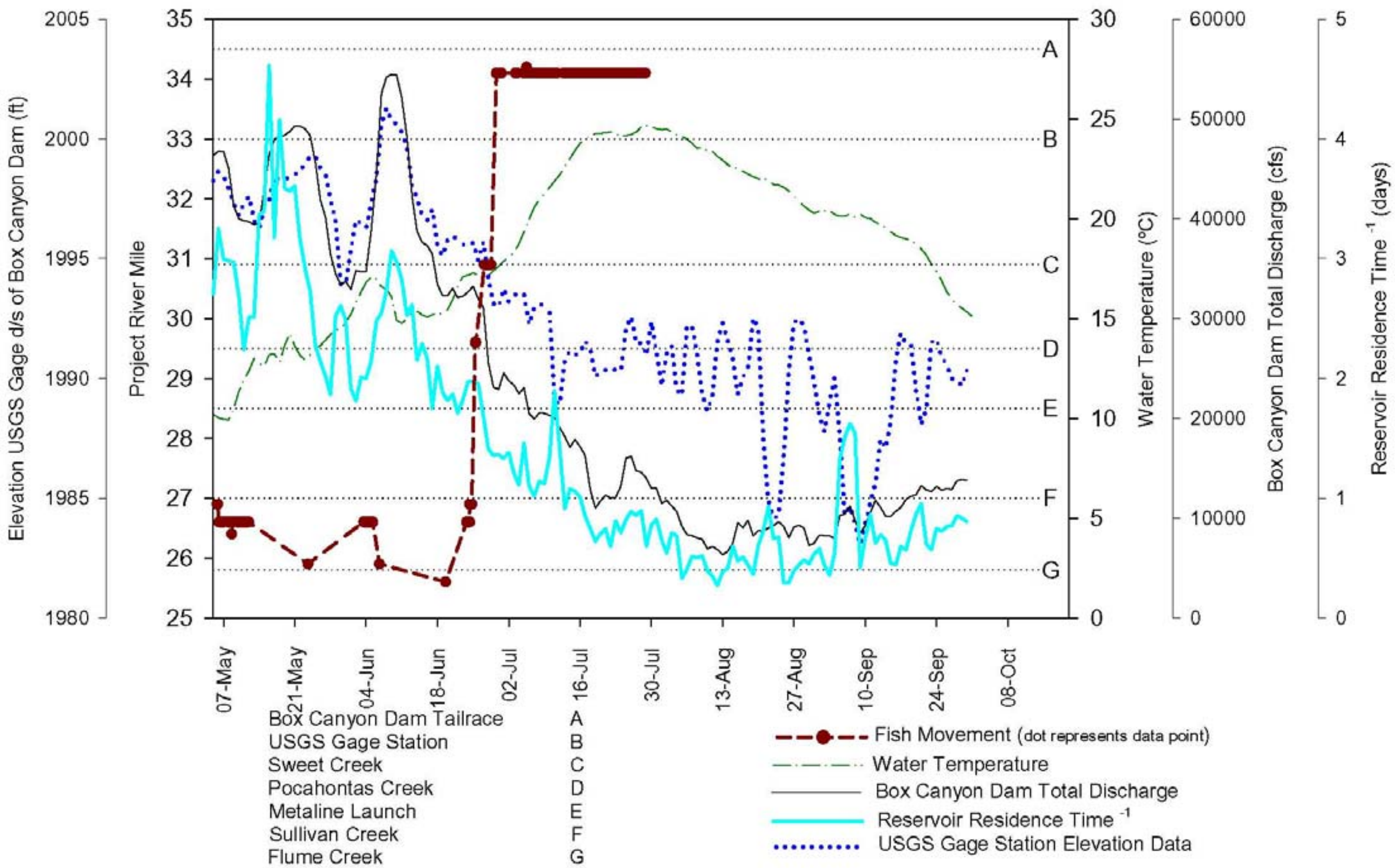


Figure A.3-13 Movement data of a radio-tagged (Fish 99) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

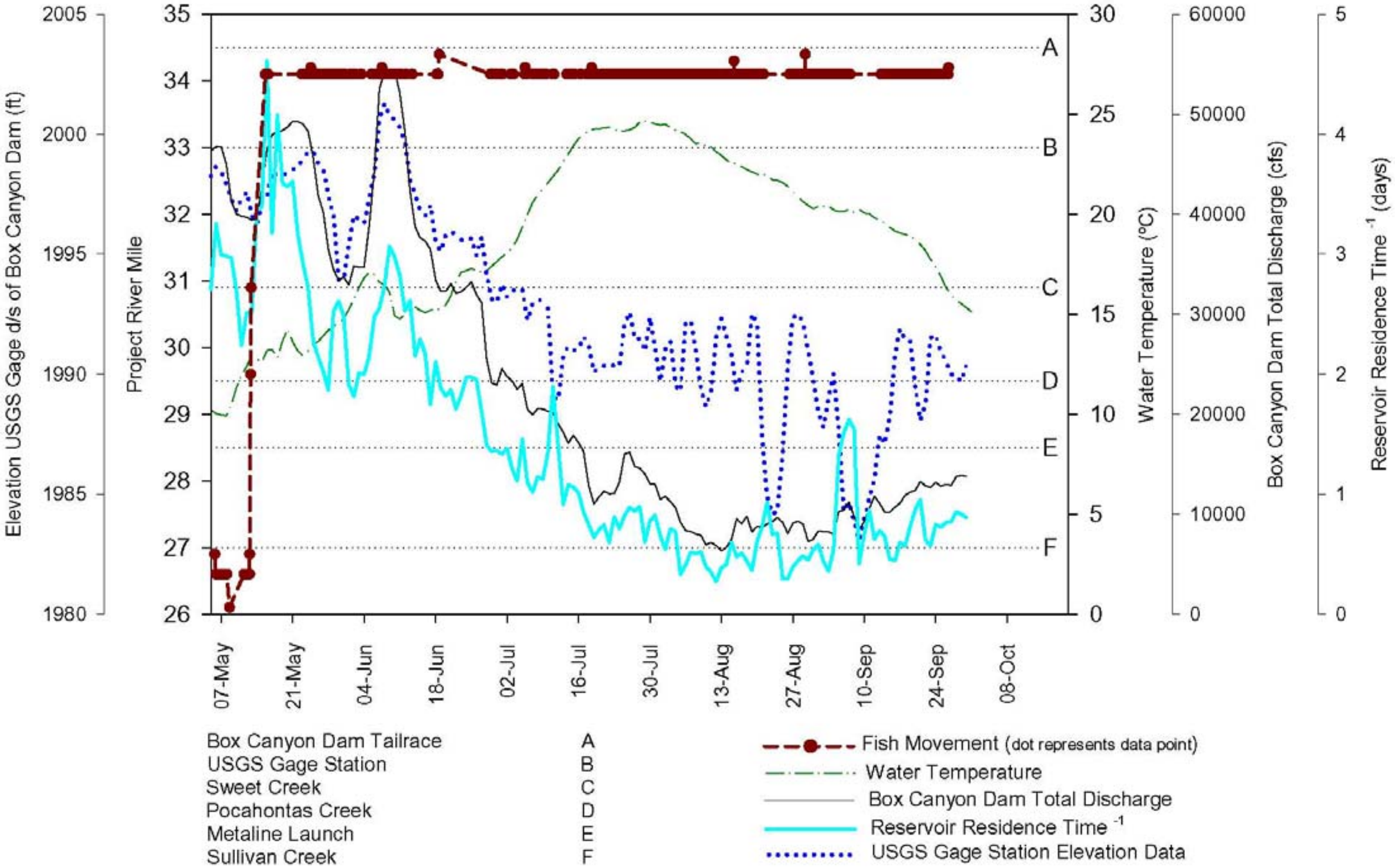


Figure A.3-14 Movement data of a radio-tagged (Fish 101) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

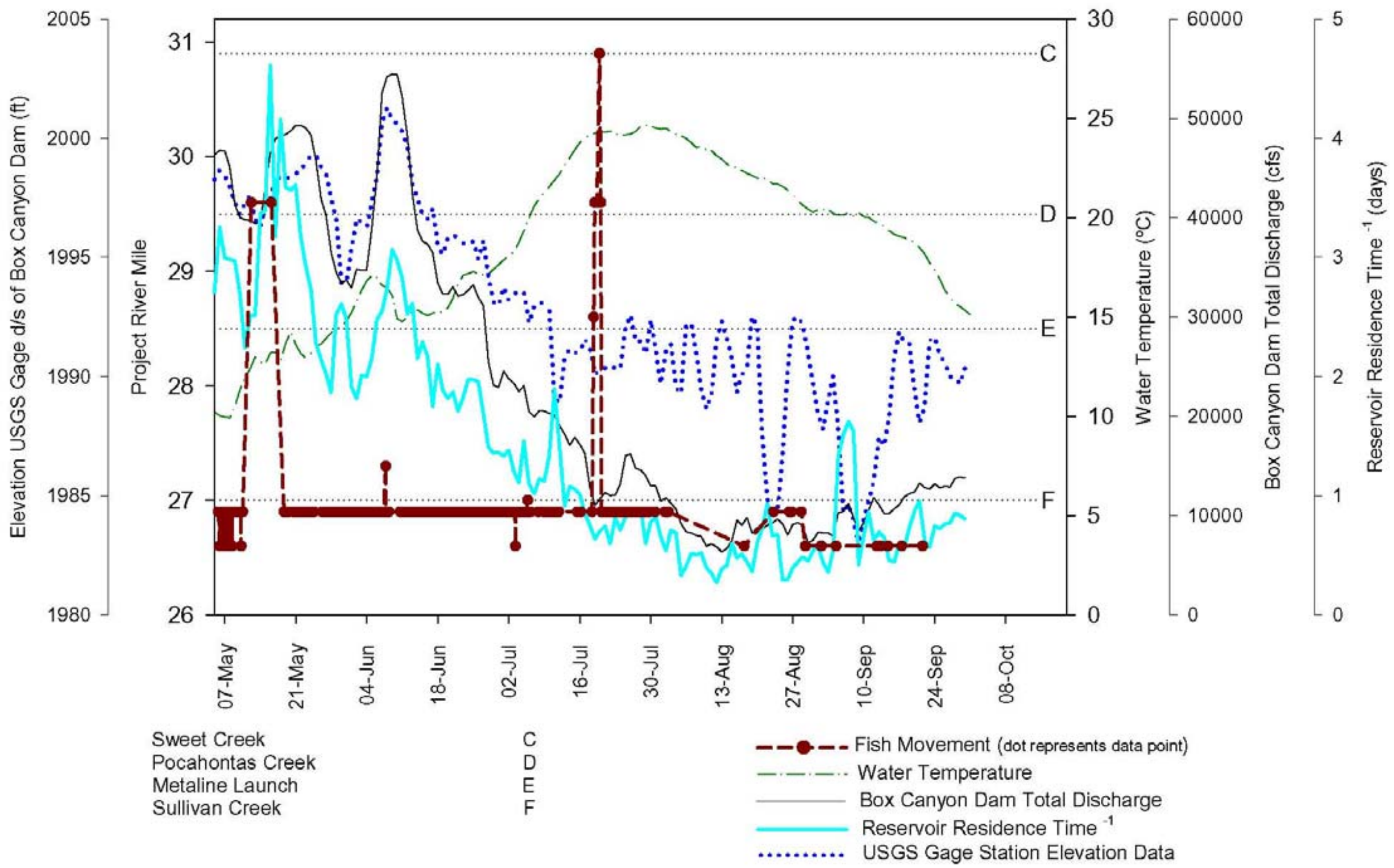


Figure A.3-15 Movement data of a radio-tagged (Fish 102) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxillary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

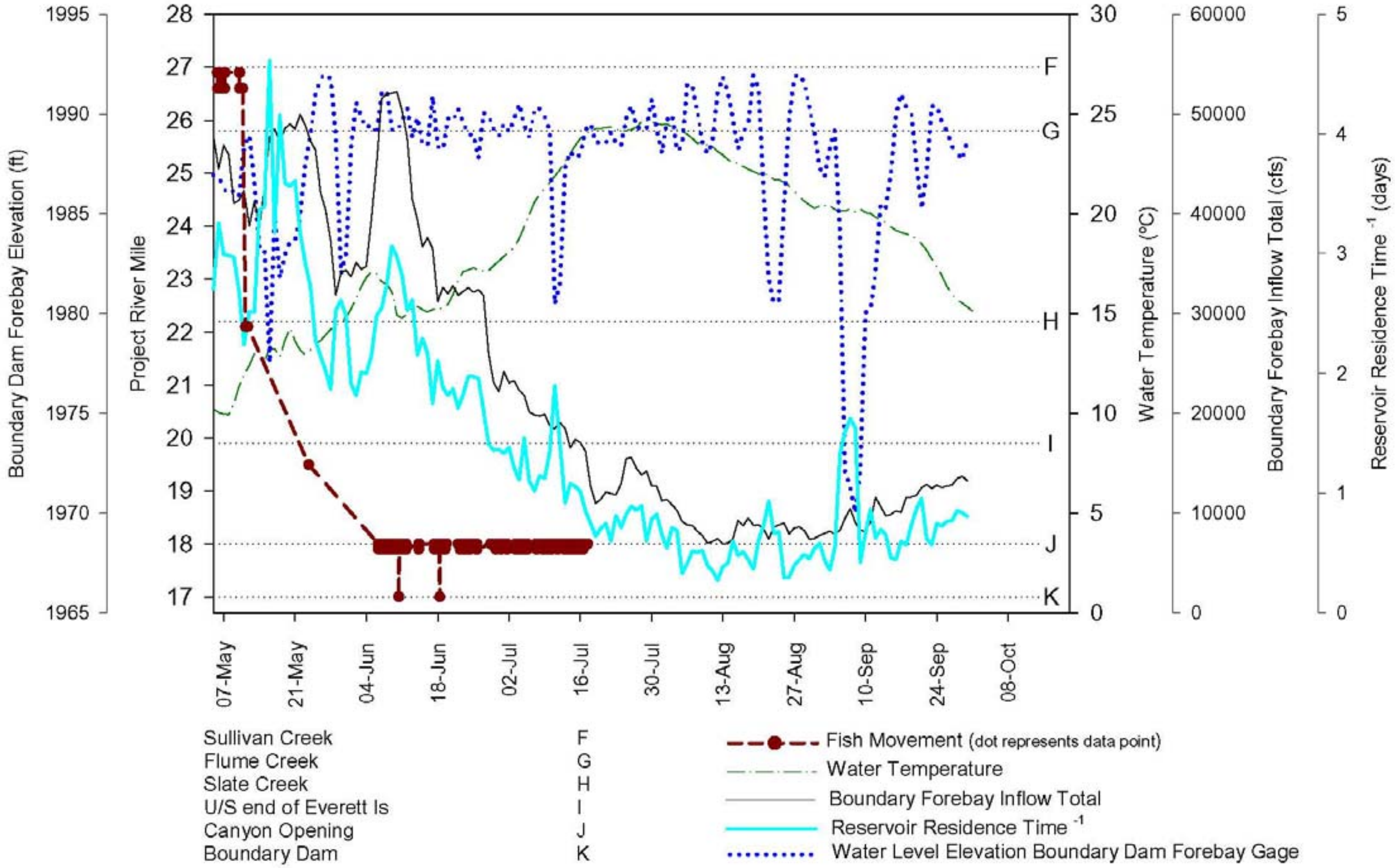


Figure A.3-16 Movement data of a radio-tagged (Fish 103) smallmouth bass (*Micropterus dolomieu*) in the Canyon and Forebay reaches in relation to daily average water temperature, daily average total Boundary forebay inflows, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at Boundary Forebay, 5 May to 30 September 2007.

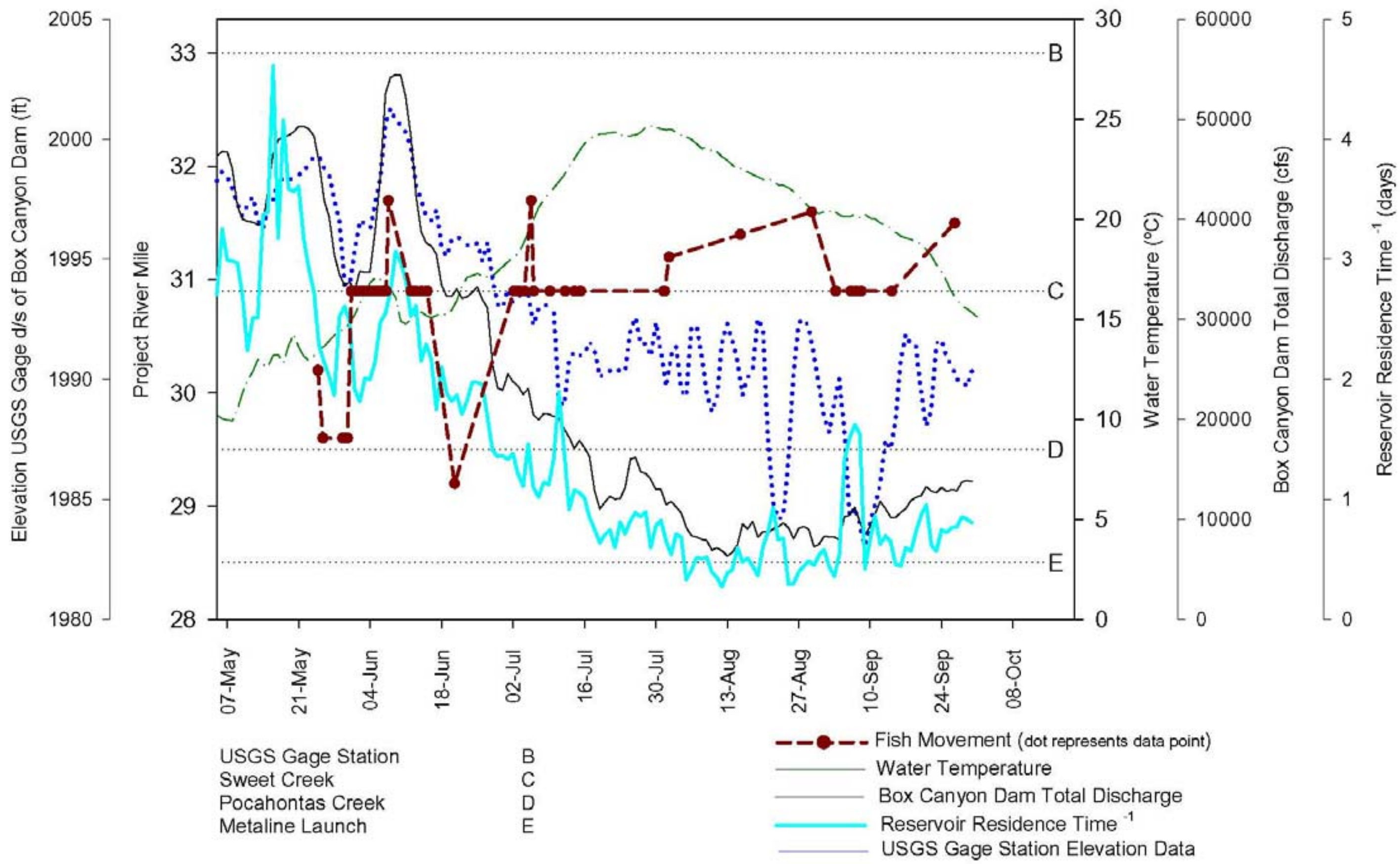


Figure A.3-17 Movement data of a radio-tagged (Fish 15) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

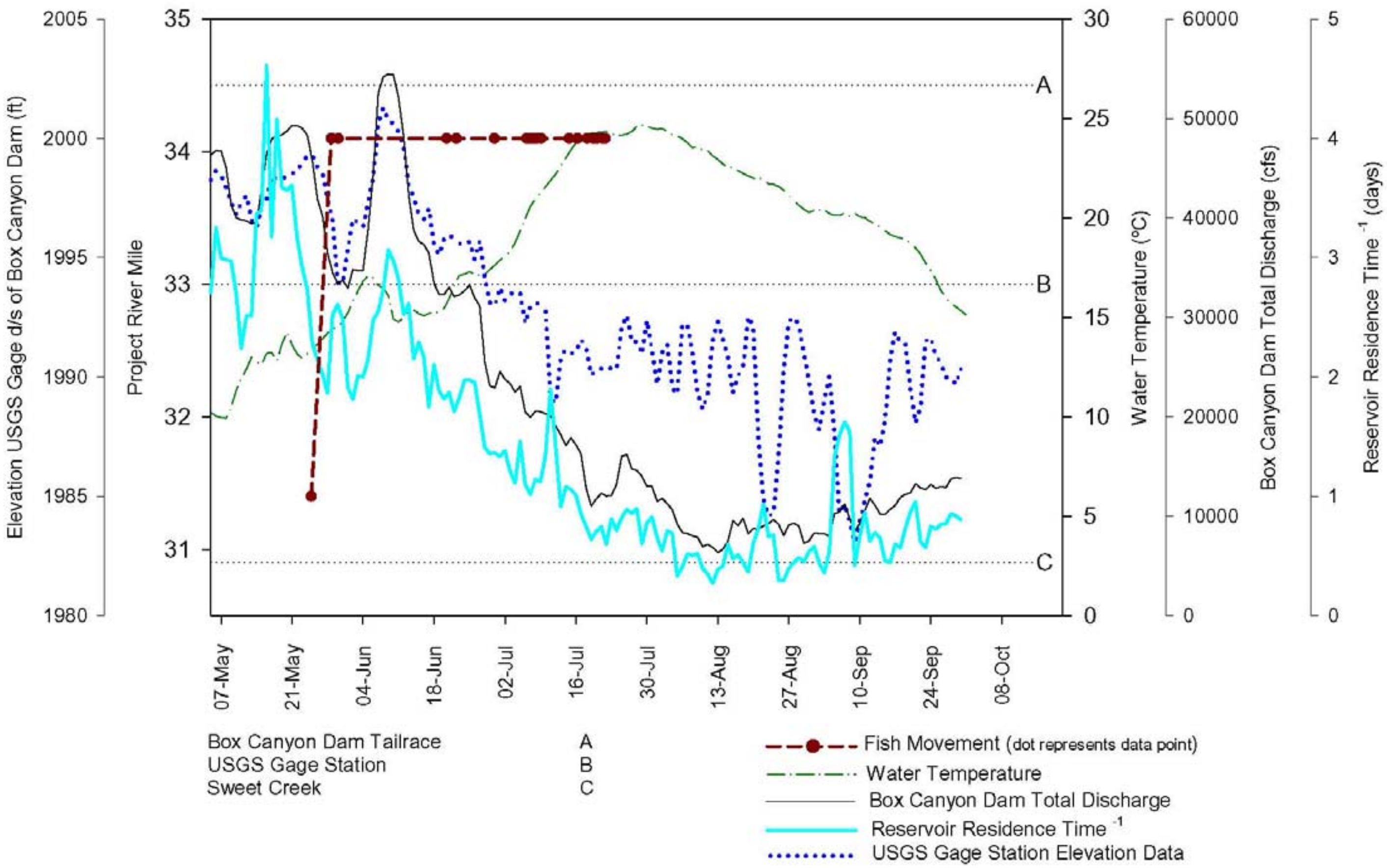


Figure A.3-18 Movement data of a radio-tagged (Fish 16) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

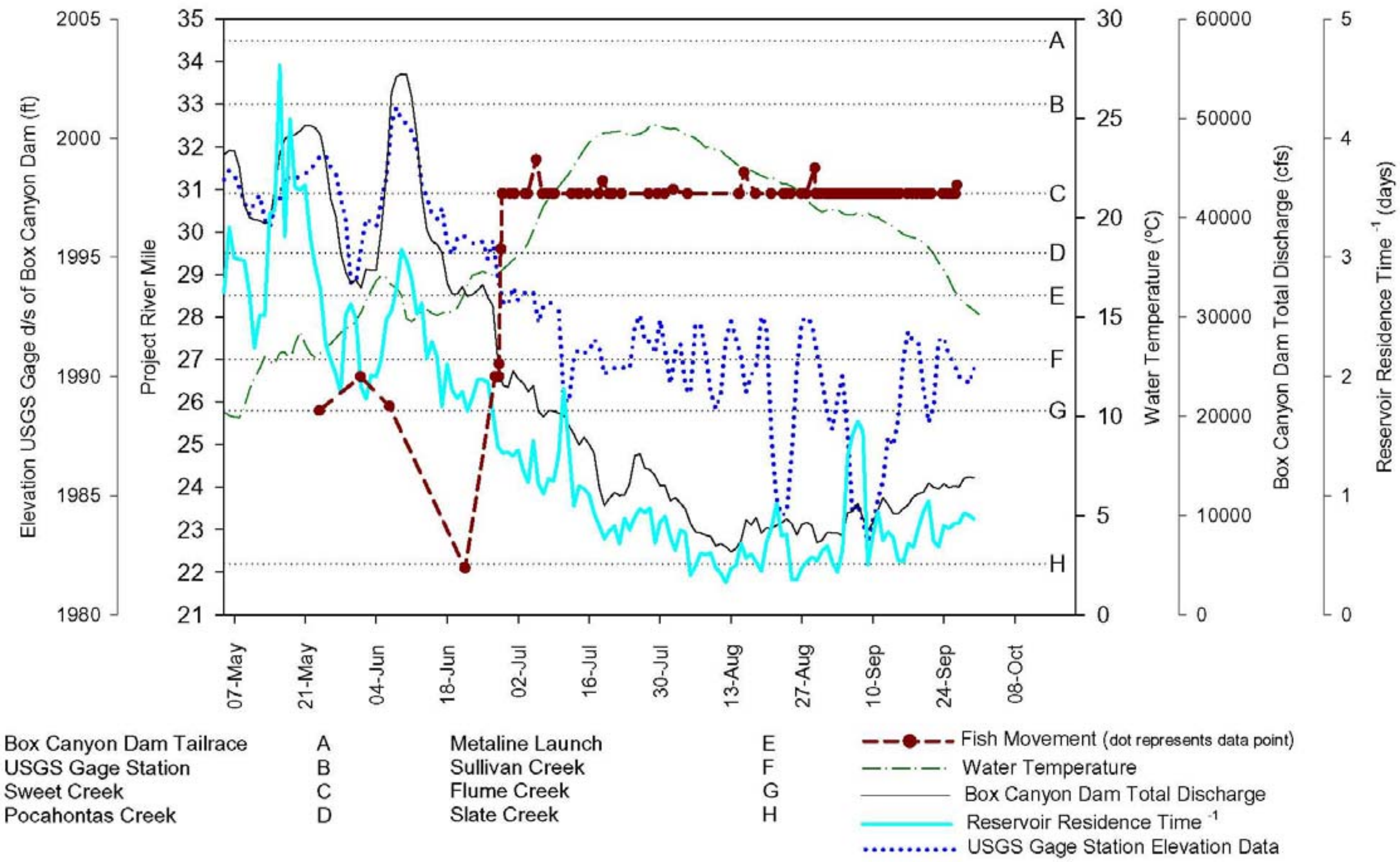


Figure A.3-19 Movement data of a radio-tagged (Fish 17) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

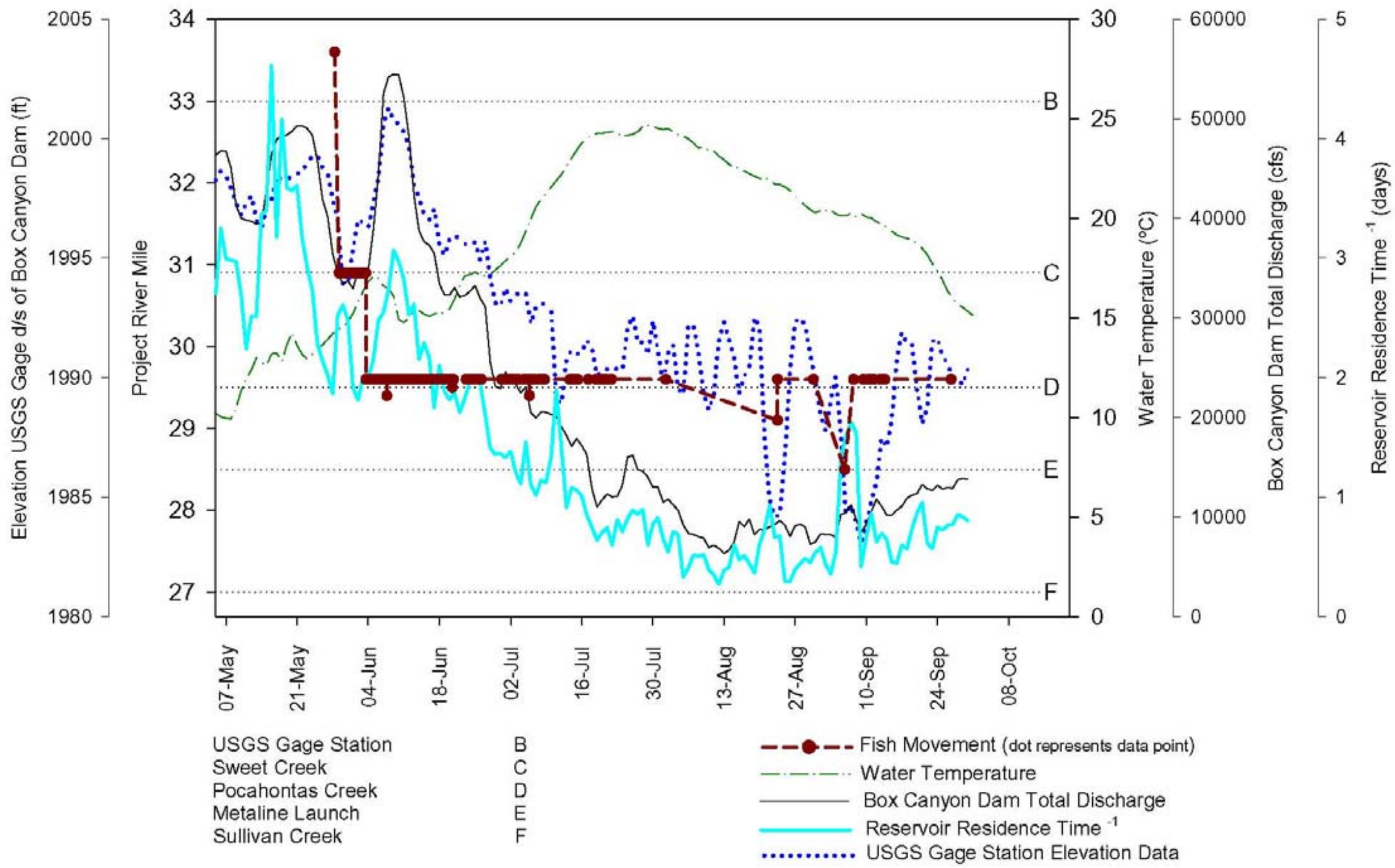


Figure A.3-20 Movement data of a radio-tagged (Fish 21) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

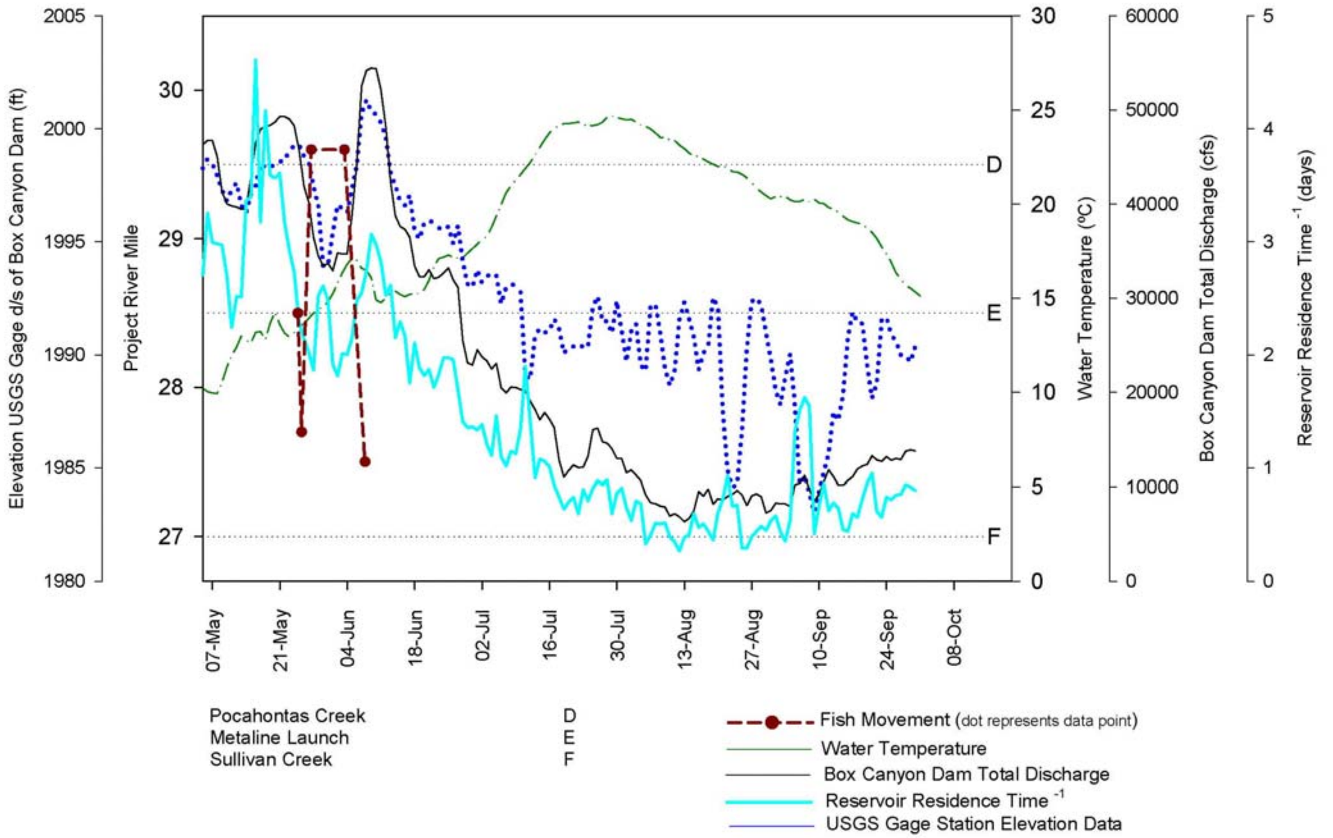


Figure A.3-21 Movement data of a radio-tagged (Fish 22) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

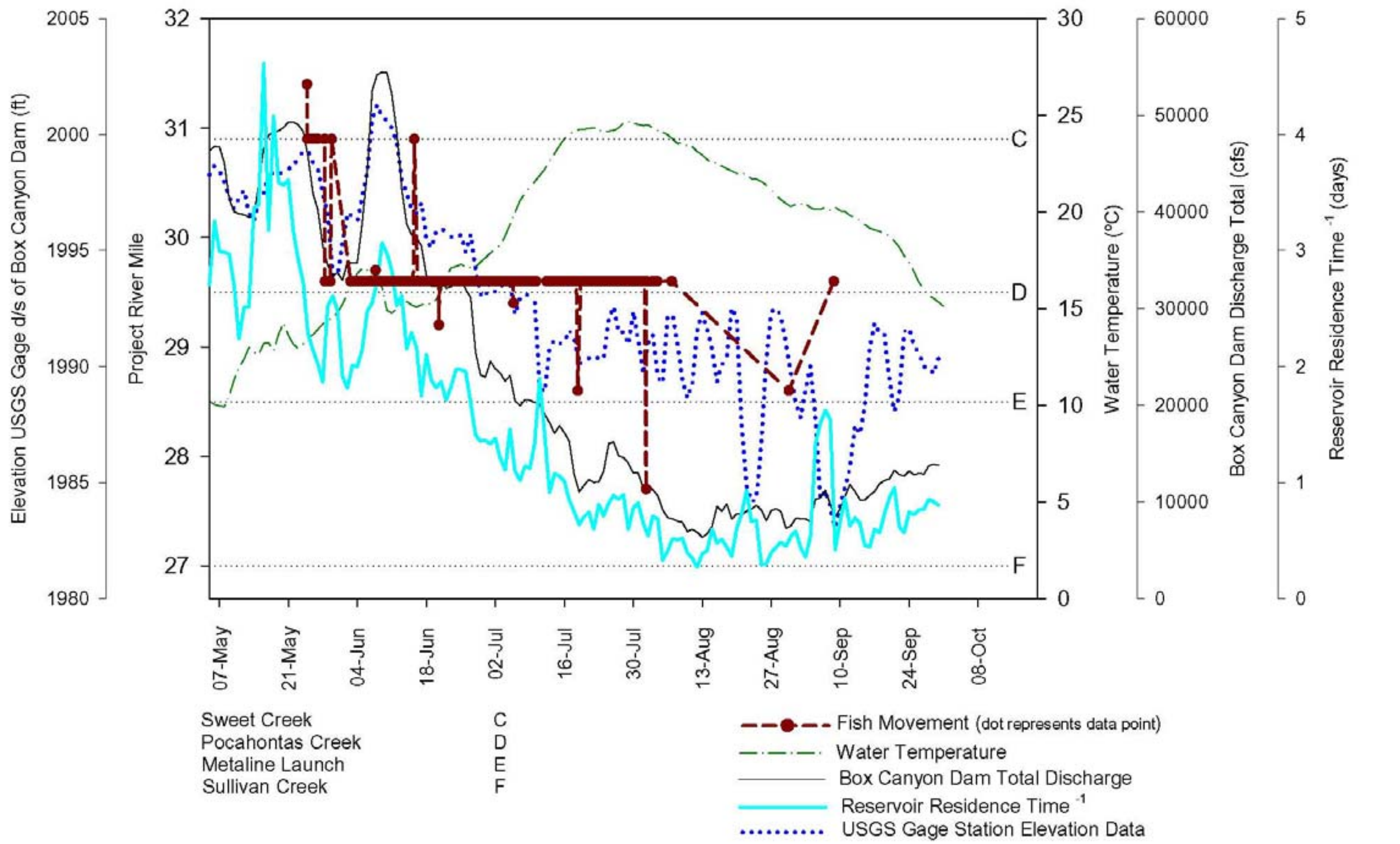


Figure A.3-22 Movement data of a radio-tagged (Fish 23) smallmouth bass (*Micropterus dolomieu*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

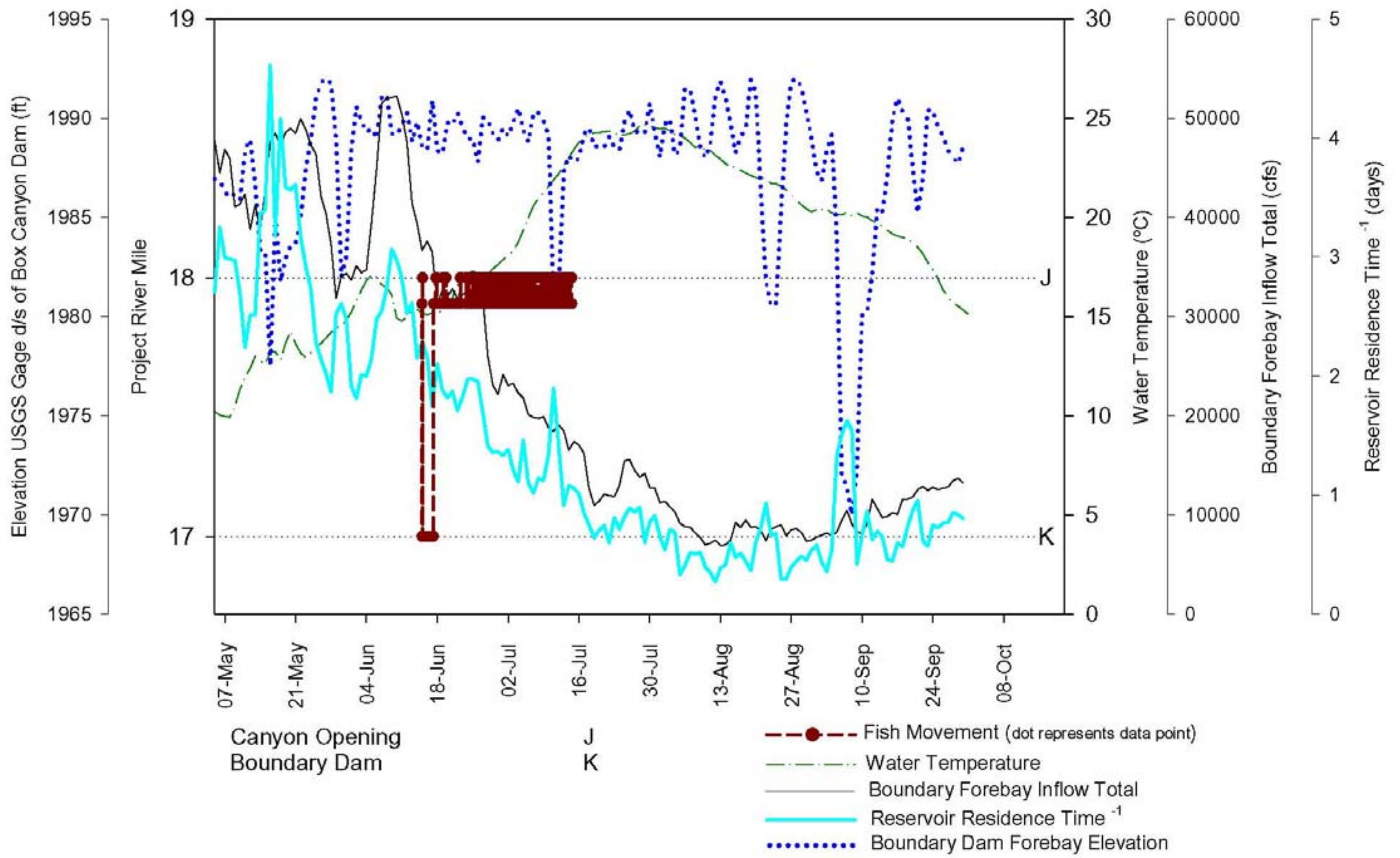


Figure A.3-23 Movement data of a radio-tagged (Fish 27) smallmouth bass (*Micropterus dolomieu*) in the Canyon and Forebay reaches in relation to daily average water temperature, daily average total Boundary forebay inflows, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at Boundary Forebay, 5 May to 30 September 2007.

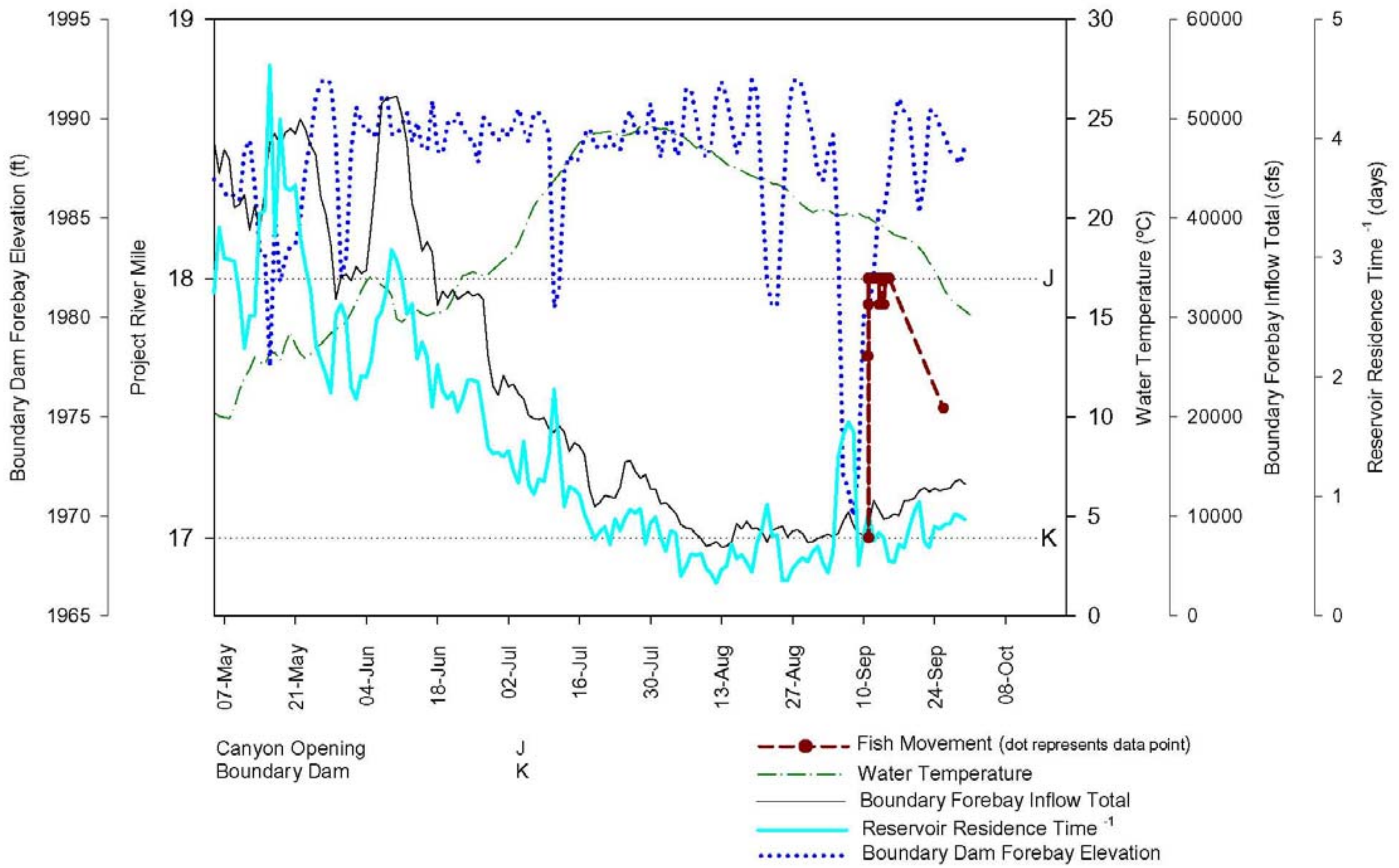


Figure A.3-24 Movement data of a radio-tagged (Fish 29) smallmouth bass (*Micropterus dolomieu*) in the Canyon and Forebay reaches in relation to daily average water temperature, daily average total Boundary forebay inflows, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at Boundary Forebay, 5 May to 30 September 2007.

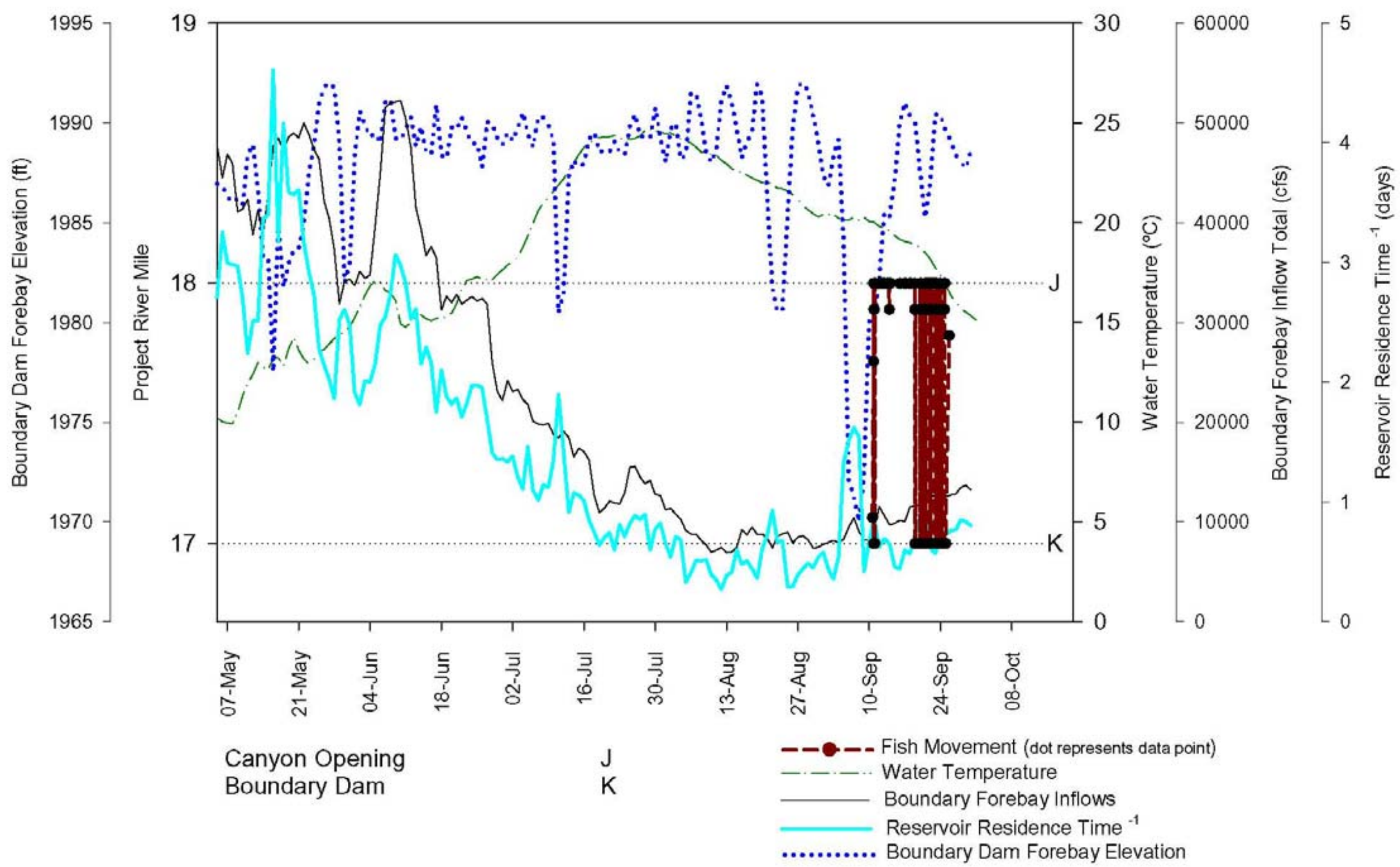


Figure A.3-25 Movement data of a radio-tagged (Fish 42) smallmouth bass (*Micropterus dolomieu*) in the Canyon and Forebay reaches in relation to daily average water temperature, daily average total Boundary forebay inflows, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at Boundary Forebay, 5 May to 30 September 2007.

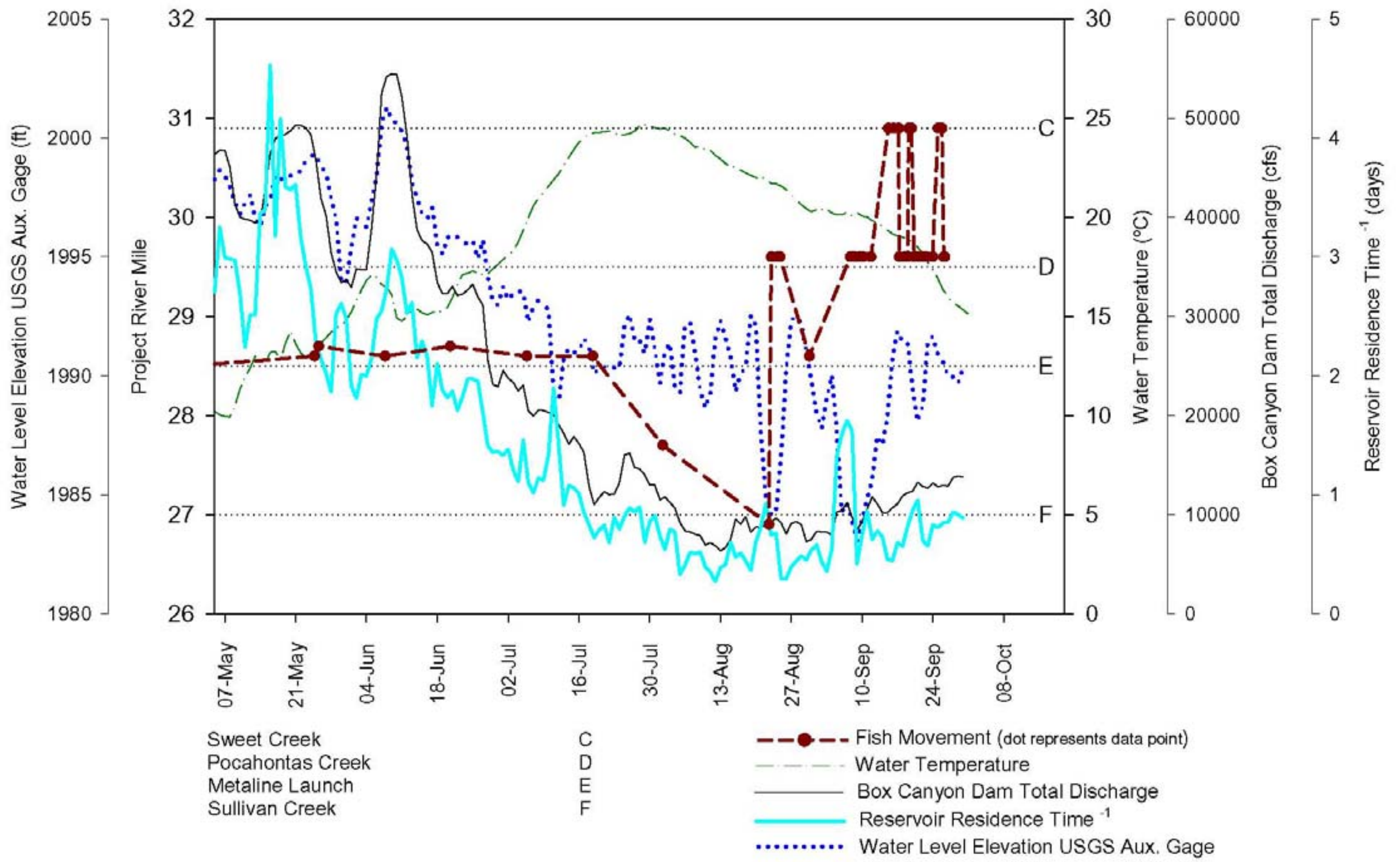


Figure A.3-26 Movement data of a radio-tagged (Fish 158) northern pike (*Esox lucius*) in the Upper Reservoir Reach in relation to daily average water temperature, daily average total discharge from Box Canyon Dam, inverse reservoir residence time (reservoir velocity), and daily average water level elevation as measured at the USGS Auxiliary Gage station 1.2 miles downstream of Box Canyon Dam, 5 May to 30 September 2007.

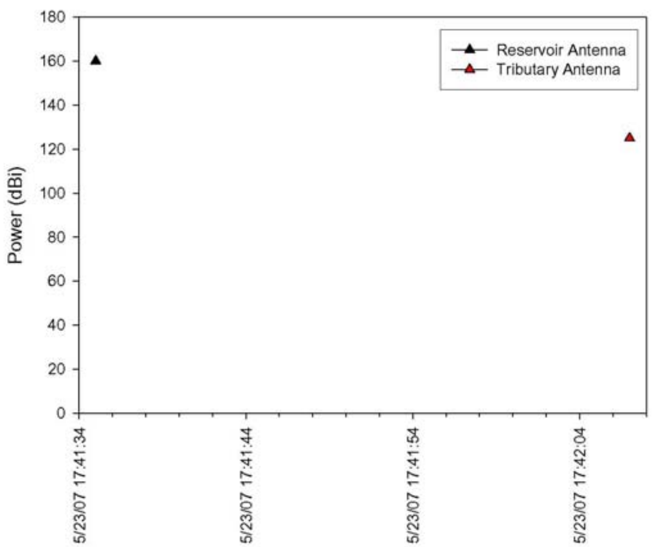


Figure A.3-27 Comparison of signal strength recorded by the reservoir and tributary antenna at Slate Creek for a smallmouth bass (Fish 17), 2007

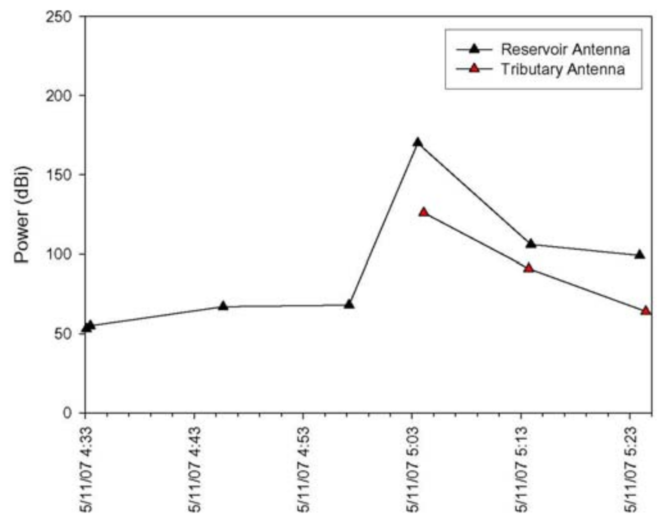


Figure A.3-28 Comparison of signal strength recorded by the reservoir and tributary antenna at Slate Creek for a smallmouth bass (Fish 103), 2007

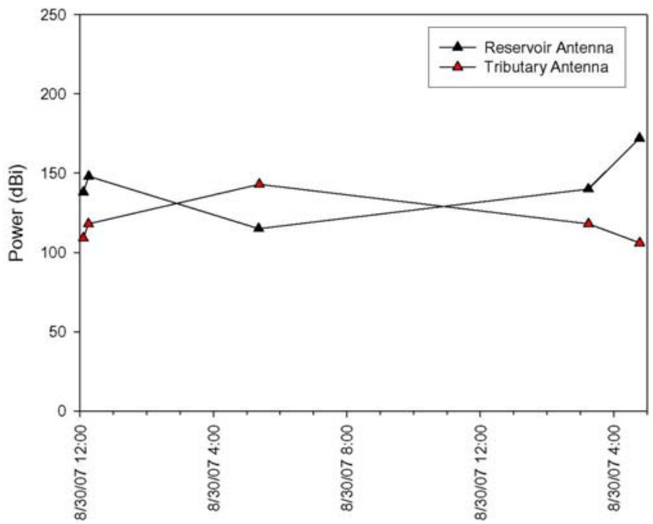


Figure A.3-29 Comparison of signal strength recorded by the reservoir and tributary antenna at Sullivan Creek for a smallmouth bass (Fish 72), 2007

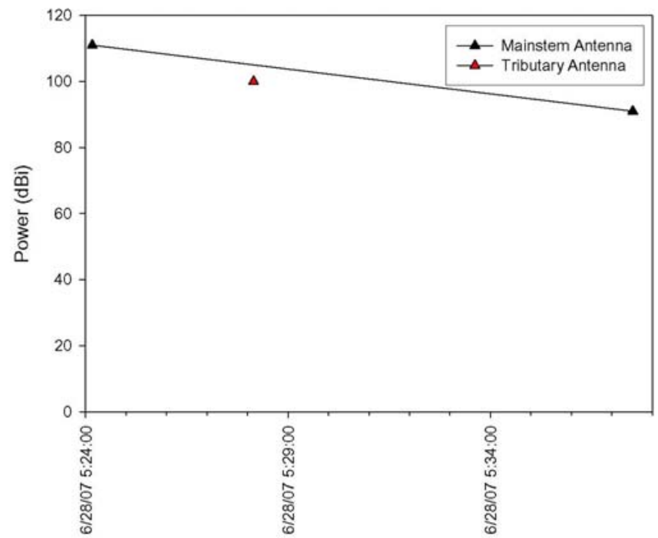


Figure A.3-30 Comparison of signal strength recorded by the reservoir and tributary antenna at Sullivan Creek for a smallmouth bass (Fish 17), 2007

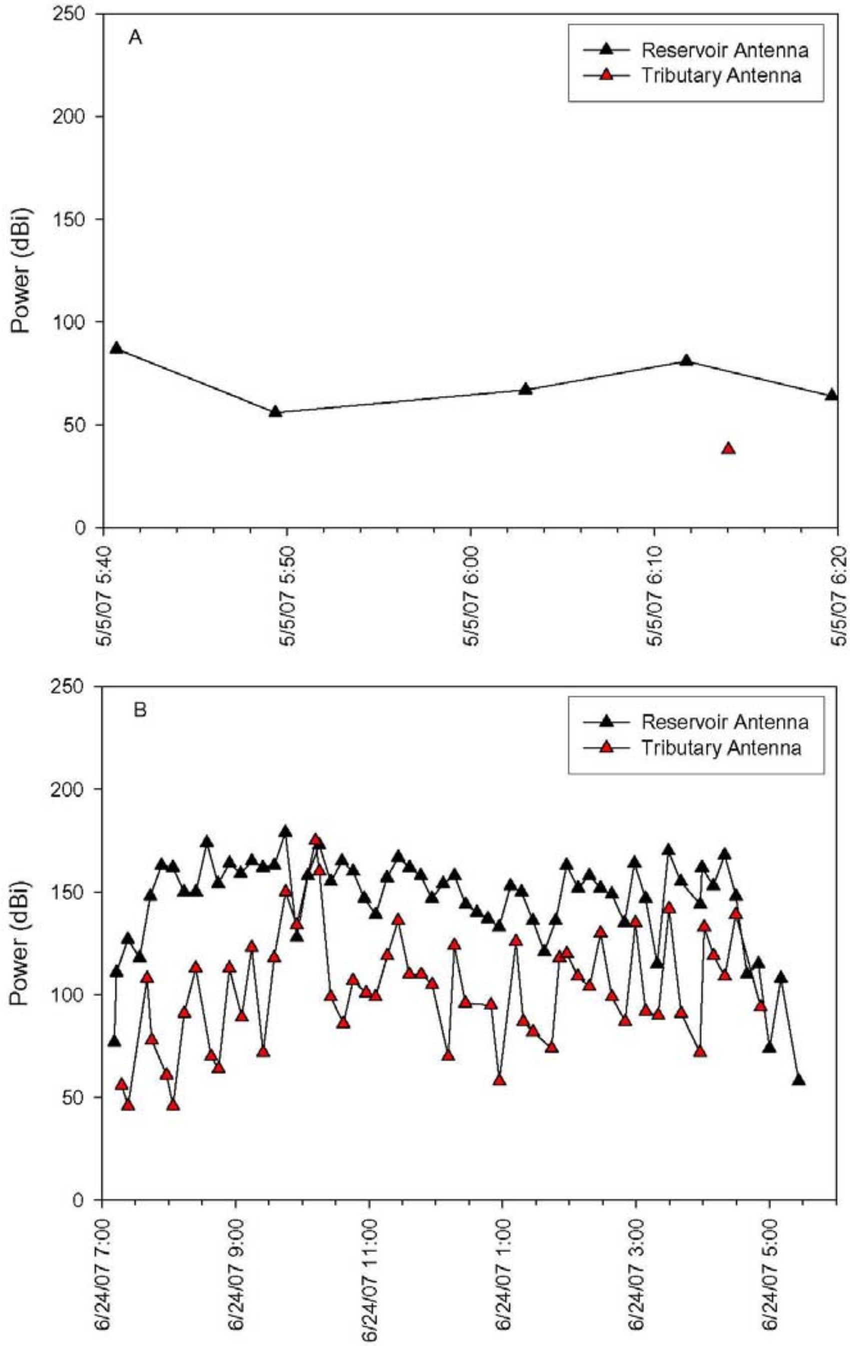


Figure A.3-31 Comparison of signal strength (plots A and B) recorded by the reservoir and tributary antenna at Sullivan Creek for a smallmouth bass (Fish 99), 2007

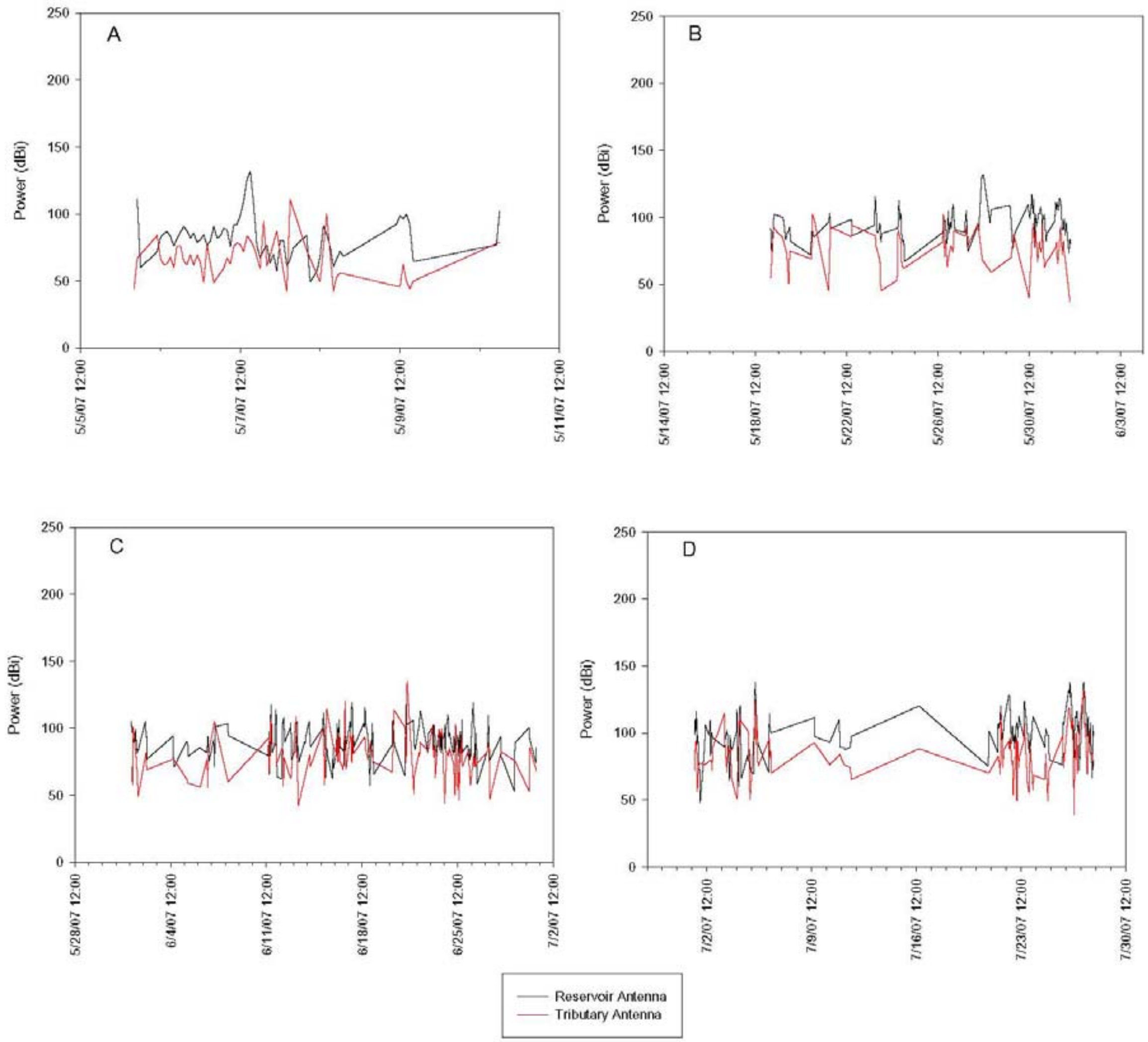


Figure A.3-32 Comparison of signal strength (plots A-D) recorded by the reservoir and tributary antenna at Sullivan Creek for a smallmouth bass (Fish 102), 2007

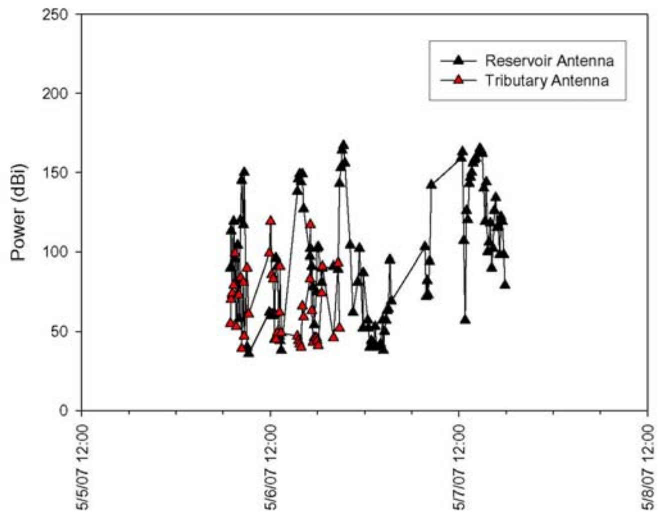


Figure A.3-33 Comparison of signal strength recorded by the reservoir and tributary antenna at Sullivan Creek for a smallmouth bass (Fish 103), 2007

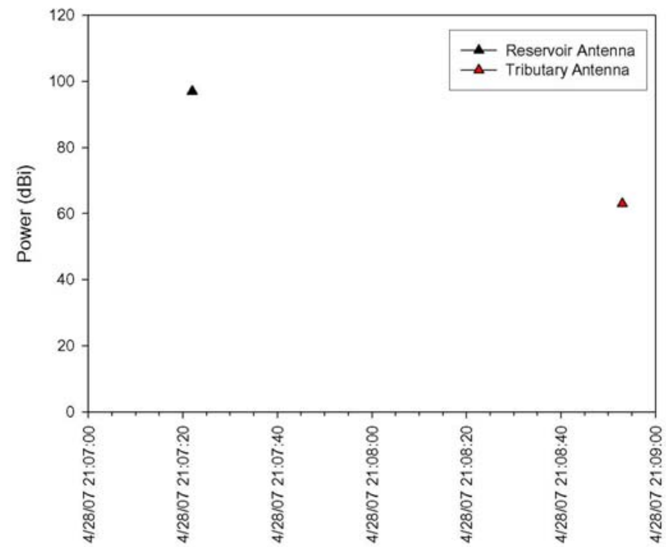
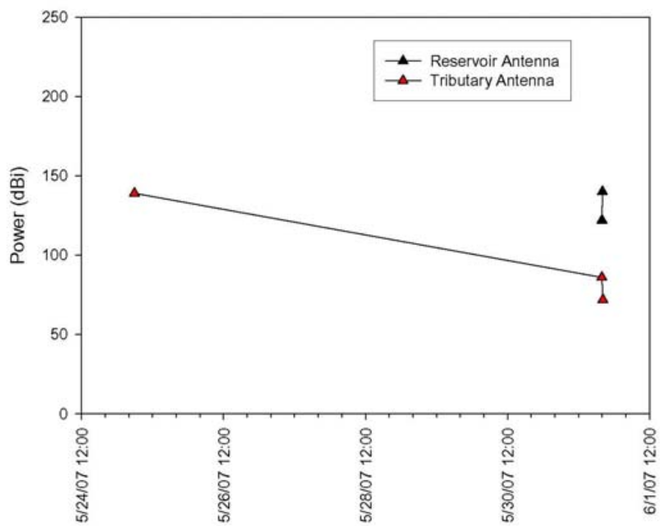


Figure A.3-34 Comparison of signal strength recorded by the reservoir and tributary antenna at Sullivan Creek for a mountain whitefish (Fish 159), 2007



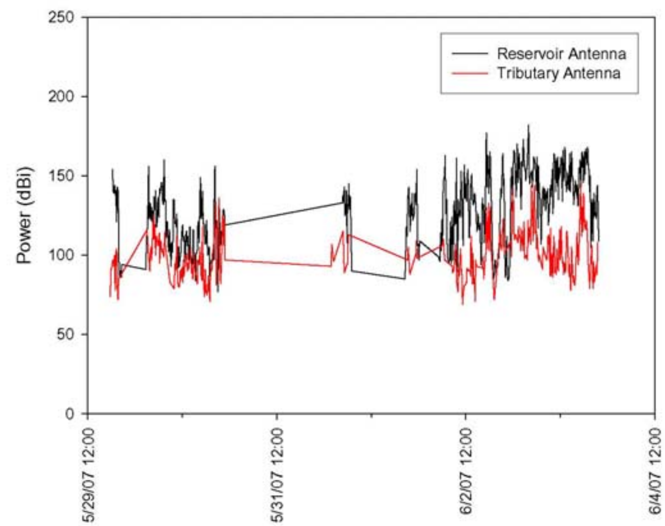


Figure A.3-36 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 21), 2007

Figure A.3-35 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 15), 2007

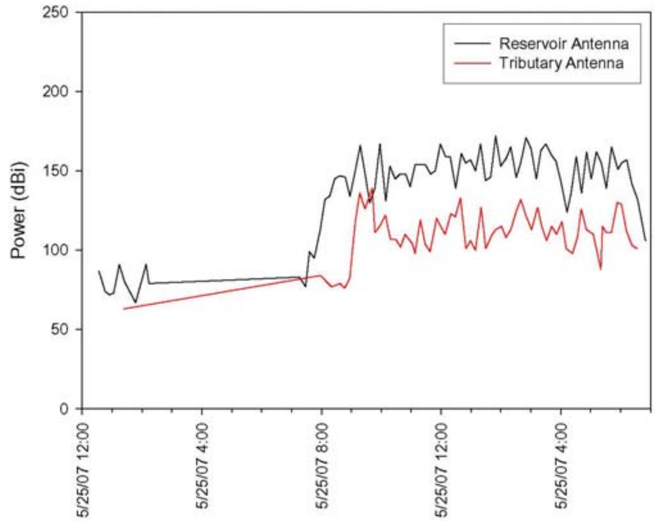


Figure A.3-37 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 23), 2007

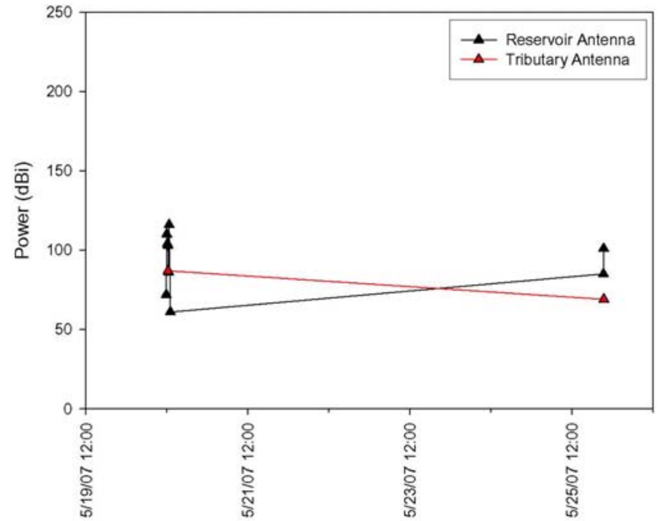


Figure A.3-38 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 107), 2007

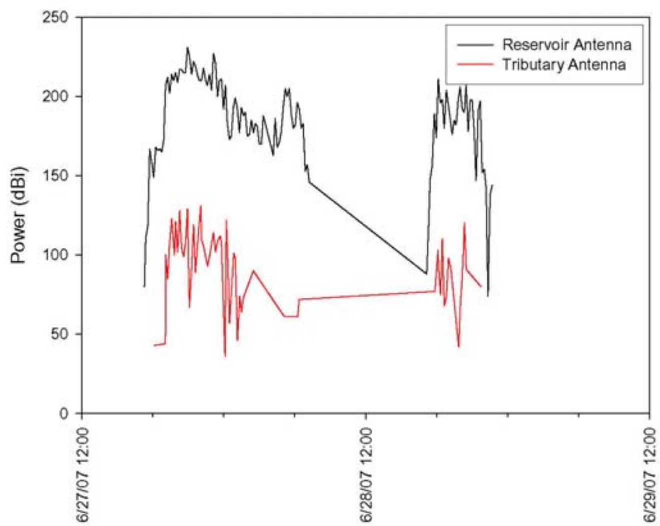


Figure A.3-39 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 99), 2007

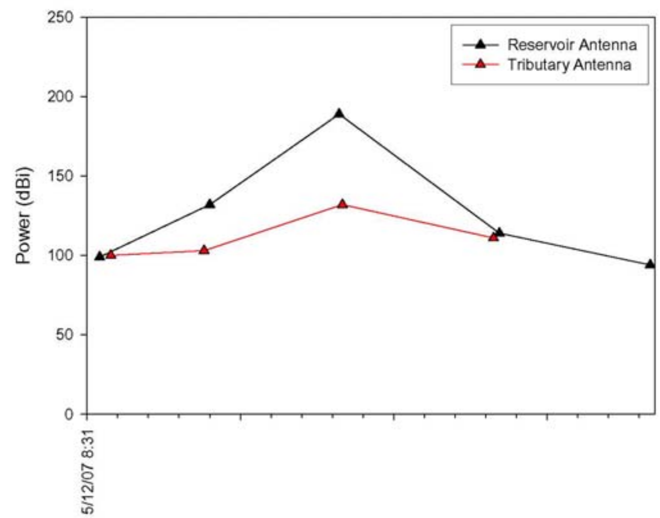


Figure A.3-40 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 101), 2007

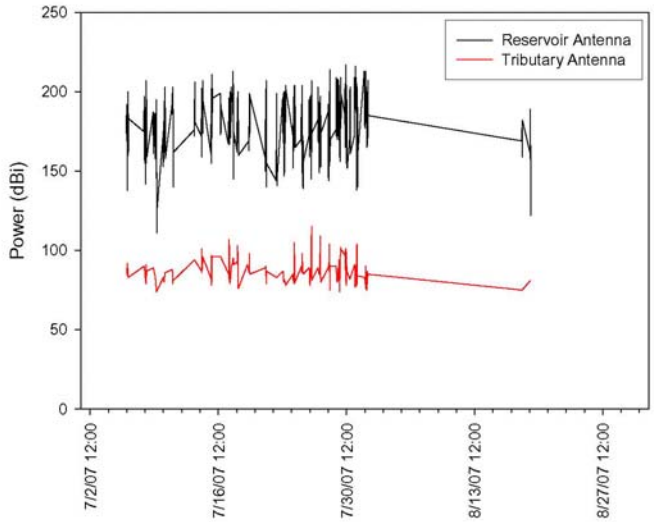


Figure A.3-41 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a Westslope cutthroat trout (Fish 24), 2007

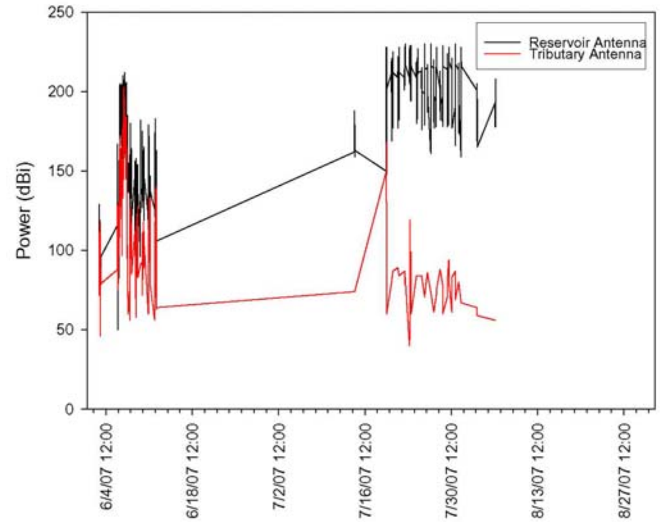


Figure A.3-42 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a Westslope cutthroat trout (Fish 181), 2007

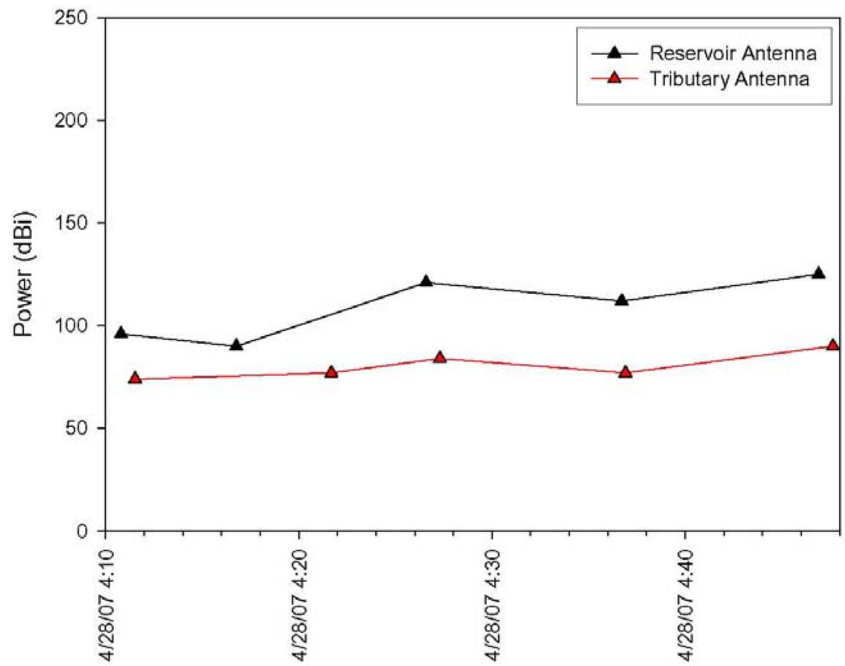


Figure A.3-43 Comparison of signal strength recorded by the reservoir and tributary antenna at Sweet Creek for a smallmouth bass (Fish 159), 2007

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