Testing of Fish and Aquatic Study Methods
Boundary Hydroelectric Facilities

Gill Net Sampling and Tailrace Boat Access

March 2007

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Introduction

Seattle City Light (SCL) is preparing to implement a series of fish and aquatic studies as part of relicensing of the Boundary Project. Under the Federal Energy Regulatory Commission Integrated Licensing Process (ILP), SCL prepared a Proposed Study Plan (PSP) that describes each study to be conducted (SCL 2006a). The PSP details the plans for those studies necessary to develop sufficient information for FERC's analysis of the Project relicensing. As a precursor to the conduct of the PSP, this investigation examines the feasibility and constraints of gill net sampling techniques proposed under the PSP.

The PSP includes a variety of methods to evaluate distribution, movement, and abundance of target native salmonids and selected non-native sport fish. The distribution study includes affixing several target species of fish with a variety of tags, including biotelemetry, Passive Integrated Transponder (PIT), and anchor tags. The success of future biotelemetry and other tagging studies is dependent upon capturing and successfully releasing the targeted fish species, which include native bull trout, westslope cutthroat, rainbow trout, and mountain whitefish. Previous studies in the reservoir and tailrace suggest that bull trout and westslope cutthroat are scarce and collecting sufficient numbers for tagging purposes may be difficult (R2 1998, Terrapin 2000, Scholz et al.2005). Washington Department of Fish and Wildlife (WDFW) conducted a fisheries assessment of Boundary Reservoir in 2000 using electrofishing and gill nets to capture fish (McLellan 2001). The gill nets were set overnight and McCellan intentionally avoided sampling in the reservoir near the mouth of tributaries to minimize salmonid mortality. During the summer and fall of 2000, only 10 of the 733 fish (1.3 percent) McLellan captured using gill nets were salmonids. Five whitefish were the only native salmonids captured.

Native salmonid use of aquatic habitats in Boundary Reservoir and its tailrace may be limited on a seasonal basis due to high summer water temperatures. Thermal refugia may be present at the mouths of some tributaries (e.g., Slate Creek) during these periods. The sampling sites and specific net deployment locations were selected to evaluate the efficacy of the study methods at locations where target species may seasonally congregate.

This study was conducted to test the efficacy of gill net sampling as a method currently considered under the Fish Distribution, Timing, and Abundance Study described in the PSP. The purpose of this investigation was to determine whether target species (bull trout, rainbow trout, westslope cutthroat trout, and whitefish) can be successfully captured and released unharmed using gill nets. The study also examined the effectiveness of gill net sampling during winter conditions.

The PSP calls for several investigations in the tailrace. Studies requiring boat access to the tailrace rely on the use of an old roadbed that was created during dam construction completed in 1967 (SCL 2006b). As such, it is rough and replete with construction debris. Although the road is known to effectively serve as a launch under some conditions, there is uncertainty as to its usability at various tailrace water surface and power generation levels. Understanding the launching constraints on various types and sizes of boats and flow and tailrace water levels is

critical for planning logistics under the proposed PSP. The purpose of the tailrace access evaluation was to identify conditions affecting boat launch and retrieval, as well as hydraulic conditions affecting use of boats in the tailrace.

Methods

Study Sites

Study sites were located at the mouths of five tributary streams (Figure 1). Submerged alluvial fans have formed to some extent at each of the tributaries. Sweet Creek and Sullivan Creek, both tributaries to the reservoir upstream of Metaline Falls, have the largest fan deposits and provide the most extensive littoral habitat of the study sites. Flume and Slate Creek drain into the canyon reach of the reservoir downstream of Metaline Falls. The Canyon Reach is predominantly narrow with steep, rock walls. The mouths of Flume Creek and Slate Creek are typical of the embayments in this portion of the reservoir, which provide localized silt-bottom and relatively shallow habitats with aquatic macrophyte beds. The relatively shallow (less than 7 m at normal full pool) portions of the fans of both Flume Creek and Slate Creek are limited in area.

Pewee Creek drains into the Forebay Reach approximately 0.8 km upstream of Boundary Dam. The Forebay Reach is a wide and deep portion of Boundary Reservoir immediately upstream of Boundary Dam. The mouth of Pewee Creek is a vertical 50 m falls and the reservoir shoreline in this area is steep-walled. A large mound of cobble sits at the base of Pewee Creek. This “fan” is very steep sided, and water depths increase to over 15 m within approximately 60 m of the waterfall.

A sixth study site was established in the tailrace reach, downstream of Boundary Dam. The study site included all of the area upstream of the hydraulic control approximately 200 m downstream of the tailrace boat launch. The site included the deep spillway pool and turbine afterbay areas. This study site is characterized by deep pools (exceeding 25 m) in the spillway and turbine afterbays, but is generally less than 8 m deep elsewhere. The Seven Mile Hydroelectric Project 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; NGVD 1929[1]), Seven Mile Reservoir encroaches upon the tailrace area of Boundary Dam.

Fish Sampling

Gill net sampling was conducted monthly within selected tailrace areas and within Boundary Reservoir near the mouths of five tributaries from July through December, 2006 for a total of six sample visits at each site. Monofilament, multi-mesh, 30 m long experimental gill nets consisting of four 7.6 m by 1.8 m panels (square mesh 2.5 cm, 3.8 cm., 5.1 cm, and 6.4 cm) were set within the reservoir near the mouths of the tributaries and at the base of the spillway, near the turbine outfalls, and other tailrace locations. The location of each gill net set was mapped using a handheld GPS unit and/or marked on high-resolution aerial photographs. Illustrations of the net locations are depicted at each sample site in Appendix A.

In the reservoir, all nets were set within or along the margins of the tributary fans. The location of net sets was modified through the course of the study in an effort identify potential fishing

[1] All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929)

hotspots. When nets were set perpendicular to the shore, the smallest mesh was placed closest to the shore. Nets were also placed parallel to the tributary channel, where the small mesh panels were placed upstream relative to the tributary current. In the tailrace, nets were set in a variety of locations at various depths. Gill nets deployed in the spillway and turbine afterbay were suspended at least 5 m from the channel bottom and at least 10 m away from the base of the dam to avoid entanglement with protruding rebar and construction debris. Gill net surveys in the turbine afterbay and in mid-channel positions were limited to periods of no generation and no spill.

Gill nets were set no earlier than one hour prior to dusk and generally retrieved within one hour. At least three gill net sets were conducted per sample visit at each tributary site. The actual minutes of each gill net set were recorded. Sample visits were repeated monthly from July through December.

All fish collected were identified to species, measured to the nearest millimeter (mm) fork length, weighed to the nearest gram (g), enumerated, and scanned for passive integrated transponder (PIT) tags using a portable tag reader. All target species that did not contain a PIT tag and were 150 mm or larger were implanted with a PIT tag below the dorsal fin in the muscle just beneath the skin, and tagged with individually numbered T-bar anchor tags. A fin punch was collected from rainbow trout captured downstream of Boundary Dam that appeared be of wild origin (dorsal fins well formed) and one cutthroat trout that appeared to be of the westslope subspecies. Tissue samples were preserved in 100 percent ethanol for later genetic analysis.

Total catch by species as well as numerical and biomass catch per unit effort (CPUE) were determined for each monthly sample visit at each site. CPUE values were computed as a function of net length and time (catch per 30 m of net per hour). Composition of the most common species was compared between sample period and among study sites with a chi-square contingency table using total numerical catch at each site. The relationships between CPUE, study site, and sample period were investigated via cross tabulation reports and mean value plots. Spearman's coefficient of rank correlation was used to test for relationships between set duration, catch rates, and mortality rate for net sets during July, August, and September.

Tailrace Access

Physical and hydraulic conditions of the tailrace boat ramp were evaluated to identify conditions affecting boat launch and retrieval. To describe launch conditions under a variety of tailrace water levels, the topographic profile of the boat ramp was surveyed during a period of no generation with tailrace water surface elevations near a typical seasonal low. Profile elevations were determined through the use of an established USGS benchmark situated along the ramp at 1763.458 ft MSL. Ramp surface conditions were generally described, and referenced to specific profile points. Existing ramp hazards, such as surface irregularities and construction debris, which might impede or prohibit boat launching were identified and mapped. The dam safety survey monument platform on the waterward side of the road (Site Photo 1) was used as a reference point for describing the location of access road features and boat ramp hazards. Tailrace water surface elevations as reported in the daily Boundary Power House Operators Report at the time of the survey were used to calibrate observations of water surface elevations to those reported at the Powerhouse gage. Measurements of surface water velocity in the vicinity of the launch area during power generation periods were also taken in order to determine any limitations to boat

launching during higher turbine output flows. Water depths and velocities along the boat ramp were measured as dam discharge went from zero to nearly full powerhouse capacity during the time of surveys. Preliminary conclusions regarding boat access conditions were identified by comparing measurements of tailrace ramp conditions to typical design standards for inland boat ramps (ODNR 2003). Launch conditions were verified by attempting to launch and retrieve a 4.8 m aluminum, V-shaped hull boat equipped with a 40 HP outboard motor under marginal launch and retrieval conditions.

Results

Fish Sampling

A total of 195 hours of 30 m net sets were conducted across the six sample sites in Boundary Reservoir and the tailrace. Gill nets were located in the same general location during each sample visit (i.e. in or along the margins of the fans), but the precise location of the net set varied (Appendix A). Effort was greatest in the tailrace, where at least 6 hours of sampling was conducted during each sample visit (Appendix B). During the first sample visit in July, one net was set at the mouth of each tributary at a time. In the remaining visits, at least two nets were set concurrently at each sample site in different locations separated by at least 200 feet. A total of 299 fish representing 16 species and 5 families were captured. Twenty-six specimens (21 mountain whitefish captured throughout the study area and 5 rainbow trout captured in the tailrace reach that appeared to be of wild origin) were affixed with numbered anchor tags and implanted with PIT tags prior to release (Tag numbers and capture locations are provided in Appendix D and the accompanying project database Excel file entitled *Boundary Fish Study Test 2006 Database*) . Tagging was limited to fish in good condition immediately upon net retrieval.

Species Composition

Largescale sucker, northern pikeminnow, rainbow trout, mountain whitefish, and peamouth accounted for 81 percent of the total numerical catch (Table 1). Except for peamouth, which were not observed in the tailrace, these species occurred at every site. By number, largescale sucker was the most abundant species captured and also accounted for the greatest biomass in the catch. Rainbow trout and northern pikeminnow catch was similar; these two species ranked second and third in total catch, respectively. Mountain whitefish, one of three native salmonid target species under the PSP, ranked fourth in total catch, and peamouth was the fifth most commonly captured species. Eleven species comprised the remaining 19 percent of the catch. Overall, total biomass catch was dominated by largescale sucker, northern pikminnow, rainbow trout, and mountain whitefish. Species composition and abundance are indicative of the sampling conducted near the mouth of the largest tributaries and may not be representative of Boundary Reservoir.

Salmonids represented 36 percent of the total numerical catch and 38 percent of the biomass catch. Rainbow trout and mountain whitefish dominated the salmonid catch and were captured at every site; brown trout were the only other salmonid represented by more than one capture (7 fish captured at three reservoir sites). Lake trout and eastern brook trout were captured at the Slate Creek and Flume Creek sites, respectively. One cutthroat trout that appeared to be of the westslope subspecies and one kokanee were captured at the Sweet Creek study site. Salmonids dominated the catch in the Sweet Creek (rainbow) and Sullivan Creek (mountain whitefish)

reservoir sites (Table 2). Most of the rainbow trout (46 of 56) were believed to be triploid hatchery plants. All of the "wild" rainbow trout captured (3 fish) at the reservoir sites exhibited characteristics of rainbow / cutthroat hybrids. In the tailrace, 7 of the 13 captured rainbow trout appeared to be of wild origin.

Five walleye were captured ranging from 460 mm to 578 mm total length; two in the reservoir (one each at the Sweet Creek and Pewee Creek sites) and three in the tailrace. Walleye are known to have been introduced into the Pend Oreille River system several years ago, but have not been previously reported as captured in Boundary Reservoir or in the tailrace. A total of five burbot were captured; two in the spillway pool of the tailrace site, and two in the Slate Creek site and one in the Flume Creek site.

Species composition of the five most common fish captured varied between months and among study sites. Largescale suckers were notably scarce at the Flume Creek and Sweet Creek study sites, but their catch at the tailrace site more than doubled expected frequencies (Table 3). Likewise, the Pewee Creek site catch was notably low in mountain whitefish, while Sullivan Creek site catch nearly tripled expected catch frequencies. Catch composition also varied between sample periods. The August catch was notably more rich in largescale suckers, whereas rainbow trout comprised a larger than expected fraction of the total catch during July.

Catch Rates

Largescale suckers dominated both numerical and biomass CPUE for the entire study period. Mountain whitefish biomass CPUE ranked second overall, although northern pikeminnow and rainbow trout biomass CPUE were only slightly lower.

Catch rates for all species combined were greatest in August and steadily declined in subsequent sample periods (Table 4). Largescale suckers dominated both numerical and biomass CPUE for the entire study period although rainbow trout dominated biomass and numerical CPUE in July. Rainbow catch rates ranked in the top three in the remainder of the months and ranked second in total numerical CPUE, tied with northern pikeminnow. Rainbow trout catch rates were ranked higher than other species during July and nearly equaled catch rates of largescale sucker in August (Figure 2). Peamouth dominated the catch rates in October.

In general, numerical and biomass CPUE for all species combined was greatest at the mouth of Pewee Creek. Biomass CPUE at Pewee Creek was more than three times greater than that of Slate Creek, the site with the lowest overall numerical and biomass CPUE (Table 5). Mean catch rates of the five most common species varied among the study sites (Figure 3). Mean numerical and biomass CPUE for largescale sucker at the Pewee and Tailrace sites were greater than all other site/species combinations. Mean numerical and biomass CPUE in Sweet Creek was dominated by rainbow trout, whereas catch rates in Sullivan Creek were highest for mountain whitefish. Slate Creek catch was dominated by northern pikeminnow. Species catch rates by biomass may be affected by the gill net sampling gear that targets larger fish. Appendix C provides monthly species specific catch rates for each study site.

Monthly overall catch rate was highest for all study sites in July and August, which also corresponded with the highest water temperatures encountered (Figure 4). Catch rates were greatest in August for the Flume, Pewee, Sweet, and Tailrace study sites, whereas higher catch rates were recorded at the Sullivan Creek and Slate Creek sites in July (Table 6). Overall catch

rates substantially declined between August and September in most study sites. Catch rates correspondingly dropped with water temperatures after August and through December.

Netting and Handling Mortality

A total of 35 of 299 fish (11.7%) captured suffered netting or handling mortality. The majority of mortality occurred at the Sweet Creek, Sullivan Creek, and Flume Creek study sites. Whitefish and triploid trout accounted for 28 (80%) of the total mortalities. One of the mortalities (captured at the tailrace site) appeared to be a wild rainbow trout. No other native trout were mortalities. Nearly all of the mortality occurred during the earliest sampling efforts of July and August when site water temperatures exceeded 20˚ C. During the July sampling effort, fish appeared especially prone to excessive net entanglement, and many salmonids were dead or moribund at the time of net retrieval.

Excessive net entanglement and higher mortality rates at Sweet Creek and Sullivan Creek sites during July and Augusts may be partially explained by less than ideal net deployments. Mortality associated with excessive net entanglement was most pronounced for three specific net sets. Each of these sets was anchored with a 2.3 kg mushroom style anchor on each end of the net. A 30 cm inflatable buoy was used to mark the net locations, support the anchor line, and aid in keeping the net upright. As water depth increased during the early morning hours, the weight of the anchors was insufficient to prevent some of the net sets from lifting and moving. Upon retrieval, it was readily apparent that anchors had shifted on at least one end of the set and the net was no longer stretched and taut. At each of these sets, two or more fish appeared to have wound themselves into a bundle of net. The slackened net may have resulted in further entanglement as captured fish continued to struggle. At least 22.8 percent (8 fish) of the total mortality was associated with excessive entanglement in slackened nets.

During September, study site water temperatures declined and mortality rates correspondingly dropped. Mortality rates declined to 7 percent (4 of 58 fish) in September with a drop in water temperatures (average water temperature of 15˚C). No handling mortality occurred in October, November, or December when water temperature fell below 14˚C. Four of 127 captured fish suffered netting mortality during the September through December sampling, with water temperatures below 20˚ C. In general, fish captured and released during September through December revived rapidly after removal from the net.

Given the high mortality suffered in the July sampling period, modifications were made to net sets during August in an effort to examine the influence of deployment duration on mortality rates. During August and September, set duration was varied from a 0.3 to 1.0 hour. Spearman's coefficient of rank correlation was used to test for relationships between set duration and mortality rate for all net sets during July, August, and September. Mortality rate was most closely related to set duration during this period (r = -0.19, P = 0.10). Following the August sampling, anchors were modified to ensure they were of sufficient weight (3.2 – 5.4 kg) to prevent net movement. Greater anchor sizes also provided for more effective deployment, as nets could be readily secured to the bottom and stretched for an overall tauter set. Sets were also modified to ensure the anchors were not subject to lift from excessive buoyancy caused by oversized floats. At sets subject to noticeable water velocities and rising water levels, smaller "crab-pot" buoys were affixed to the anchor lines. Realizing that rising water levels may result in buoy

submergence, a second buoy was affixed approximately 10 feet above the primary buoy in order to relocate the nets.

Tailrace Access

Launching a boat in the Boundary tailrace requires use of a road bed originally constructed in the late 1960s during construction of the Project. The road bed was protected by a coffer dam during Project construction and presumably was designed to serve as a one-lane access to the turbine outlet tunnels. The road bed was not decommissioned following Project construction and it serves as an informal boat launch for Project maintenance activities. The road bed is within a restricted public access area and there is no public use of the old road bed. Increased use of the road bed is expected as fish and aquatic research studies are implemented as part of relicensing of the Project. The tailrace boat ramp does not meet the design standards for an inland recreational boat ramp (Table 7), but it will provide access during most conditions.

Tailrace boat ramp evaluations revealed several logistical considerations for future studies requiring boat access to the Boundary Dam tailrace. First off, the widened turn around area is situated well upslope from the waters' edge. This distance requires backing a trailer vehicle down a narrow, unimproved roadway for nearly 245 m. The west side of the road is bounded by a steep slope of boulders strewn with construction debris. A precipitous drop toward the waters' edge bounds the east side. The roadway is generally narrow and leaves little room for steering error (Site Photo 1), which can be especially difficult during the nighttime. There is one additional widened area situated approximately 45 m upslope of the waters' edge during periods of power generation or Seven Mile full pool, but it is too narrow to effectively turn a truck with a trailer in tow.

A 4.8 m aluminum, V-shaped hull boat outfitted with a 40 HP outboard propeller motor was used for all phases of this study. The boat and trailer extend approximately 5.8 m beyond the truck hitch. The boat draws approximately 0.3 m of water with the motor in a raised position. Trailer axle clearance is 0.28 m. The stern of the boat extends approximately 2 m beyond the trailer wheels. The boat is relatively light, and requires minimal flotation in order to push the boat from the trailer while launching. We encountered water surface elevations ranging from 1720 feet to 1732 feet MSL (NGVD 29 Datum). Tailrace discharge varied from little discernible flow under no generation to approximately 40,000 cfs. Water velocities measured in the immediate launch area during the 40,000 cfs discharge were negligible, less than 0.05 m per second. Once launched, field staff were able to access all areas of the tailrace during these discharge levels using the 4.8 m aluminum skiff with 40-hp outboard. Maximum powerhouse generation is approximately 56,000 cfs under full reservoir pool conditions. Boundary Powerhouse staff report that a boat can be launched and retrieved under maximum generation.

The boat was successfully launched from a boat trailer on numerous occasions during both daylight and darkness. Subsequent take-out and reloading of the boat onto its trailer was also performed successfully. However, on two occasions launch attempts were thwarted due to low tailrace water levels. Likewise on two other nights we were unable to retrieve the boat due to low water levels. During all of these situations, reported tailrace water levels were below 1725 ft MSL and no Boundary power generation was occurring. However, levels exceeded 1725 ft soon after Boundary power generation began. As water levels drop to approximately 1727 ft, boat

launch and retrieval requires maneuvering a boat trailer on the rougher lower end of the boat ramp.

Existing hazards in the launch area include an uneven driving surface due to coarse cobble and small embedded boulders requiring improved traction tires and four-wheel drive capability for trailer pullout (Site Photo 2). Other hazards to be aware of are the existence of protruding construction debris, specifically metal rebar material that presents a potential tire puncture hazard (Site Photo 3). At a slope distance of approximately 130 m down the ramp from the dam safety survey monument platform on the left edge of the road (Site Photo 1 includes the platform), the launch surface has limited "drivability" or maneuvering room for a boat trailer. Boulders and an uneven ramp surface create holes and obstructions that threaten axle and tire damage (Site Photo 4). During successful boat launches, field staff avoided ramp hazards and managed to back beyond this first group of ramp hazards that included a large, potentially damaging hole (approximately 1 m across and 0.3 m deep) situated at approximately 132 m down the ramp from the survey monument platform, by straddling the boat trailer over the hole (Site Photo 5). This hazard must be contended with when water surface elevations drop to or below 1727 ft MSL. At 138 m from the tower, a group of particularly uneven large cobbles and boulders prohibited further trailer backing during this study. A trailer with axle clearance exceeding 0.4 m could conceivably continue down an additional 5 m, albeit at some risk of high-centering the trailer or towing vehicle.

At a slope distance of approximately 143 m down the ramp from the survey monument platform, a boulder near the shoreline would force the trailer off of the ramp, onto an uneven boulder surface with hazardous construction debris. Beyond this point, the launch ramp becomes completely unusable due to uneven boulder surfaces (Site Photo 5).

It is recognized that different watercraft and truck/trailer combinations will vary in their ability to overcome launch access limitations. Large boats with greater water draw will typically require deeper water. To describe launch conditions under a variety of tailrace water levels, the longitudinal profile of the boat ramp was surveyed during a period of no generation with tailrace water surface elevations near a typical seasonal low. Slope of the boat launch averages 7.5 percent.

The launch profile survey allowed for computation of launch water depths under varying tailrace water levels. To determine the tailrace levels that effectively limit use of the launch for an average 6 m boat, it is assumed a minimum water depth of 1 m at the stern of the trailered boat would be required. The stern of the boat is assumed to be situated 2.5 m behind the trailer tires. Ramp survey results suggest that the absolute furthest point down the ramp that a boat trailer could be safely positioned occurs approximately 146 meters down the ramp from the observation platform. Elevation of the center of the ramp is 1722.7 ft MSL at this point. If a boat trailer could make it to this point, the bottom surface elevation at the projected stern is approximately 1721.5 ft MSL. In order to float a boat off its trailer at this position on the ramp, the minimum tailrace water elevation needed would be approximately 1724.5 feet above MSL. It should be noted that this ramp position represents the maximum waterward extend of trailer travel and would require aggressive driving with careful spotting to avoid hazards to the trailer axle and tire.

However, under the current study and using a small trailer with limited axle clearance, the waterward limit of trailer maneuverability was identified at 138 m down the ramp from the survey monument platform. At this point, the ramp surface elevation is 1724.02 ft MSL. At 2.5

m further down the launch the ramp surface elevation is approximately 1723.1 feet above MSL. Using the assumption that at least one m depth at the stern is necessary, a tailrace elevation of approximately 1726.1 ft MSL is required for a successful launch. Under this study, boat launch and retrieval was successful at a tailrace level of 1725.1 MSL. However, the study team used a relatively light boat that draws less than a foot of water at the stern, which allowed launching and retrieval at water depths of approximately 0.7 m. In addition, the light boat was pushed from the trailer prior to lowering the propeller, further reducing launch depth requirements.

Future Survey Considerations

Gill Net Sampling

The relicensing PSP called for gill netting to attempt capture of target species for tagging as part of a biotelemetry study, as well as to evaluate spatial and temporal variability in fish distribution and abundance in the tailrace and reservoir tributary mouths through catch statistics. This study demonstrated that salmonids can be captured through the use of short-duration gill net sets in Boundary Reservoir near the mouths of the largest tributaries and tailrace area. Previous sampling by WDFW intentionally avoided sampling near tributary mouths to reduce the potential mortality of salmonids captured through overnight gill net sets in 2000. Only 1.3 percent of the fish they captured were salmonids (McLellan 2001). In comparison, 34.7 percent of the fish captured using short-duration gill net sets near tributary mouths in 2006 were salmonids. Large native cyprinids (northern pikeminnow) and Catostomus (largescale sucker) dominated the total catch in the three most downstream study sites (Tailrace, Pewee, and Slate). Salmonids dominated the catch at the Sweet, Sullivan, and Flume Creek sites, especially during the July and August surveys. Despite catching only one cutthroat trout with westslope characteristics and no bull trout, several mountain whitefish large enough to carry a biotelemetry tag were captured in the reservoir and tailrace. Rainbow trout that appeared to be of wild origin and large enough to carry a biotelemetry tag were captured in the tailrace.

The study demonstrates that the Boundary reservoir near the mouths of Sweet, Sullivan, and Flume Creek are locations that appear particularly suited for seasonal capture of salmonids, especially during the period of elevated water temperatures during the summer. Catch rates were higher for all sites and most species during July and August, suggesting some attraction to the tributary mouths. However, salmonids are most vulnerable to handling mortality during periods of elevated water temperatures that can occur in July and August.

The relationships among water temperatures, set duration, and catch and mortality rates suggest that net deployment times as short as 0.5 hours may be warranted in order to reduce the risk of handling mortality when water temperatures exceed 16˚C (Table 8). Moreover, sample gear should be adequately anchored and buoy markers appropriately sized and rigged to ensure that gill net sets are sufficiently taut and not prone to drift as water levels rise. Captured fish appeared to be especially prone to excessive entanglement where nets are subject to shift and become slack. Perhaps as much as 20 percent of the netting mortality observed in this study could have been avoided with the use of more appropriately sized anchors and floats during July and August.

As water temperatures reach and exceed 16 ˚C, sampling mortality rates should be closely monitored even with set durations as short as 0.5 hours to determine if the mortality risk negates the opportunity to capture, tag, and release target species unharmed. Although not completely

prevented, mortality was reduced with reduction of net deployment times with water temperatures as high as 22˚C. Fish revived rapidly after netting and handling during October, November and December when water temperatures were less than 14˚C, suggesting that longer net deployment times may be considered during winter sampling (Table 8). Both catch rates and mortality substantially declined during October through December, periods typified by low water temperatures. As mortality risk decreases, extended set durations would also increase the opportunity for capture of targeted native salmonid species, which, with the exception of whitefish, appear to be relatively uncommon.

In addition, inclement winter weather creates arduous field conditions that make one-hour net sets more difficult. The November and December sample visits were conducted during stormy weather. The November visits occurred during an extended rainy weather pattern. Stream discharges in the surrounding drainages were near or above their average seasonal highs. Higher stream discharge conditions required particular vigilance during nighttime boat operations to avoid floating debris. The December sampling period was preceded by a significant winter storm, with snowpack depths of up to a foot surrounding the reservoir. Air temperatures fell below -5.0˚C during the nightly sample visits in early December. Tending to two or more one-hour gill net set per evening often necessitated several consecutive hours of field time, thus increasing the risk for exposure. Extended net sets would provide field staff respite from extended exposure. During this period of cold weather, embayments at the mouths of Slate and Pewee Creeks became ice covered. Nets were deployed at least 150 m away from the confluence of these tributaries with the reservoir, as the previously used net set locations were inaccessible.

As described in the PSP, one objective of the gill netting is to capture fish for the biotelemetry study. Target sample sizes for biotelemetry have been identified as 20 bull trout, 20 cutthroat trout, and 20 mountain whitefish in the tailrace reach and 30 bull trout, 30 cutthroat trout, and 30 mountain whitefish in the reservoir. Given the catch rates of these three native salmonids under this study, it appears that the PSP target sample sizes are likely to be attained only for mountain whitefish. For instance, using the capture rate of cutthroat trout (0.01 fish per 30 m net per hour) as a surrogate for projected catch rates for both bull trout and cutthroat trout, a minimum of 10,000 hours of gill netting using 30 m long nets (or 5,000 hours using 60 m nets) would be required to attain a combined sample of 100 bull trout and cutthroat trout. This also assumes that all nets have a capture rate similar to that observed at the reservoir tributary mouths in 2006. Under the PSP, gill net sampling will be conducted with 60 m long nets at as many as 20 sites. In the reservoir, sample plans call for three hours per month for 2 years at 17 sites. This results in approximately 1,224 hours of 60 m nets (or 2,448 hours of 30 m nets for comparative purposes). Similarly, in the tailrace, sampling is planned for three one-hour periods at three sites monthly for 8 months per year over the two year study period, which would result in approximately 144 hours using 60 m nets. The combined tailrace and reservoir effort is about 3,000 hours using 60 m nets. Increasing the duration of gill net sets would increase total net fishing time, but it is likely that the capture rate of targeted salmonids in the reservoir away from tributary mouths will be much lower than that observed in 2006. Given the scarcity of bull trout and cutthroat trout, the projected catch under the planned PSP sampling intensity is likely to fall short of meeting the target sample size for those species.

Using similar calculations, mountain whitefish catch rates of 0.20 fish per 30 meter net per hour observed under this study would require approximately 125 hours of fishing with 60 m nets. Considering the catch rates observed under the current study, opportunity for increased capture

for all species is likely during periods of warmer water temperatures. However, the increased risk of handling and netting mortality associated with increased water temperatures must be considered, and deployment durations of each individual net should be reduced to 0.5 hour, with an attendant increase in number of sets to meet the sampling intensity objectives.

Tailrace Boat Access

During December, boat ramp snow and shoreline ice prohibited the use of the public boat launch above Metaline Falls (Site Photo 6). The reservoir was accessed via the SCL forebay launch. Snow was removed from both the tailrace and forebay launch sites prior to the December sample visits. The use of traction devices on four-wheel drive vehicles and periodic snow removal from the boat ramps are likely to be necessary for year round sampling.

Fluctuating tailrace water level elevations determine boat launching limitations. A tailrace water level elevation of 1726 ft above MSL or higher appears suitable to launch and retrieve most watercraft. At this level, water depth is sufficient to float a boat off and onto a trailer and also provide enough horizontal distance to avoid ramp hazards noted above. Tailrace water level elevations exceeded 1726 ft above MSL during some period of the day on a daily basis during the course of this study. Within the range of Seven Mile pool levels encountered during the study, the backwater effect caused by the hydraulic control situated downstream of the boat launch provided sufficient depths for launching most watercraft during periods of Boundary power generation. However, during periods of no generation and no spill, launch limitations are highly dependent upon the water levels of the Seven Mile Pool. The Seven Mile project located downstream in Canada and operated by the British Columbia Hydro and Power Authority (BC Hydro) creates a backwater effect on the tailwater of Boundary Dam. As a result, BC Hydro's operation of Seven Mile influences the tailwater elevations and boat ramp use when Boundary Dam is not releasing water.

It appears that some access difficulties at the tailrace boat ramp could be remedied by reasonably low cost measures. First, several pieces of rebar and other construction debris at or near 1726 ft MSL could be partially excavated, cut-off, and removed. In addition, the holes and protrusions created by a few large boulders and the uneven ramp surface could possibly be excavated with a pry bar and/or backhoe. Once the protrusions are removed, the ramp surface could be smoothed with gravels and small cobbles by simply filling the holes left from the boulder removal. Repair operations on the ramp should avoid any fill that would raise the elevation of the ramp, as low tailrace gradient is clearly a limiting factor in tailrace boat launch use. It should also be noted that "easy" improvement opportunities are limited, as the ramp and channel bed material is largely angular and interlocked large cobble and boulder size material at approximately 1723 feet MSL.

Summary

Gill netting has been demonstrated as an effective means to capture salmonids and to provide information on the spatial and temporal change in relative fish abundance in the Boundary reservoir tributary mouths and tailrace. Given the findings of this study and past research on the reservoir, it is apparent that the gill net sets at the mouth of the tributaries, as well as other reservoir and tailrace locations are effective at capturing triploid trout, and other larger sport fish

species for tagging and biotelemetry studies. However, it is apparent that bull trout and westslope cutthroat trout are rare in the reservoir.

It is unlikely that the gill net sampling identified in the PSP will result in the capture of the targeted number of bull trout and westslope cutthroat trout. Additional gill net effort at the mouths of tributaries and other identified high use habitat areas (including the tailrace of Box Canyon Dam and tailrace of Boundary Dam) may increase the likelihood of capturing native bull trout and westslope cutthroat trout, but the likelihood of capturing sufficient numbers of subject fish only by gillnet appears remote. However, the PSP also includes electrofishing and fyke net fishing to collect fish in the project area.

The capture rate of salmonids is greater during periods when water temperatures exceed 16˚C, and it appears that mouths of the tributaries may receive concentrated use during such times. Sampling at the tributary mouths should continue during warm water periods in order to increase the likelihood of native salmonid capture. However, it must be recognized that risk of handling and netting mortality increases at this time, so net sets should be reduced to a maximum of 0.5 hours and closely monitored. Net sets conducted in shallow waters near the tributary mouths could be affixed with small, brightly colored floats to serve as a "bobber" in an effort to continually detect fish capture. Fish could then be removed immediately upon capture and placed in a holding box stationed in the cool water tributaries for recovery.

For studies downstream of Boundary dam, the tailrace boat ramp is useable whenever Boundary is generating power and providing discharge. During periods of no Boundary generation or discharge, the ramp is still readily useable whenever the Seven Mile pool exceeds 1726 feet MSL. If a boat must be launched or retrieved during the time of day with lower tailrace levels, inflatable rafts and Zodiac-type watercraft with removable outboard motors may be launched by hand. Minor alterations of the ramp area around between the 1723 and 1727 ft MSL should be considered to remove potential launch hazards created by construction debris and the coarse ramp surface.

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Table 1. The total number (percentage of total number individuals), mean total length (range of total length), biomass (percent of total biomass), and netting/handling mortalities of fish captured in the Boundary Reservoir and tailrace during July through December, 2006 gill net fishing.

Species	Number Captured (% of Total)	Mean Length (mm) (Range)	Total Species Biomass (kg) (% of Total)	Handling Mortality
Black crappie *(Poxomis nigromaculatus)*	3 (10.0)	273 (203 - 377)	0.93 (0.7)	
Eastern brook trout *(Salvelinus fontinalis)*	1 (0.3)	281	0.23 (0.2)	
Brown trout (*Salmo trutta*)	7 (2.3)	428 (222 - 580)	6.03 (4.4)	1
Burbot *(Lota lota)*	5 (1.7)	619 (430 - 820)	6.54 (4.8)	
Kokanee *(Onchorhynchus nerka)*	1 (0.3)	221	0.09 (0.1)	
Lake trout *(Salvelinus namaycush)*	1 (0.3)	530	1.02 (0.7)	
Largescale sucker *(Catostomus macrocheilus)*	72 (24.1)	374 (280 - 514)	37.55 (27.4)	1
Mountain whitefish *(Prosopium williamsoni)*	40 (13.4)	397 (250 - 532)	22.04 (16.1)	15
Northern pikeminnow *(Pthchocheilus oregonensis)*	55 (18.4)	328 (247 - 594)	19.50 (14.2)	3
Peamouth *(Mylocheilus caurinus)*	38 (12.7)	275 (174 - 375)	7.74 (5.7)	
Rainbow trout [a] (*Oncorhynchus mykiss*)	56 (18.7)	337 (205 - 510)	21.66 (15.8)	13[b]
Smallmouth bass *(Micropterus dolomieui)*	11 (3.7)	285 (205 - 431)	4.25 (3.1)	
Tench *(Tinca tinca)*	2 (0.7)	441 (437 - 445)	2.46 (1.8)	
Walleye (*Stizostedion vitreum*)	5 (1.7)	508 (460 - 578)	6.65 (4.9)	2
Cutthroat trout[c] *(Oncorhynchus clarkii)*	1 (0.3)	190	0.07 (0.1)	
Yellow perch *(Perca flavescens)*	1 (0.3)	202	0.12 (0.1)	
Total	299	351 (174 - 820)	136.89	35

[a] 46 of the 56 rainbow trout captured appeared to be triploid trout hatchery origin based on dorsal fin characteristics and scale patterns

[b] 1 of the 13 rainbow trout mortalities appeared to be of wild origin; the one "wild" rainbow trout mortality occurred within the tailrace reach, which are considered to possibly be a native strain

[c] The captured cutthroat trout appeared to be of the westslope subspecies.

Table 2. Between-site comparisons of total catch (including percentage of total catch for study site) in the Boundary Reservoir and tailrace during July through December, 2006 gill net fishing.

	Study Site													
Species	**Flume**		**Pewee**		**Slate**		**Sullivan**		**Sweet**		**Tailrace**		**Total**	
Black crappie	1	(2.3)	0	(0)	1	(3.6)	1	(2.2)	0	(0)	0	(0)	3	(1.0)
Eastern brook trout	1	(2.3)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.3)
Brown trout	2	(4.7)	0	(0)	0	(0)	2	(4.4)	3	(6.4)	0	(0)	7	(2.3)
Burbot	1	(2.3)	0	(0)	2	(7.1)	0	(0)	0	(0)	2	(2.7)	5	(1.7)
Kokanee	0	(0)	0	(0)	0	(0)	0	(0)	1	(2.1)	0	(0)	1	(0.3)
Lake trout	0	(0)	0	(0)	1	(3.6)	0	(0)	0	(0)	0	(0)	1	(0.3)
Largescale sucker	1	(2.3)	22	(34.9)	3	(10.7)	3	(6.7)	1	(2.1)	42	(57.5)	72	(24.1)
Mountain whitefish	9	(20.9)	1	(1.6)	1	(3.6)	17	(37.8)	8	(17.0)	4	(5.5)	40	(13.4)
Northern pikeminnow	9	(20.9)	16	(25.4)	11	(39.3)	7	(15.6)	5	(10.6)	7	(9.6)	55	(18.4)
Peamouth	10	(23.3)	10	(15.9)	3	(10.7)	6	(13.3)	9	(19.1)	0	(0)	38	(12.7)
Rainbow trout	4	(9.3)	10	(15.9)	6	(21.4)	7	(15.6)	16	(34.0)	13	(17.8)	56	(18.7)
Smallmouth bass	5	(11.6)	1	(1.6)	0	(0)	1	(2.2)	2	(4.3)	2	(2.7)	11	(3.7)
Tench	0	(0)	2	(3.2)	0	(0)	0	(0)	0	(0)	0	(0)	2	(0.7)
Walleye	0	(0)	1	(1.6)	0	(0)	0	(0)	1	(2.1)	3	(4.1)	5	(1.7)
Cutthroat trout	0	(0)	0	(0)	0	(0)	0	(0)	1	(2.1)	0	(0)	1	(0.3)
Yellow perch	0	(0)	0	(0)	0	(0)	1	(2.2)	0	(0)	0	(0)	1	(0.3)
Total	43		63		28		45		47		73		299	

Table 3. Summary of chi-square analyses comparing number of fish captured for the five most common species between sample period and among study site. Expected frequencies (in parentheses) are based on the proportion of fish captured in each species category; chi-square values are significant at P <0.001.

	Species Composition by Study Site (χ^2 = 133.2)					
Species	**Flume**	**Pewee**	**Slate**	**Sullivan**	**Sweet**	**Tailrace**
Largescale sucker	1 (9.1)	22 (16.3)	3 (6.6)	3 (11.0)	1 (10.8)	42 (18.2)
Mountain whitefish	9 (5.1)	1 (9.0)	1 (3.7)	17 (6.1)	8 (6.0)	4 (10.1)
Northern pikeminnow	9 (7.0)	16 (12.4)	11 (5.1)	7 (8.4)	5 (8.2)	7 (13.9)
Peamouth	10 (4.8)	10 (8.6)	3 (3.5)	6 (5.8)	9 (5.7)	0 (9.6)
Rainbow trout	4 (7.1)	10 (12.7)	6 (5.1)	7 (8.6)	16 (8.4)	13 (14.2)
	Species Composition by Sample Period (χ^2 = 91.1)					
Species	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**
Largescale sucker	9 (14.1)	44 (28.7)	13 (13.0)	4 (8.8)	2 (4.4)	0 (3.0)
Mountain whitefish	10 (7.8)	20 (15.9)	6 (7.2)	0 (4.9)	1 (2.5)	3 (1.7)
Northern pikeminnow	14 (10.7)	14 (21.9)	13 (9.9)	8 (6.7)	4 (3.4)	2 (2.3)
Peamouth	2 (7.4)	10 (15.1)	3 (6.8)	17 (4.7)	6 (2.3)	0 (1.6)
Rainbow trout	16 (10.9)	16 (22.3)	12 (10.1)	3 (6.9)	3 (3.4)	6 (2.4)

Table 4. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) in the Boundary Reservoir and the tailrace during July through December, 2006 gill net fishing.

	Numerical CPUE for:								Biomass (kg) CPUE for:						
Species	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Black crappie	0	0.04	0.05	0	0	0	0.02		0	0.01	0.02	0	0	0	0.01
Eastern brook trout	0	0	0	0.03	0	0	0.01		0	0	0	0.01	0	0	0
Brown trout	0.06	0.09	0.03	0	0.08	0	0.04		0.06	0.05	0	0	0.10	0	0.03
Burbot	0	0.04	0	0.03	0.05	0.02	0.03		0	0.04	0	0.02	0.09	0.03	0.03
Kokanee	0	0	0	0	0	0.02	0.01		0	0	0	0	0	0	0
Lake trout	0.06	0	0	0	0	0	0.01		0.06	0	0	0	0	0	0.01
Largescale sucker	0.50	1.95	0.33	0.13	0.05	0	0.36		0.14	1.08	0.21	0.04	0.04	0	0.19
Mountain whitefish	0.56	0.89	0.15	0	0.03	0.06	0.20		0.33	0.42	0.10	0	0.02	0.04	0.11
Northern pikeminnow	0.78	0.62	0.33	0.27	0.10	0.04	0.28		0.32	0.21	0.08	0.08	0.03	0.05	0.10
Peamouth	0.11	0.44	0.08	0.57	0.15	0	0.19		0.03	0.09	0.01	0.13	0.02	0	0.04
Rainbow trout	0.89	0.71	0.31	0.10	0.08	0.12	0.28		0.37	0.31	0.09	0.04	0.04	0.04	0.11
Smallmouth bass	0.17	0.22	0.08	0	0	0	0.06		0.04	0.12	0.02	0	0	0	0.02
Tench	0	0	0.05	0	0	0	0.01		0	0	0.06	0	0	0	0.01
Walleye	0	0.04	0.08	0.03	0	0	0.03		0	0.05	0.09	0.07	0	0	0.03
Cutthroat trout	0.06	0	0	0	0	0	0.01		0	0	0	0	0	0	0
Yellow perch	0.06	0	0	0	0	0	0.01		0.01	0	0	0	0	0	0
All fish captured	3.22	5.05	1.48	1.17	0.53	0.26	1.50		1.35	2.37	0.68	0.38	0.33	0.16	0.69

Table 5. Between-site comparison of species catch per unit effort (CPUE: value per 30 m of net per hour) in the Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. (Sites: FL= Flume, PW = Pewee, SL = Slate, SU = Sullivan, SW = Sweet, TR = Tailrace)

	Numerical CPUE for:							Biomass (kg) CPUE for:						
Species	**FL**	**PW**	**SL**	**SU**	**SW**	**TR**	**Total**	**FL**	**PW**	**SL**	**SU**	**SW**	**TR**	**Total**
Black crappie	0.04	0	0.04	0.03	0	0	0.02	0.02	0	0.01	0.01	0	0	0.01
Eastern brook trout	0.04	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0
Brown trout	0.07	0	0	0.06	0.09	0	0.04	0.04	0	0	0.06	0.09	0	0.03
Burbot	0.04	0	0.07	0	0	0.04	0.03	0.02	0	0.08	0	0	0.07	0.03
Kokanee	0	0	0	0	0.03	0	0.01	0	0	0	0	0	0	0
Lake trout	0	0	0.04	0	0	0	0.01	0	0	0.04	0	0	0	0.01
Largescale sucker	0.04	0.92	0.11	0.09	0.03	0.78	0.36	0.01	0.51	0.03	0.05	0.03	0.40	0.19
Mountain whitefish	0.34	0.04	0.04	0.49	0.25	0.07	0.20	0.16	0.04	0.02	0.29	0.11	0.05	0.11
Northern pikeminnow	0.34	0.67	0.40	0.20	0.16	0.13	0.28	0.07	0.22	0.10	0.05	0.04	0.12	0.10
Peamouth	0.37	0.42	0.11	0.17	0.28	0	0.19	0.07	0.12	0.02	0.03	0.05	0	0.04
Rainbow trout	0.15	0.42	0.22	0.20	0.50	0.24	0.28	0.09	0.18	0.08	0.09	0.18	0.07	0.11
Smallmouth bass	0.19	0.04	0	0.03	0.06	0.04	0.06	0.09	0.01	0	0.01	0.02	0.02	0.02
Tench	0	0.08	0	0	0	0	0.01	0	0.10	0	0	0	0	0.01
Walleye	0	0.04	0	0	0.03	0.06	0.03	0	0.09	0	0	0.04	0.06	0.03
Cutthroat trout	0	0	0	0	0.03	0	0.01	0	0	0	0	0	0	0
Yellow perch	0	0	0	0.03	0	0	0.01	0	0	0	0	0	0	0
All fish captured	1.60	2.63	1.03	1.31	1.47	1.35	1.50	0.58	1.27	0.37	0.58	0.56	0.80	0.69

Table 6. Between-site comparison of monthly total catch per unit effort (CPUE: value per 30 m of net per hour) in Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. (Sites: FL= Flume, PW = Pewee, SL = Slate, SU = Sullivan, SW = Sweet, TR = Tailrace)

	Numerical CPUE for:								Biomass (kg) CPUE for:						
Month	**FL**	**PW**	**SL**	**SU**	**SW**	**TR**	**Total**		**FL**	**PW**	**SL**	**SU**	**SW**	**TR**	**Total**
July	[a]	5.00	2.67	5.67	4.33	0.83	3.22		[a]	1.41	0.99	2.85	1.61	0.63	1.35
August	4.18	9.00	1.49	3.46	10.14	4.82	5.05		2.06	4.51	0.58	1.45	3.85	2.51	2.37
September	2.00	3.25	1.00	1.89	0.70	1.15	1.48		0.50	2.33	0.35	0.89	0.16	0.55	0.68
October	2.00	1.67	0.83	1.00	0.33	[a]	1.17		0.62	0.84	0.22	0.19	0.02	[a]	0.38
November	0.83	0.50	0.62	0.17	0.50	0.56	0.53		0.23	0.20	0.25	0.17	0.48	0.55	0.33
December	0	1.33	0.33	0	0.11	0.40	0.26		0	0.52	0.09	0	0.01	0.33	0.16
All months surveyed	1.60	2.63	1.03	1.31	1.47	1.35	1.50		0.58	1.27	0.37	0.58	0.56	0.80	0.69

[a] – not surveyed

Table 7. Comparison of Boundary tailrace boat ramp conditions to standard design characteristics of an inland recreational boat ramp (ODNR 2003). Note that the Boundary tailrace ramp consists of an old road bed built during construction of Boundary Dam to access the turbine outlet tunnels. The road bed is in a Project area with restricted public access and there is no public use of the launch site.

Parameter	**Standard Ramp Design Characteristics**	**Boundary Tailrace Ramp Conditions**
Slope	12 - 15 percent	7.5 percent
Alignment orientation	Perpendicular to bank to up to 30 degrees rotation	Approximately 80 degrees rotation from perpendicular
Alignment direction	Perpendicular to bank or downstream	Upstream alignment
Ramp lane width	Single lane width $\geq$ 20 feet	Average 18 feet, range 16 to 24 feet
Ramp surface	Concrete preferred, gravel for low use or small boats	Cobble and boulder
Design water elevation	3 feet below ordinary low water for year-round use	Bottom of drivable ramp is at least 2 feet below the tailrace water surface elevations during typical daily low Seven Mile pool levels and with no Boundary generation
Ramp abutment	Abutment extending from top of ramp through vertical curve	Steep, 8-ft drop off with no abutment on left side
Access road width	15 feet for one-way traffic	Access road exceeds 15 feet in width

Table 8. Proposed duration of gill net sets by water temperature and reservoir location during implementation of Boundary Project relicensing studies.

Water Temperature and Location	Duration of Gill Net Deployment		
	0.5 hour	1.0 hour	Overnight
Boundary Tailrace and downstream 200 m			
Water temperature >16 ˚ C	X		
Water temperature 14 -16 ˚ C		X	
Water temperature <14 ˚ C			X
Reservoir Tributary Mouths			
Water temperature >16 ˚ C	X		
Water temperature 14 - 16 ˚ C		X	
Water temperature <14 ˚ C			X
Open Reservoir and Non-Tributary Margins			
Water temperature >16 ˚ C			X
Water temperature 14 - 16 ˚ C			X
Water temperature <14 ˚ C			X

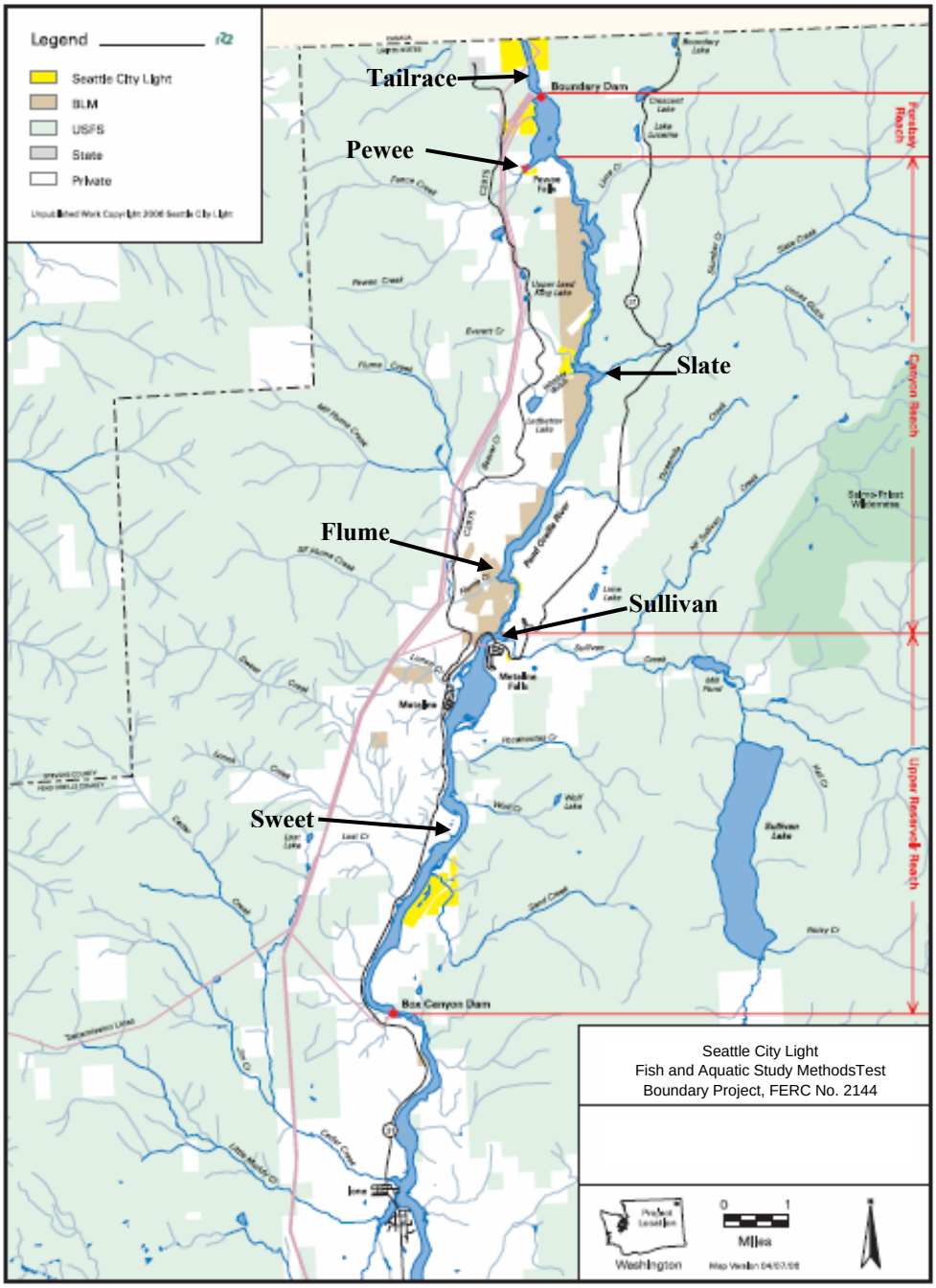


Figure 1. Map of the Boundary Reservoir and Boundary Dam tailrace on the Pend Oreille River, Washington showing locations of the 6 study sites investigated during the testing of fish and aquatic study methods.

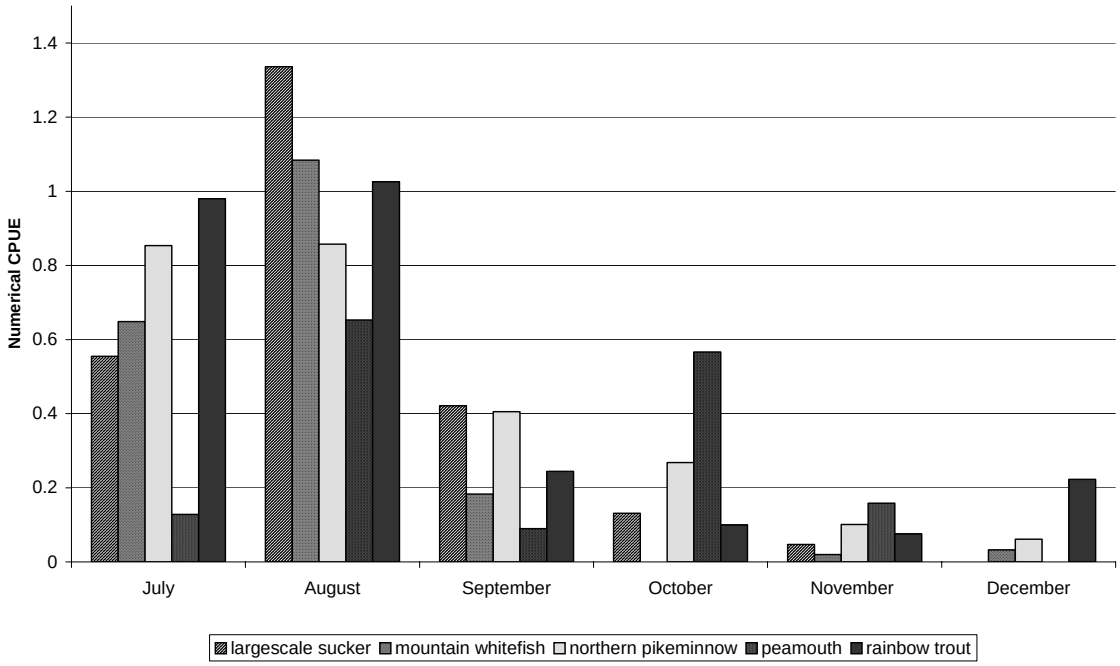


Figure 2. Monthly mean numerical catch per unit effort (CPUE: value per 30 m net per hour) in the Boundary Reservoir and in the tailrace downstream of Boundary Dam on the Pend Oreille River, Washington.

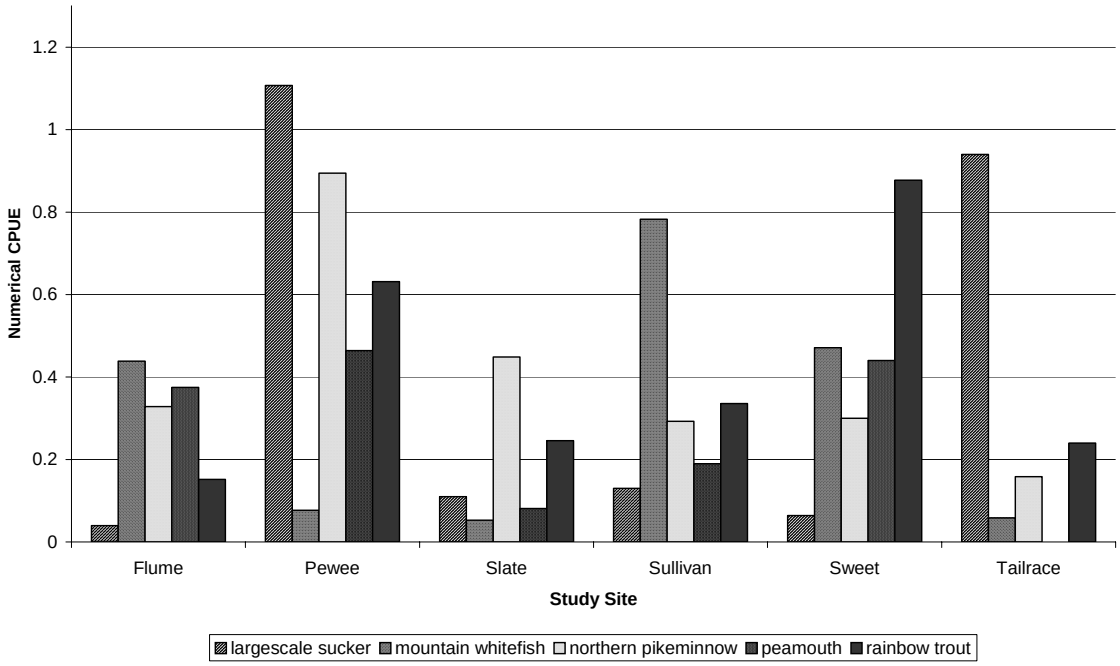


Figure 3. Mean numerical catch per unit effort (CPUE: value per 30 m net per hour) for study sites in the Boundary Reservoir and in the tailrace downstream of Boundary Dam on the Pend Oreille River, Washington.

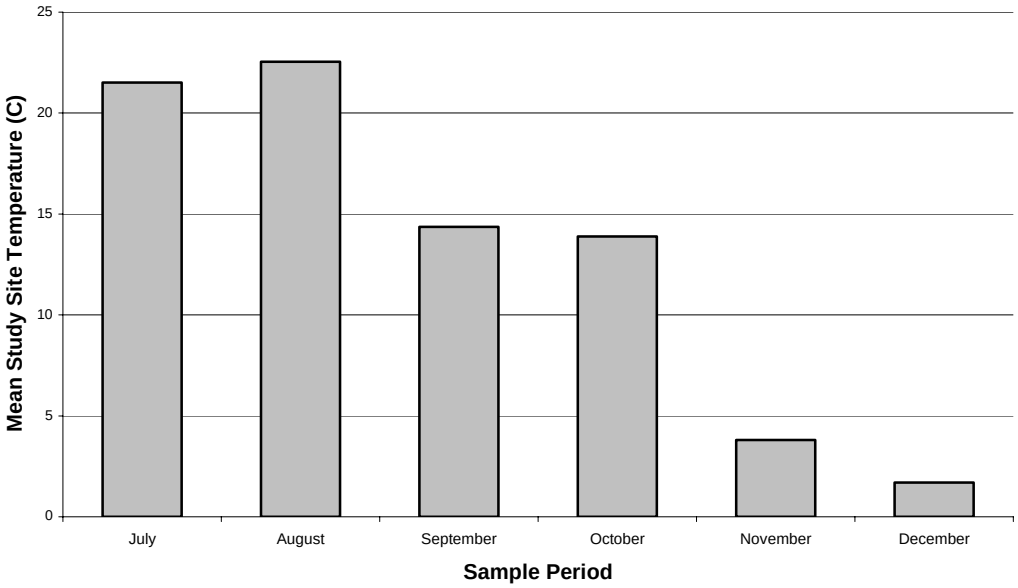


Figure 4. Mean water temperatures encountered during nightly sampling for study sites in the Boundary Reservoir and in the tailrace downstream of Boundary Dam on the Pend Oreille River, Washington.

Site Photograph 1. Large boulder hazards, drop offs, and narrow road prism pose hazards to backing a trailered vehicle during hours of darkness at the Boundary tailrace boat ramp. The dam safety survey monument platform at the upper right of the picture (white arrow) was used as a reference point for describing the location of access road features and boat ramp hazards.

Site Photograph 2. Existing hazards in the launch area include uneven driving surface due to coarse cobble and small embedded boulders requiring improved traction tires and possibly 4WD capability for trailer pullout. Note boulders along the right side of the water force trailers towards the outer edge of the launch, where a very coarse bed precludes maneuvering.

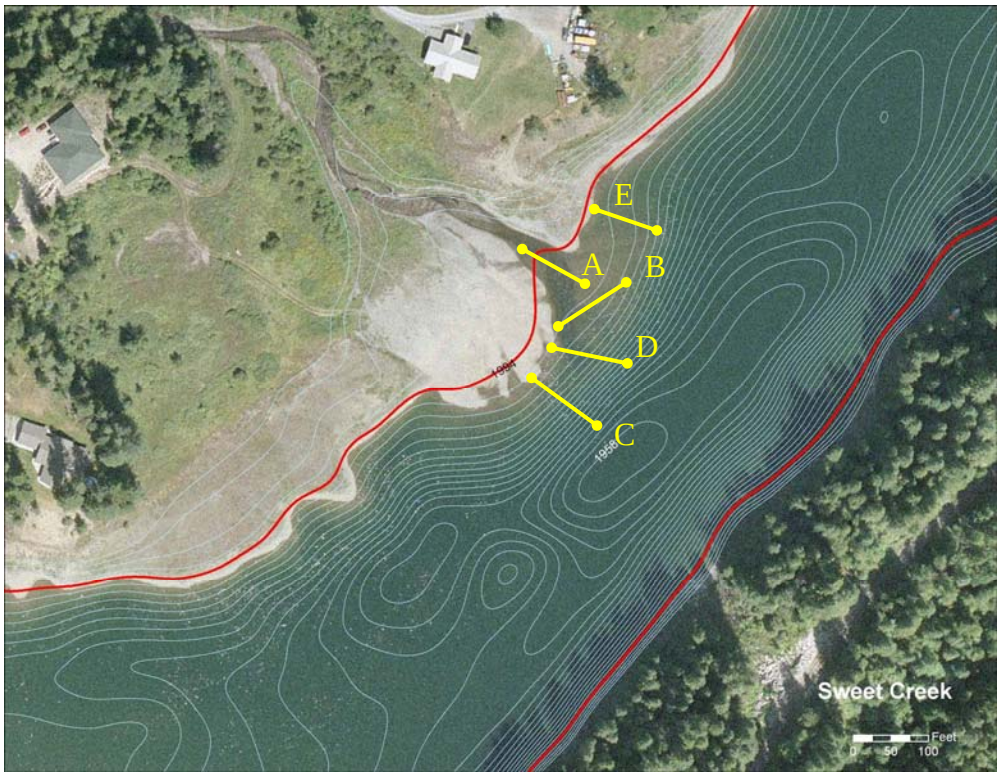
Site Photograph 3. Hazards to be aware of on the tailrace boat ramp include protruding construction debris, including metal rebar material which presents a potential tire puncture hazard

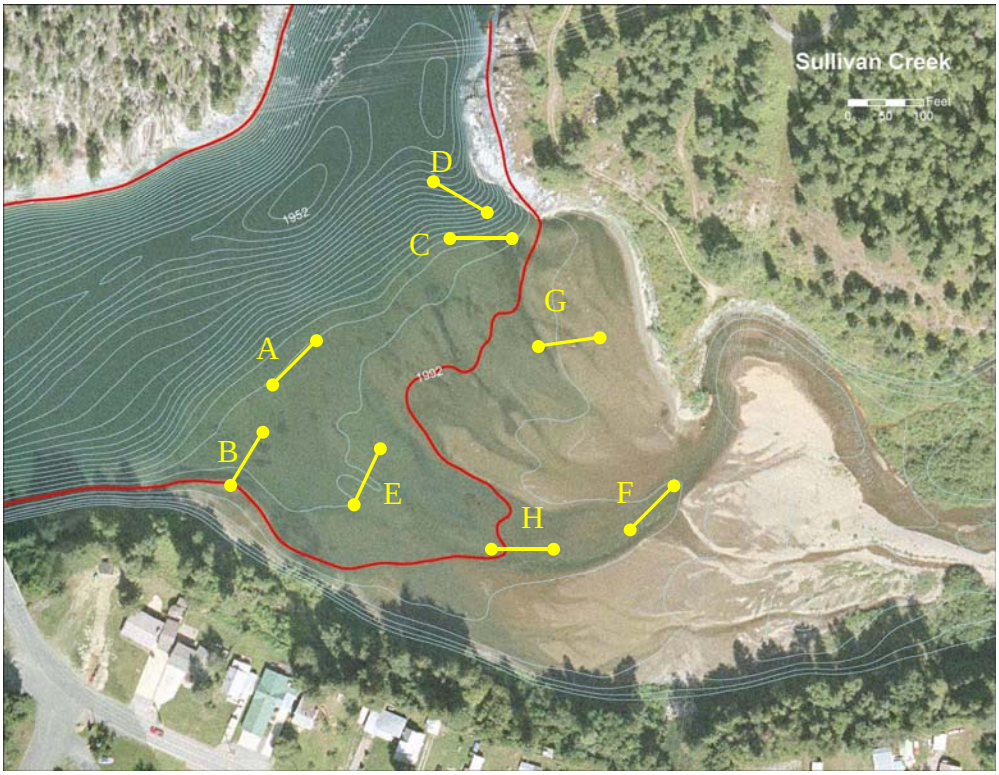
Site Photograph 4. Boulders and an uneven ramp surface create holes and obstructions that threatened axle and tire damage at the Boundary tailrace boat ramp. Here the drivable portion of the ramp narrows to less than 5 m.

Site Photograph 5. At a slope distance of approximately 143 m down the ramp from the survey monument platform, a boulder near the shoreline (white arrow) would force the trailer off of the ramp onto an uneven boulder surface with hazardous construction debris. Beyond this point, the launch ramp becomes completely undrivable due to uneven boulder surfaces. A potentially damaging hole (red arrow) approximately 1 m across and 0.3 m deep situated approximately 133 m down the ramp from the platform requires straddling with trailer tires for successful launch and retrieval when water surface elevations drop to or below 1727 ft MSL.

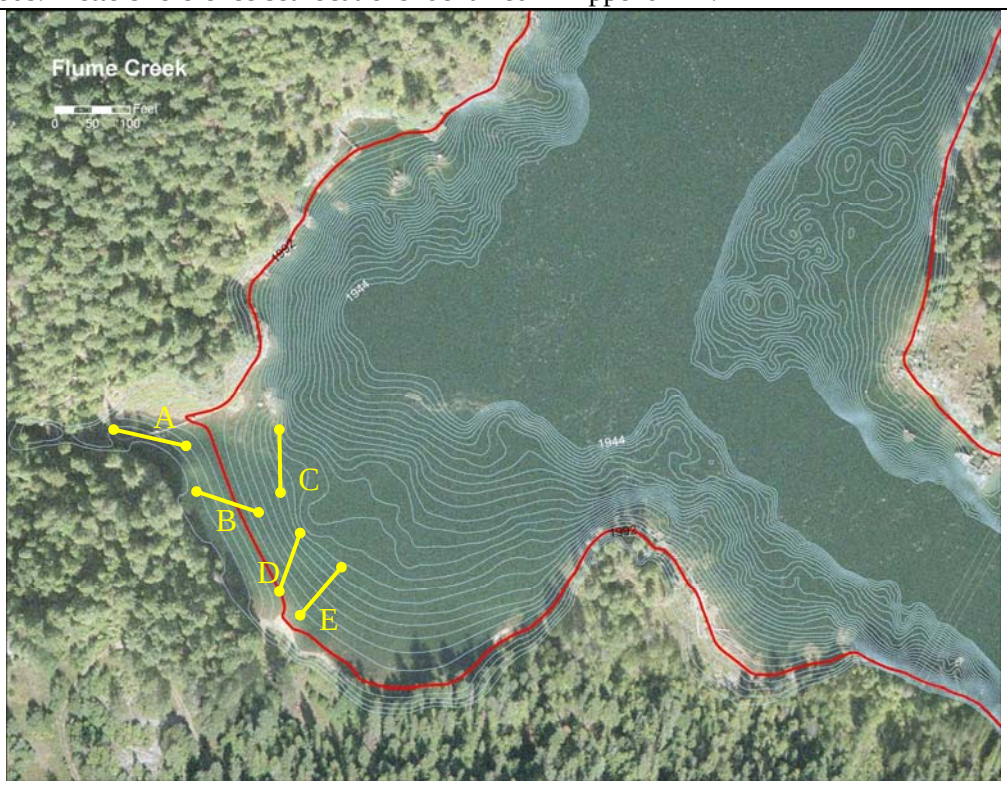
Site Photograph 6. During December, boat ramp snow and shoreline ice also prohibited the use of public boat launch at the Metaline City Park.

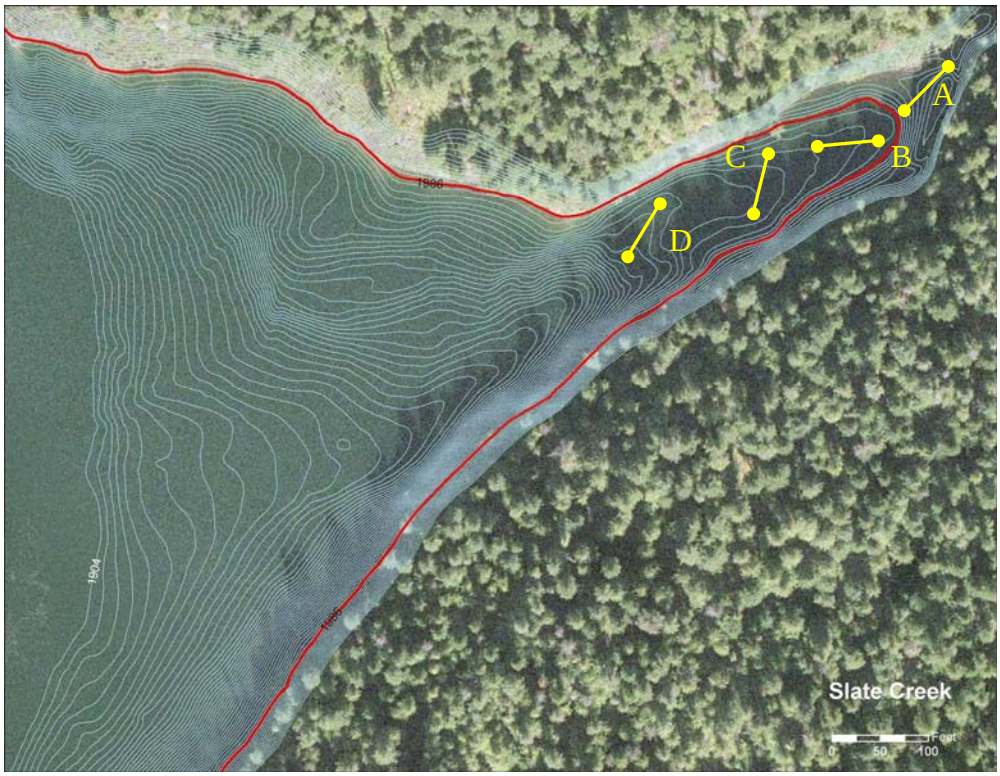
Appendix A.1. Aerial photographs of the Sweet Creek and Sullivan Creek study sites in Boundary reservoir depicting locations of gill net sets deployed during the testing of fish and aquatic study methods. Letters reference set locations identified in Appendix B.



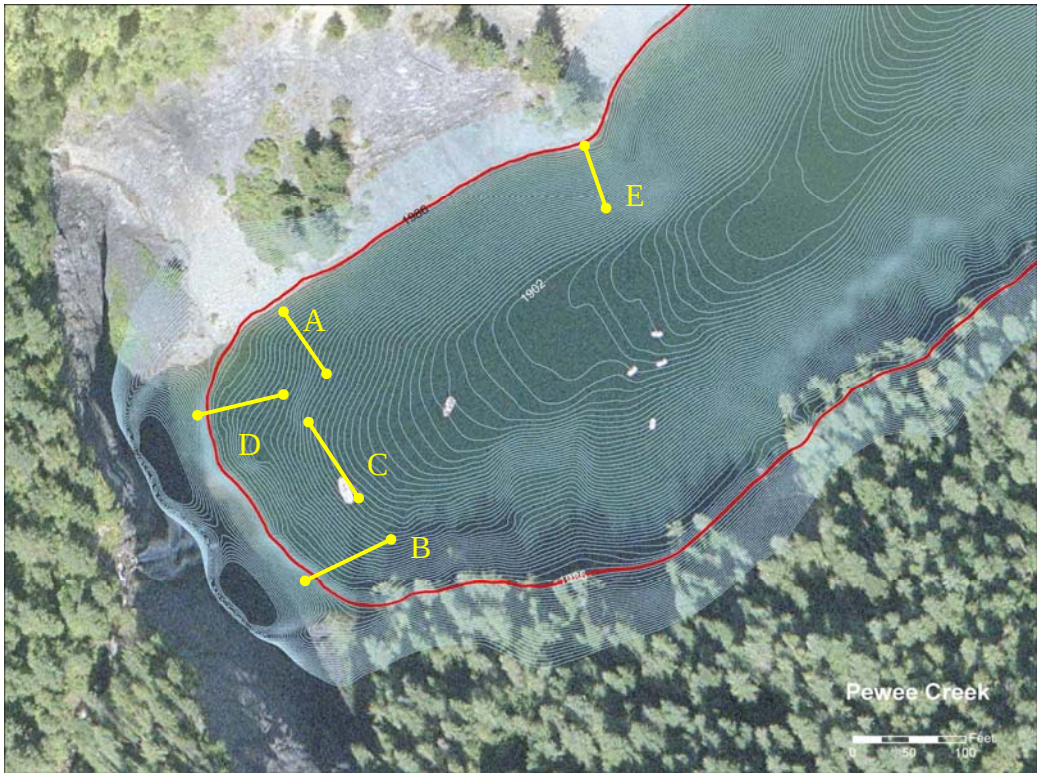


Appendix A.2. Aerial photographs of the Flume Creek and Slate Creek study sites in Boundary reservoir depicting locations of gill net sets deployed during the testing of fish and aquatic study methods. Letters reference set locations identified in Appendix B.

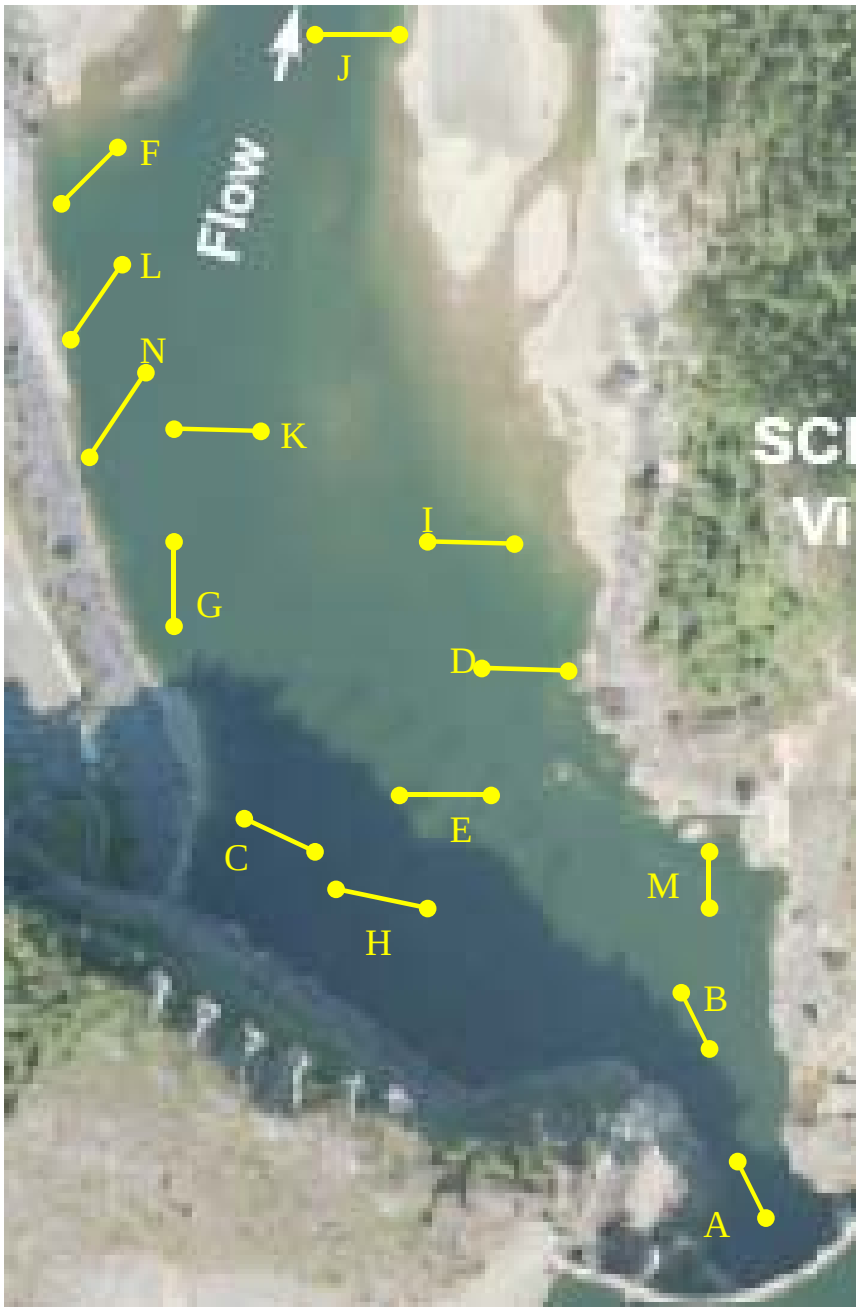




Appendix A.3. Aerial photograph of the Pewee Creel study site depicting locations of gill net sets deployed during the testing of fish and aquatic study methods. Letters reference set locations identified in Appendix B.



Appendix A.4. Aerial photograph of the Boundary tailrace study sites depicting locations of gill net sets deployed during the testing of fish and aquatic study methods. Letters reference set locations identified in Appendix B.



Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
Flume								
Aug	1.1	B	48.87802	117.3699	1	6	2	22.5
Aug	1.2	B	48.87802	117.3699	1			22.5
Aug	2.1	E	48.87795	117.3688	1.2	2		22.5
Aug	2.2	E	48.87795	117.3688	0.7	8	3	22.5
Aug Total					3.8	16	5	
Sept	1.1	A	48.8783	117.3704	0.5			13.9
Sept	1.2	A	48.8783	117.3704	1.0	1		13.9
Sept	1.3	A	48.8783	117.3704	1.0	1		13.9
Sept	2.1	B	48.87802	117.3699	1.0	1		13.9
Sept	2.2	C	48.87827	117.3698	1.0	5		13.9
Sept	2.3	C	48.87827	117.3698	0.5	2		13.9
Sept Total					5.0	10	0	
Oct	1.1	A	48.8783	117.3704	1.0			13.8
Oct	1.2	A	48.8783	117.3704	1.0			13.8
Oct	2.1	B	48.87802	117.3699	1.0	3		13.8
Oct	2.2	B	48.87802	117.3699	1.0	1		13.8
Oct	3.1	D	48.878	117.3693	1.0	4		13.8
Oct	3.2	D	48.878	117.3693	1.0	4		13.8
Oct Total					6.0	12	0	
Nov	1.1	A	48.8783	117.3704	1.0			3.3
Nov	1.2	A	48.8783	117.3704	1.0	2		3.3
Nov	2.1	B	48.87802	117.3699	1.0			3.3
Nov	2.2	B	48.87802	117.3699	1.0	1		3.3
Nov	3.1	C	48.87827	117.3698	1.0			3.3
Nov	3.2	C	48.87827	117.3698	1.0	2		3.3
Nov Total					6.0	5	0	
Dec	1.1	A	48.8783	117.3704	1.0			1.1
Dec	1.2	A	48.8783	117.3704	1.0			1.1
Dec	1.3	A	48.8783	117.3704	1.0			1.1
Dec	2.1	C	48.87827	117.3698	1.0			1.1
Dec	2.2	C	48.87827	117.3698	1.0			1.1
Dec	2.3	C	48.87827	117.3698	1.0			1.1
Dec Total					6.0	0	0	
	Flume Total				26.8	43	5	
Pewee								
July	1.1	A	48.97128	117.3542	1.0	6		23.1
July	1.2	A	48.97128	117.3542	1.0	5		23.1
July	1.3	A	48.97128	117.3542	1.0	4		23.1
July Total					3.0	15	0	69.3
Aug	1.1	A	48.97128	117.3542	1.0	8		22.6
Aug	2.1	B	48.97135	117.3542	1.0	10	2	22.6
Aug Total					2.0	18	2	
Sept	1.1	C	48.97062	117.3550	1.0	3		14.4
Sept	1.2	C	48.97062	117.3550	1.0	2		14.4
Sept	2.1	D	48.97136	117.3550	1.0	5		14.4
Sept	2.2	D	48.97136	117.3550	1.0	3		14.4
Sept Total					4.0	13	0	

Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
Oct	1.1	C	48.97062	117.3550	1.0	2		14.0
Oct	1.2	C	48.97062	117.3550	1.0	2		14.0
Oct	2.1	D	48.97136	117.3550	1.0	2		14.0
Oct	2.2	D	48.97136	117.3550	1.0			14.0
Oct	3.1	A	48.97128	117.3542	1.0	3		14.0
Oct	3.2	A	48.97128	117.3542	1.0	1		14.0
Oct Total					6.0	10	0	
Nov	1.1	D	48.97136	117.3550	1.0	1		3.3
Nov	1.2	D	48.97136	117.3550	1.0			3.3
Nov	2.1	C	48.97062	117.3550	1.0	1		3.3
Nov	2.2	C	48.97062	117.3550	1.0			3.3
Nov	3.1	B	48.97135	117.3542	1.0	1		3.3
Nov	3.2	B	48.97135	117.3542	1.0			3.3
Nov Total					6.0	3	0	
Dec	1.1	E	48.9718	117.3531	1.0	2		1.1
Dec	1.2	E	48.9718	117.3531	1.0	1		1.1
Dec	1.3	E	48.9718	117.3531	1.0	1		1.1
Dec Total					3.0	4	0	3.3
	Pewee Total				24.0	63	2	
				Slate				
July	1.1	B	48.92373	117.3297	1.0	1	1	22.7
July	1.2	B	48.92373	117.3297	1.0	4		22.7
July	1.3	B	48.92373	117.3297	1.0	3		22.6
July Total					3.0	8	1	67.9
Aug	1.1	A	48.92386	117.3294	0.9	1		22.5
Aug	1.2	A	48.92386	117.3294	1.0			22.5
Aug	2.1	B	48.92373	117.3297	0.8	3		22.5
Aug	2.2	B	48.92373	117.3297	1.0			22.5
Aug Total					3.6	4	0	
Sept	1.1	A	48.92386	117.3294	1.0			11.5
Sept	1.2	A	48.92386	117.3294	1.0			11.5
Sept	1.3	A	48.92386	117.3294	1.0			11.5
Sept	2.1	B	48.92373	117.3297	1.0	3		14.5
Sept	2.2	B	48.92373	117.3297	1.0	1		14.5
Sept	2.3	B	48.92373	117.3297	1.0	2	1	14.5
Sept Total					6.0	6	1	
Oct	1.1	A	48.92386	117.3294	1.0			13.9
Oct	1.2	A	48.92386	117.3294	1.0			13.9
Oct	2.1	A	48.92386	117.3294	1.0	1		13.9
Oct	2.2	A	48.92386	117.3294	1.0	1		13.9
Oct	3.1	C	48.92347	117.3304	1.0	2		13.9
Oct	3.2	C	48.92347	117.3304	1.0	1		13.9
Oct Total					6.0	5	0	
Nov	1.1	B	48.92373	117.3297	1.0			3.3
Nov	1.2	B	48.92373	117.3297	1.5			3.3
Nov	2.1	C	48.92347	117.3304	1.0	3		3.3
Nov	2.2	C	48.92347	117.3304	1.0	1		3.3
Nov	3.1	D	48.92344	117.3308	1.0			3.3
Nov	3.2	D	48.92344	117.3308	1.0			3.3

Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
Nov Total					6.5	4	0	
Dec	1.1	D	48.92344	117.3308	1.0	1		1.1
Dec	1.2	D	48.92344	117.3308	1.0			1.1
Dec	1.3	D	48.92344	117.3308	1.0			1.1
Dec Total					3.0	1	0	
	Slate Total				28.1	28	2	
				Sullivan				
July	1.1	A	48.86522	117.3706	1.0	4		23.1
July	1.2	A	48.86522	117.3706	1.0	9	5	23.1
July	1.3	A	48.86522	117.3706	1.0	4		23.1
July Total					3.0	17	5	
Aug	1.1	B	48.86478	117.3711	0.5	5	4	22.0
Aug	1.2	B	48.86478	117.3711	0.5	2		22.0
Aug	1.3	B	48.86478	117.3711	0.5	1	1	22.0
Aug	2.1	C	48.86552	117.3704	0.6			22.0
Aug	2.2	C	48.86552	117.3704	0.6	3		22.0
Aug	2.3	C	48.86552	117.3704	0.5			22.0
Aug Total					3.2	11	5	
Sept	1.1	B	48.86478	117.3711	0.6			14.5
Sept	1.2	B	48.86478	117.3711	1.0	1		14.5
Sept	2.1	C	48.86552	117.3704	0.8	2		14.5
Sept	2.2	D	48.86568	117.3702	0.8			14.5
Sept	2.3	G	48.8652	117.3699	0.8	1		14.5
Sept	3.1	E	48.86463	117.3707	0.8	4		14.5
Sept	3.2	E	48.86463	117.3707	0.8	2		14.5
Sept Total					5.3	10	0	
Oct	1.1	F	48.86427	117.3702	1.0			13.9
Oct	1.2	F	48.86427	117.3702	1.0			13.9
Oct	2.1	B	48.86478	117.3711	1.0			13.9
Oct	2.2	B	48.86478	117.3711	1.0			13.9
Oct	3.1	H	48.86441	117.3705	1.0	5		13.9
Oct	3.2	H	48.86441	117.3705	1.0	1		13.9
Oct Total					6.0	6	0	
Nov	1.1	G	48.8652	117.3699	1.0			3.3
Nov	1.2	G	48.8652	117.3699	1.0			3.3
Nov	2.1	E	48.86463	117.3707	1.0			3.3
Nov	2.2	E	48.86463	117.3707	1.0			3.3
Nov	3.1	H	48.86441	117.3705	1.0			3.3
Nov	3.2	H	48.86441	117.3705	1.0	1		3.3
Nov Total					6.0	1	0	
Dec	1.1	B	48.86478	117.3711	1.0			1.1
Dec	1.2	B	48.86478	117.3711	1.0			1.1
Dec	1.3	B	48.86478	117.3711	1.0			1.1
Dec	1.4	B	48.86478	117.3711	2.5			1.1
Dec	2.1	C	48.86568	117.3702	1.0			1.1
Dec	2.2	C	48.86552	117.3704	1.0			1.1
Dec	2.3	C	48.86552	117.3704	1.0			1.1
Dec	2.4	C	48.86552	117.3704	2.5			1.1
Dec Total					11.0	0	0	
	Sullivan Total				34.5	45	10	

Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
				Sweet				
July	1.1	B	48.81997	117.3894	1.0	7	2	22.0
July	1.2	B	48.81997	117.3894	1.0	3	1	22.0
July	1.3	B	48.81997	117.3894	1.0	3		22.0
July Total					3.0	13	3	
Aug	1.1	B	48.81997	117.3894	0.7	5	1	22.0
Aug	1.2	B	48.81997	117.3894	0.5	4	1	22.0
Aug	1.3	B	48.81997	117.3894	0.7	7	4	22.0
Aug	1.4	B	48.81997	117.3894	0.5	8	1	22.0
Aug Total					2.4	24	7	
Sept	1.1	C	48.81974	117.3893	0.5	1	1	14.2
Sept	1.2	C	48.81974	117.3893	0.8			14.2
Sept	1.3	C	48.81974	117.3893	0.7			14.2
Sept	2.1	D	48.81983	117.3890	0.5			14.2
Sept	2.2	D	48.81983	117.3890	0.5			14.2
Sept	2.3	D	48.81983	117.3890	0.5	1		14.2
Sept	3.1	E	48.8203	117.3884	0.5			14.2
Sept	3.2	E	48.8203	117.3884	0.5			14.2
Sept	3.3	E	48.8203	117.3884	0.5	1		14.2
Sept	4.1	D	48.81983	117.3890	0.8	1		14.2
Sept	4.2	D	48.81983	117.3890	0.8			14.2
Sept Total					6.5	4	1	
Oct	1.1	A	48.8204	117.3891	1.0			13.8
Oct	1.2	A	48.8204	117.3891	1.0			13.8
Oct	2.1	C	48.81974	117.3893	1.0			13.8
Oct	2.2	C	48.81974	117.3893	1.0	1		13.8
Oct	3.1	E	48.8203	117.3884	1.0			13.8
Oct	3.2	E	48.8203	117.3884	1.0	1		13.8
Oct Total					6.0	2	0	
Nov	1.1	E	48.8203	117.3884	1.0	1		3.3
Nov	1.2	E	48.8203	117.3884	1.0			3.3
Nov	2.1	A	48.8204	117.3891	1.0	1		3.3
Nov	2.2	A	48.8204	117.3891	1.0			3.3
Nov	3.1	D	48.81983	117.3890	1.0	1		3.3
Nov	3.2	D	48.81983	117.3890	1.0			3.3
Nov Total					6.0	3	0	
Dec	1.1	B	48.81997	117.3894	1.5			1.1
Dec	1.2	B	48.81997	117.3894	1.0			1.1
Dec	1.3	B	48.81997	117.3894	1.0			1.1
Dec	1.4	B	48.81997	117.3894	1.0			1.1
Dec	2.1	D	48.81983	117.3890	1.0	1		1.1
Dec	2.2	D	48.81983	117.3890	1.0			1.1
Dec	2.3	D	48.81983	117.3890	1.0			1.1
Dec	2.4	D	48.81983	117.3890	1.5			1.1
Dec Total					9.0	1	0	
	Sweet Total				32.8	47	11	
				Tailrace				

Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
July	1.1	A	48.98736	117.3482	1.0	1		22.3
July	1.2	A	48.98736	117.3482	1.0			22.3
July	1.3	B	48.98806	117.3484	1.0			22.3
July	1.4	H	48.98897	117.3504	1.0	4		22.3
July	2.1	C	48.98908	117.3509	1.0			22.3
July	2.2	C	48.98908	117.3509	1.0			22.3
July Total					6.0	5	0	
Aug	1.1	G	48.98995	117.3517	0.8			23.0
Aug	2.1	F	48.9921	117.3517	0.8	4	1	23.0
Aug	2.2	F	48.9921	117.3517	1.0	4		23.0
Aug	3.1	D	48.98908	117.3509	1.0	5		23.0
Aug	3.2	D	48.98908	117.3509	1.0	5		23.0
Aug	4.1	I	48.99005	117.3491	1.0	3		23.0
Aug	4.2	I	48.99005	117.3491	1.0	3		23.0
Aug	5.1	J	48.9926	117.3496	1.0	13		23.0
Aug	6.1	K	48.9908	117.3506	1.0	4		23.0
Aug	1.1	D	48.98908	117.3509	0.3	2		14.9
Aug Total					8.8	43	2	
Sept	1.1	A	48.98736	117.3482	1.0	1	1	14.9
Sept	1.2	D	48.98908	117.3509	0.7	4	1	14.9
Sept	1.3	D	48.98908	117.3509	0.4	2		14.9
Sept	1.4	D	48.98908	117.3509	0.4			14.9
Sept	1.5	D	48.98908	117.3509	0.7			14.9
Sept	2.1	L	48.99098	117.3521	0.5	1		14.9
Sept	2.2	L	48.99098	117.3521	0.5			14.9
Sept	2.3	L	48.99098	117.3521	0.5			14.9
Sept	2.4	L	48.99098	117.3521	0.9	1		14.9
Sept	3.1	C	48.98908	117.3509	0.5			14.9
Sept	3.2	C	48.98908	117.3509	1.0	2	1	14.9
Sept	4.1	E	48.98933	117.3501	0.6	2	1	14.9
Sept	4.2	E	48.98933	117.3501	0.5	1		14.9
Sept Total					8.2	14	4	
Nov	1.2	A	48.98736	117.3482	1.0			3.3
Nov	1.3	A	48.98736	117.3482	1.0			3.3
Nov	2.1	M	48.98847	117.3486	1.0	1		3.3
Nov	2.2	M	48.98847	117.3486	1.0	1		3.3
Nov	2.3	M	48.98847	117.3486	1.0	1		3.3
Nov	3.1	L	48.99098	117.3521	1.0	1		3.3
Nov	3.2	L	48.99098	117.3521	1.0			3.3
Nov Total					7.0	4	0	
Dec	3.3	L	48.99098	117.3521	1.0			3.3
Dec	1.1	A	48.98736	117.3482	1.5	1		1.1
Dec	1.2	A	48.98736	117.3482	1.0	1		1.1
Dec	1.3	A	48.98736	117.3482	1.0			1.1
Dec	1.4	A	48.98736	117.3482	1.0			1.1
Dec	2.1	M	48.98847	117.3486	1.3			1.1
Dec	2.2	M	48.98847	117.3486	1.0			1.1
Dec	2.3	M	48.98847	117.3486	1.0			1.1
Dec	2.4	M	48.98847	117.3486	1.0			1.1
Dec	3.1	D	48.98908	117.3509	1.0	2		1.1

Appendix B. Summary of individual gill net sets deployed at six study sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006. Set location reference positions depicted on study site aerial photos provided in Appendix A (6 pages).

Sample Month	Net Set	Set Location	Latitude (dd) NAD 83	Longitude (dd) NAD 83	Set Duration (hours)	Fish Captured	Handling Mortality	Water Temperature (˚C)
Dec	3.2	D	48.98908	117.3509	1.0	1		1.1
Dec	3.3	D	48.98908	117.3509	1.0	1		1.1
Dec	3.4	D	48.98908	117.3509	1.3	1		1.1
Dec	4.1	E	48.98933	117.3501	1.5			1.1
Dec	4.2	E	48.98933	117.3501	1.0			1.1
Dec	4.3	E	48.98933	117.3501	1.0			1.1
Dec	4.4	E	48.98933	117.3501	1.0			1.1
Dec Total					18.6	7	0	
	Tailrace Total				48.7	73	5	

Appendix C. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) of all species and the total catch for each of the sample sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006 (6 pages).

	Individual CPUE for:								Biomass (kg) CPUE for:						
Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
	Flume														
Black crappie		0	0.20	0	0	0	0.04			0	0.11	0	0	0	0.02
Eastern brook trout		0	0	0.17	0	0	0.04			0	0	0.04	0	0	0.01
Brown trout		0.26	0.20	0	0	0	0.07			0.25	0.03	0	0	0	0.04
Burbot		0	0	0.17	0	0	0.04			0	0	0.07	0	0	0.02
Kokanee		0	0	0	0	0	0			0	0	0	0	0	0
Lake trout		0	0	0	0	0	0			0	0	0	0	0	0
Largescale sucker		0	0.20	0	0	0	0.04			0	0.05	0	0	0	0.01
Mountain whitefish		2.09	0.20	0	0	0	0.34			1.01	0.09	0	0	0	0.16
Northern pikeminnow		0	0.80	0.50	0.33	0	0.34			0	0.15	0.12	0.06	0	0.07
Peamouth		0.52	0.20	0.83	0.33	0	0.37			0.07	0.03	0.20	0.05	0	0.07
Rainbow trout		0.26	0	0.33	0.17	0	0.15			0.15	0	0.19	0.12	0	0.09
Smallmouth bass		1.04	0.20	0	0	0	0.19			0.59	0.03	0	0	0	0.09
Tench		0	0	0	0	0	0			0	0	0	0	0	0
Walleye		0	0	0	0	0	0			0	0	0	0	0	0
Cutthroat trout		0	0	0	0	0	0			0	0	0	0	0	0
Yellow perch		0	0	0	0	0	0			0	0	0	0	0	0
Total Flume		4.18	2.00	2.00	0.83	0	1.60			2.06	0.50	0.62	0.23	0	0.58
	Pewee														
Black crappie	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Eastern brook trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Burbot	0	0	0	0	0	0	0		0	0	0	0	0	0	0

Appendix C. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) of all species and the total catch for each of the sample sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006 (6 pages).

	Individual CPUE for:								Biomass (kg) CPUE for:						
Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Kokanee	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Lake trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Largescale sucker	2.33	2.00	2.00	0.33	0.17	0	0.92		0.69	1.61	1.53	0.08	0.06	0	0.51
Mountain whitefish	0	0.50	0	0	0	0	0.04		0	0.52	0	0	0	0	0.04
Northern pikeminnow	1.67	2.50	0.75	0.17	0.17	0.33	0.67		0.38	0.68	0.18	0.13	0.06	0.33	0.22
Peamouth	0.33	1.50	0	1.00	0	0	0.42		0.13	0.34	0	0.29	0	0	0.12
Rainbow trout	0.33	2.50	0	0	0.17	1.00	0.42		0.17	1.35	0	0	0.08	0.20	0.18
Smallmouth bass	0.33	0	0	0	0	0	0.04		0.04	0	0	0	0	0	0.01
Tench	0	0	0.50	0	0	0	0.08		0	0	0.62	0	0	0	0.10
Walleye	0	0	0	0.17	0	0	0.04		0	0	0	0.35	0	0	0.09
Cutthroat trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Total Pewee	5.00	9.00	3.25	1.67	0.50	1.33	2.63		1.41	4.51	2.33	0.84	0.20	0.52	1.27
	Slate														
Black crappie	0	0.37	0	0	0	0	0.04		0	0.05	0	0	0	0	0.01
Eastern brook trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Burbot	0	0.37	0	0	0.15	0	0.07		0	0.36	0	0	0.17	0	0.08
Kokanee	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Lake trout	0.33	0	0	0	0	0	0.04		0.34	0	0	0	0	0	0.04
Largescale sucker	0.33	0	0	0.33	0	0	0.11		0	0	0	0.13	0	0	0.03
Mountain whitefish	0.33	0	0	0	0	0	0.04		0.15	0	0	0	0	0	0.02
Northern pikeminnow	1.00	0.74	0.50	0.50	0	0	0.40		0.29	0.16	0.13	0.09	0	0	0.10

Appendix C. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) of all species and the total catch for each of the sample sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006 (6 pages).

	Individual CPUE for:								Biomass (kg) CPUE for:						
Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Peamouth	0	0	0	0	0.46	0	0.11		0	0	0	0	0.08	0	0.02
Rainbow trout	0.67	0	0.50	0	0	0.33	0.22		0.21	0	0.23	0	0	0.09	0.08
Smallmouth bass	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Tench	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Walleye	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Cutthroat trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Total Slate	2.67	1.49	1.00	0.83	0.62	0.33	1.03		0.99	0.58	0.35	0.22	0.25	0.09	0.37
	Sullivan														
Black crappie	0	0	0.19	0	0	0	0.03		0	0	0.04	0	0	0	0.01
Eastern brook trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Brown trout	0.33	0	0	0	0.17	0	0.06		0.36	0	0	0	0.17	0	0.06
Burbot	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Kokanee	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Lake trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Largescale sucker	0	0.63	0.19	0	0	0	0.09		0	0.34	0.09	0	0	0	0.05
Mountain whitefish	2.67	1.57	0.75	0	0	0	0.49		1.69	0.59	0.59	0	0	0	0.29
Northern pikeminnow	0.67	0.63	0.38	0.17	0	0	0.20		0.18	0.16	0.07	0.07	0	0	0.05
Peamouth	0.33	0	0	0.83	0	0	0.17		0.05	0	0	0.12	0	0	0.03
Rainbow trout	1.33	0.63	0.19	0	0	0	0.20		0.53	0.36	0.04	0	0	0	0.09
Smallmouth bass	0	0	0.19	0	0	0	0.03		0	0	0.05	0	0	0	0.01
Tench	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Walleye	0	0	0	0	0	0	0		0	0	0	0	0	0	0

Appendix C. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) of all species and the total catch for each of the sample sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006 (6 pages).

	Individual CPUE for:								Biomass (kg) CPUE for:						
Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Cutthroat trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Yellow perch	0.33	0	0	0	0	0	0.03		0.04	0	0	0	0	0	0
Total Sullivan	5.67	3.46	1.89	1.00	0.17	0	1.31		2.85	1.45	0.89	0.19	0.17	0	0.58
	Sweet														
Black crappie	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Eastern brook trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Brown trout	0	0.42	0	0	0.33	0	0.09		0	0.04	0	0	0.45	0	0.09
Burbot	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Kokanee	0	0	0	0	0	0.11	0.03		0	0	0	0	0	0.01	0
Lake trout	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Largescale sucker	0	0.42	0	0	0	0	0.03		0	0.41	0	0	0	0	0.03
Mountain whitefish	0.33	2.54	0.18	0	0	0	0.25		0.13	1.16	0.08	0	0	0	0.11
Northern pikeminnow	0.67	1.27	0	0	0	0	0.16		0.13	0.36	0	0	0	0	0.04
Peamouth	0	2.11	0.35	0.17	0.17	0	0.28		0	0.41	0.06	0.02	0.02	0	0.05
Rainbow trout	2.33	2.96	0.18	0.17	0	0	0.50		1.14	0.96	0.02	0	0	0	0.18
Smallmouth bass	0.67	0	0	0	0	0	0.06		0.19	0	0	0	0	0	0.02
Tench	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Walleye	0	0.42	0	0	0	0	0.03		0	0.51	0	0	0	0	0.04
Cutthroat trout	0.33	0	0	0	0	0	0.03		0.02	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Total Sweet	4.33	10.14	0.70	0.33	0.50	0.11	1.47		1.61	3.85	0.16	0.02	0.48	0.01	0.56
	Tailrace														
Black crappie	0	0	0		0	0	0		0	0	0		0	0	0

Appendix C. Between-month comparison of catch per unit effort (CPUE: value per 30 m of net per hour) of all species and the total catch for each of the sample sites of Boundary Reservoir and the tailrace downstream of Boundary Dam in 2006 (6 pages).

	Individual CPUE for:								Biomass (kg) CPUE for:						
Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Eastern brook trout	0	0	0		0	0	0		0	0	0		0	0	0
Brown trout	0	0	0		0	0	0		0	0	0		0	0	0
Burbot	0	0	0		0.11	0.06	0.04		0	0	0		0.26	0.09	0.07
Kokanee	0	0	0		0	0	0		0	0	0		0	0	0
Lake trout	0	0	0		0	0	0		0	0	0		0	0	0
Largescale sucker	0.17	4.35	0.23		0.11	0	0.78		0.06	2.24	0.10		0.11	0	0.40
Mountain whitefish	0	0	0		0.11	0.17	0.07		0	0	0		0.08	0.10	0.05
Northern pikeminnow	0.33	0.24	0.08		0.11	0.06	0.13		0.47	0.18	0.03		0.06	0.08	0.12
Peamouth	0	0	0		0	0	0		0	0	0		0	0	0
Rainbow trout	0.33	0.12	0.53		0.11	0.11	0.24		0.10	0.03	0.14		0.04	0.06	0.07
Smallmouth bass	0	0.12	0.08		0	0	0.04		0	0.07	0.02		0	0	0.02
Tench	0	0	0		0	0	0		0	0	0		0	0	0
Walleye	0	0	0.23		0	0	0.06		0	0	0.26		0	0	0.06
Cutthroat trout	0	0	0		0	0	0		0	0	0		0	0	0
Yellow perch	0	0	0		0	0	0		0	0	0		0	0	0
Total Tailrace	0.83	4.82	1.15		0.56	0.40	1.35		0.63	2.51	0.55		0.55	0.33	0.80

Appendix D. Capture location, species, size, and tag numbers for fish tagged and released at the Boundary Project in 2006.

Study Site	Date	Project Reach	Set Location	Species*	Total Length (mm)	Weight (g)	Floy Tag No.	Floy Tag Color	PIT Tag No.
Sweet	07/20/06	Upper Reservoir	B	MWF	373	399	6201	Orange	985161000895218
Slate	07/21/06	Canyon	B	LKT	530	1021	6103	Yellow	985161001129876
Sullivan	07/23/06	Upper Reservoir	A	MWF	410	386	6202	Orange	985161001156987
Sullivan	07/23/06	Upper Reservoir	A	MWF	432	635	6204	Orange	
Sullivan	07/23/06	Upper Reservoir	A	MWF	395	408	6206	Orange	
Sweet	08/23/06	Upper Reservoir	B	MWF	363	442	6211	Orange	985161001140528
Sweet	08/23/06	Upper Reservoir	B	MWF	350	457	6212	Orange	985161000891988
Sweet	08/23/06	Upper Reservoir	B	MWF	418	635	6213	Orange	985161001137215
Sweet	08/23/06	Upper Reservoir	B	MWF	350	422	6214	Orange	985161001129020
Sullivan	08/24/06	Upper Reservoir	B	MWF	365	443	6106	Yellow	985161001127016
Sullivan	08/24/06	Upper Reservoir	C	MWF	378	515	6107	Yellow	985161001128643
Flume	08/25/06	Canyon	B	MWF	378	470	6108	Yellow	985161000886179
Flume	08/25/06	Canyon	E	MWF	384	460	6109	Yellow	985161001140101
Flume	08/25/06	Canyon	E	MWF	369	450	6110	Yellow	985161000892782
Tailrace	09/16/06	Tailrace	D	RBT	285	180	6003	White	985161000894008
Tailrace	09/16/06	Tailrace	L	RBT	326	318	6002	White	985161000895272
Sullivan	09/17/06	Upper Reservoir	E	MWF	460	1040	6216	Orange	985161000871894
Sullivan	09/17/06	Upper Reservoir	E	MWF	428	693	6217	Orange	985161000874617
Sullivan	09/17/06	Upper Reservoir	E	MWF	532	1397	6218	Orange	985161000878513
Sweet	09/17/06	Upper Reservoir	D	MWF	364	460	6215	Orange	985161001143035
Tailrace	11/17/06	Tailrace	L	MWF	457	740	6004	White	985161001134581
Tailrace	12/02/06	Tailrace	D	MWF	372	453	6006	White	985161000871920
Tailrace	12/02/06	Tailrace	D	MWF	450	872	6007	White	985161001143396
Tailrace	12/02/06	Tailrace	D	MWF	375	470	6008	White	985161000899285
Tailrace	12/02/06	Tailrace	D	RBT	337	368	6009	White	985161001138033
Tailrace	12/02/06	Tailrace	D	RBT	405	612	6010	White	985161000889513

* Species Codes: MWF = mountain whitefish; LKT = lake trout; RBT = rainbow trout.