BONNEVILLE POWER ADMINISTRATION

Resident Fish Stock Status Above Chief Joesph and Grand Coulee Dams

Annual Report 2003 - 2004 November 2005 DOE/BP-00004619-4

This Document should be cited as follows:

Connor, Jason, Jason McLellan, Chris Butler, Brian Crossley, "Resident Fish Stock Status Above Chief Joesph and Grand Coulee Dams", 2003-2004 Annual Report, Project No. 199700400, 386 electronic pages, (BPA Report DOE/BP-00004619-4)

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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

Resident Fish Stock Status Above Chief Joseph and Grand Coulee Dams 2003 Annual Report

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PROJECT NUMBER 199700400
CONTRACT NUMBER 00004619
AMMENDMENT NUMBER 003

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Executive Summary

In 1980, the United States Congress enacted the Northwest Power Planning and Conservation Act (PL 96-501, 1980), which established the Northwest Power and Conservation Council (NPCC), formerly the Northwest Power Planning Council. The NPCC was directed by Congress to develop a regional Power Plan and also the Columbia River Basin Fish and Wildlife Program (FWP) to restore or replace losses of fish caused by construction and operation of hydroelectric dams in the Columbia River Basin. In developing the FWP, Congress specifically directed NPCC to solicit recommendations for measures to be included in the Program from the region's fish and wildlife agencies and Indian tribes. All measures adopted by the Council were also required to be consistent with the management objectives of the agencies and tribes [Section 4.(h)(6)(A)], the legal rights of Indian tribes in the region [Section 4.(h)(6)(D)] and be based upon and supported by the best available scientific knowledge [Section 4.(h)(6)(B)]. The Resident Fish Stock Status above Chief Joseph and Grand Coulee Dams Project, also known as the Joint Stock Assessment Project (JSAP) specifically addresses NPPC Council measure 10.8B.26 of the 1994 program.

The Joint Stock Assessment Project is a management tool using ecosystem principles to manage artificial and native fish assemblages in altered environments existing in the Columbia River System above Chief Joseph and Grand Coulee Dams (Blocked Area). A three-phase approach of this project will enhance the fisheries resources of the Blocked Area by identifying data gaps, filling data gaps with research, and implementing management recommendations based on research results. The Blocked Area fisheries information is housed in a central location, allowing managers to view the entire system while making decisions, rather than basing management decisions on isolated portions of the system.

The JSAP is designed and guided jointly by fisheries managers in the Blocked Area. The initial year of the project (1997) identified the need for a central data storage and analysis facility, coordination with the StreamNet project, compilation of Blocked Area fisheries information, and a report on the ecological condition of the Spokane River System. These needs were addressed in 1998 by acquiring a central location with a data

storage and analysis system, coordinating a pilot project with StreamNet, compiling fisheries distribution data throughout the Blocked Area, identifying data gaps based on compiled information, and researching the ecological condition of the Spokane River.

In order to ensure that any additional information collected throughout the life of this project will be easily stored and manipulated by the central storage facility, it was necessary to develop standardized methodologies between the JSAP fisheries managers. Common collection and analytical methodologies were developed in 1999. The project began addressing identified data gaps throughout the Blocked Area in 1999. Data collection of established projects and a variety of newly developed sampling projects are ongoing.

Projects developed and undertaken by JSAP fisheries managers include investigations of the Pend Orielle River and its tributaries, the Little Spokane River and its tributaries, and water bodies within and near the Spokane Indian Reservation. Migration patterns of adfluvial and reservoir fish in Box Canyon Reservoir and its tributaries, a baseline assessment of Boundary Reservoir and its tributaries, ecological assessment of mountain lakes in Pend Oreille County, and assessments of streams and lakes on the Spokane Indian Reservation were completed by 2001. Assessments of the Little Spokane River and its tributaries, Spokane River below Spokane Falls, tributaries to the Pend Oreille River, small lakes in Pend Oreille County, WA, and water bodies within and near the Spokane Indian Reservation were conducted in 2002 and 2003. This work was done in accordance with the scope of work approved by Bonneville Power Administration (BPA).

Introduction

The area currently known as the Blocked Area was a highly productive, stable ecosystem prior to hydroelectric development (Scholz et al. 1985). This area contained healthy, native, self-sustaining populations of resident fish, wildlife, and anadromous fish. The native fish assemblage consisted of resident salmonids (trout, whitefish, char), anadromous salmonids (salmon, steelhead), catostomids (suckers), and cyprinids (minnows) very well adapted to pristine riverine conditions.

The amount of the anadromous fish resources was enormous throughout pre-dam history (Scholz et al. 1985, Osterman 1995, and Hewes 1973). Scholz et al. (1985) conservatively estimated the total salmon and steelhead escapement above the current Grand Coulee Dam location was between 1.1 million and 1.9 million fish annually. This estimate was calculated after Upper Columbia stocks targeted by lower river fisheries had been harvested, thus the anadromous fish production in the Upper Columbia was far greater than estimated escapements. This abundant resource supported the Upper Columbia ecosystem by transporting nutrients back to the Upper Columbia. The large nutrient transport by anadromous fish to the Upper Columbia played a functional role in supporting resident fish, wildlife, riparian communities, and human populations, thus making anadromous fish the keystone component (Willson and Halupka 1995; Cederholm et al. 1989; Kline et al. 1989; and Mills et al. 1993) in the Upper Columbia System. Anadromous fish provided 18,000,000 pounds annually to an Indian population of 50,000 individuals (Scholz et al. 1985).

The resident fish population was also very abundant in the Upper Columbia area (Scholz et al. 1985, Osterman 1995, and Bonga 1978). For example, in a U.S. Fish Commission Survey, Bean (1894) and Gilbert and Evermann (1895) noted that cutthroat trout and mountain whitefish were abundant in the Spokane River System. Gilbert and Evermann (1895) also noted that bull trout were abundant in the Pend Oreille River in an 1894 survey of that stream. To provide an idea of the numbers of resident trout found in these systems Lt. Abercrombie (U.S. Army) reported that a party of three anglers caught about 450 cutthroat trout in one afternoon fishing on the Spokane River near the City of Spokane Falls in August, 1877 (Scholz et al. 1985). Indian people harvested an estimated

153,000 resident fish accounting for 360,000 pounds of resident fish annually (Scholz et al. 1985).

The construction of Grand Coulee Dam eliminated over 1,140 linear miles of anadromous fish spawning and rearing habitat in the Upper Columbia River System (Scholz et al. 1985). In addition to the blockage and loss of habitat, dams and impoundments have created vast changes in the environment. Free-flowing rivers with rapids and gravel bars for spawning and incubation have been replaced with a series of reservoirs and impoundments. These severe habitat alterations have created habitat conditions more suitable for non-native species than for native species. This condition has allowed non-native species to thrive, effectively displacing native species.

The fish assemblage existing today in the Blocked Area is drastically different than pre-dam development. Anadromous fish, the keystone component of the Upper Columbia, are extinct due to the construction of Grand Coulee Dam. At least thirty-six (36) resident fish species are currently known to exist in the Blocked Area, the majority of which are not native. This largely non-native assemblage is, in part, the product of authorized and unauthorized introductions. Of the remaining native resident species, bull trout (*Salvelinus confluentus*) are listed as threatened under the Endangered Species Act (1973), and westslope cutthroat trout (*Oncorhynchus clarki lewisi*) are currently under court ordered status review for listing.

Westslope cutthroat trout were originally petitioned for listing in 1997. The U. S. Fish and Wildlife Service determined, in 2000, that listing was not warranted. The subspecies were found to inhabit 23,000 linear miles of stream habitat in 4275 tributaries, distributed among 12 major drainages and 62 watersheds throughout their historic range (U. S. Fish and Wildlife Service 2000). For the purpose of the status review, westslope cutthroat trout were evaluated on the basis of present stocks, regardless of their genetic characteristics. Westslope cutthroat are known to hybridize with other cutthroat subspecies and rainbow trout, and genetically pure westslope cutthroat are estimated to exist on only 2-4% of their historic range (McIntyre and Rieman 1995). Determining the distribution of genetically pure westslope cutthroat stocks and levels of introgression and hybridization is the focus of the current status review.

Dynamics of the current system have been developing over the last five decades, and have not reached equilibrium. Although recent research has begun to focus on resident species, managers today are still unclear on ecological conditions of the system and distribution and range of many of the 36 known resident species.

Fish managers are charged with providing subsistence and recreational fisheries in the Blocked Area given historical expectations and current environmental conditions. This task is extremely unique in that nearly every variable throughout the system is artificial from the species assemblage, to the available habitats, to river level fluctuations. The JSAP has been designed to function as a tool for Blocked Area fish managers. This tool will focus on understanding the dynamics of fish and their habitats throughout the Blocked Area and recommend management action based on the best available science and the condition of the entire Blocked Area ecosystem. The JSAP allows managers to view the Blocked Area as a system by compiling previously collected data, organizing available data, identifying areas needing data, performing necessary research, and recommending management actions.

Information gathered by other projects has been provided to the JSAP for synthesis. Synthesized information consists of habitat information, fish distribution information, stocking histories, and results of enhancement monitoring and evaluations. Managers using synthesized information for recommendations depend on the JSAP to provide accurate and precise synthesis of available information. Likewise, the JSAP depends on quality data collection procedures used by individual projects. Thus, the symbiotic relationships between projects have positive synergistic effects on successful implementation of management actions in the Blocked Area by making the best available science available.

Acknowledgements

We would like to thank Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council, and members of the Tribe for providing support and the opportunity to implement this project. We would like to thank the participating project members; Brian Crossley and Chris Butler of the Spokane Tribe of Indians, and Jason McLellan, John Whalen, and Dick O'Connor of Washington Department of Fish and Wildlife for their willingness to integrate ideologies and staff as a means of broader scoped fisheries management. Special thanks go to Deane Osterman (Director, KNRD) and Joe Maroney (Fisheries Program Manager, KNRD) for representing the project regionally.

Financial support for the project was provided by the U.S. Department of Energy, Bonneville Power Administration (BPA), Contract No. 00004619 Amendment No. 003, Project No.199700400. Ron Morinaka (Contracting Officer/Technical Representative) is due special thanks for ensuring smooth project implementation and needed insight

Kalispel Tribe of Indians
Annual Report
2003

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Introduction

During field season 2003, the Kalispel Natural Resource Department (KNRD) conducted fish and habitat inventories of five tributaries within the Pend Oreille River watershed. KNRD, in cooperation with Eastern Washington University (EWU) Department of Biology, conducted fishery and productivity investigations of three lakes in Pend Oreille County, WA (Appendix 1). The focus of these inventories was a compilation of the baseline habitat conditions and status of resident fish stocks in the Pend Oreille River watershed in Pend Oreille County, WA.

The following report summarizes the results of data collection activities in the five tributaries and three lakes (Figure 1 and Figure 2), with recommendations, habitat enhancement opportunities, and further research needs. A summary of database integration, GIS development, coordination, data sharing, and standardization activities appears in Appendix 4.

Additionally, a comprehensive limnological and fishery investigation of Sullivan Lake, including a nine-month creel survey was conducted in 2003. This was a cooperative project between the KNRD, EWU (principal investigators), USDA Forest Service, and Washington Department of Fish and Wildlife. Data analysis and reporting will be completed by Brett Nine, of EWU, as his master's thesis. Preliminary results of the creel survey of Sullivan Lake will be included in this annual report (Appendix 3).

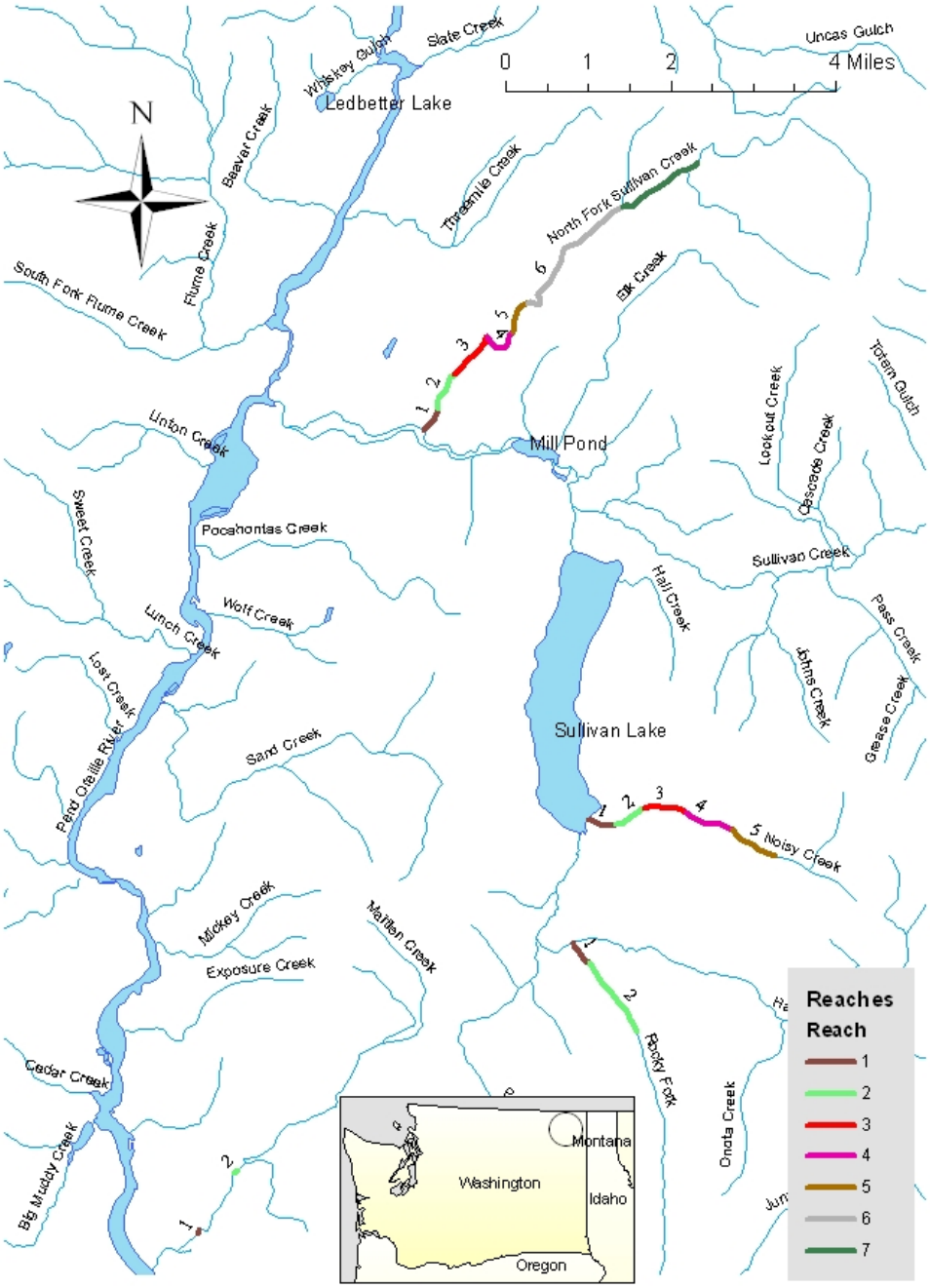

Figure 1. Map of northern lakes and tributaries showing sample reaches surveyed in 2003.

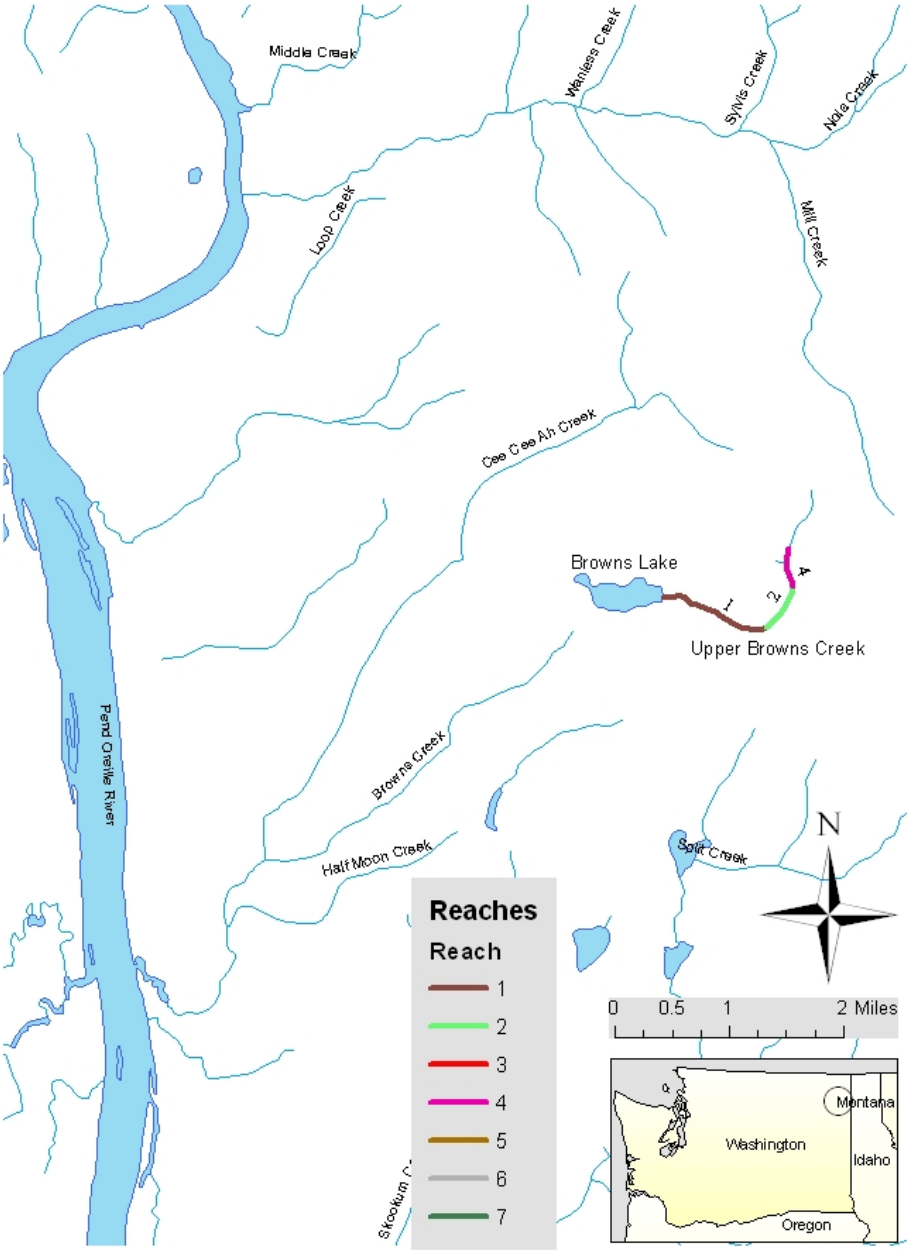

Figure 2. Map of southern lakes and tributaries showing sample reaches surveyed in 2003.

Study Area

Five tributary streams and three lakes within the Lower Pend Oreille River watershed in Pend Oreille County, Washington were surveyed in 2003 (Figure 1 and Figure 2). Rocky Fork, Noisy, and North Fork Sullivan creeks are in the Sullivan Creek watershed eventually flowing into the Boundary Pool of the Pend Oreille River north of Metaline Falls, Washington. Rocky Fork Creek is a tributary to Harvey Creek, which flows into the south end of Sullivan Lake (location of the confluence is 48.7698°N, 117.2880°W). Rocky Fork Creek has a drainage basin area of 1008 hectares (ha). Noisy Creek, a tributary to Sullivan Lake, empties directly into the lake from the southeast (48.7919°N, 117.2845°W), and has a drainage basin area of 1242 ha. Water from these streams eventually enters Sullivan Creek via the Sullivan Lake Dam and Outlet Creek. North Fork Sullivan Creek flows into Sullivan Creek downstream of Mill Pond (48.8600°N, 117.3284°W) and has the largest drainage basin area (2612 ha) of the tributaries surveyed in 2003. Maitlen Creek (48.7127°N, 117.3991°W) flows into the Pend Oreille River from the east 1.9 Km south of the Ione Bridge. The drainage basin area of Maitlen Creek is 1777 ha, much of which is intermittent and dry at the time of the survey. Upper Browns Creek is a relatively small watershed (976 ha drainage basin area) which flows into Browns Lake (48.4382°N, 117.1843°W), northeast of Usk, WA. It is the only tributary flowing into Browns Lake, and is naturally disconnected from Browns Creek below the lake, which originates from springs southwest of the lake.

Fishery and productivity investigations were conducted in Browns Lake, Mill Pond, and Ledbetter Lake. Browns Lake is a natural lake located in Sections 13-14 and 23-24 of Township 34 North Range 44 East, having a surface area of 36 ha. Ledbetter Lake is a small natural lake located west of the Pend Oreille River near Metaline, WA (Township 39 North, Range 43 East, Section 3). The surface area of the lake is approximately 12 ha. Mill Pond is a small storage reservoir (25 ha) northeast of Metaline Falls, WA (Township 39 North, Range 43 East, Section 30 and Township 39 North, Range 44 East, Section 25) managed by the Pend Oreille Public Utility District as part of the Sullivan Creek Hydroelectric Project (FERC Project No. 2225). The Project was constructed in 1909 by the Inland Portland Cement Company to supply electricity to the

town of Metaline Falls. The project consisted of the Sullivan Lake dam, Mill Pond dam, intake and wooden flume, canal, tunnel, and powerhouse. Water was conveyed to the powerhouse via an elevated wooden aquaduct until 1956. Maintenance problems with the wooden flume caused the project to cease operation and the project has been licensed as a non-power generating project until present (Public Utility District No. 1 of Pend Oreille County 1998).

Methods

Stream Habitat Surveys

Each stream was stratified into homogeneous reaches. Reaches were defined as portions of streams with similar gradient and morphological characteristics. Rosgen's system (Rosgen 1994) was used to classify stream reaches. The Joint Stock Assessment Project (JSAP) stream habitat survey methodology (modified from Kalispel Natural Resource Department stream survey methodology, 1997; WDFW et al. 2002) was used to assess stream reaches. Surveys consisted of two elements, reach variable measurements and transect measurements.

Reach variable measurements were those that were measured for the entire length of the reach and included air and water temperature, stream channel gradient, acting large woody debris (LWD), primary pools, and bank stability (Table 1). Primary pool and LWD counts were used to calculate mean densities per reach, as well as the entire stream. Densities were reported as the number of primary pools per kilometer (km) and the number of LWD per 100 meters (m). A primary pool was defined as a pool that was longer or wider than the mean wetted width of the stream. The length (0.1 m), width (0.1 m), maximum depth (centimeter; cm), and tailout depth (cm) were measured in each primary pool (KNRD 1997). The residual pool depth was calculated by summing the maximum and tailout depths and dividing by two.

Acting LWD consisted of any stable piece of organic debris with a diameter > 10 cm and a length > 1 m that intruded into the stream (KNRD 1997). Exposed root wads of live trees were not counted unless they intruded into the stream channel and provided habitat. Large debris dams causing one particular effect on the stream were counted as a

single piece of LWD (KNRD 1997). Stream channel gradient was defined as the change in vertical elevation per unit horizontal distance of the channel (Platts et al. 1983; KNRD 1997). Gradient (%) was measured with a clinometer (Suunto Corp. ™). Bank stability (%) was calculated by summing unstable bank measurements (m) and dividing by reach length, then subtracting from 100. Air and water temperatures were measured (˚C) at the beginning of each reach.

Table 1. Reach variables and method of collection.

Variables	**Method of Collection**
Air and Water Temperature	Thermometer reading in Celsius taken at the beginning of each reach.
Channel Type	A general classification of channel type based on channel morphology (see Rosgen 1994).
Gradient	Measured with a clinometer, at each transect.
Acting Large Woody Debris	Number of woody debris with a diameter >10cm and a length >1m in the stream.
Primary Pools	Count of number of pools with length or width greater than the avg. width of stream channel within each transect. Measure length (m), maximum depth (cm), and tailout depth (cm).
Bank Stability	Visual estimate of the length in meters of unstable bank per transect for possible sediment sources.

Transect measurements were recorded along the stream and were oriented perpendicular to the stream flow; distance between transects was 60 m. The 60 m interval was measured with a hip chain while walking upstream. Transect parameters included habitat type, habitat width, wetted width, mean depth, maximum depth, percent

composition of each dominant substrate type, and estimated percent embeddedness (Table 2). Mean values of each habitat parameter were calculated for each reach and stream.

Habitat types were divided into three categories; pool, riffle, and run. Pools were defined as portions of the stream with reduced current velocity and maximum depths two times greater than the tailout depth (WDFW et al. 2002). A riffle was a shallow rapid where the water flowed swiftly over completely or partially submerged obstructions to produce surface agitation (KNRD 1997). Runs were stream segments with intermediate characteristics between pools and riffles (Platts et al. 1983).

The wetted width of a stream was defined as the distance from the edge of the water on each shoreline, perpendicular to the flow of the stream. If the channel was braided, the wetted width of each braid was measured and summed to provide a total wetted width. Wetted width was measured to the nearest tenth of a meter.

Mean stream depth was determined by summing the depth measurements (cm) taken at ¼, ½, and ¾ the wetted width along the transect line and dividing them by four to account for the zero depth values at each shoreline (Platts et al. 1983). Maximum stream depths (cm) (Thalwag depth) were measured at each transect.

The dominant substrate type was determined for each habitat segment along the transect line (Table 3). The percent embeddedness, defined as the percentage of the surface area of larger substrate particles (gravel, cobble, rubble, and boulder) that were surrounded by fine particles (coarse sand and smaller; <0.6 cm) (Platts et al. 1983), of each substrate type was visually estimated along the transect line.

In streams that private landowners limited access, a sampling protocol modified from Simonson et al. (1994) was used to assess the stream. Simonson et al. (1994) reported that estimates spaced two mean stream widths apart within a survey section 35 mean stream widths long were within 5% of the true value 95% of the time. The first transect occurred at the downstream end of our fish sampling station with subsequent transects measured in an upstream direction. Transect spacing was determined by visual estimation of mean stream width multiplied by two. The total number of transects was determined by how many occurred in a distance 35 times the mean stream width up to 100 m. All reach variables and transect measurements were the same as in the JSAP

stream survey methodology. The habitat surveys were conducted at the same time and location as fishery surveys, allowing us to rapidly assess fish and habitat conditions and overcome the constraints of private landownership.

Table 2. Transect Variables and method of collection.

Variable	Method of Collection
Habitat Type	Visually determine habitat types (i.e., pool, riffle, run).
Habitat Widths	Measure each specific habitat type in a transect to the nearest 0.1m.
Wetted Width	Sum of all habitat type widths along the transect line.
Mean Depth	Measure of depth at 1/4, 1/2, 3/4 across channel to the nearest cm.
Maximum Depth (Thalwag)	Maximum stream depth measured along each transect. The Thalwag is defined as the line connecting the deepest points along the streambed (Hunter 1991).
Dominant Substrate Size	Visually determine largest percentage of substrate for that habitat type (i.e., silt, sand, gravel, cobble, boulder, bedrock).
Substrate Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding larger substrates.

Table 3. Description of substrate classification used for stream habitat assessments (modified from KNRD 1997).

Substrate Type	Description
Bedrock	Large masses of solid rock
Boulder	>30.5 cm (>12.0 in.)
Rubble	15.2 - 30.5 cm (6.0 in. - 12.0 in.)
Cobble	7.6 - 15.2 cm (3.0 in. - 6.0 in.)
Gravel	0.6 - 7.6 cm (0.25 in. - 3.0 in.)
Sand	<0.6 cm (<0.25 in.)
Silt	Fine sediments with little grittiness.
Muck	Decomposed organic material, usually black in color.
Organic Debris	Undecomposed herbaceous material.

In addition to measuring transect and reach parameters, a summary was written for each reach. The purpose of this overview was to provide qualitative information on the general habitat conditions of the reach and describe any unique features, impacts, or attributes. Recorded in the reach overview were notable disturbances such as logging, erosion sources, livestock grazing impacts, road encroachment, etc. Road culverts were recorded and mapped on USGS topographic maps or global positioning system (GPS). The percentage of aquatic vegetation cover and overhead canopy cover were estimated. Potential limiting factors and enhancement opportunities were described. Fish passage barriers were recorded and mapped on USGS topographic maps or GPS.

Attributes of potential barriers were assessed relative to fish species and size present as well as stream size. Jump height, velocity, and water depth restrictions will limit passage of fish relative to their size. Barriers were identified as potential, temporal/seasonal, and definite (WDFW et al. 2002). Natural fish barriers were described as falls or chutes (Powers and Orsborn 1985). Falls were vertical overflow portions of the stream and chutes were defined as steep, sloping, open channels with high velocities (Orsborn and Powers 1985). Human-made barriers consisted of culverts and dams. A falls or culvert was determined to be a potential barrier if it had a vertical jump height > 0.9 m, which would prevent passage of most smaller resident species. Vertical

jump heights > 3.4 m were considered definite barriers, which exceeded the maximum leaping height of the healthiest steelhead (610-792 mm TL) with a maximum burst speed of 8.1 m/s (26.5 ft/s) (Powers and Orsborn 1985). We assumed the swimming abilities of steelhead exceeded those of resident trout (McLellan and O'Connor 2003). A good takeoff pool is required for fish to leap any height, so a relatively low fall without a good take off pool may act as a total barrier (Powers and Orsborn 1985).

Stream flow, in cubic feet per second (cfs), was measured using methods similar to the midsection method developed by USGS (WDFW et al 2002). Discharge (Q; cfs) was measured with a Pygmy flow meter, and converted to m^3/s.

Stream temperatures (^oC) were monitored with Tidbit® temperature loggers (Onset Corp., MA) between 24 June and 7 October 2002. Temperatures were recorded hourly. The loggers were enclosed in camouflaged PVC tubes and attached to logs, rocks, or root wads on the stream bottom, out of direct sunlight. Loggers were placed at practical locations near the start of the first reach surveyed in each stream.

Stream Fish Sampling

Fish population data were collected using multiple pass depletion electrofishing sampling techniques (Murphy and Willis 1996, Heimbuch et al. 1997). Daytime sampling was conducted during the period from 26 August through 18 November 2002. One 100 m electrofishing station was established per reach, and selected to be representative of the reach. Block nets were set at the upstream and downstream boundaries to prevent immigration and emigration during the sampling period (Zippen 1958). Upon capture fish were transferred to 5-gallon holding containers of stream water until processed. Fish were anesthetized with Tricaine-S brand tricaine methanesulfonate (MS-222) (Western Chemical Inc., Ferndale, WA) prior to identification, measuring total length (TL) (mm), and weighing (g). All fish over 100 mm TL were weighed on an Ohaus electronic scale. Once fish were processed they were held in 5-gallon containers filled with stream water until fully recovered and returned to the stream.

Life history and population data were addressed by species composition, relative abundance, size (age class), and density (fish per 100 m^2). Population estimates were

obtained using the MicroFish 2.2 Interactive Program, the interactive version of "Fisheries Population and Statistical Package" (Van Deventer and Platts 1986). The program uses the maximum likelihood population estimation model developed by Dr. Kenneth Burnham of North Carolina State University (Van Deventer and Platts 1985), and Zippin's (1958) removal-depletion strategy assumptions. Fish < 50 mm have been reported to pass through the mesh of blocknets (McLellan and O'Connor 2003), and were excluded from the population estimates.

Fish densities were calculated by dividing the population estimate by the total sample area (sample station length [m] x mean stream width [m]). This density was multiplied by 100 to yield number of fish per 100 m^2. For some species within stream reaches, Microfish 2.2 population estimates were not reliable due to low or variable capture probability, or non-descending removal pattern. In these cases actual capture numbers were used instead of population estimates to calculate densities.

A small fin tissue sample was extracted from cutthroat trout sampled in North Fork Sullivan Creek. Samples were stored in absolute ethanol and sent to the WDFW Genetics Laboratory for microsatellite and mitochondrial DNA analysis to determine population structure and measure levels of introgression with rainbow trout.

Lake Fish Sampling

In 2003, baseline fishery assessments were conducted during summer and fall in Browns Lake, Ledbetter Lake, and Mill Pond. The objectives of these sampling efforts were determination of species composition, relative abundance, and catch per unit effort (CPUE). The littoral zone was sampled with horizontal gillnets set in all lakes for a duration no longer than four hours.

A total of four horizontal experimental monofilament gillnets, two floating and two sinking, were set in each lake except Ledbetter. Due to the small size of the lake, two randomly selected gillnets were set during summer. Three nets were deployed in the fall sample, due to extremely low catch rates in the first sample.

Horizontal gillnets were set perpendicular to shore at systematically selected sites. This sampling strategy was chosen over a simple random sampling strategy because the

lakes were typically small (< 36 hectares surface area), shallow (< 10 meters maximum depth), and had sunken timber and other obstacles along the shoreline. Nets measured 2.44 m by 60.96 m with four 15.24 m panels each with different square mesh sizes (1.27, 2.54, 3.81, and 5.08 cm, respectively). The smallest mesh size was set closest to shore.

Each fish collected was identified to species, measured (TL; mm) and weighed (grams). CPUE by sampling gear was calculated for each species collected (number of fish per hour) and relative abundance (species composition) was calculated for each lake.

Relative weight (W_r) and condition factor (K_{TL}) indices were used to evaluate fish condition in all lakes. Relative weight was calculated as:

$$W_r = (W / W_s) \times 100$$

Where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length (Anderson and Neuman 1996). The W_s equations and minimum applicable total lengths were obtained from Anderson and Neuman (1996) and Bister et al. (2000). Fish of all lengths in good condition have a W_r of about 100 (Anderson and Neuman 1996).

Fulton-type condition factors were calculated as an index of how fish add weight in relation to increasing length (Anderson and Neuman 1996). Mean condition factor was calculated for all fish using the formula:

$$K_{TL} = (W / TL^3) \times 10^5$$

Where W is the weight (g) and TL is the total length (mm) of an individual fish. Condition factors were used to compare fish of the same species between water bodies.

Results

Streams

North Fork Sullivan Creek

Seven reaches totaling 5.1 Km were assessed in North Fork Sullivan Creek between the confluence with Sullivan Creek and the Red Bluff Trail # 553 stream crossing. The uppermost reaches of the stream were not surveyed due to extremely remote conditions. No major impacts from human development were observed above the North Fork Sullivan Creek Dam (480 m above the confluence), which provides drinking water for the town of Metaline Falls. The watershed is roadless and borders the Salmo-Priest Wilderness Area. A summary of channel characteristics and habitat attributes recorded for North Fork Sullivan Creek appear in Table 4.

Mean wetted width of North Fork Sullivan Creek was 3.8 m and depth was 23.7 cm with gravel and cobble the dominant substrates (42.2% and 27.9% of transects, respectively). Overall, substrate embeddedness was relatively high (mean = 69.9%) in all but the first reach below the dam, which acts as a sediment trap. Riffle was the dominant habitat type recorded in 58.0% of transects, with pools and runs recorded in 19.0% and 23.0%, respectively. Mean channel gradient was 2.2% and ranged from 0.5% to 15.0%. Eighty-four primary pools were counted corresponding to a density of 16.5 pools/Km. Average length, maximum depth, and residual depths were 3.8 m, 63.8 cm, and 46.7 cm, respectively. Active LWD was abundant in the watershed (mean = 35.9 pieces/100 m) and many large cedar log jams were present.

Stream temperature was recorded hourly between 19 June and 16 October 2003 (Figure 3). Mean daily temperature was 9.4 °C (n=2854, SD=1.98). The minimum temperature recorded was 4.8 °C on 15 October. The maximum temperature, recorded on 19 August, was 14.0 °C. Discharge of North Fork Sullivan Creek at the mouth measured 0.038 m^3/sec on 4 September 2003.

Table 4. Channel characteristics and habitat attributes of North Fork Sullivan Creek, 2003.

	Reach							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Length (m)	480	540	1020	420	780	960	900	5100
No. Transects	8	9	17	7	13	16	15	85
Mean Width (m)	4.6	4.8	3.8	3.4	3.3	3.9	3.5	3.8
Mean Depth (cm)	25.3	30.4	19.5	27.0	23.9	21.1	24.5	23.7
Gradient (%):								
Mean	6.4	2.2	2.0	4.8	1.2	1.0	1.4	2.2
Min.	4.0	1.0	0.5	1.5	0.5	0.5	0.5	0.5
Max	15.0	4.0	3.0	9.0	2.0	2.0	4.0	15.0
Channel Type	A-3	B-4	C-3/D-4	A-2/A-3	D-4	C-4	B-3/C-4	
Temp (C):								
Air	14.0	14.0	15.0	13.0	7.5	10.0	10.0	
Stream	7.5	7.5	8.0	8.0	6.0	6.0	6.0	
Acting LWD (#/100 m)	14.0	48.1	24.9	22.9	41.5	52.3	36.4	35.9
Habitat Type:								
Pool (%)	24.7	30.2	11.5	43.5	8.8	24.3	6.5	19.0
Mean Width	4.5	4.3	7.4	3.4	3.8	5.1	3.4	4.4
Riffle (%)	75.3	49.7	69.0	19.4	60.3	61.4	50.4	58.0
Mean Width	4.6	3.6	3.0	4.6	2.9	3.9	3.3	3.4
Run (%)	0.0	20.2	19.5	37.1	30.9	14.3	43.2	23.0
Mean Width	0.0	4.4	4.2	2.9	3.3	3.0	3.8	3.6
Substrate Embeddedness (%):								
Mean	53.6	70.0	69.5	70.8	72.5	75.6	69.0	69.9
Min.	25.0	25.0	25.0	25.0	40.0	25.0	25.0	25.0
Max.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Substrate Composition:								
Bedrock (%)	21.1	0.0	0.0	10.1	0.0	0.0	0.0	3.1
Boulder (%)	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.9
Rubble (%)	0	0.0	0.0	44.3	0.0	0.0	0.0	3.2
Cobble (%)	55.1	16.0	40.7	13.5	9.0	24.3	29.1	27.9
Gravel (%)	10.7	71.0	23.5	0.0	23.0	17.1	44.3	28.7
Small Gravel (%)	0.0	0.0	7.9	0.0	63.3	28.7	0.0	15.5
Sand (%)	13.2	13.0	27.9	13.5	4.6	29.8	21.3	19.5
Silt (%)	0.0	0.0	0.0	18.6	0.0	0.0	0.0	1.3
Primary Pools:								
No.	6	6	16	11	16	18	11	84
Density (#/km)	12.5	11.1	15.7	26.2	20.5	18.8	12.2	16.5
Mean Length (m)	5.1	2.5	3.3	4.4	4.7	4.0	2.9	3.8
Mean Max. Depth (cm)	100.3	65.0	53.0	65.4	59.3	63.4	64.4	63.8
Mean Tailout Depth (cm)	12.8	8.5	14.7	14.9	22.1	14.1	14.5	15.4
Mean Residual Depth (cm)	67.6	56.5	38.3	50.5	37.1	49.4	49.9	46.7
Pool/Riffle Ratio	0.3:1	0.5:1	0.0:1	3.0:1	0.1:1	0.3:1	0.1:1	0.2:1

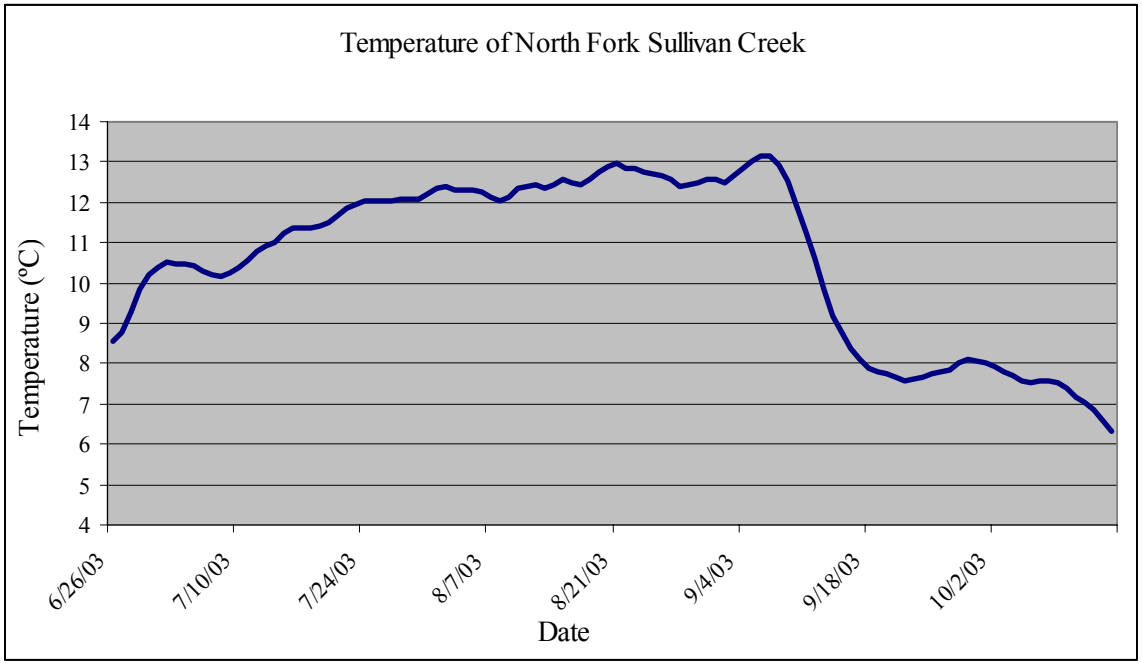

Figure 3. Seven day average daily maximum temperature recorded in North Fork Sullivan Creek, 2003.

Two 100-meter electrofishing stations were sampled (reaches 1 and 2) in North Fork Sullivan Creek. Cutthroat trout was the only species collected both above and below the dam. Electrofishing of the uppermost reaches was not feasible due to the remote location and steep valley walls with large downed trees posing a safety risk. Cutthroat trout were observed throughout the upper reaches while conducting the habitat survey, although we failed to collect any fish by hook and line sampling. Eighty-two fish were collected electrofishing in the first two reaches. The mean length of cutthroat trout collected was 111.3 mm TL (SD=30.3), and ranged from 47-212 mm TL (Figure 4). Fin tissue samples were taken from 30 fish and sent to the WDFW genetics laboratory in Olympia, Washington for analysis. This data was collected in conjunction with a separate BPA funded project entitled "Genetic Inventory of Bull Trout and Westslope Cutthroat Trout in the Pend Oreille Subbasin" and results will be reported in that projects annual report.

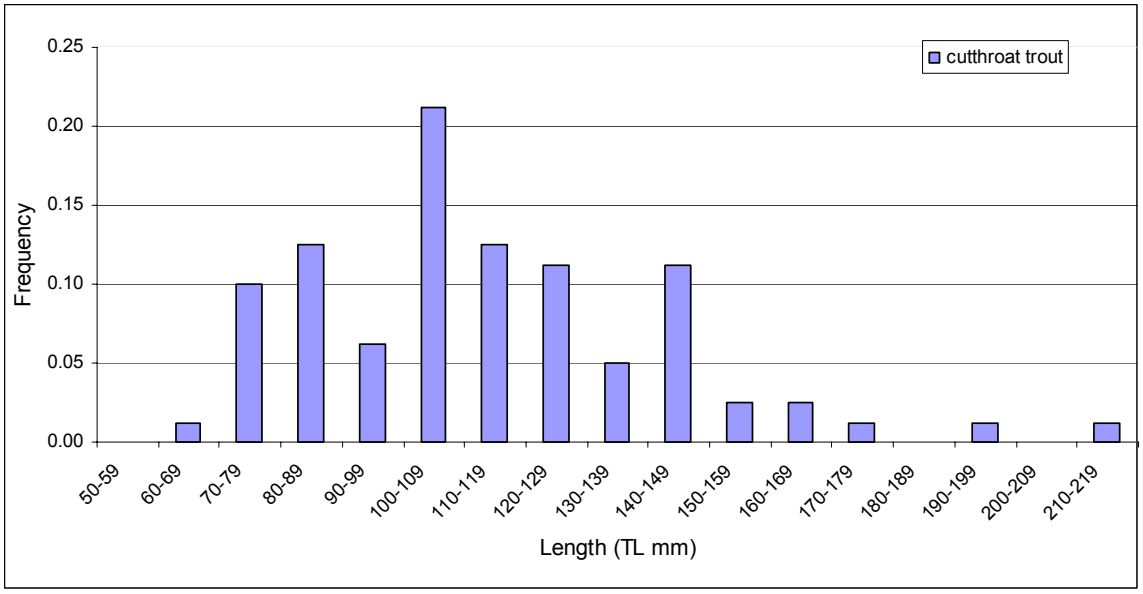

Figure 4. Length-frequency distribution of cutthroat trout sampled in North Fork Sullivan Creek, 2003.

Reach 1

Reach one was classified as a Rosgen A-3 type channel that extended from the confluence with Sullivan Creek to the outlet of the North Fork Sullivan Lake Dam 480 m upstream. Mean stream width was 4.6 m and depth was 25.3 cm. Gradient ranged from 4% to 15% (mean=6.4%). Cobble was the dominant substrate in 55.1% of transects with average embeddedness of 31.3%. Overall embeddedness averaged 53.6%, the lowest of any reach measured in the stream. Riffle was the dominant habitat type (75.3%), with pools present in 24.7% of transects. Primary pools were fairly abundant (n=6, 12.5 pools/Km), and averaged 5.1 m in length, 100.3 cm in depth, and 67.6 cm in residual pool depth. Acting LWD density was moderate at 14.0 pieces/100 m, although much lower than reaches above the dam.

One definite barrier (dam) and two potential barriers were recorded in the reach. A series of three falls between 2-4 meters high located 180 m below the dam were considered potential barriers. The culvert under Sullivan Lake Road is a potential slope and velocity barrier. One electrofishing station was established below the falls and 58 cutthroat trout were collected, resulting in an estimated density of 13.9 fish/100 m^2.

Reach 2

Reach two flowed through entrenched narrow canyons and cedar forest. The reach was classified as a Rosgen B-4 type channel that extended from the North Fork Sullivan Lake Dam to a significant gradient and habitat change 540 m upstream. Mean stream width was 4.8 m and depth was 30.4 cm. Gradient ranged from 1% to 4% (mean=2.2%). Gravel was the dominant substrate in 71.0% of transects, with an average embeddedness of 70.0%, within threshold limits for salmonid spawning (KNRD 1997). Riffle was the dominant habitat type (49.7%) with pools and riffles present in 30.2% and 20.2% of transects, respectively. Primary pool density was 11.1 pools/Km (n=6), and averaged 2.5 m in length, 65.0 cm in depth, and 56.5 cm in residual pool depth. Acting LWD density was high at 48.1 pieces/100 m, over three times greater than the reach below the dam. Several large downed cedars and large logjams were present in the reach. The reach two electrofishing station was established just above the dam. Twenty-four cutthroat trout were collected, resulting in an estimated density of 5.2 fish/100 m^2.

Reach 3

Reach three included 1020 m of Rosgen C-3/D-4 type channel flowing through an alder (A*lnus incana*) and dogwood (*Cornus stolinifera*) dominated broad valley. Mean stream width was 3.8 m and depth was 19.5 cm, with areas of braided channel. Average gradient was 2% and ranged from 0.5% to 3%. Cobble was the dominant substrate (40.7% of transects), with gravel and sand dominant in 31.4% and 27.9% of transects, respectively. Average embeddedness was 69.5% and ranged from 55.0% to 81.7%. Riffle was the dominant habitat type (69.0%) with pool and run habitat present in 11.5% and 19.5% of transects, respectively. Primary pool density was 15.7 pools/Km (n=16), pools and averaged 3.3 m in length, 53.0 cm in depth, and 38.3 cm in residual pool depth. Again, acting LWD was abundant (24.9 pieces/100 m), although species composition differed from reaches 1 and 2. Cutthroat trout were observed in many pools, but we were unable to collect any using hook and line in this or any other upstream reach.

Reach 4

Reach four flowed through a 420 m steep, narrow canyon, classified as Rosgen type A-2/A-3 channel. Gradient averaged 4.8%, ranging from 1.5% to 9.0%. Mean stream width was 3.4 m and depth was 27.0 cm. Pools were the dominant habitat feature in 43.5% of transects. Primary pools were abundant (26.2 pools/Km) and relatively large (4.4 m average length, 65.4 cm mean maximum depth, 50.5 cm mean residual depth). Rubble was the dominant substrate (44.3%), with bedrock (10.1%), cobble (13.5%), and sand/silt (32.1% combined) also present. Potential barriers included a 2.3 m fall and bedrock cascades near the upstream reach boundary.

Reach 5

Reach five flowed through a large meadow with braided channels owed to several remnant beaver dams. The reach measured 780 m and was classified as Rosgen D-4 channel type. Stream gradient ranged from 0.5% to 2% and averaged 1.2%. Average wetted width and depth were 3.3 m and 23.9 cm, respectively. Riffle was the dominant habitat type (60.3%), and gravel/small gravel were the dominant substrates (23.0% and 63.3%, respectively). Embeddedness averaged 72.5% and ranged from 40%-100%. Acting LWD was abundant (41.5 pieces/100 m) and potential for recruitment high due to snags created from inundation. Consequently, primary pools were abundant and relatively large (20.5 pools/Km, 4.7 m average length, 59.3 cm mean maximum depth, 46.1 cm mean residual depth).

Reach 6

Reach six measured 960 m and was low gradient Rosgen C-4 type channel flowing through cedar forest. Mean stream width was 3.9 m and depth was 21.1 cm. Average gradient was 1.0% and ranged from 0.5% to 2.0%. Gravel and small gravel combined accounted for 45.8% of the substrate, with sand and cobble dominant in 29.8% and 24.3% of transects, respectively. An abundance of fine sediment and sand contributed to the highest recorded mean embeddedness level in the stream (75.6%). Riffle was the dominant habitat type (61.4%) with pools and runs recorded in 24.3% and 14.3% of transects, respectively. Eighteen primary pools were counted corresponding to

a density of 18.8 pools/Km. Average length, depth, and residual depths were 4.0 m, 63.4 cm, and 49.4 cm, respectively. Acting LWD density was highest of any reach in North Fork Sullivan Creek (52.3 pieces/100 m), at times completely concealing the stream for several meters.

Reach 7

Reach seven included 900 m of Rosgen B-3/C-4 type habitat flowing through dense alder thickets with cedar overstory. The reach and survey terminated at the Red Bluff Trail # 553 crossing. Two potential barriers falls were recorded in reach seven, one 2.1 m high and the other 1.5 m. Stream gradient averaged 1.4%, ranging from 0.5% to 4.0%. Mean stream width was 3.5 m and depth was 24.5 cm. Gravel was the dominant substrate (44.3%) and embeddedness averaged 69.0%. Riffle was the dominant habitat in 50.4% of transects, with run recorded in 43.2%. Acting LWD and primary pool densities were lower than in reach six (36.4 pieces/100 m, and 12.2 pools/Km, respectively). Primary pools were also smaller on average (2.9 m average length, 64.4 cm mean maximum depth, 49.9 cm mean residual depth).

Noisy Creek

Five reaches totaling 3.7 Km were assessed in Noisy Creek from the Noisy Creek Campground to just upstream (East) of the Noisy Creek Trail # 588 switchback heading North to Hall Mountain Trail # 533. The stream is a tributary to Sullivan Lake located on the Southeast side of the lake. At the time of the survey, Noisy Creek was dewatered from the lake to just upstream of the campground footbridge (200 m). Like Harvey Creek, the largest tributary to Sullivan Lake, Noisy Creek flows subsurface below large substrates (cobble and rubble) near the mouth. Impacts from human development in the Noisy Creek watershed are limited to historic logging and mining activity. One abandoned roadbed has failed and washed into the channel through a steep canyon in reach two. Additionally, remnants of a corduroy road running up the channel were present throughout reaches two and three. A summary of the channel characteristics and habitat attributes recorded for Noisy Creek appear in Table 5.

Mean wetted width of Noisy Creek was 2.6 m and depth was 16.6 cm with cobble the dominant substrate (50.3%). Overall substrate embeddedness averaged 34.8%. Spawning sized gravel accounted for 8.1% of the substrate and averaged 45.0% embedded. Mean stream gradient was 7.2% and ranged from 2.0%-21.0%. Fish passage barriers appear to be the major limiting factor in the watershed. Thirty-one potential or definite barriers including falls from 1.1 m to 2.2 m and cascades and chutes as long as 40 m over bedrock substrate with >20% gradient were observed in the first two reaches. Riffle was the dominant habitat type recorded in 65.8% of transects with pools and runs recorded in 18.9% and 15.3%, respectively. Eighty-eight primary pools were recorded corresponding to a density of 24.0 pools/Km. Average length, maximum depth, and residual depths were 2.7 m, 59.1 cm, and 50.6 cm, respectively. Acting LWD density averaged 19.9 pieces/100 m.

Table 5. Channel characteristics and habitat attributes of Noisy Creek, 2003.

	Reach					
	1	**2**	**3**	**4**	**5**	**Total**
Length (m)	360	900	720	840	840	3660
No. Transects	6	15	12	14	14	61
Mean Width (m)	2.5	3.1	2.8	2.7	1.9	2.6
Mean Depth (cm)	15.1	20.4	25.9	12.8	9.1	16.6
Gradient (%):						
Mean	5.8	12.0	8.3	5.5	3.2	7.2
Min.	4.5	7.5	5.5	3.5	2.0	2.0
Max	8.5	21.0	14.0	9.0	4.0	21.0
Channel Type	A-3	Aa+3	A-3	A-3	B-4	
Temp (C):						
Air	25.0	24.0	24.0	21.0	18.0	
Stream	11.0	11.5	11.5	10.0	9.0	
Acting LWD (#/100 m)	4.7	18.9	25.7	22.4	20.2	19.9
Habitat Type:						
Pool (%)	16.6	30.7	40.2	0.0	0.0	18.9
Mean Width	2.5	2.1	2.7	0.0	0.0	2.3
Riffle (%)	83.4	61.6	34.4	92.1	64.8	65.8
Mean Width	2.5	2.4	1.9	2.7	1.7	2.3
Run (%)	0.0	7.7	25.4	7.9	35.2	15.3
Mean Width	0.0	3.6	2.8	3.0	2.4	2.7
Substrate Embeddedness (%):						
Mean	12.5	14.8	32.5	53.8	57.5	34.8
Min.	5.0	5.0	0.0	20.0	25.0	0.0
Max.	20.0	40.0	75.0	80.0	90.0	90.0
Substrate Composition:						
Bedrock (%)	0.0	0.0	4.8	0.0	0.0	1.0
Boulder (%)	25.8	25.2	33.5	15.5	0.0	20.5
Rubble (%)	27.8	12.6	19.3	20.3	8.2	16.5
Cobble (%)	46.4	59.1	42.3	59.7	33.3	50.3
Gravel (%)	0.0	3.2	0.0	4.5	36.7	8.1
Small Gravel (%)	0.0	0.0	0.0	0.0	21.7	3.6
Primary Pools:						
No.	7	35	19	14	13	88
Density (#/km)	19.4	38.9	26.4	16.7	15.5	24.0
Mean Length (m)	2.2	3.1	3.0	2.3	2.0	2.7
Mean Max. Depth (cm)	46.1	60.9	69.7	56.6	48.6	59.1
Mean Tailout Depth (cm)	7.9	8.1	10.4	10.0	6.2	8.6
Mean Residual Depth (cm)	38.3	52.9	59.3	46.6	42.5	50.6
Pool/Riffle Ratio	0.2:1	0.5:1	0.8:1	0.0:1	0.0:1	0.2:1

Stream temperature was recorded hourly between 19 June and 20 October 2003 (Figure 5). Mean daily temperature was 8.8 °C (n=2948, SD=1.80). The minimum temperature recorded was 4.6 °°C on 15 and 16 October. The maximum temperature, recorded on 31 July and 1 August, was 11.8 °C. Discharge of Noisy Creek just upstream of the footbridge measured .005 m^3/sec on 4 September 2003.

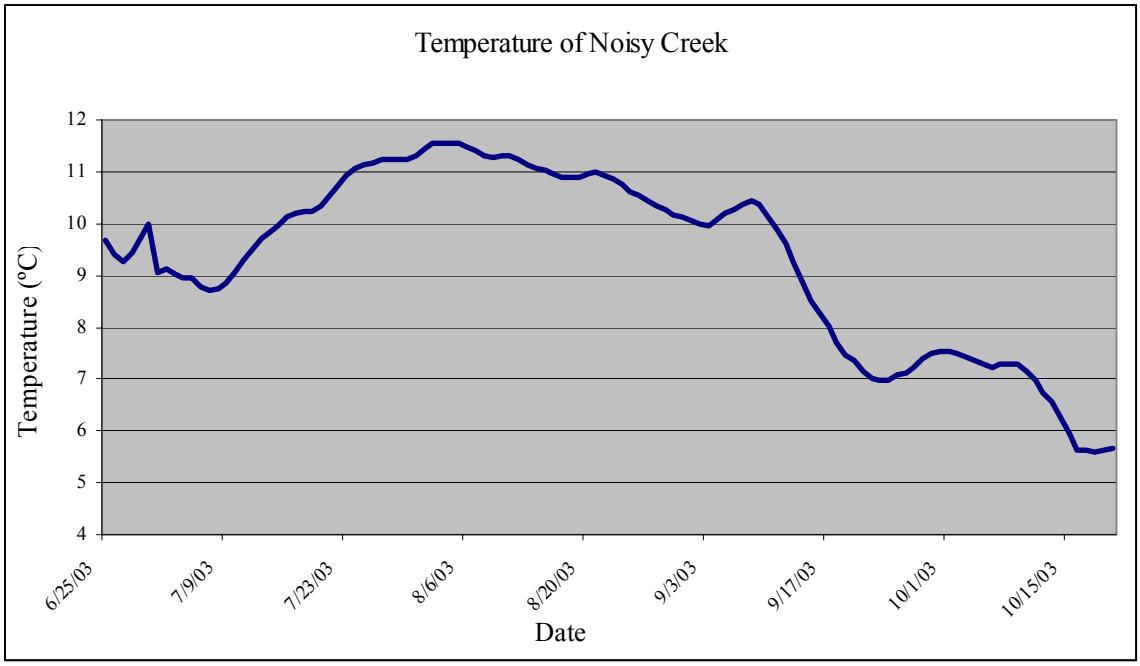

Figure 5. Seven day average daily maximum temperature recorded in Noisy Creek, 2003.

Two 100-meter electrofishing stations were established in reach one of Noisy Creek. The first station was set at the boat launch bridge prior to the channel becoming dewatered (8 June). Fifteen cutthroat trout were collected at this site ranging in size from 55-145 mm TL (mean=81.9, SD=24.2) (Figure 6). The second sample was taken just upstream of the campground footbridge on 9 October. The mean length of fish collected was 130.1 mm TL (n=20, SD=37.0) and ranged from 89-212 mm TL. Fifty-one fish <50 mm TL were collected during the second sample, but were excluded from analysis, as they have been observed passing through the mesh of blocknets (McLellan and O'Connor 2003). Density of cutthroat trout was estimated at 7.2 fish/100 m^2 in the first sample and 8.4 fish/100 m^2 in the second sample.

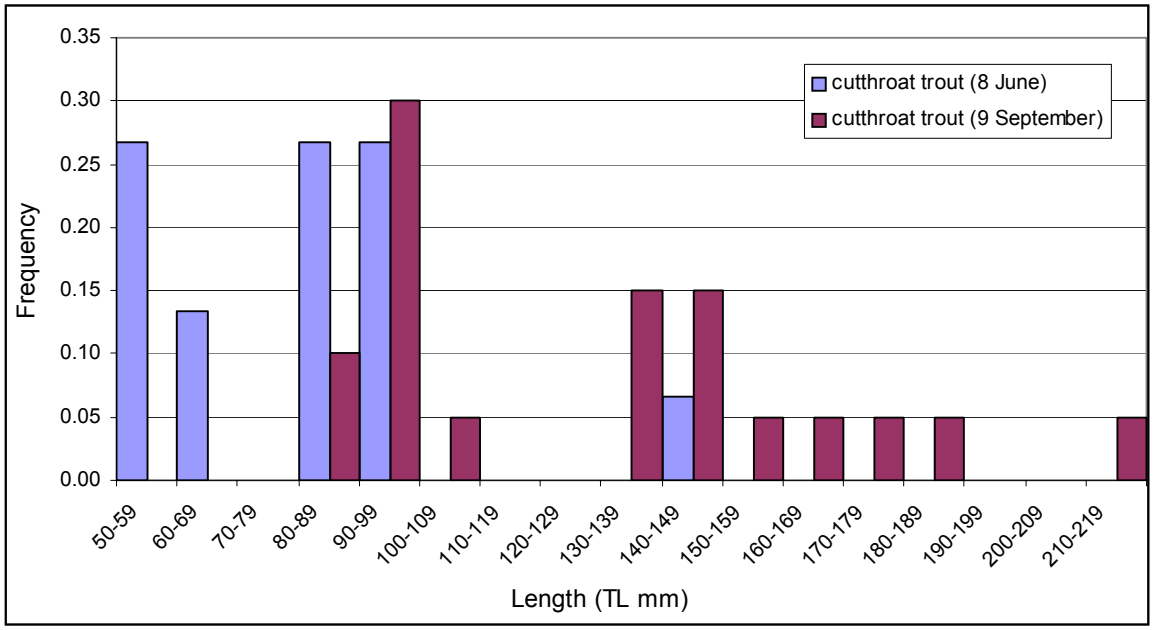

Figure 6. Length-frequency distribution of cutthroat trout sampled in Noisy Creek, 2003.

Reach 1

Reach one extended from Sullivan Lake to a significant gradient change just upstream of the Noisy Creek Campground. The reach measured 360 m and was classified as a Rosgen A-3 type channel. The channel was deeply incised with a mean stream width of 2.5 m and depth of 15.1 cm. Average gradient was 5.8% and ranged from 4.5% to 8.5%. The streambed consisted of large substrate with low embeddedness. Cobble, rubble, and boulders occurred in 46.4%, 27.8%, and 25.8%, respectively and mean embeddedness measured 12.5%. Riffle was the dominant habitat (83.4%), with pools recorded in 16.6% of transects. Primary pools were relatively abundant (n=7, 19.4 pools/Km), with an average length of 2.2 m, depth of 46.1 cm, and residual depth of 38.3 cm. Acting LWD was scarce (4.7 pieces/100 m), the lowest density recorded in the stream. The stream appeared channelized through the campground, and LWD may have been removed.

Reach 2

Reach two was an extremely high gradient, entrenched section through a narrow canyon. The reach measured 900 m and was classified as a Rosgen Aa+3 type channel. Several fish passage barriers (>20) were recorded and an abandoned road has washed out into the channel (37.0 m of unstable bank). Mean stream width was 3.1 m and depth averaged 20.4 cm. Cobble was the dominant substrate (59.1% of transects) with an average embeddedness of 13.2%. Gradient ranged from 7.5% to 21.0% and averaged 12.0%. Riffle was the dominant habitat type recorded in 61.6% of transects with pools recorded in 30.7%. Primary pools were abundant (n=35, 38.9 pools/Km), twice the density of reach one. Average length, maximum depth, and residual depth of primary pools were 3.1 m, 60.9 cm, and 52.9 cm, respectively. Acting LWD density was 18.9 pieces/100 m, the majority of which came from old corduroy road running up the channel. No fish were observed during the habitat survey and no electrofishing occurred. The gradient and rough terrain posed a safety risk to electrofishing.

Reach 3

Reach three began at the end of the narrow canyon 60 m downstream of the Noisy Creek Trail # 588 fjord and extended upstream 720 m to a large log jam. Stream gradient was lower than reach two (mean=8.3%) and the channel was classified as Rosgen A-3. Seven potential barrier falls between one and two meters in height were recorded in reach three. The mean stream width was 2.8 m and depth was 25.9 cm. The substrate was again comprised of large material, with cobble (42.3%) and boulders (33.5%) the dominant substrates. Embeddedness was slightly higher than downstream reaches (mean=32.5%). Pools were the dominant habitat type (40.2%), with riffles and runs recorded in 34.4% and 25.4%, respectively. Primary pools were also abundant (n=19, 26.4 pools/Km). Average length of primary pools was 3.0 m, maximum depth was 69.7 cm, and residual depth 59.3 cm. Acting LWD density was calculated at 25.7 pieces/100 m.

We snorkeled 79 m near the beginning of the reach, between the fjord and a potential barrier, with no fish being observed. Three large pools (3 m - 9m in length) and four riffles were included in the snorkel survey. No fish were observed during the habitat

assessment either, and we presume the numerous barriers downstream have permanently prevented upstream colonization.

Reach 4

Reach four was classified as a Rosgen A-3 type channel measuring 840 m. Mean gradient was 5.5%, ranging from 3.5% to 9.0%. The mean stream width was 2.7 m and depth was 12.8 cm. Cobble was the dominant substrate (59.7%), with still higher average embeddedness (49.3%). Acting LWD density was moderate at 22.4 pieces/100 m and one large log jam was present. The log jam consisted of over 40 downed trees across the stream and both banks had eroded and discharged fine sediment to the channel. Riffle was the dominant habitat type (92.1%), and no pools were recorded at transects. Fourteen primary pools were recorded, though, corresponding to a density of 16.7 pools/Km. On average, pools were relatively small (2.3 m mean length, 56.6 cm average maximum depth, and 46.6 cm residual depth). No fish were observed during our habitat survey and we assumed no fish were present; therefore no electrofishing survey was conducted.

Reach 5

Reach five was classified as a Rosgen B-4 type channel measuring 840 m. The reach had the lowest average gradient surveyed in Noisy Creek (3.2%, range 2%-4%). Mean stream width was 1.9 m and depth was 9.1 cm. Gravels were the dominant substrate (large gravel 36.7% and small gravel 21.7%) with cobble present in 33.3% of transects. Embeddedness in reach five averaged 57.5%. Like reach four, riffle and pool were the only habitats recorded at transects (64.8% and 35.2%, respectively). There was however thirteen primary pools counted, a density of 15.5 pools/Km. Average primary pool length, maximum depth, and residual depths were 2.0 m, 48.6 cm, and 42.5 cm, respectively. Acting LWD occurred at a density of 20.2 pieces/100 m. No fish were observed during our habitat survey and we assumed no fish were present; therefore no electrofishing survey was conducted.

Rocky Fork Creek

Two reaches totaling 2.0 Km were assessed in Rocky Fork Creek from the confluence with Harvey Creek to the point where the stream becomes intermittent. No major impacts from human development were observed in the watershed, except historic fire. Only one road crosses the stream (Forest Service Rd #1935) at the mouth. The majority of the habitat in Rocky Fork Creek was characterized as an A-2 type channel through narrow canyon, with several potential to definite barriers. A summary of channel characteristics and habitat attributes recorded for the stream appear in Table 6.

Mean wetted width of Rocky Fork Creek was 2.2 m, and depth was 19.0 cm. Boulders were the dominant substrate in 50.0% of transects with a mean embeddedness (of all substrates) of 26.8%. Riffle was the dominant habitat type recorded in 73.0% of transects, with pools and runs recorded in 10.8% and 16.2%, respectively. Channel gradient averaged 10.1% and ranged from 3.5% in the upper watershed and to 44.0% near the mouth. Thirty-one primary pools were counted, corresponding to a density of 15.7 pools/Km. Average length was 2.7 m, maximum depth was 67.5 cm, and residual depth was 59.4 cm. Acting LWD was scarce, averaging 8.9 pieces/100 m.

Stream temperature was recorded hourly between 19 June and 16 October 2003 (Figure 7). Mean daily temperature was 10.5 °C (n=2855, SD=3.00). The minimum temperature, recorded on 15 October, was 4.1 °C. The maximum temperature recorded was 18.2 °C on 30 July and 1 August. The thermograph housing was found partially dewatered on 19 August. We were unable to determine the exact date the thermograph became dewatered, but it appears from the hydrograph that it was around the middle of July. Daily temperature fluctuations up to 5.5 °C were recorded during this period, compared to < 2.0 °C before and after. Maximum temperatures throughout the Harvey Creek watershed ranged from 13.6 °C in Middle Fork Harvey Creek to 17.0 °C in Upper Harvey Creek during the same period (Andersen and Olson 2004).

We electrofished 100 m of Rocky Fork Creek beginning at the mouth and did not collect any fish. We also snorkeled 22 pools throughout the stream and failed to observe any fish. No fish were observed during the habitat survey and we assume no fish are present in the stream.

Table 6. Channel characteristics and habitat attributes of Rocky Fork Creek, 2003.

	Reach 1	Reach 2	Total
Length (m)	480	1500	1980
No. Transects	8	25	33
Mean Width (m)	2.7	2.1	2.2
Mean Depth (cm)	20.9	18.4	19.0
Gradient (%):			
Mean	19.5	7.1	10.1
Min.	11.5	3.5	3.5
Max	44.0	12.0	44.0
Channel Type	Aa+2	A-2/A-3	
Temp (C):			
Air	28.0	22.0	
Stream	12.0	11.5	
Acting LWD (#/100 m)	9.0	8.9	8.9
Habitat Type:			
Pool (%)	9.2	11.5	10.8
Mean Width	2.0	1.5	1.6
Riffle (%)	90.8	65.6	73.0
Mean Width	2.5	1.8	2.0
Run (%)	0.0	22.9	16.2
Mean Width	0.0	2.4	2.4
Substrate Embeddedness (%):			
Mean	13.9	30.9	26.8
Min.	0.0	5.0	0.0
Max.	25.0	75.0	75.0
Substrate Composition:			
Bedrock (%)	8.8	0.0	2.6
Boulder (%)	91.2	32.9	50.0
Rubble (%)	0.0	27.9	19.7
Cobble (%)	0.0	39.2	27.7
Gravel (%)	0.0	0.0	0.0
Small Gravel (%)	0.0	0.0	0.0
Sand (%)	0.0	0.0	0.0
Silt (%)	0.0	0.0	0.0
Organic Debris (%)	0.0	0.0	0.0
Primary Pools:			
No.	13.0	18.0	31.0
Density (#/km)	27.1	12.0	15.7
Mean Length (m)	3.4	2.3	2.7
Mean Max. Depth (cm)	67.5	67.5	67.5
Mean Tailout Depth (cm)	8.6	7.7	8.1
Mean Residual Depth (cm)	58.9	59.8	59.4
Pool/Riffle Ratio	0.1:1	0.2:1	0.1:1

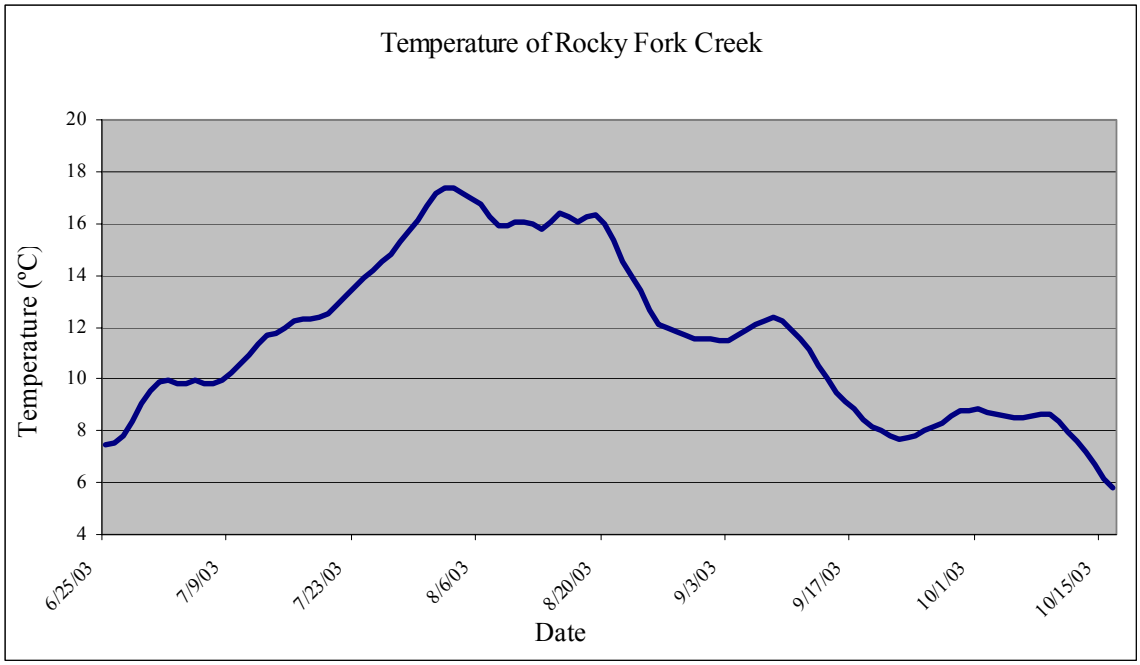

Figure 7. Seven day average daily maximum temperatures recorded in Rocky Fork Creek, 2003.

Reach 1

Reach one was classified as a Rosgen Aa+2 type channel that extended from the confluence with Harvey Creek to an old footbridge and gradient change 480 m upstream. Several potential and at least one definite passage barrier (a bedrock cascade with 44% gradient and vertical fall with no plunge pool) were present in the reach. Gradient ranged from 11.5% to 44.0% (mean=19.5%). Riffle was the dominant habitat type (90.8%) with pools present in 9.2% of transects. Boulders were the dominant substrate in 91.2% of transects and mean embeddedness was 15.6%. Numerous waterfall plunges contributed to abundant primary pools (27.1 pools/Km). Average length, maximum depth, and residual depths were 3.4 m, 67.5 cm, and 58.9 cm, respectively. Very little acting LWD was present in the reach, and the density was 9.0 pieces/100 m.

Reach 2

Reach two included 1500 m of Rosgen A-2/A-3 type habitat from the footbridge gradient change to the point where the stream became intermittent. Gradient averaged 7.1%, and ranged from 3.5% to 12.0%. Mean stream width was 2.1 m and depth was 18.4 cm. Riffle was the dominant habitat type (65.6%) with pool and run habitat

recorded in 11.5% and 22.9%, respectively. Substrate composition comprised of large materials with boulders, rubble, and cobble present in 38.1%, 23.9%, and 31.4%, respectively. Acting LWD and primary pool densities were relatively low (8.9 pieces/100 m, 12.0 pools/Km). Lack of LWD, spawning sized gravels, and numerous fish passage barriers appear to be factors limiting fish production in Rocky Fork Creek.

Maitlen Creek

Numerous private landowners limited access to Maitlen Creek to conduct fishery and habitat assessments. Of 21 landowners we contacted, only 7 would grant us permission to survey the stream where it crosses their property. Four of these seven parcels were located in the upper watershed, which was dry at the time of the survey. Given these constraints we surveyed two 100 m sections, one each in reaches two and three, using the modified Simonson et al. (1994) methodology. Residential development, roads, agricultural use, logging, and grazing have impacted the stream. Horse and cattle grazing in the first three reaches have caused devegetation and bank failure in several locations. A summary of channel characteristics and habitat attributes recorded for Maitlen Creek appear in Table 7.

Mean wetted width of Maitlen Creek was 0.8 m and depth was 9.4 cm. Overall, small gravel was the dominant substrate, accounting for 37.9% of all transects and 65.9% of transects in site two. Cobble was the dominant substrate in site one (36.0%) with sand present in 30.1% of transects. Mean substrate embeddedness was relatively high at 74.4%, ranging from 25%-100%. Channel gradient averaged 2.2% and ranged from 1.0% to 4.0%. The channel was classified as a Rosgen B type channel at both sites (B-3/B-5 in site 1, B-4 in site 2). Riffle was the dominant habitat type at both sites (61.1% overall), with run and pool habitat recorded in 33.3% and 5.5%, respectively. No pool habitat was recorded in site two. Additionally, no primary pools were recorded at either site. Acting LWD density was low (3.3 pieces/100 m), and no acting LWD was recorded in site two. It was apparent that lack of LWD and primary pools, livestock grazing, high substrate embeddedness, and agricultural development were potential limiting factors in Maitlen Creek. Discharge of Maitlen Creek at the Le Clerc Road crossing measured .045

m^3/sec on 4 September 2003. The thermograph placed at this site was never recovered, and may have been stolen or destroyed.

Two species of fish were collected in the reach three electrofishing site, brook trout and cutthroat trout. The mean length of brook trout collected was 164.9 mm TL (n=11, SD=59.8) and ranged from 90-240 mm TL (Figure 8). The estimated density of brook trout was 17.1 fish/100 m^2. Thirteen cutthroat trout were collected corresponding to an estimated density of 15.8 fish/100 m^2. Mean length was 80.8 mm (SD=27.3) and ranged from 67-171 mm TL (Figure 8). We failed to collect any fish in the reach two electrofishing station.

Table 7. Channel characteristics and habitat attributes recorded in Maitlen Creek, 2003.

	Site 1	Site 2	Total
Length (m)	36	25	61
No. Transects	18	18	36
Mean Width (m)	0.8	0.8	0.8
Mean Depth (cm)	8.7	10.1	9.4
Gradient (%):			
Mean	2.4	2.0	2.2
Min.	1.0	2.0	1.0
Max	4.0	2.0	4.0
Channel Type	B-3/B-5	B-4	NA
Temp (C):			
Air	12.0	15.5	NA
Stream	7.0	7.0	NA
Acting LWD (#/100 m)	7.9	0.0	3.3
Habitat Type:			
Pool (%)	11.0	0.0	5.5
Mean Width	0.8	0.0	0.8
Riffle (%)	66.7	55.6	61.1
Mean Width	0.8	0.8	0.8
Run (%)	22.2	44.4	33.3
Mean Width	0.7	0.7	0.7
Substrate Embeddedness (%):			
Mean	75.6	73.3	74.4
Min.	25	25	25
Max.	100	100	100
Substrate Composition:			
Bedrock (%)	0.0	6.5	3.3
Cobble (%)	36.0	6.5	21.2
Gravel (%)	24.3	17.6	20.4
Small Gravel (%)	9.5	65.9	37.9
Sand (%)	30.1	0.0	15.0
Silt (%)	0.0	4.3	2.2
Primary Pools:			
No.	0	0	0
Density (#/km)	0	0	0
Mean Length (m)	0	0	0
Mean Max. Depth (cm)	0	0	0
Mean Tailout Depth (cm)	0	0	0
Mean Residual Depth (cm)	0	0	0
Pool/Riffle Ratio	0	0	0

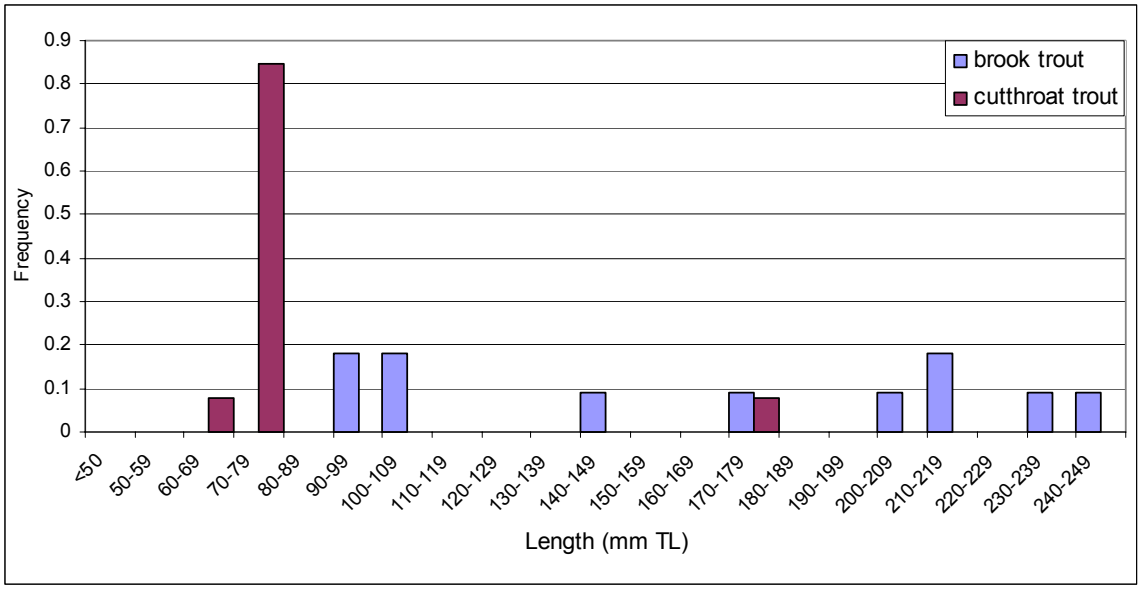

Figure 8. Length frequency distribution of brook trout and cutthroat trout sampled in Maitlen Creek, 2003.

Upper Browns Creek

Four reaches totaling 2.4 Km were assessed in Upper Browns Creek from the inlet to Browns Lake to the point where the stream becomes intermittent. The Kalispel Tribe surveyed Browns Creek from the confluence with Cee Cee Ah Creek to near Browns Lake in 1996. The headwaters of Browns Creek are south-west of the lake originating from underground springs in a large beaver dam complex. There is no connectivity to the lake or Upper Browns Creek. Brook, brown, and cutthroat trout were observed in snorkel surveys conducted by the Tribe in 1996.

The majority of Upper Browns Creek lies on privately owned timber company lands and had been recently harvested prior to our survey. The direct impacts to the stream appeared negligible and adequate buffers were used. The stream is utilized by adfluvial cutthroat trout, and has several artificial log enhancement structures and a viewing platform meant to attract public viewing of spawning fish. The USDA Forest Service placed these structures in the early 1990's. No fish distribution or physical habitat surveys were associated with these enhancements (T. Shuhda pers. Comm.). A summary of channel characteristics and habitat attributes recorded for Upper Browns Creek appear in Table 8.

Mean wetted width of Upper Browns Creek was 2.1 m and depth was 16.6 cm with cobble the dominant substrate (50.7%). A fair amount of spawning sized gravel was present (20.7%) with mean embeddedness of 49.4%, suitable for salmonid spawning. Gradient averaged 4.2%, and ranged from 1.0% to 8.0%. Riffle was the dominant habitat type (63.4%), with pools and runs present in 14.8% and 21.8% of transects, respectively. Acting LWD density was 16.0 pieces/100 m, including 14 artificial log structures in the first reach. Primary pools were abundant (n=60, 25.0 pools/Km) and relatively large. Average primary pool length was 3.0 m, maximum depth 54.4 cm, and residual depth 46.4 cm.

Stream temperature was recorded hourly between 19 June and 14 October 2003 (Figure 9). Mean daily temperature was 9.5 °C (n=2811, SD=2.16). The minimum temperature recorded was 3.8 °C on 10 October. The maximum temperature, recorded on 30 July, was 14.3 °C. Discharge of Upper Browns Creek near the mouth measured .006 m^3/sec on 23 September 2003.

Four electrofishing stations were established in Upper Browns Creek. Cutthroat trout were the only species collected at all four sites. Fish ranged from 50 mm TL to 189 mm TL, with a mean of 101.5 mm TL (n=218, SD=24.6) (Figure 10). Ninety-four YOY fish less than 50 mm were collected, but were excluded from analysis because they have been observed passing through the mesh of blocknets (McLellan and O'Connor 2003). As expected, the highest densities of cutthroat trout were located in the reaches furthest downstream in close proximity to the lake. Estimated densities ranged from 63.3 fish/100 m^2 in reach one to 18.1 fish/100 m^2 in reach three (Figure 11).

Table 8. Channel characteristics and habitat attributes recorded in Upper Browns Creek, 2003.

	Reach				
	1	**2**	**3**	**4**	**Total**
Length (m)	1020	480	360	540	2400
No. Transects	17	8	6	9	40
Mean Width (m)	2.4	2.5	1.9	1.6	2.1
Mean Depth (cm)	17.0	16.8	18.8	14.2	16.6
Gradient (%):					
Mean	3.0	4.1	7.7	4.6	4.2
Min.	1.0	2.0	7.0	2.5	1.0
Max	7.0	6.0	8.0	8.0	8.0
Channel Type	B-3	A-3	A-3	A-4	
Temp (C):					
Air	22.0	23.0	28.0	25.0	
Stream	10.0	10.0	11.0	11.0	
Acting LWD (#/100 m)	12.4	20.2	22.2	15.2	16.0
Habitat Type:					
Pool (%)	7.9	11.7	0.0	49.3	14.8
Mean Width	1.6	2.3	0.0	1.8	1.8
Riffle (%)	68.5	63.8	61.1	50.7	63.4
Mean Width	2.1	2.1	1.7	1.5	1.9
Run (%)	23.6	24.5	38.9	0.0	21.8
Mean Width	3.2	2.4	1.5	0.0	2.3
Substrate Embeddedness (%):					
Mean	43.3	43.9	72.1	55.0	50.6
Min.	5.0	25.0	30.0	40.0	5.0
Max.	90.0	60.0	100.0	75.0	100.0
Substrate Composition:					
Rubble(%)	0.0	38.3	12.4	0.0	10.4
Cobble (%)	51.6	61.7	57.5	25.3	50.2
Gravel (%)	31.5	0.0	0.0	34.9	20.7
Small Gravel (%)	16.9	0.0	8.8	39.7	15.9
Sand (%)	0.0	0.0	21.2	0.0	2.8
Primary Pools:					
No.	26.0	15.0	4.0	15.0	60.0
Density (#/km)	25.5	31.3	11.1	27.8	25.0
Mean Length (m)	3.8	3.0	1.3	2.3	3.0
Mean Max. Depth (cm)	60.7	54.5	40.8	46.9	54.4
Mean Tailout Depth (cm)	9.7	6.7	7.0	6.5	8.0
Mean Residual Depth (cm)	51.1	47.7	33.8	40.4	46.4
Pool/Riffle Ratio	0.1:1	0.1:1	0.0:1	0.8:1	0.2:1

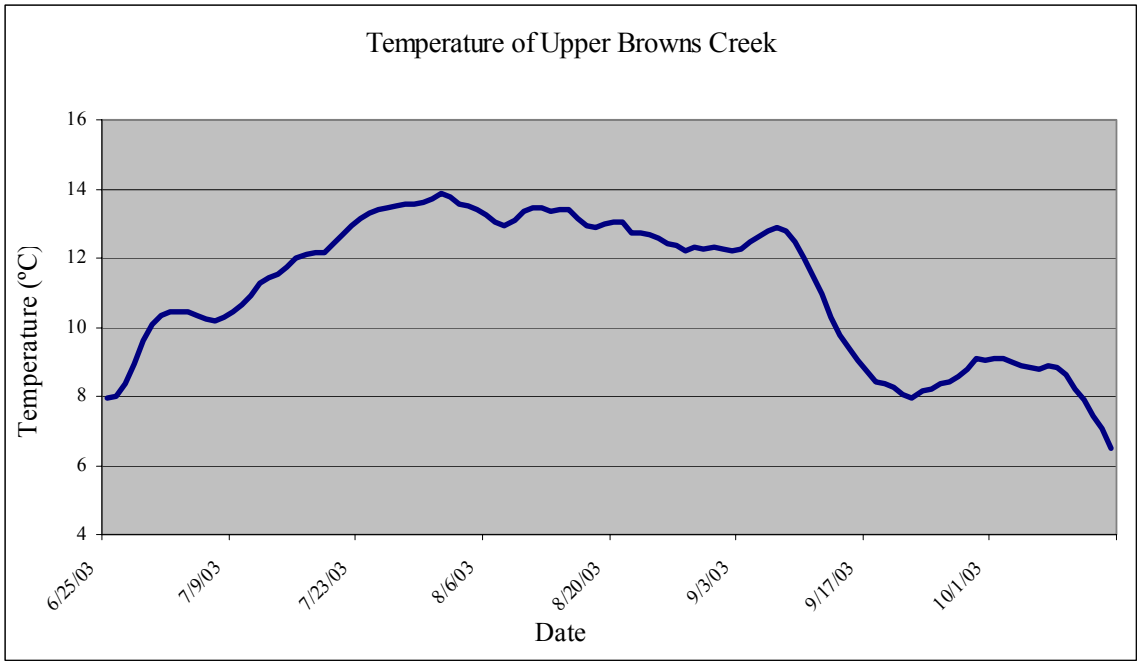

Figure 9. Seven day average daily maximum temperatures recorded in Upper Browns Creek, 2003.

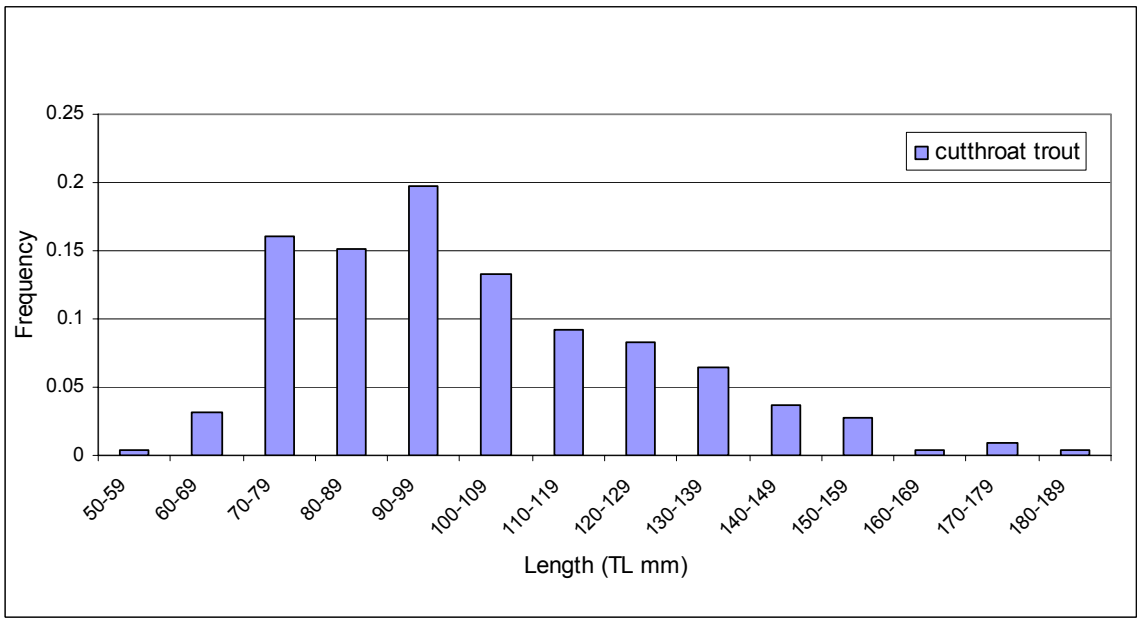

Figure 10. Length-frequency distribution of cutthroat trout sampled in Upper Browns Creek, 2003.

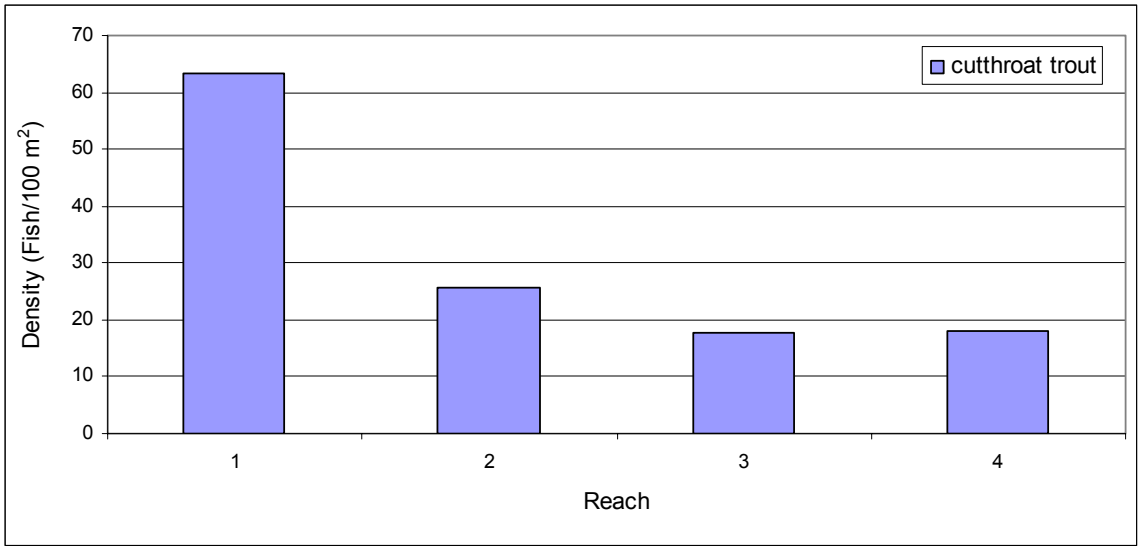

Figure 11. Estimated densities of cutthroat trout sampled in Upper Browns Creek by reach.

Reach 1

Reach one was classified as a Rosgen B-3 type channel that extended from the mouth of Upper Browns Creek to a right-bank unnamed tributary 1020 m upstream. Mean stream width was 2.4 m and depth was 17.0 cm. Gradient ranged from 1.0%-7.0% and averaged 3.0%. Cobble was the dominant substrate in 51.6% of transects and averaged 30.0%. Spawning sized gravel was abundant (31.5%) and had favorable embeddedness (52.5%). Riffle was the dominant habitat type recorded (68.5%), and primary pools were abundant (n=26, 25.5 pools/Km). Although acting LWD density was relatively low (12.4 pieces/100 m), artificial LWD structures contributed to several large pools. Average length, maximum depth, and residual depths were 3.8 m, 60.7 cm, and 51.1 cm, respectively.

Throughout the first reach, bank instability is increasing fine sediment recruitment to the channel. Several pools in the lower portion of the reach are nearly filled with fine sediments, and several artificial structures are functioning as sediment traps. Overall bank stability was 96.7%. Two culverts present in the reach appeared adequate for fish passage. One electrofishing station was established immediately upstream of the first culvert and 112 cutthroat trout were collected. The resulting population estimate of 152 (+/- 46) corresponded to density of 63.3 fish/100 m^2.

Reach 2

Reach 2 included 480 m of Rosgen A-3 type channel from the unnamed tributary to another unnamed split in the stream. Mean wetted width and depth was 2.5 m and 16.8 cm, respectively. Gradient averaged 4.1% and ranged from 2.0%-6.0%. Cobble was the dominant substrate (61.7%) with rubble present in 38.3% of transects. No spawning sized gravel was recorded in reach two. Riffle was the dominant habitat type (63.8%) with pools and runs recorded in 11.7% and 24.5% of transects, respectively. Active LWD was more abundant (20.2 pieces/100 m) and primary pool density was high (31.3 pools/Km). Unstable banks were again contributing fine sediments to the channel, but substrate embeddedness remained low (mean=43.9%). The reach two electrofishing station yielded 49 cutthroat trout, resulting in a density estimate of 25.6 fish/100 m^2.

Reach 3

Reach three included 360 m of the south split in the stream and was classified as a Rosgen A-3 type channel. Stream flow diminished substantially above a logging road crossing. The road culvert was identified as a seasonal water depth and velocity barrier. Mean stream width was 1.9 m and depth was 18.8 cm. Cobble was the dominant substrate (57.5%) and embeddedness averaged 72.1%. Sand and highly embedded small gravel were recorded in 21.2% and 8.8% of transects, respectively. No spawning sized gravel was recorded in the reach. Riffle was the dominant habitat type in 61.1% of transects, with run recorded in 38.9%. No pool habitat was recorded at transects and primary pool density was low (11.1 pools/Km). Mean gradient was 7.7% and ranged from 7.0% to 8.0%. Acting LWD density was the highest of any reach surveyed at 22.2 pieces/100 m. One electrofishing was established downstream of the barrier culvert and 33 cutthroat trout were collected. Density was estimated at 17.9 fish/100 m^2.

Reach 4

Reach four continued on the mainstem from the split to the point where the stream became intermittent. The reach measured 540 m and was classified as a Rosgen A-4 type channel. Mean gradient was 4.6%, ranging from 2.5% to 8.0%. Mean wetted width was 1.6 m and depth was 14.2 cm. Gravel and small gravel were the dominant substrates

(34.9% and 39.7%, respectively) with relatively low embeddedness (55.0% overall). Riffle and pool habitat were equally represented (50.7% and 49.3%, respectively) and primary pools were abundant (n=15, 27.8 pools/Km). Average length of primary pools was 2.3 m, maximum depth was 46.9 cm, and residual depth was 40.4 cm. Acting LWD density was moderate at 15.2 pieces/100 m. Twenty-four cutthroat trout were collected in the reach four electrofishing station. The density was estimated at 18.1 fish/100 m^2.

Lake Fishery Assessments

Baseline fishery assessments were conducted in early summer and late fall in Browns Lake, Ledbetter Lake, and Mill Pond in 2003. There were 328 individuals representing eight species of fish collected (Table 9). Catch-per-unit-effort (CPUE), relative abundance, and condition indices were calculated for each species, gear type, and season, within each lake.

Table 9. Common and scientific names, and numbers of fish collected in summer and fall samples of three Pend Oreille County lakes, 2003.

Common Name	**Scientific Name**	**Number Captured**	
		Summer	**Fall**
Salmonidae			
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	98	94
Rainbow trout	*Oncorhynchus mykiss*	8	47
Rainbow-cutthroat hybrid		9	13
Brook trout	*Salvelinus fontinalis*	6	4
Brown trout	*Salmo trutta*	2	4
Kokanee	*Oncorhynchus nerka*	0	1
Mountain whitefish	*Prosopium williamsoni*	0	6
Cyprinidae			
Redside shiner	*Richardsonius balteatus*	22	0
Catostomidae			
Longnose sucker	*Catostomus catostomus*	3	11

Browns Lake

Four horizontal gillnets were deployed in Browns Lake on 29 June and 21 October 2003. Gillnet sets ranged from 2.0-3.85 hours and totaled 10.33 net hours in June and 11.36 net hours in October. Three species of fish were collected: cutthroat trout, rainbow trout, and brown trout. Twenty-two fish had morphological characteristics consistent with both rainbow and cutthroat trout and were considered potential hybrids. Characteristics included coloration, spotting, and the presence of reddish stripe consistent with rainbow trout, as well as red slash marks of the cutthroat trout on the lower jaw.

Relative abundance, CPUE, mean length (range), and condition indices were calculated for each species and appear in Table 10. Westslope cutthroat trout was the most abundant species in both samples based on relative abundance (85% of the summer sample and 61% of fall sample) and CPUE (9.4 fish/hour in summer, 8.1 fish/hour in fall). Rainbow trout was the second most abundant species in the fall sample (29% relative abundance, 4.5 fish/hour), and rainbow/cutthroat hybrids were second most abundant in the summer sample (8% relative abundance, 0.8 fish/hour). One male brown trout was collected in the fall sample, measuring 705 mm and weighing 3491 g (estimated weight, fish segmented for weighing).

Table 10. Relative abundance, CPUE, mean total length, size range, and condition indices of fish collected in Browns Lake, 2003.

Species		n	R A (%)	CPUE #/hour (+/- sd)	Mean TL mm (+/- sd)	Size Range (mm TL)	Wr Range	Mean K_{TL} (+/- sd)
Cutthroat trout	Summer	97	85	9.4 (3.9)	173 (82)	100-317	59-148	1.02 (.15)
	Fall	92	61	8.1 (1.5)	293 (48)	99-360	66-116	0.95 (.09)
Rainbow trout	Summer	8	7	0.7 (0.8)	313 (49)	256-390	77-96	1.05 (.08)
	Fall	44	29	4.5 (2.5)	320 (63)	111-415	70-113	1.09 (.12)
Rainbow/cutthroat	Summer	9	8	0.8 (1.1)	323 (45)	260-402	N/A	1.10 (.10)
hybrids	Fall	13	9	1.1 (0.6)	335 (76)	221-427	N/A	0.94 (.16)
Brown trout	Summer	0	0	N/A	N/A	N/A	N/A	N/A
	Fall	1	<1	0.1 (0.2)	705	705	95	0.99

Mean total lengths of cutthroat trout sampled in Browns Lake varied between summer and fall (Table 10; Figure 12). More small fish (<150 mmTL) were collected in summer and total length was more variable (mean=173 mm; SD=82 mm; n=97) than fall (mean=293 mm; SD=48 mm; n=92). Size range was similar between samples (100-317 mm in summer; 99-360 mm in fall). A gap in the length-frequency distribution between 130-220 mm and these fish absent from the fall sample altogether may indicate a weak year class, intra/interspecific competetion, or rapid growth rates of hatchery stocked fish. Condition of cutthroat trout varied greatly between seasons (Figure 13). In summer, nearly half the fish had relative weights above the national standard, although small fish (100-130 mm) were highly variable (Wr 59-148). Relative weights of fish between 200-360 mm were higher in summer, with nearly all fish of this size below the national standard in the fall sample.

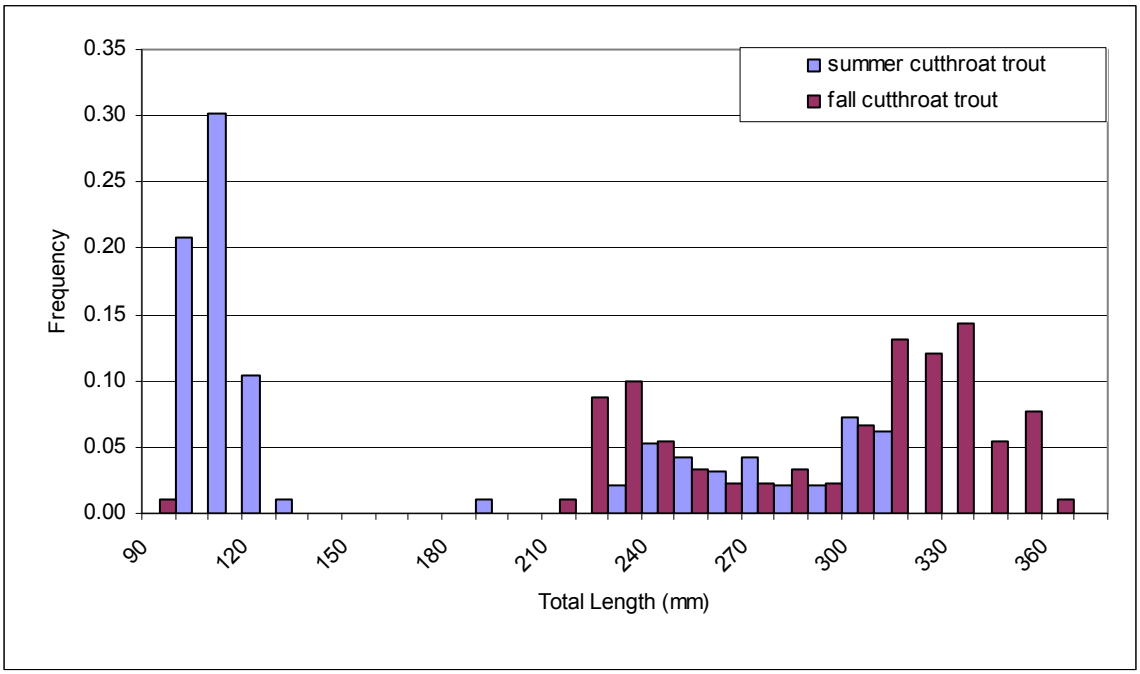

Figure 12. Length-frequency distribution of cutthroat trout sampled in the summer (n=97) and fall (n=92) of 2003 in Browns Lake.

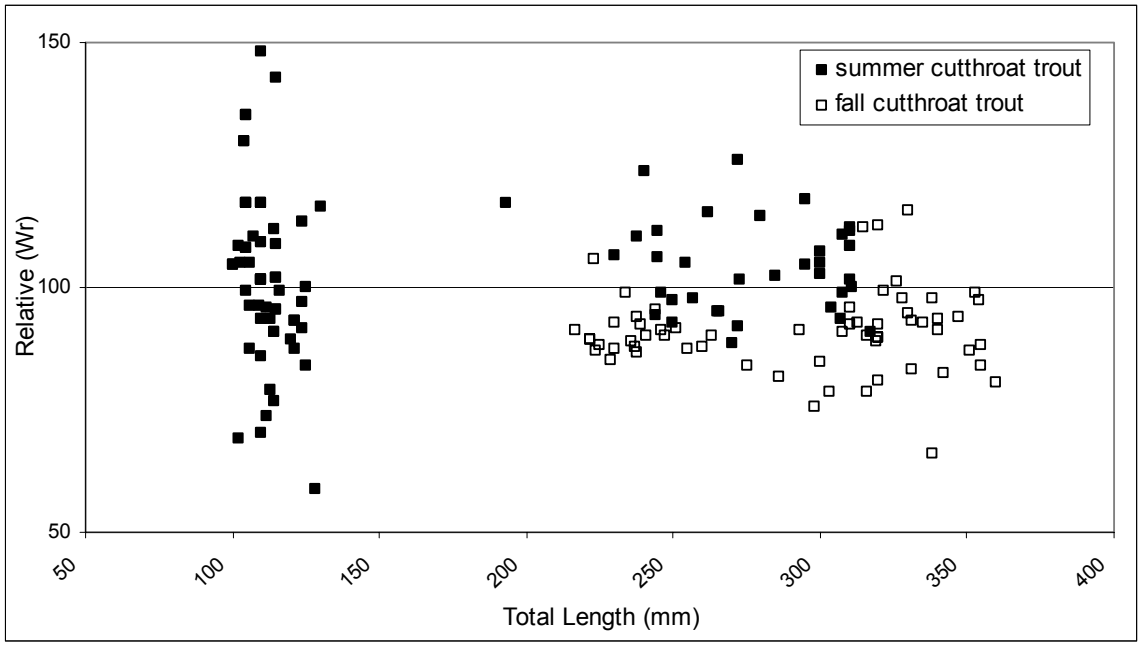

Figure 13. Relative weights of cutthroat trout (n=189) sampled in Browns Lake during summer and fall 2003.

Relative abundance of rainbow trout in Browns Lake varied greatly between the summer and fall samples (n=8, 7% relative abundance; n=44, 29% relative abundance, respectively). Rainbow trout ranged in length from 111-415 mm TL (Table 10; figure 14). Mean total lengths were similar between samples (313 mm in summer vs. 320 mm in fall). The presence of at least three distinct size/age classes in the length-frequency distribution indicates natural reproduction is occurring in Browns Lake. The majority of fish collected in both samples had relative weights below the national standard of 100 (Figure 15), and only five fish had Wr higher than the standard.

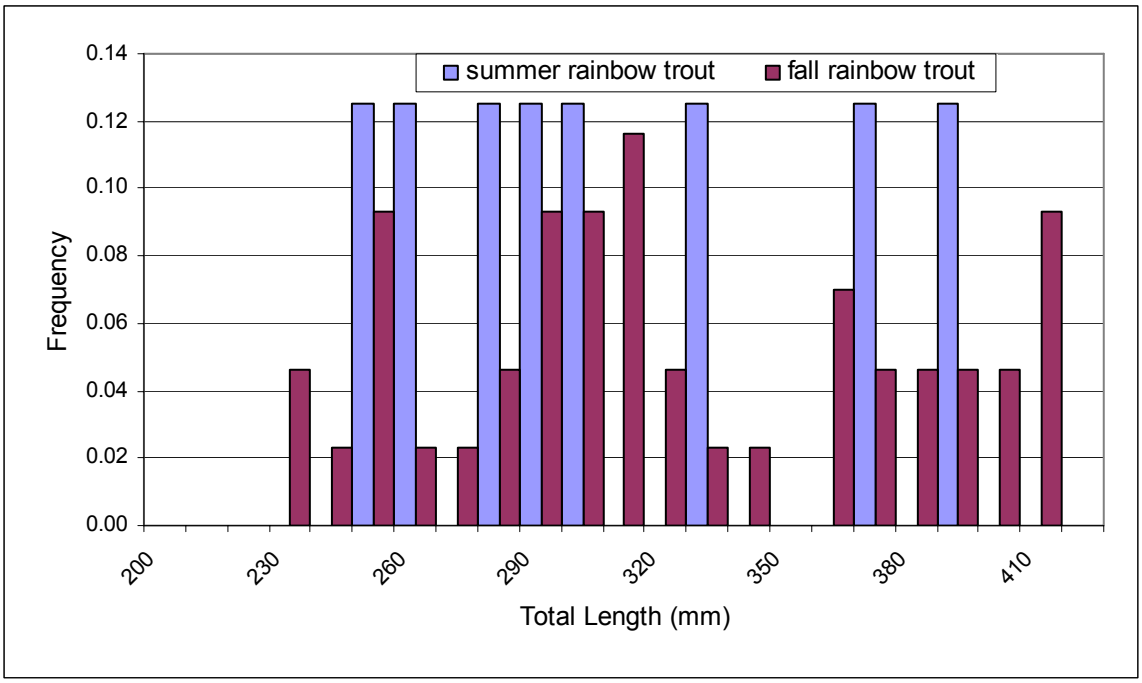

Figure 14. Length-frequency distribution of rainbow trout sampled in the summer (n=8) and fall (n=44) of 2003 in Browns Lake.

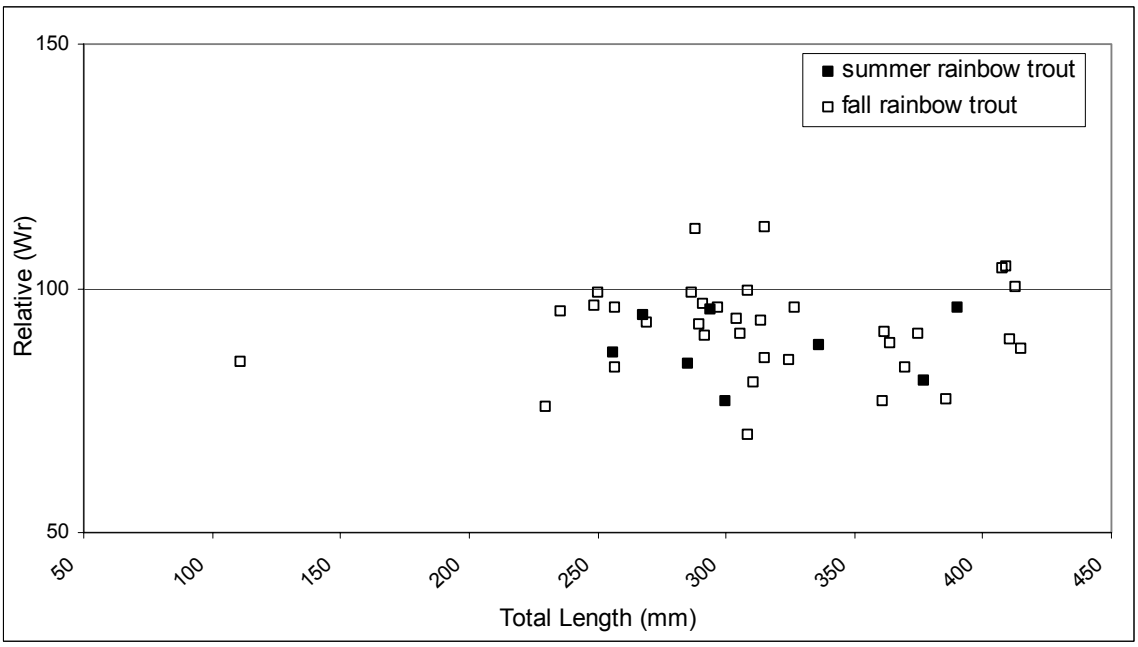

Figure 15. Relative weights of rainbow trout (n=52) sampled in Browns Lake during summer and fall 2003.

Nine potential rainbow/cutthroat hybrids were collected in the summer and 13 in fall, comprising 8% and 9% of the relative abundance, respectively. Mean total lengths and size ranges were similar in each sample (mean=323 mm TL, range 260-402 mm in summer; mean=335 mm TL, range 221-427 mm in fall) (Table 10; Figure 16). Interpretation of the length-frequency distribution is difficult, as sample sizes during both seasons were small.

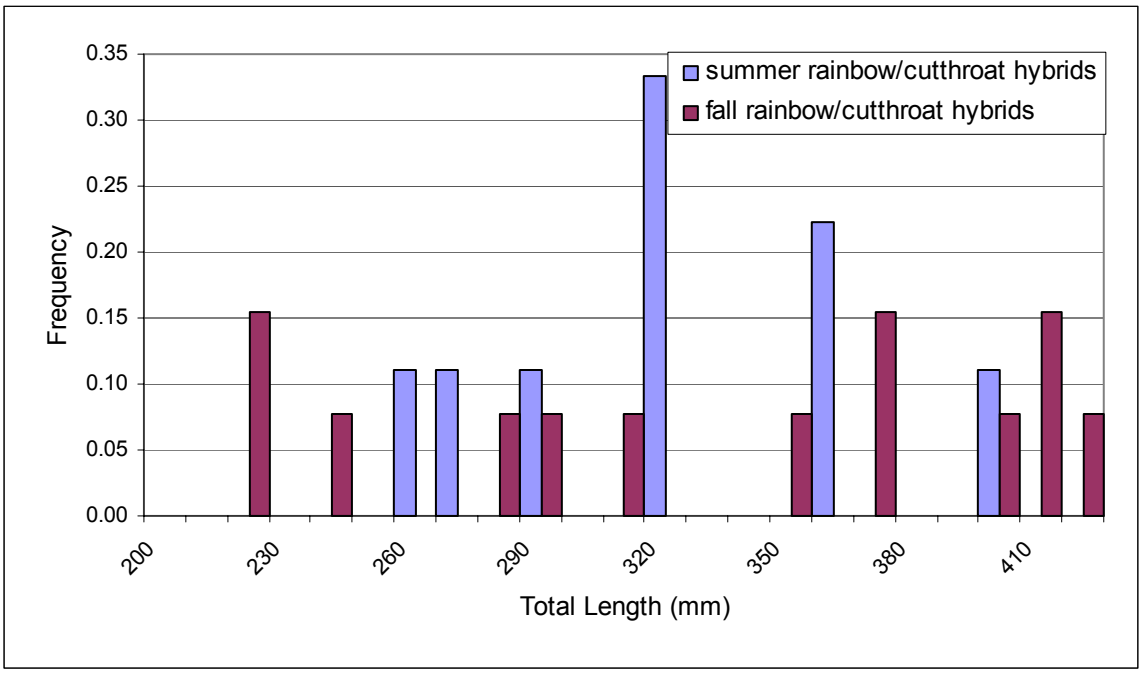

Figure 16. Length-frequency distribution of rainbow/cutthroat trout hybrids sampled in the summer (n=9) and fall (n=13) of 2003 in Browns Lake.

Ledbetter Lake

Two horizontal gillnets were deployed in Ledbetter Lake on 16 July 2003. Due to low catch rates in the first sample, three nets were set on 30 September. Gillnet sets ranged from 2.0-2.18 hrs and totaled 4 net hours in July and 6.18 net hrs in September. One species of fish was collected, brook trout. Relative abundance, CPUE, mean length (range), and condition indices were calculated and appear in Table 11.

A total of 10 brook trout were collected during 2003. Catch-per-unit-effort of brook trout varied from 1.5 fish/hour (n=6) in summer to 0.7 fish/hour (n=4) in fall. Mean total lengths were 228 mm in summer and 273 mm in fall, and ranged from 119-303 mm (figure 17). Condition of brook was similar between samples (Wr 91-112 in summer; Wr 82-111 in fall), although 3 of the 4 fish collected in fall were below the national standard of 100 (figure 18).

Table 11. Relative abundance, CPUE, mean total length, size range, and condition indices of fish collected in Ledbetter Lake, 2003.

Species		n	R A (%)	CPUE #/hour (+/- sd)	Mean TL mm (+/- sd)	Size Range (mm TL)	Wr Range	Mean KTL (+/- sd)
Brook trout	Summer	6	100	1.5 (2.1)	228 (77)	119-303	91-112	1.00 (.08)
	Fall	4	100	0.7 (0.8)	273 (41)	211-295	82-111	0.97 (.14)

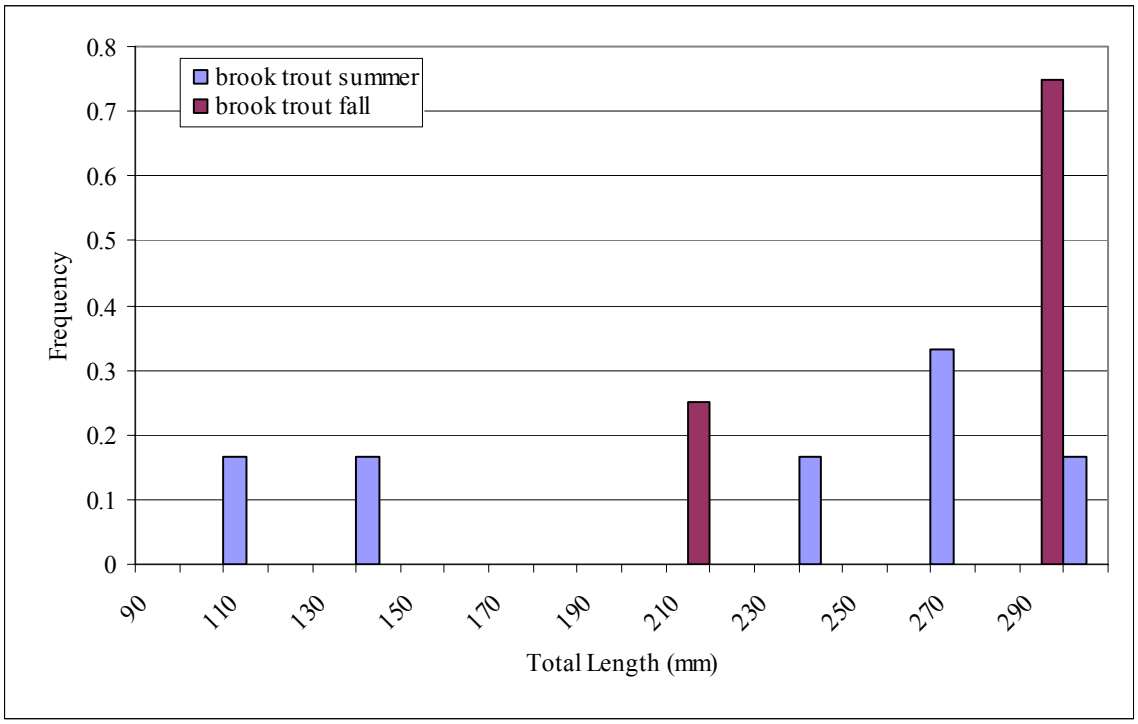

Figure 17. Length-frequency distribution of brook trout sampled in the summer (n=6) and fall (n=4) of 2003 in Ledbetter Lake.

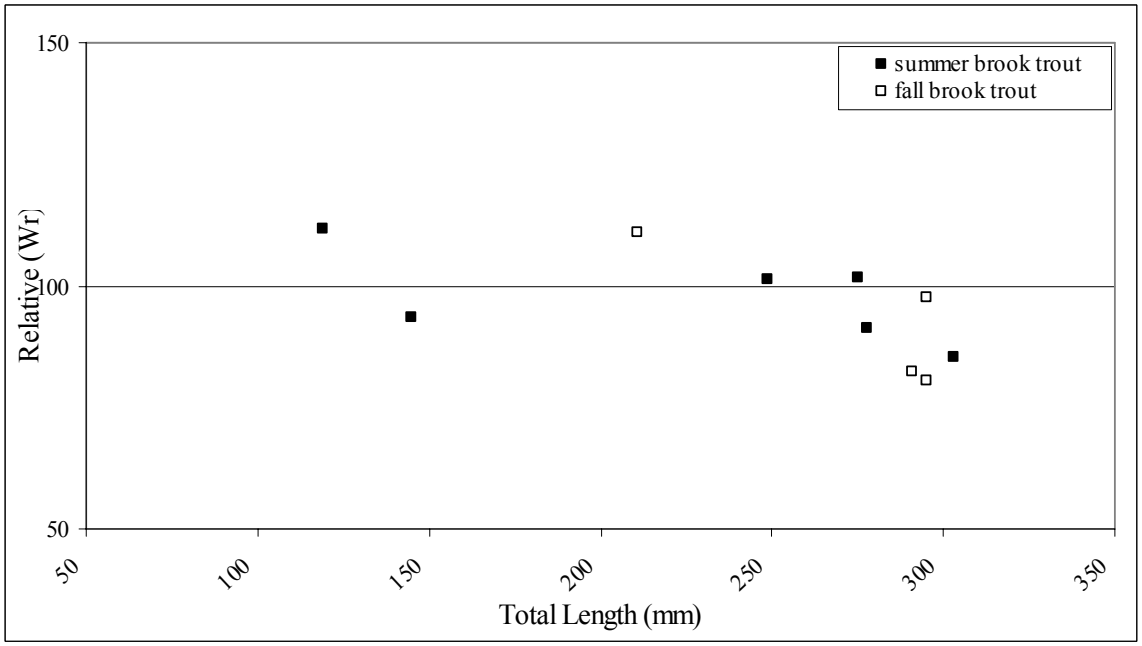

Figure 18. Relative weights of brook trout (n=10) sampled in Ledbetter Lake during summer and fall 2003.

Mill Pond

Four horizontal gillnets were deployed in Mill Pond on 2 June and 5 November 2003. Gillnet sets ranged from 2.0-2.4 hrs and totaled 8.0 net hrs in June and 9.37 net hrs in November. Seven species of fish were collected: brown trout, cutthroat trout, rainbow trout, mountain whitefish, kokanee, redside shiner, and longnose sucker. Relative abundance, CPUE, mean length (range), and condition indices were calculated for each species and appear in Table 12.

Redside shiner was the most abundant species in the summer sample based on relative abundance (79%) and CPUE (2.75 fish/hour) (n=22). No redside shiners were collected in the fall sample. Longnose sucker was the most abundant species in the fall sample (n=11) (42% relative abundance, CPUE 1.2 fish/hour) and second most abundant in the summer (n=3) (11% relative abundance, CPUE 0.4 fish/hour).

Mean total length of redside shiner was 95 mm, and ranged from 87-114 mm. Relative weights ranged widely (Wr range 60-172) and only two fish had relative weights below the national standard of 100 (figure 19).

Total lengths of longnose sucker ranged from 114-460 mm, with a means of 199 mm in summer and 296 mm in fall. Condition of longnose sucker was generally low and did not vary by size class (figure 19). Thirteen of fourteen fish relative weight values were below the national standard of 100 (Wr range 75-89 in summer, 63-139 in fall). One adult male kokanee was collected in the fall sample measuring 255 mm TL and weighing 130 g.

Table 12. Relative abundance, CPUE, mean total length, size range, and condition indices of fish collected in Mill Pond, 2003.

Species		n	R A (%)	CPUE #/hour (+/- sd)	Mean TL mm (+/- sd)	Size Range (mm TL)	Wr Range	Mean KTL (+/- sd)
Brown trout	Summer	2	7	0.25 (2.1)	286 (47)	253-320	81-86	0.91 (.13)
	fall	3	12	0.35 (0.5)	296 (69)	250-376	60-86	0.80 (.14)
Cutthroat trout	Summer	1	4	0.13 (0.3)	260 (N/A)	260	89.0	0.93
	fall	2	8	0.24 (0.3)	251 (40)	222-279	62-71	0.69 (.06)
Rainbow trout	Summer	0	0	N/A	N/A	N/A	N/A	N/A
	fall	3	12	0.35 (0.5)	252 (53)	215-313	57-84	0.81 (.17)
Mountain whitefish	Summer	0	0	N/A	N/A	N/A	N/A	N/A
	fall	6	23	0.71 (0.9)	251 (50)	151-284	53-93	0.77 (.17)
Kokanee	Summer	0	0	N/A	N/A	N/A	N/A	N/A
	fall	1	4	0.11 (0.2)	255 (N/A)	255	N/A	0.78
Redside shiner	Summer	22	79	2.75 (2.1)	95 (6)	87-114	60-172	1.09 (.23)
	fall	0	0	N/A	N/A	N/A	N/A	N/A
Longnose sucker	Summer	3	11	0.4 (0.5)	199 (74)	114-245	75-89	0.96 (.10)
	fall	11	42	1.2 (0.9)	296 (69)	217-460	63-139	1.00 (.11)

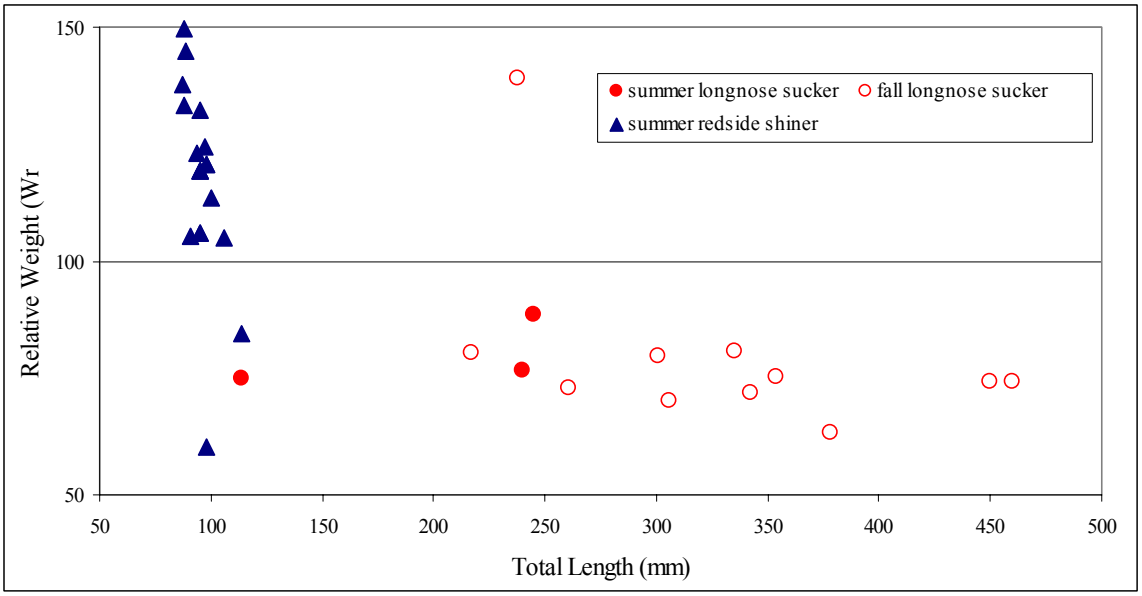

Figure 19. Relative weights of longnose sucker and redside shiner sampled in Mill Pond during summer and fall 2003.

Brown trout were collected in low numbers in both samples and relative abundance ranged from 7% in the summer to 12% in the fall sample. Mean total lengths were similar between samples (286 mm in summer vs. 296 mm in fall) and ranged from 250-376 mm. Relative weight and condition factor were low in both samples, with no fish Wr above the national standard of 100 (Wr range 60-86) (Figure 20).

One cutthroat trout was collected in the summer sample and two were collected in fall. Total lengths ranged from 250-376 mm. Similar to brown trout, all relative weights were below the national standard (Wr range 62-89) (figure 20).

Mountain whitefish and rainbow trout were both collected in fall, but absent in the summer sample. Relative abundances were 23% (n=6) and 12% (n=3), respectively. Mean total length of mountain whitefish was 251 mm, ranging from 151-284 mm and relative weight was low (Wr range 53-93). Mean total length of rainbow trout was 252 mm, ranging from 215-313 mm and relative weight was again low (Wr range 57-84) (Figure 20).

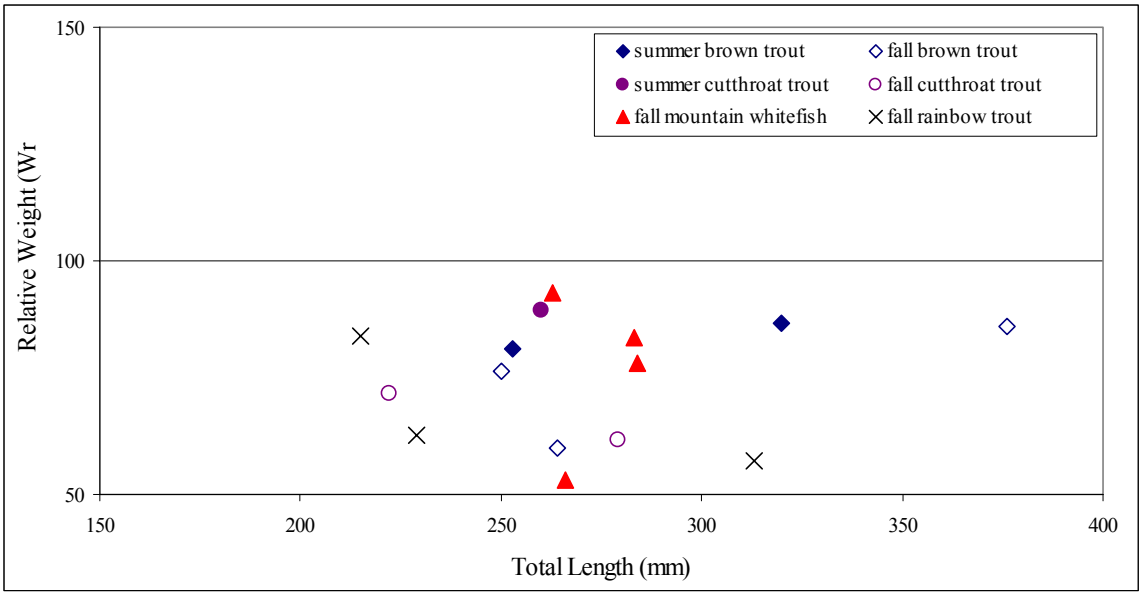

Figure 20. Relative weights of brown trout, cutthroat trout, rainbow trout, and mountain whitefish sampled in Mill Pond during summer and fall 2003.

Discussion

Streams

North Fork Sullivan Creek

North Fork Sullivan Creek is one of the most undisturbed streams the Tribe has surveyed in the Lower Pend Oreille watershed. The typical land use practices observed in watersheds of the Pend Oreille such as logging, road building, and grazing were absent in North Fork Sullivan Creek. The entire watershed lies within the Colville National Forest and the headwaters are protected in the Salmo-Priest Wilderness Area. Above the North Fork Sullivan Creek Dam (500 m upstream from the mouth), disturbance was limited to historic fire and campsite development at the Red Bluff Trail # 553 crossing.

Habitat in North Fork Sullivan Creek ranged from high gradient entrenched canyons to wide valleys with sediment laden, braided channels influenced by past beaver activity. Gravel was the dominant substrate, although spawning habitat may be limited due to high levels of embeddedness (mean embeddedness of gravel 69%). Fine sediment limits salmonid reproduction, invertebrate production, species diversity, water quality, and stream depth (MacDonald et al. 1991, Beschta and Platts 1986, Hynes 1970). Substrate embeddedness greater than 20 percent decreases salmonid alevin emergence from the interstitial spaces by 30 to 40 percent (Hynes 1970). The presence of abundant LWD (mean 35.9 pieces/100 m) and LWD dams are retaining much of the sediments from the upper watershed in North Fork Sullivan Creek. Additionally, the dam located near the mouth is nearly half full of settled sand and sediment.

Large woody debris is integral to the structure and functioning of forest stream ecosystems (Ruediger and Ward 1996, and references within). LWD influences channel form, movement and retention of sediment and organic matter, and biological community composition (Ruediger and Ward 1996). LWD provides cover for fish, influences pool formation, size, and location, and deposition of spawning gravel (Ruediger and Ward 1996, and references within). The stream flows through mature cedar forest with large downed trees dominating the LWD material (many > 120 cm in diameter). LWD recruitment potential is high throughout much of the watershed, and overhead canopy cover is nearly complete. Water temperatures were cool, averaging 9.4°C, with a

maximum summer temperature of 14.0°C. Many quality primary pools (mean 16.5 pools/Km) were available, which provide overwinter habitat and spawning gravel in the pool tailout (KNRD 1997).

Westslope cutthroat trout was the only species of fish collected electrofishing or observed during our habitat survey. Three distinct size/age groups were present in the length-frequency distribution indicating natural reproduction is occurring. Studies by McLellan (2001) and Geyaski et al. (2001) collected westslope cutthroat trout from North Fork Sullivan Creek. In both cases, westslope cutthroat trout were the only species encountered. Genetic analysis by WDFW indicated the population was of a distinct genetic stock (Shaklee and Young 2000), and Gayeski et al. (2001) assigned an A-rating (Binns 1977) to the population for genetic purity owing to the freedom from hybridization and the absence of any record of past stocking (Gayeski et al. 2001).

Both previous genetic collections occurred in the first reach below the dam. Shaklee and Young (2000) found that populations from Upper Sullivan (isolated above the Mill Pond Dam) and North Fork Sullivan creeks were distinct not only from hatchery strains, but also distinct from one another, indicating they exist as reproductively isolated, separate stocks. Through genetic analysis of samples collected in 2003 we intend to determine whether the stock from above the North Fork Sullivan Creek Dam is distinct from below the dam.

Although identified as a potential barrier, the culvert under Sullivan Lake Road is likely definite. Road culverts can be barriers to migration usually because of outfall drops, excessive water velocity in the culvert, insufficient water in the culvert, lack of resting pools below culverts, or a combination of these conditions (Yee and Roelofs 1980). Six species of fish were observed in Sullivan Creek below Mill Pond Dam during snorkel surveys conducted in 2000 (McLellan 2001). Cutthroat, rainbow, and brown trout, mountain whitefish, largescale sucker, and sculpin spp. were observed, although all were at low densities (<3 fish/100 m^2) (McLellan 2001). It is assumed that these species would also be found in North Fork Sullivan Creek if passage at the culvert were possible.

Several streams in the Pend Oreille Watershed contain isolated resident populations of Westslope cutthroat trout above natural or man-made passage barriers (KNRD Resident Fish Project). Maintaining barriers may play a critical role in

preserving isolated populations of westslope cutthroat trout in the Pend Oreille watershed by limiting competition with non-native species and hybridization with rainbow trout and other cutthroat sub-species.

Noisy Creek

Noisy Creek is the second largest tributary to Sullivan Lake entering from the Southeast corner of the lake approximately 600 m northeast of the mouth of Harvey Creek (full pool). The uppermost extent of fish bearing water in Noisy Creek is 600 m from the mouth. A series of impassable falls, cascades, and chutes present in the second reach prevent passage. No fish were observed above the passage barriers during snorkel or habitat surveys. Additionally, the channel is seasonally dewatered from the mouth through the lower portion of the Noisy Creek Campground. The stream flows subsurface under large substrates, limiting available habitat to 340 m between the campground and the first passage barrier.

Although density estimates of cutthroat trout were similar between two samples taken in the reach (7.2 – 8.4 fish/100 m^2 in summer and fall samples, respectively), 51 YOY fish < 50 mm were collected in the fall sample. Overwinter survival of YOY fish in Noisy Creek may be impacted both directly and indirectly by low flow, lack of quality primary pools, lack of stream structure (i.e. LWD), and overcrowding. It is unknown whether cutthroat trout ever inhabited upper Noisy Creek. No known studies of the upper watershed have been conducted. Several other streams in the Pend Oreille watershed, though, contain isolated resident populations above natural or man-made passage barriers (KNRD Resident Fish Project).

Impacts from human development were limited to the lower watershed. A Road associated with mining and logging activity has caused bank instability and failure through steep sections in reach two. Mass wasting of the roadbed has had little permanent effect on instream habitat though. Hydraulic energy related to spring flows and high channel gradient have transported fine sediments downstream depositing them in Sullivan Lake. Alluvial deposition in the southern end of the lake by Noisy and Harvey Creeks creates the only littoral habitat to speak of in the lake.

Rocky Fork Creek

Rocky Fork Creek was the steepest stream surveyed in 2003. Mean stream gradient in the first reach was 19.5% and ranged from 11.5-44.0%. Numerous natural passage barriers were present in the reach including a potential barrier fall at the mouth. Electrofishing in the first reach was unsuccessful, and no fish were observed in snorkel surveys in the upper reach. The Tribe also unsuccessfully electrofished the lower reach in 2002, attempting to collect westslope cutthroat trout for genetic analysis. We assume no fish are present in the stream, and it is unknown whether fish have ever inhabited Rocky Fork Creek. No other studies are known to have been conducted in the stream. Westslope cutthroat trout were present exclusively throughout the Upper Harvey Creek watershed during snorkel surveys conducted in 2003 (Olson and Andersen 2004). Isolated resident populations have been documented above natural or man-made passage barriers in the Pend Oreille drainage (KNRD Resident Fish Project) and habitat in the upper portion of Rocky Fork Creek appears suitable for salmonids.

Nevertheless, non fish-bearing streams can play an important role in downstream fish-bearing habitat. They help control stream temperature (Murphy and Meehan 1991, Meehan 1991), serve as temporary storage sites for sediment and particulate organic matter (Bisson et al. 1992), and contribute to LWD recruitment in downstream reaches (Chamberlin et al. 1991).

Mean daily temperature of Rocky Fork Creek was 10.5 ºC, which is similar to other Harvey Creek tributary temperatures recorded during the same period (Olson and Andersen 2004). These small tributary streams help cool the mainstem of Harvey Creek in lower reaches. Maximum temperatures recorded during summer in upper, middle, and lower Harvey Creek were 17 ºC, 15.8 ºC, and 15.0 ºC, respectively.

Maitlen Creek

Maitlen Creek was the most heavily impacted stream surveyed in 2003. The stream lies almost entirely on private land, with evidence of logging, roads, residential development, agriculture, and livestock grazing. These land use activities have likely contributed to higher mean substrate embeddedness (>73%), lack of LWD (<3.3 pieces/100 m), and lack of primary pool habitat (0.0 pools/Km). Mean wetted width and

depths were the smallest of any stream surveyed, measuring 0.8 m and 8.7-10.1 cm, respectively.

Despite the poor habitat conditions in our sampling stations and numerous landowners indicating the stream was void of fish; thirteen cutthroat trout (presumably westslope) and eleven brook trout were collected in reach three. Although local landowners indicated they had never seen fish in Maitlen Creek, and the majority of the upper watershed is intermittent and only flows in the spring, relatively large brook trout were present in the stream. The largest fish, a ripe male, measured 240 mm TL, and five out eleven fish collected were over 200 mm TL. We observed fish easily from the Sherman Road culvert crossing. These fish may potentially reside in a spring-fed wetland in reach two and return upstream to spawn in fall. Resident cutthroat trout present in the stream were comparatively small. The largest fish measured 171 mm TL, with all others measuring between 60-80 mm TL.

Interactions between brook and cutthroat trout have been well documented in the literature. Novinger and Rahel (1999) examined the competitive effects of brook trout on cutthroat trout in Colorado. Their findings indicated that age 0 brook trout had negative effects on growth and survival of age 0 cutthroat trout when held sympatrically in enclosures. Cummings (1987) studied the effects of competition between greenback cutthroat trout and brook trout Colorado. In sympatry with brook trout, cutthroat trout juveniles occupied higher focal point velocities (water velocity at the fish's snout). After brook trout were removed, juvenile cutthroat trout (50-150 mm) shifted to occupy significantly lower focal point velocities and distances to nearest cover, indicating brook trout excluded cutthroat trout from using more profitable stream positions, and had a competitive advantage.

Upper Browns Creek

Upper Browns Creek is the only perennial inlet tributary to Browns Lake. The majority of the watershed lies on private timber company lands that have been recently logged, and the first reach lies on USDA Forest Service Lands. Although the watershed is relatively small (2.4 Km of available stream habitat), Upper Browns Creek may play an important role in spawning, rearing, and overwintering of adfluvial cutthroat trout from

Browns Lake. Stream habitat conditions including temperature (mean=9.5 ºC, range 3.8-14.3 ºC), spawning gravel (20.7% of substrate, 49.4% mean embeddedness), habitat diversity, and primary pool abundance (25 pools/Km) are suitable for salmonid spawning and rearing.

Efforts by the USDA Forest Service to improve stream habitat by placement of LWD structures throughout the first reach were completed in the early 1990's, along with a fish viewing platform and interpretive board to increase public awareness. Public viewing opportunities are somewhat limited, though, because the road to the viewing area is usually snow covered during the peak of the spawning season (March-April).

Artificial wedge dams create sediment traps and calm water above, scour pools below, and increase spawning gravel at the pool tailout (KNRD 1997). These structures are retaining sediments resulting from bank instability and sloughing, and providing relatively large primary pools (mean residual depth 51.1 cm) and clean spawning gravel (52.5% mean embeddedness). Outfall drops as high as 1.2 m were recorded, possibly limiting upstream migration of smaller fish. Height of outfall drops that constitute passage barriers have been debated, although resident adult trout can generally negotiate a vertical jump of 1 foot (0.3 meters) (Yee and Roelofs 1980).

Cutthroat trout was the only species of fish identified in four electrofishing stations. Densities were relatively high, particularly in the first reach (63.3 fish/100 m^2). Surprisingly, no rainbow trout were collected in the stream during our sampling period, although multiple age classes were present in Browns Lake. Rainbow trout require cool flowing water for spawning and typically spawn between February and June (Wydoski and Whitney 2003). We collected 94 YOY fish identified as cutthroat trout during our late summer sample, and would also expect rainbow trout to be represented in our sample if spawning had occurred. Possible explanations for the absence of rainbow trout include; variations in spawning run timing, earlier out-migration of YOY fish, lack of rainbow trout spawning in the stream, or misidentification of YOY fish.

Due to the fact that rainbow trout have only been stocked in Browns lake on one occasion (1996, 5115 fry planted) (WDFW unpublished hatchery records, Appendix 2), and multiple age groups were present in the lake in 2003, natural reproduction in Upper Browns Creek is presumed. Both species were visible passing the viewing station in

March 2004. The timing of adfluvial rainbow trout migration is unknown and should be studied further to determine the extent that competition and hybridization may limit cutthroat trout production in Browns Lake and Upper Browns Creek. Genetic analysis of cutthroat trout in Upper Browns Creek will help determine whether a native resident or adfluvial population is present, or whether the fishery is dominated by the hatchery strain (Kings Lake) planted annually in Browns Lake. Additionally, genetic analysis will determine the level of hybridization between rainbow and cutthroat trout present in Browns Creek and likely Browns Lake as well.

Genetically pure westslope cutthroat trout are estimated to exist in only 2-4% of their historic stream distribution (McIntyre and Reiman 1995). Habitat loss and degradation, competition with non-native species, hybridization with rainbow trout and other cutthroat sub-species, and overfishing have contributed to the decline. This supports the argument that protection of high quality habitat and protection from non-native fish introductions are essential for the continued existence of westslope cutthroat populations (Liknes and Graham 1988). Management actions to suppress a breeding rainbow trout population in Browns Lake may be warranted to protect native cutthroat trout in Upper Browns Creek.

Lakes

Fishery assessments were conducted in conjunction with baseline water quality, and primary and secondary productivity (phytoplankton, zooplankton, and zoobenthos) characterization of Browns Lake, Ledbetter Lake, and Mill Pond in 2003. Results and discussion of water quality and productivity sampling appear in Appendix 1. Horizontal floating and sinking gillnets were used to sample fish in each lake in early summer and late fall. Westslope cutthroat trout was the most abundant species of fish collected during both seasons. The Washington Department of Fish and Wildlife has planted numerous rainbow, cutthroat, and brook trout in these lakes dating back to the 1930's (WDFW unpublished hatchery records, Appendix 2).

Browns Lake

Three species of fish were collected in Browns Lake: Westslope cutthroat trout, rainbow trout, and brown trout. Between 1934 and 2003, 1.7 million cutthroat trout were planted in Browns Lake (WDFW unpublished hatchery records, Appendix 2). Westslope cutthroat trout from the Kings Lake stock have been planted since 1983. Fall fry plants of approximately 10,000 fish have occurred in recent years and may have influenced the length frequency distributions we observed. Rapid growth rates of stocked fry during the following summer may explain the gap in the distribution from 130-220 mm. Growth and potential maximum size varies from stock to stock and is dependant on area, altitude, and habitat (Scott and Crossman 1998). Scott and Crossman (1998) referenced coastal cutthroat annual growth rates of 107 mm between ages 1+ and 2+, and Yellowstone cutthroat growth rates of 96 mm between ages 2+ and 3+. In the Pend Oreille River and five tributaries, average annual westslope cutthroat growth between ages 2+ and 3+ ranged from 66 mm to 77 mm (Wydoski and whitney 2003).

Given the habitat conditions and prey abundance in Browns Lake, the growth rates we observed (90 mm during the growing season) likely lead to the quality fishery in Browns Lake. The lake was classified as mesotrophic and stratified in June. Although summer temperatures were greater than 23 ºC at all depths, an abundance of dissolved oxygen was present throughout the year and not likely to be a regulatory factor. An abundance of large-bodied zooplankton (*Daphnia rose*a and *Epischura*) indicated that vertebrate planktivory is not a regulatory factor (Black et al. 2005, Appendix 1).

The only other documented fish stocking in Browns Lake was 5115 rainbow trout planted in 1995 (WDFW unpublished hatchery records, Appendix 2). This planting was the result of a shortage of cutthroat trout for planting in Northeastern Washington (Joe Maroney, personal communication, 2003). The presence of multiple size classes of rainbow trout indicate they have become established in Browns Lake, and presumably utilize Upper Browns Creek for spawning. Both species have been observed passing the viewing station. The variation in the relative abundance of rainbow trout between summer and fall (7% versus 29% relative abundance, respectively) is likely due to spawning run timing, and rainbow trout being in Upper Browns Creek at the time of the summer sample. The presence of fish that appeared to be rainbow/cutthroat hybrids

raises some concerns about the preservation of native stocks of westslope cutthroat trout in the Pend Oreille Watershed and is currently being investigated through the project "Genetic Inventory of Bull Trout and Westslope Cutthroat Trout in the Pend Oreille Subbasin" (BPA Project # 200204300; see discussion above for Upper Browns Creek). The single brown trout collected was likely the result of an illegal introduction, as brown trout are not native and do not appear in the stocking record.

Ledbetter Lake

Brook trout was the only species collected in Ledbetter Lake, which were stocked exclusively between 1947 and 1982 (544,000 total fish), at which time stocking ended. Stocking resumed in 1994 with 6375 rainbow trout and 2046 brook trout. Annual plants of around 10,000 brook trout have been made since 1995 (WDFW unpublished hatchery records, Appendix 2). Based on this stocking record, one would expect higher catch rates than what we observed (0.7-1.5 fish/hour, n=6 and n=4 in summer and fall, respectively). Fishing pressure is unknown, although little sign of fishing activity was observed (i.e. vehicles, litter, etc.) and fishing access to the small remote lake is limited by rough roads, lack of bank fishing areas, and no launch facility. The lake is completely lined with dense hardstem bulrush (*Scirpus acutus*) and other emergent vegetation, and small boat access is limited to a muddy swath through the emergents.

Black et al. (2005, appendix 1) recorded temperatures of 24 ºC on bottom (5 m) and 26 ºC at the surface in July, which is near the lethal limit for brook trout (Wydoski and Whitney 2003). The lakes shallow depth, however, permits frequent water column mixing, maintaining relatively high dissolved oxygen concentrations. Ledbetter Lake had the highest chlorophyll concentrations of the lakes surveyed, and the entire lake basin was covered with the green alga *Chara*. Similar to Browns Lake, the zooplankton community was dominated by *Daphnia rosea* throughout summer, and the benthic community dominated by chironomid larvae. Given these habitat and productivity conditions, and the catch rates we observed, it appears high water temperatures may be limiting brook trout production in Ledbetter Lake.

Mill Pond

Seven species of fish were collected in Mill Pond including brown, cutthroat, and rainbow trout, mountain whitefish, kokanee, redside shiner, and longnose sucker, closely resembling the fish assemblage in Sullivan Lake. Rainbow trout is the only species that has been planted since 1939; with annual plants of about 10,000 fish occurring since 1974 (WDFW unpublished hatchery records, Appendix 2). Interestingly, rainbow trout were absent from the summer sample and only accounted for 12% of the relative abundance (n=3) in the fall sample. It is unknown whether limiting factors such as habitat conditions or inter/intraspecific competition, entrainment over Mill Pond Dam, or an inability to capture fish with our gear lead to the low capture rates we observed.

Water temperatures were the lowest of the three lakes we surveyed in 2003, ranging from 10-20 ºC. Thermal stratification was only recorded in July with an epilimnetic temperature of 16 ºC, thermocline between 5 and 8 meters, and hypolimnetic temperature of 13 ºC. Short water residence time in the reservoir likely limits stratification, and outflow from Sullivan Lake filling Mill Pond maintains lower temperatures than the other lakes in the survey. Zooplankton abundance and biomass were very low and only two species *Bosmina* and *Diacyclops* exceeded 5 *u*g/l (Black et al. 2005, Appendix 1). Lack of zooplankton abundance is likely due to short water retention times, and probably limits fishery production. This was reflected in the low relative weights and condition factors we observed. Relative weights of gamefish in Mill Pond were the lowest of the three lakes surveyed in 2003, and lower than many other lakes the tribe has surveyed (Connor et al. 2003b, KNRD unpublished data).

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Appendix 1

Biological Investigation of Three Lakes in the Pend Oreille River Drainage

Biological Investigation of Three Lakes in the Pend Oreille River Drainage.

prepared for
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Project Description

The proposed study includes early, mid, and late summer assessment of the condition and aquatic organism constituents of three lakes in the Pend Oreille River Drainage. Assessment includes collection of replicate samples necessary for water quality, phytoplankton, zooplankton, zoobenthos, and macrophyte characterization of each water body. The study lakes lie within Pend Oreille Co, Washington.

Methods

Study Lakes: The three water bodies of concern include Browns, Ledbetter, and Millpond Lakes. All three lakes lie within the Pend Oreille River Drainage, Pend Oreille County, Washington (see Washington Atlas and Gazetteer, 1998, DeLorme Mapping Co.). Browns Lake is a natural 88 acre water body located in sections 13-14 and 23-24 of Township T34N R44E and is approximately four miles east and nine miles north of Usk, Washington. Mill Pond Lake (Sullivan Mill Pond, Wolcott 1973) is a 62 acre reservoir located in section 30 of township T39N R43E and section 25 of township T39N R44E and is three miles east of Metaline Falls, Washington and 1 mile north of Sullivan Lake. Ledbetter Lake is a small natural water body with a surface area of approximately 30 acres. It lies within section 3 of township T39N R43E and section 34 of township T40N R43E and is approximately four miles north of Metaline Falls, Washington.

Water quality: All water samples were collected from the surface at the site of maximum depth within each lake. Temperature and dissolved oxygen were collected surface to bottom in 1 m increments using a YSI Model 85 environmental meter. Water samples for chlorophyll analysis were collected with an ARI student water bottle sampler at 1 increments and stored in 125 ml amber bottles, and on ice, until analysis (within 24 hours) with a Turner Designs Model 10-AU field fluorometer. Triplicate 125 ml water samples for nitrate and phosphate determination were collected from a mid water column depth at this same deep water location. Water samples for nutrient assay were stored in

acid and phosphate-free detergent washed bottles and assayed using Hach colorimetry. Samples were collected in mid June, late July, and mid September.

Phytoplankton Biovolume : On each of the three sample dates, a 250 ml sample of lake water for phytoplankton identification and biovolume calculation was collected at a mid water column depth, from the deep water location and an additional 2 sample locations on each lake. All samples were collected with an ARI student water bottle sampler, preserved with Lugol's fixative, and stored in amber bottles until analysis. Samples were collected mid-June, the end of July, and mid-September. Samples were analyzed to determine species composition and biovolume by taxonomic division as per the methods presented in Wetzel and Likens (1991).

Zooplankton: Zooplankton samples were collected as individual vertical tows with a 20cm dia., 153 um mesh conical zooplankton net. Each individual sample consisted of the contents of a single lake-bottom to surface vertical tow and three replicate samples were collected within each lake and from separate locations. All samples were preserved and stored as per Black and Dodson (2003). Samples were collected mid-June, the end of July, and mid-September. Species were enumerated and identified using the keys of Brooks (1959: branchiopoda), Wilson (1959: calanoida), Yeatman (1959: cyclopoida). Species specific biomass was estimated using the length:weight regressions of Bottrell et al (1976).

Zoobenthos: Benthic invertebrate samples were collected using an Eckman Dredge sampler. Replicate samples will were collected along three distinct transects, extending from shallow to deep water Along each transect, one single grab sample was collected at each of four depths, divided equally from 0.5 meters of depth, to the lake's maximum depth. Retrieved dredge samples were rinsed of small fines and detritus in a 500 um sieve, then stored in 70% EtOH for later analysis. Zoobenthos sample collection occurred during late August. Animals collected in benthic samples were identified to sub-Order or family (as was deemed reasonable within time and budget constraints) with

the use of keys provided in Merritt and Cummins (1996) and in Thorp and Covich (1991). Densities of individual taxa (inds. m^{-2}) were calculated following enumeration.

Macrophytes: Rooted and submerged aquatic vegetation were collected from each lake during August. Sampling occurred within each lake along two (Ledbetter and Mill Pond) or three (Browns) separate transects within each lake. Divers used a 1 m^2 quadrat to assess the proportional species composition at one meter depth intervals along each transect. Vascular plant samples were identified using the keys of Muenscher (1959) and WDOE (2001) to determine species-specific proportional abundance or coverage.

Results and Discussion:

Water Quality: Water temperature profiles of each of the lakes are presented in figure 1. Water temperatures within Brown's Lake ranged from 12 to 25 ^{o}C. In Ledbetter Lake, water temperatures ranged from 16 to 26 ^{o}C. Water temperatures within Sullivan Mill Pond were the lowest observed in the study and ranged from 10 to 20 ^{o}C. Thermal stratification was only evident on one date in both Brown's Lake and Sullivan Mill Pond. On 13 June in Browns Lake, surface waters (upper two meters) were 17 ^{o}C, the thermocline occurred in water from 2 to 4 meter in depth, and the hypolimnion ranged from 13 to 10 ^{o}C in waters below four meters. In Sullivan Mill Pond, on 30 July, epilimnetic temperatures were in excess of 16 ^{o}C, a distinct thermocline existed between 5 and 8 meters of depth, and the hypolimnetic waters (below 8 meters) were 13 ^{o}C. Little stratification was evident in Ledbetter Lake. There was just less than 3 ^{o}C difference between surface and deep water temperatures on 13 June and 30 July.

The lack of, or infrequent, stratification observed in Ledbetter and Brown's Lake is due to their shallow depth which permits frequent water column mixing. In Sullivan Mill Pond, although the lake basin is approximately 10 meters deep and thus deep enough for stratification to occur, the low water residence time of this small reservoir prevents stratification. Additionally, because Sullivan Mill Pond is filled with the outflow from deep and cold Sullivan Lake, its water temperatures never rise to the summer-time high

temperatures one would expect in a natural lake of similar bathymetry (e.g. compare the 30 July profiles in figure 1).

Dissolved oxygen (DO) profiles are presented in figure 2. Dissolved oxygen levels within the lakes were observed to be close to saturation (in excess of 8 mg l^{-1} at all depths) on 13 June and remained high (in excess of 5 mg l^{-1}) at all depths on each of the later sample dates. Among depth variation (or DO stratification) occurred on those dates with thermal stratification. For example, in Brown's Lake on 13 June, temperature ranged from 17 to 12 ^{o}C and DO ranged from 8 to 12 mg l^{-1} mg l^{-1}, from the surface to the deepest water just above the 7 m deep lake bottom (figure 1). In Ledbetter Lake, DO stratification was evident on 13 June and 30 July, but the variation did not exceed 2.5 mg l^{-1} mg l^{-1} and DO concentrations at all depths were observed to be above 8 mg l^{-1}. On only one occasion did DO stratification suggest hypolimnetic oxygen depletion, a condition which is typically associated with productive lakes. On 30 July, Sullivan Mill Pond epilimnetic DO concentrations were a consistent 9 mg l^{-1} while hypolimnetic DO concentrations were just above 5 mg l^{-1}. An anoxic hypolimnion is not likely to develop however as long as the water column is frequently mixed. In this study, by our 18 September sample date, DO was a uniform 8.8 mg l^{-1} surface to lake bottom (figure 2). Abundant oxygen exists in all of the study lakes and is not a likely regulatory factor affecting productivity or species composition.

Nitrate-nitrogen (N) and phosphate-phosphorus (P) concentrations are presented in figure 3. The N:P ratios are presented in figure 4. Phosphorus levels in all three lakes were approximately 0.05 mg l^{-1} and showed little variation among sample dates. Nitrogen concentration decreased through time in Ledbetter Lake and Sullivan Mill Pond.

In Brown's Lake, nitrogen concentration decreased from 0.7 on 13 June to 0.4 mg l^{-1} on 30 July, then increased to 0.55 mg l^{-1} on 18 September. Nutrient ratios in Sullivan Mill Pond were observed to range from 35:1 on 13 June to an observed low of 15:1. In Brown's Lake, the N:P ratio ranged from 22:1 on 13 June to 13:1 on 30 July. And in Ledbetter Lake, the N:P ratio ranged from 28:1 on 13 June to 9:1 on 30 July. The N:P ratio in all of the lakes increased slightly from 30 July to 18 September. Lakes with N:P ratios in excess of 30:1 are categorized as oligotrophic or low productivity lakes. Lakes with N:P ratios less than 8:1 are considered eutrophic or high productivity lakes. All of

the observed N:P ratios, ranging between 9:1 and 33:1 suggest the lakes included in this study are mesotrophic, or having intermediate productivity. Not surprising, the highest N:P ratios were observed in Sullivan Mill Pond which is fed by oligotrophic Sullivan Lake.

Phytoplankton: Chlorophyll is commonly used as a measure of phytoplankton biomass. Chlorophyll profiles are presented in figure 5. Chlorophyll was consistently low (approximately 1 ug l^{-1}) and exhibited little variation with depth in Sullivan Mill Pond. Only on 30 July did chlorophyll concentration vary with depth when the deepest three meters of water had chlorophyll concentrations approaching 2 ug l^{-1}. The low chlorophyll concentrations in Sullivan Mill Pond are likely an artifact of the low water residence time of this small reservoir. Observed chlorophyll concentrations were generally highest in Ledbetter Lake and ranged from 3.5 to 6 ug l^{-1}. In Brown's Lake, chlorophyll concentrations ranged from 1.5 to 3.6 ug l^{-1} on 13 June, and 1.3 to 2.8 ug l^{-1} on 30 July. Additionally, a late summer algal bloom increased chlorophyll concentration to approximately 6 ug l^{-1}. In all of the lakes, when chlorophyll concentration was not equal among water depths, the highest concentrations tended to occur in the lower half of the water column which is typical of oligotrophic and mesotrophic lakes.

Algal biovolume, presented by algal division, in Brown's and Ledbetter Lakes, and Sullivan Millpond, are presented in Figures 6, 7, and 8, respectively. Phytoplankton constituents within Brown's Lake (figure 6) include a mixture of green algae (chlorophyta), diatoms (chrysophyta) and small flagellated golden brown algae (cryptophyta). The algal bloom which resulted in the relatively high chlorophyll concentrations observed on 18 September was composed primarily of green algae. The highest observed biovolume values were seen in Ledbetter Lake (figure 7) and composed primarily of green algae. The lowest observed biovolume occurred in Sullivan Mill Pond (figure 8) where the phytoplankton were primarily composed of diatoms on 13 June, very low levels of green, diatom, and golden brown algae on 30 July, and golden brown algae on 18 September. No blue-green algae were detected in the study lakes. Thus, the phytoplankton composition in each of the lakes can be summarized as being composed of low quantities of edible algae.

Aquatic Macrophytes: Aquatic macrophyte composition and abundance (% coverage) within Brown's Lake are presented in Table 1. Macrophytes have a patchy distribution within Brown's Lake. There are few macrophytes found growing from those portions of the lake bottom where there is little sediment (i.e. along transect #1: Table 1). In those regions where sediments have accumulated (transects 2 and 3), macrophytes are abundant (100% coverage) extending to depths in excess of two meters, but not extending to four meters water depth. Where macrophytes were encountered, they were primarily members of the genera *Potamogeton* and *Elodea*.

In Ledbetter Lake the entire lake basin was covered with dense growth of the green alga *Chara* (Table 2), which has a vertical and branching growth form similar to the aquatic macrophytes. Only one other species, *Utricularia vulgaris*, was observed in the lake and it was only observed along one transect.

The macrophyte constituents of Sullivan Mill Pond are presented in Table 3 and are similar to what was observed within Brown's Lake. Macrophyte coverage ranged from 40 to 100% in water out to 2.5 m depth. Macrophytes were less abundant at 5 m depth where coverage ranged from 2 to 25%. As in Brown's Lake, *Potamogeton* and *Elodea* were common constituents within Sullivan Mill Pond, but *Chara* and *Myriophyllum sibiricum* were also present.

Abundant macrophytes should be expected in shallow mesotrophic and eutrophic lakes. Thus, the abundances observed in this study are not unusual. None of the lakes possessed detectable populations of Eurasian water milfoil, *Myriophyllum spicatum*.

Zooplankton: The zooplankton constituents within Brown's Lake include the branchiopods *Daphnia rosea*, *Ceriodaphnia reticulata*, *Holopedium gibberum*, *Bosmina longirostris*, and *Chydorus sphaericus*. Calanoid copepods observed in Brown's Lake include the facultative predator *Epischura nevadensis*, and a member of the genus *Diaptomus*. Two species of cyclopoid copepod were also detected in Browns Lake and include *Diacyclops thomasi* and *Mesocyclops edax*. The abundance and biomass of each of the species mentioned above are presented in figures 9 and 10, respectively. Those species making the largest contribution to numerical abundance (figure 9) include

Daphnia rosea (all sample dates), *Holopedium* (all sample dates), *Bosmina* (all sample dates), and *Epischura* (30 July and 18 Sept). Of these species, only *Daphnia* and *Epischura* have the potential to have large body lengths (approaching 2 mm) and thus it is these two species which make a consistent and relatively large contribution to the zooplankton biomass in Brown's Lake (figure 10).

The zooplankton encountered in Ledbetter Lake included the branchiopods *Daphnia pulex*, *Daphnia rosea*, *Ceriodaphnia reticulata*, *Diaphanosoma brachyurum*, *Alona affinis*, *Bosmina longirostris*, and *Chydorus sphaericus*. Also observed were one species within the calanoid copepods genus *Diaptomus*, the cyclopoid copepod *Diacyclops*, and larvae of the phantom midge, *Chaoborus*. The species that made the greatest contribution to numerical abundance (figure 11) include *Daphnia rosea* (all sample dates), *Ceriodaphnia* (13 June and 30 July), *Diaphanosoma* (all sample dates), and *Diaptomus* (all sample dates). Cumulative zooplankton biomass in Ledbetter Lake was highest on 13 June and decreased through the summer. Species making the greatest contribution to biomass include *D. rosea*, *Ceriodaphnia*, *Diaphanosoma*, and *Diaptomus* on 13 June and 30 July. On 18 September, biomass was dominated by *Diaptomus*, though *Daphnia pulex*, *D. rosea* and *Diaphanosoma* each contribute to a lesser extent (figure 12).

Zooplankton detected within Sullivan Mill Pond included *Daphnia rosea*, *Ceriodaphnia reticulata*, *Diaphanosoma brachyurum*, *Alona affinis*, *Bosmina longirostris*, *Chydorus sphaericus*, one species of *Diaptomus*, and *Diacyclops thomasi*. Although species richness here was similar to zooplankton richness in the other water bodies, zooplankton abundance and biomass were very low (figures 13 and 14, respectively). The densities of most species were less than one individual l^{-1} and species-specific biomass exceeded 5 *u*g l^{-1} for only two species (*Bosmina* and *Diacyclops*) on one sample date (18 September). As expected in this small reservoir, zooplankton abundance and biomass were greatest when water residence time was at its end of the summer season high.

The zooplankton observed within this study represents a diversity of pelagic and littoral species which is typical of shallow lakes where macrophytic vegetation is present but does not eliminate open water. The diversity of sizes represented by the species

present, from the large-bodied *Daphnia* and *Diaptomus* to the small bodied cyclopids and *Bosmina*, suggest vertebrate predators are present and an important regulatory force shaping each of the plankton communities. However, vertebrate planktivores appear not to be overly abundant as the effect of planktivore overabundance is virtual elimination of large and intermediate sized species (Brooks and Dodson 1965, Zaret 1980)

Benthic Macroinvertebrates: The benthic macroinvertebrate constituents of Brown's Lake are presented in Table 4. An abundant and diverse assemblage of annelids, amphipods, insects, and molluscs were present at all depths. In Ledbetter Lake, the same pattern was observed although here richness was higher and constituents included aquatic mites, caddis flies, and a greater diversity of damsel and dragon fly larvae (Table 5). The benthic invertebrates within Sullivan Mill Pond are presented in Table 6 and include annelids, insects, amphipods and molluscs. Although it is true that within all of the lakes chironomid larvae were the most abundant benthic organism and that high densities of chironomids are often associated with the sediments of over-productive or nutrient laden lakes (Roback 1974), it is when chironomids, and perhaps also amphipods in the genus *Gammarus*, are the only taxa present that one should be concerned with eutrophic conditions (Welch 1980).

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Table 1. Aquatic macrophyte composition and percent coverage for each of three transects in Brown's Lake, Pend Oreille County, Washington, August 2003.

Transect	Depth (m)	Species	% Coverage
1	0.5	None	0
	1	*Isoetes* sp.	2
	2	None	0
	4	None	0
2	0.5	*Potamogeton zosteridormis*	90
		Callitriche hermaphroditica	8
		Potamogeton epihydrus	2
	1	*Potamogeton zosteridormis*	80
		Potamogeton epihydrus	10
	2	*Elodea canadensis*	70
		Potamogeton pectinatus	20
		Potamogeton zosteridormis	5
		Potamogeton pusillus	5
	4	None	
3	0.5	*Potamogeton zosteridormis*	90
		Isoetes sp.	10
		Potamogeton pectinatus	5
		Potamogeton epihydrus	2
	1	*Potamogeton zosteridormis*	80
		Isoetes sp.	5
	2	*Potamogeton pectinatus*	40
		Elodea canadensis	15
		Isoetes sp.	5
	4	None	

Table 2. Aquatic macrophyte composition and percent coverage for each of three transects in Ledbetter Lake, Pend Oreille County, Washington, August 2003.

Transect	Depth (m)	Species	% Coverage
1	0.5	*Chara* sp.	100
	1	*Chara* sp.	100
	2.5	*Chara* sp.	100
	5	*Chara* sp.	100
2	0.5	*Chara* sp.	100
	1	*Chara* sp.	100
	2.5	*Chara* sp.	95
	2.5	*Utricularia vulgaris*	5
	5	*Chara* sp.	100
3	0.5	*Chara* sp.	50
	1	*Chara* sp.	50
	2.5	*Chara* sp.	100
	5	*Chara* sp.	90

Table 3. Aquatic macrophyte composition and percent coverage for each of three transects in Sullivan Mill Pond, Pend Oreille County, Washington, August 2003.

Transect	Depth (m)	Species	% Coverage
1	0.5	*Chara* sp.	40
		Myriophyllum sibiricum	1
		Potamogeton richardsonii	1
	1.5	*Elodea canadensis*	70
		Potamogeton richardsonii	10
	2.5	*Elodea canadensis*	90
		Potamogeton richardsonii	10
	5	*Elodea canadensis*	20
		Chara sp.	5
2	0.5	*Elodea canadensis*	25
		Chara sp.	25
		Myriophyllum sibiricum	5
	1.5	*Elodea canadensis*	90
	2.5	*Elodea canadensis*	40
	5	*Chara* sp.	1
		Elodea canadensis	1
3	0.5	*Elodea canadensis*	60
		Potamogeton richardsonii	10
	1.5	*Elodea canadensis*	95
		Potamogeton praelongus	5
		Potamogeton richardsonii	5
	2.5	*Elodea canadensis*	95
		Potamogeton richardsonii	1
	5	*Elodea canadensis*	15

Table 4. Benthic macroinvertebrate densities in Brown's Lake, Pend Oreille County, Washington, August 2003. Depth-specific descriptive statistics were calculated from three replicate transects.

Depth (m)	Class	Order	Family	Genus	Mean	SE
1	Hirudinea				108.3	96.1
	Insecta	Diptera	Chironomidae		1100	931
	Insecta	Ephemeroptera	Siphlonuridae	*Siphlonurus*	8.333	8.33
	Insecta	Megaloptera	Sialidae	*Sialis*	16.67	8.33
	Oligochaeta				341.7	248
	Amphipoda		Talitridae	*Hyalla*	1008	660
	Bivalvia		Sphaeriidae		50	38.2
	Gastropoda		Physidae		16.67	16.7
1.5	Hirudinea				16.67	8.33
	Insecta	Coleoptera			16.67	16.7
	Insecta	Diptera	Chironomidae		716.7	529
	Insecta	Megaloptera	Sialidae	*Sialis*	8.333	8.33
	Oligochaeta				150	76.4
	Amphipoda		Talitridae	*Hyalla*	558.3	497
	Bivalvia		Sphaeriidae		8.333	8.33
	Gastropoda		Physidae		16.67	16.7
2	Hirudinea				191.7	118
	Insecta	Diptera	Chironomidae		708.3	204
	Insecta	Megaloptera	Sialidae	*Sialis*	8.333	8.33
	Insecta	Odonata	Coenagrionidae		8.333	8.33
	Oligochaeta				466.7	347
	Amphipoda		Talitridae	*Hyalla*	450	142
	Bivalvia		Sphaeriidae		83.33	22
	Gastropoda		Lymnaeidae	*Fossaria*	66.67	33.3
	Gastropoda		Physidae		8.333	8.33
3	Hirudinea				200	109
	Insecta	Diptera	Chironomidae		475	368
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	33.33	33.3
	Oligochaeta				75	43.3
	Amphipoda		Talitridae	*Hyalla*	16.67	16.7
	Bivalvia		Sphaeriidae		8.333	8.33
	Gastropoda		Physidae		25	14.4

Table 5. Benthic macroinvertebrate densities in Ledbetter Lake, Pend Oreille County, Washington, August 2003. Depth-specific descriptive statistics were calculated from three replicate transects.

Depth (m)	Class	Order	Family	Genus	Mean	SE
0.5	Arcaria	Hydracarina			58.33	16.67
	Insecta	Diptera	Ceratopogonidae		108.3	22.05
	Insecta	Diptera	Chironomidae		525	226.8
	Insecta	Ephemeroptera			8.333	8.333
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	58.33	16.67
	Insecta	Odonata	Libellulidae	*Libellula*	8.333	8.333
	Insecta	Trichoptera			16.67	8.333
	Amphipoda		Talitridae	*Hyalla*	66.67	54.65
	Gastropoda		Physidae		50	38.19
1	Arcaria	Hydracarina			133.3	58.33
	Insecta	Diptera	Ceratopogonidae		133.3	133.3
	Insecta	Diptera	Chironomidae		1725	1004
	Insecta	Ephemeroptera			33.33	33.33
	Insecta	Odonata	Aeshnidae	*Anax*	8.333	8.333
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	116.7	60.09
	Insecta	Odonata	Corduliidae		191.7	71.2
	Insecta	Trichoptera			16.67	16.67
	Amphipoda		Talitridae	*Hyalla*	133.3	68.21
	Bivalvia		Sphaeriidae		500	321.5
	Gastropoda		Physidae		300	300
	Gastropoda		Planorbidae		41.67	41.67
2	Arcaria	Hydracarina			66.67	54.65
	Insecta	Diptera	Ceratopogonidae		75	61.24
	Insecta	Diptera	Chironomidae		850	453.7
	Insecta	Ephemeroptera			16.67	8.333
	Insecta	Odonata	Coenagrionaidae	*Coenagrion*	75	43.3
	Insecta	Odonata	Corduliidae	*Somatochlora*	91.67	91.67
	Insecta	Trichoptera			8.333	8.333
	Amphipoda		Talitridae	*Hyalla*	58.33	30.05
	Bivalvia		Sphaeriidae		25	25
	Gastropoda		Lymnaeidae	*Fossaria*	50	50
	Gastropoda		Physidae		41.67	41.67
	Gastropoda		Planorbidae		25	25
4	Arcaria	Hydracarina			33.33	22.05
	Insecta	Diptera	Ceratopogonidae		16.67	8.333
	Insecta	Diptera	Chironomidae		316.7	221
	Insecta	Odonata	Corduliidae	*Somatochlora*	8.333	8.333
	Bivalvia		Sphaeriidae		125	125
	Gastropoda		Lymnaeidae	*Fossaria*	708.3	708.3
	Gastropoda		Physidae		75	43.3
	Gastropoda		Planorbidae		16.67	16.67

Table 6. Benthic macroinvertebrate densities in Sullivan Mill Pond, Pend Oreille County, Washington, August 2003. Depth-specific descriptive statistics were calculated from three replicate transects.

Depth (m)	Class	Order	Family	Genus	Mean	SE
0.5	Insecta	Diptera	Chironomidae		183.3	50.7
	Insecta	Ephemeroptera			25	14.4
	Insecta	Megaloptera	Sialidae	*Sialis*	16.67	16.7
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	16.67	8.33
	Amphipoda		Talitridae	*Hyalla*	50	25
	Bivalvia		Sphaeriidae		275	138
	Gastropoda		Lymnaeidae	*Fossaria*	8.333	8.33
	Gastropoda		Physidae		33.33	16.7
	Gastropoda		Planorbidae		33.33	33.3
1.5	Hirudinea				8.333	8.33
	Insecta	Diptera	Chironomidae		366.7	194
	Insecta	Megaloptera	Sialidae	*Sialis*	16.67	16.7
	Insecta	Odonata	Aeshnidae	*Aeshna*	8.333	8.33
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	8.333	8.33
	Insecta	Trichoptera	Leptoceridae		8.333	8.33
	Insecta	Trichoptera	Phryganeidae		33.33	33.3
	Oligochaeta				16.67	16.7
	Amphipoda		Talitridae	*Hyalla*	8.333	8.33
	Bivalvia		Sphaeriidae		100	57.7
	Gastropoda		Physidae		8.333	8.33
	Gastropoda		Planorbidae		25	14.4
2.5	Hirudinea				8.333	8.33
	Insecta	Diptera	Chironomidae		341.7	178
	Insecta	Ephemeroptera			16.67	16.7
	Insecta	Megaloptera	Sialidae	*Sialis*	16.67	16.7
	Insecta	Trichoptera	Phryaneidae		8.333	8.33
	Oligochaeta				108.3	96.1
	Bivalvia		Sphaeriidae		116.7	92.8
	Gastropoda		Lymnaidae	*Fossaria*	8.333	8.33
	Gastropoda		Physidae		8.333	8.33
	Gastropoda		Planorbidae		16.67	16.7
5	Hirudinea				8.333	8.33
	Hydracarina				8.333	8.33
	Insecta	Diptera	Ceratopogonidae		8.333	8.33
	Insecta	Diptera	Chironomidae		300	109
	Insecta	Odonata	Coenagrionidae	*Coenagrion*	8.333	8.33
	Oligochaeta				241.7	126
	Bivalvia		Sphaeriidae		25	25
	Gastropoda		Lymnaeidae	*Fossaria*	16.67	16.7

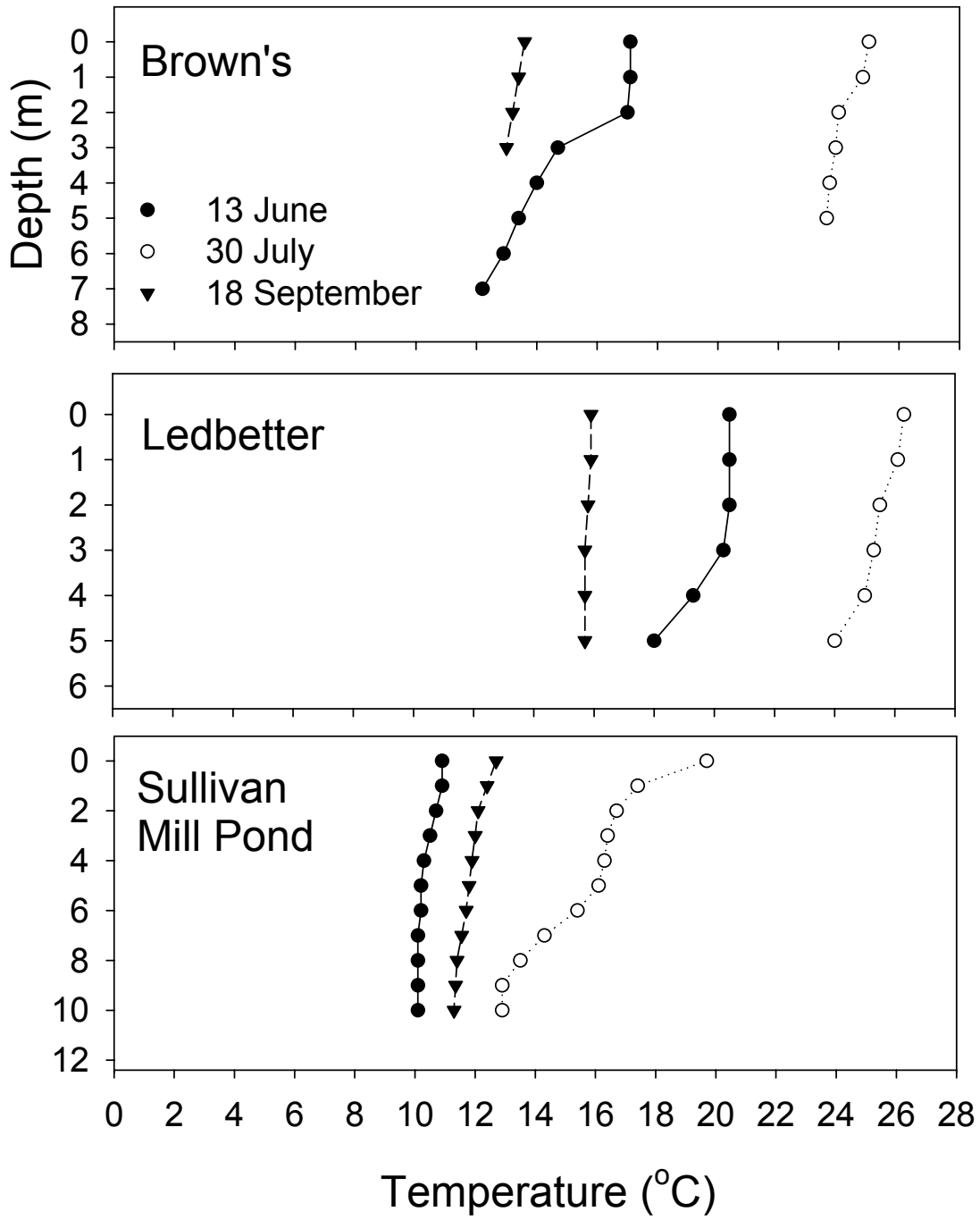

Figure 1. Temperature profiles of three lakes within the Pend Oreille River drainage, Washington, summer 2003. The decreased depth of the July and September profiles in Brown's Lake is an artifact of water loss from the lake basin which occurred throughout the summer.

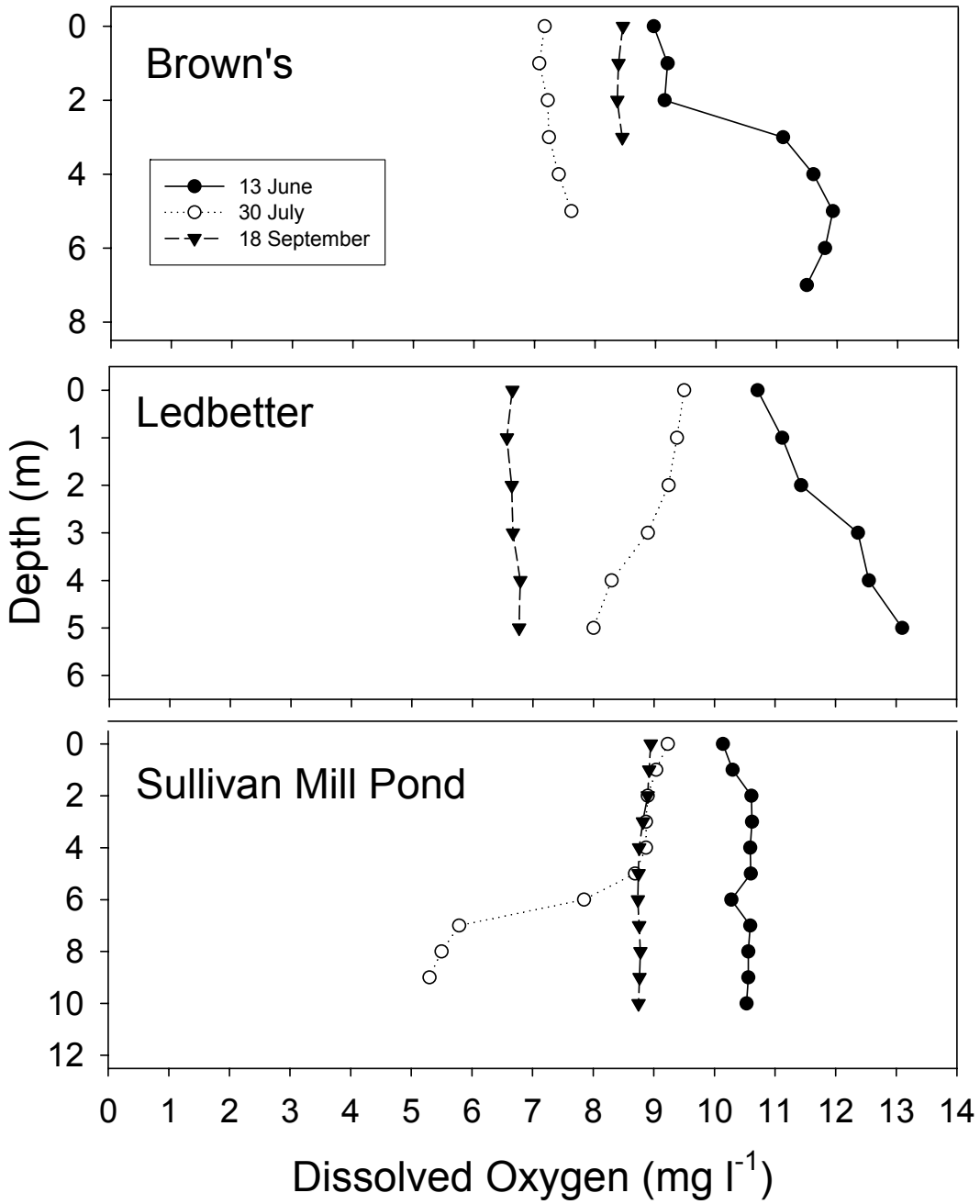

Figure 2. Dissolved oxygen profiles of three lakes within the Pend Oreille River drainage, Washington, summer 2003. The decreased depth of the July and September profiles in Brown's Lake is an artifact of water loss from the lake basin which occurred throughout the summer.

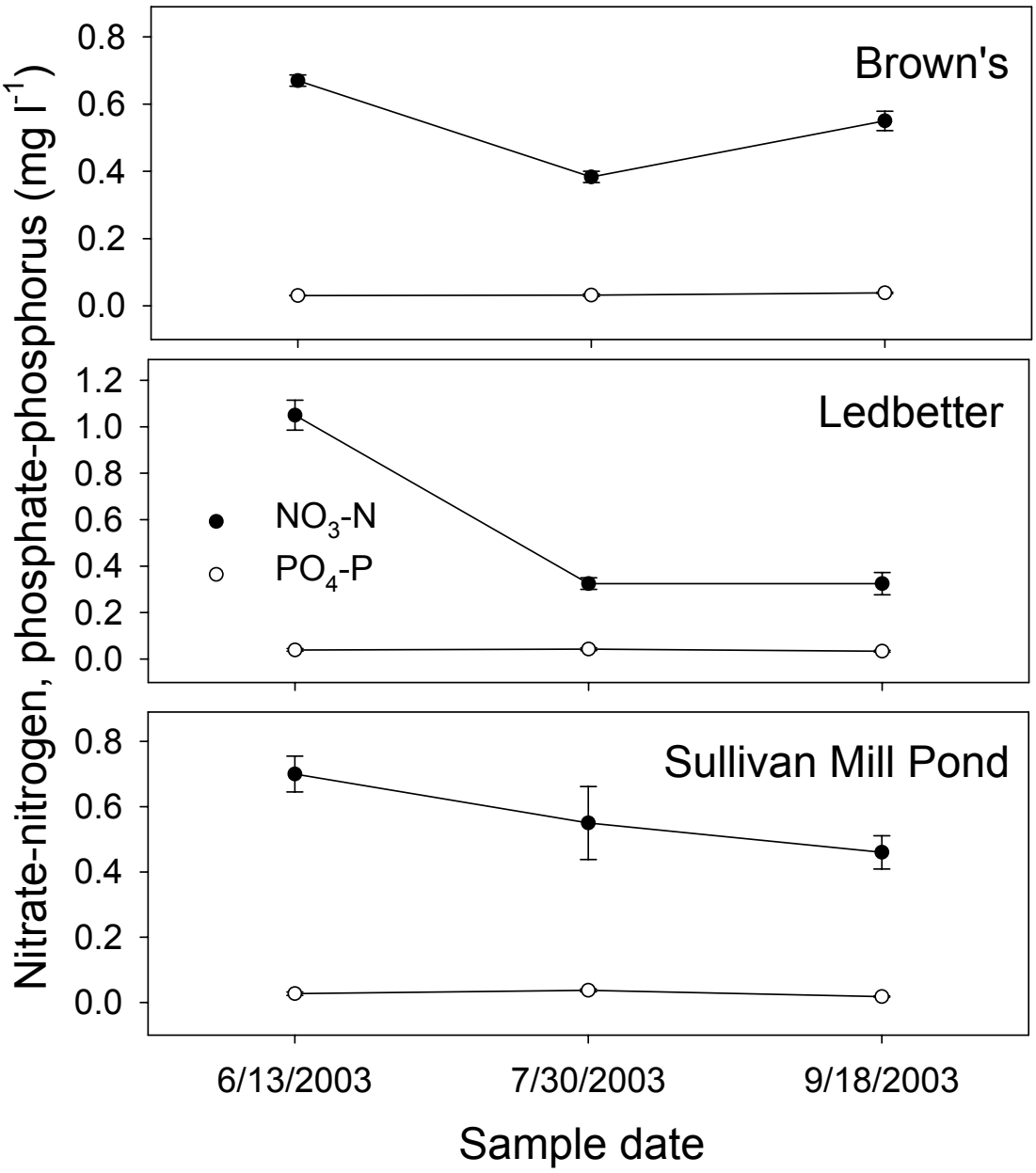

Figure 3. Mean (± 1SE) nitrate-nitrogen and phosphate-phosphorus concentrations measured on each of three sample dates. Means were calculated from 6 replicate samples in Brown's Lake and four replicate samples in Ledbetter and Mill Pond Lakes.

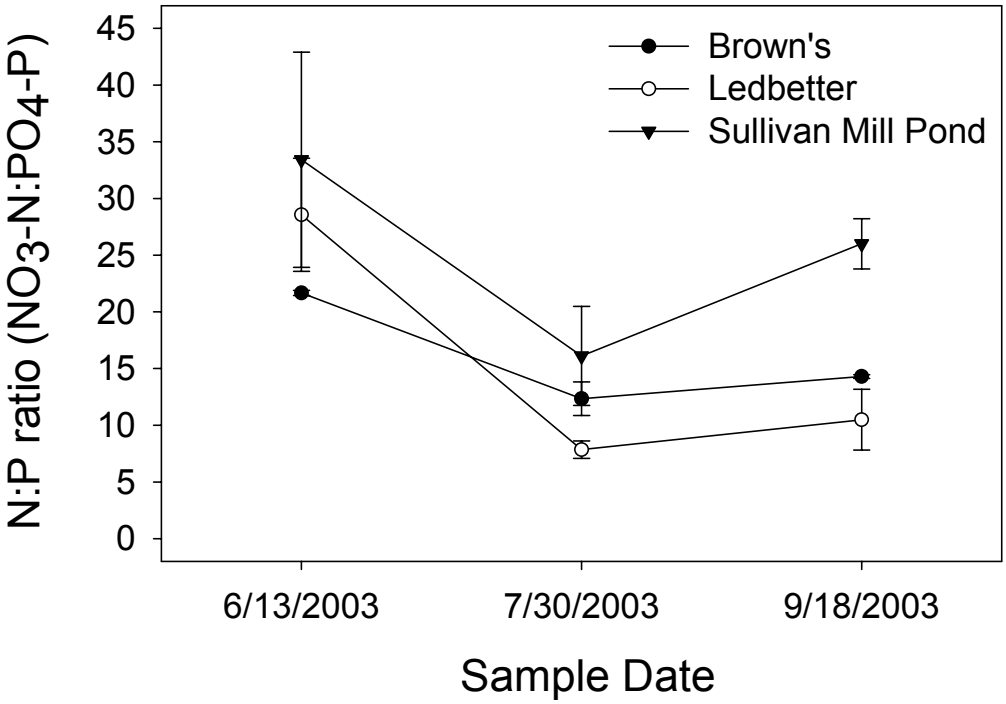

Figure 4. Mean nitrogen:phosphorus ratios (± 1SE) for each of three lakes within the Pend Oreille River drainage, Washington, on each of three sample dates, summer 2003. Six replicate samples were collected from Brown's Lake, and 4 replicate samples were collected from Ledbeter and Mill Pond Lakes on each sample date.

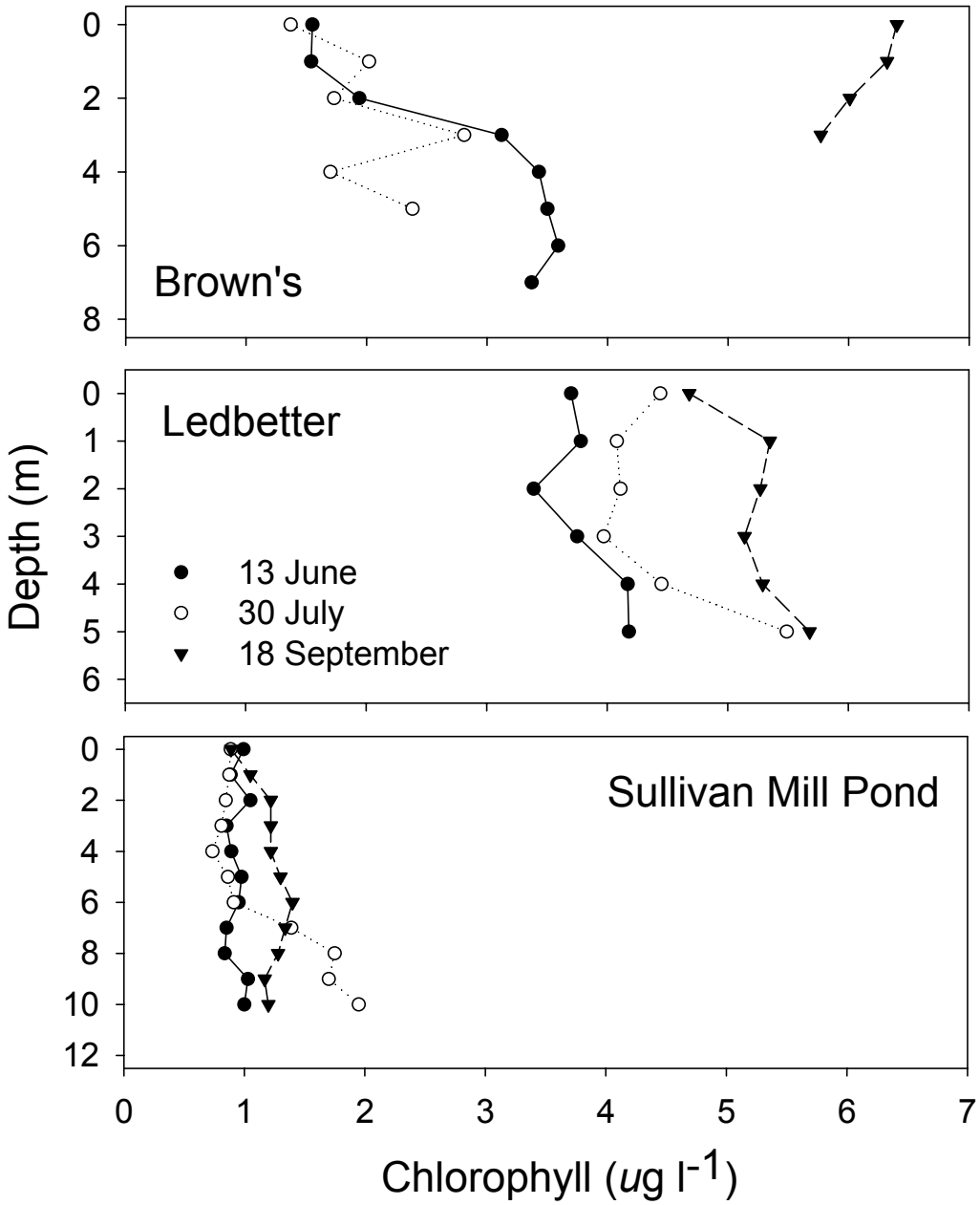

Figure 5. Chlorophyll profiles of three lakes within the Pend Oreille River drainage, Washington, summer 2003. The decreased depth of the July and September profiles in Brown's Lake is an artifact of water loss from the lake basin which occurred throughout the summer.

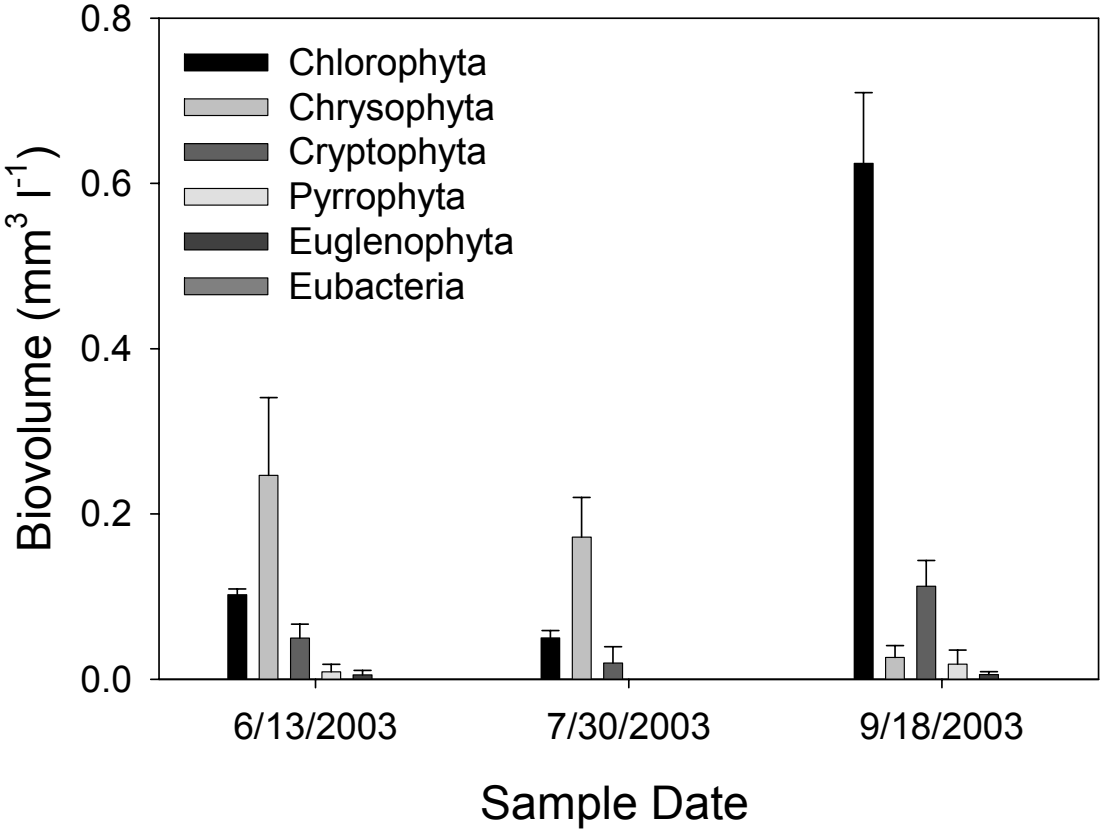

Figure 6. Mean (± 1SE) phytoplankton biovolume by algal division, Brown's Lake, Washington, 2003. Means and standard errors were calculated from six replicate samples collected from the mid-depth of the water column on each sample date.

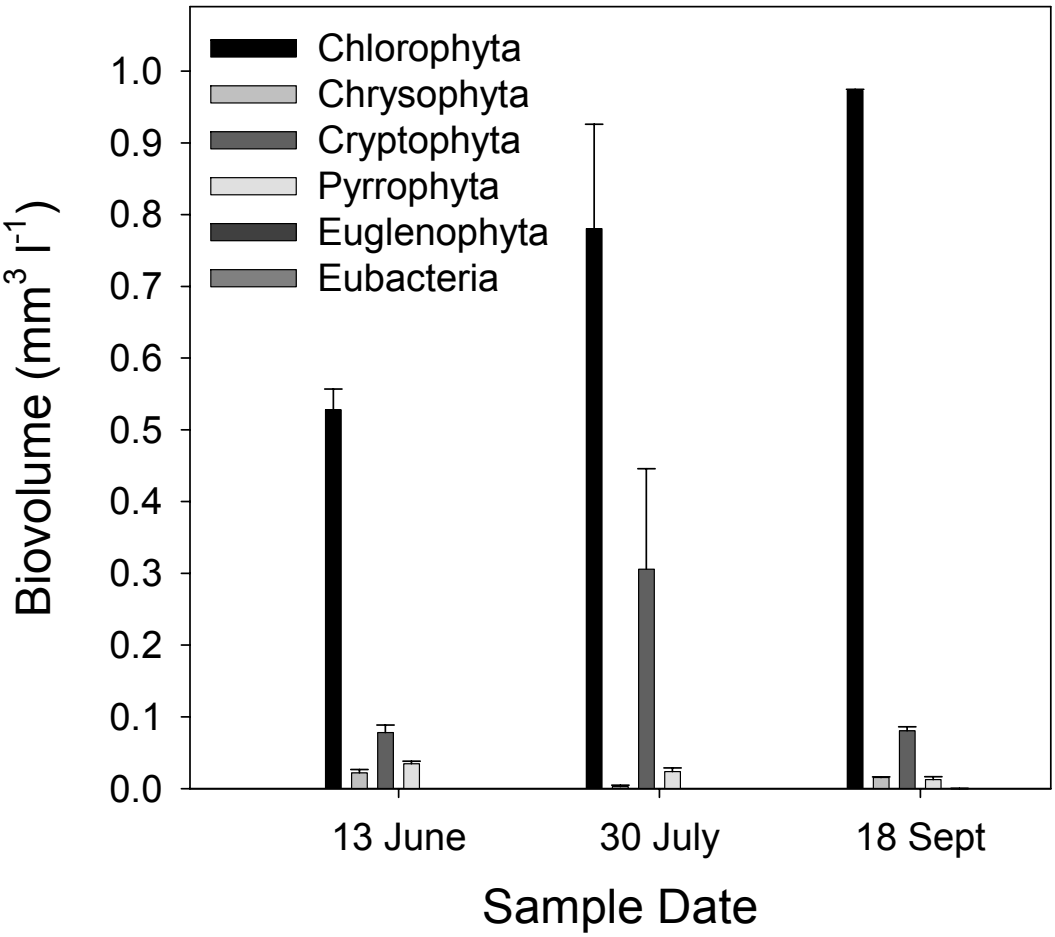

Figure 7. Mean (± 1SE) phytoplankton biovolume by algal division, Ledbetter Lake, Washington, 2003. Means and standard errors were calculated from four replicate samples collected from the mid-depth of the water column on each sample date.

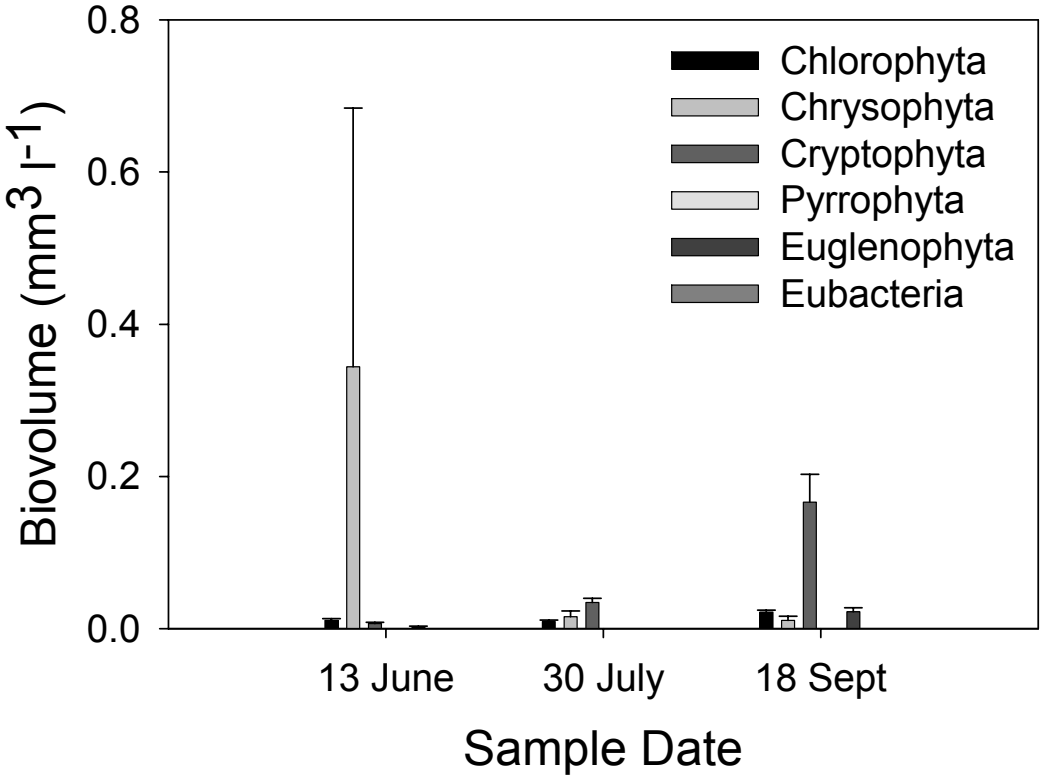

Figure 8. Mean (± 1SE) phytoplankton biovolume by algal division, Sullivan Mill Pond, Washington, 2003. Means and standard errors were calculated from six replicate samples collected from the mid-depth of the water column on each sample date.

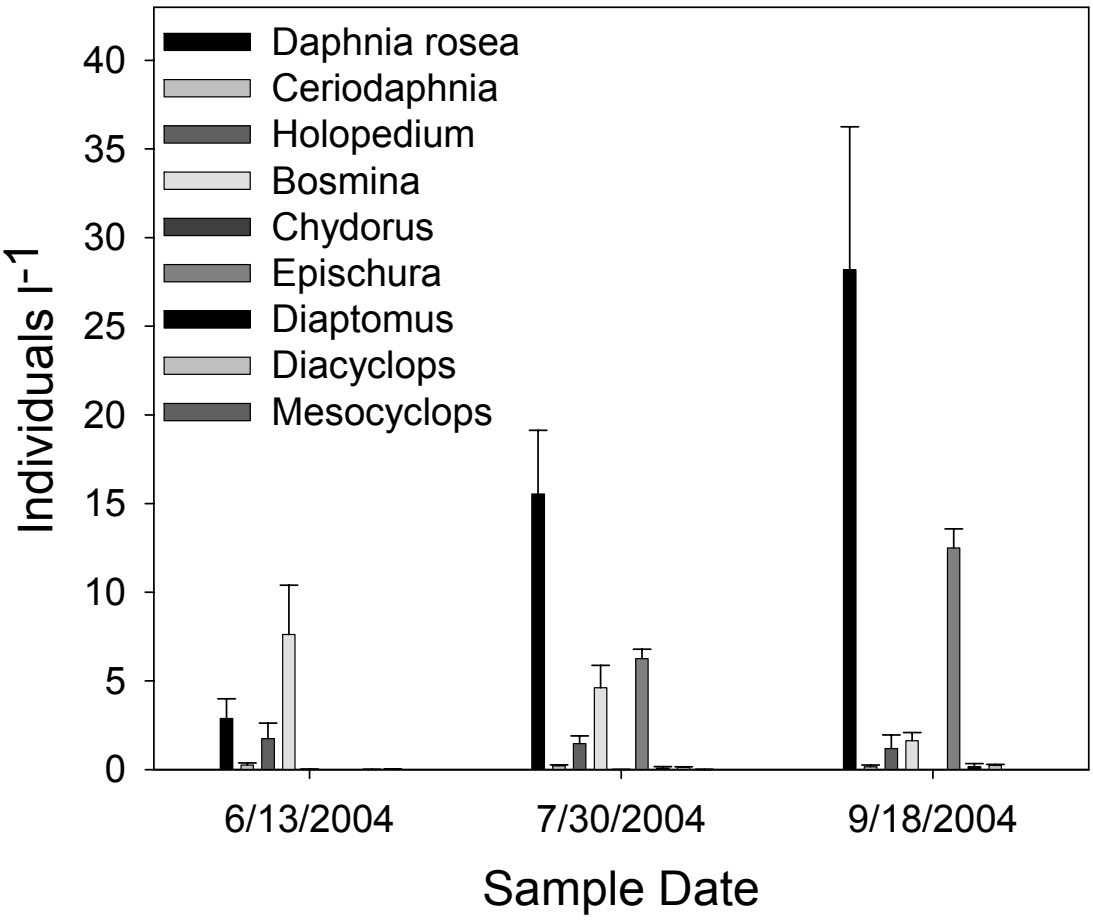

Figure 9. Zooplankton abundance in Brown's Lake, Washington, summer 2003.

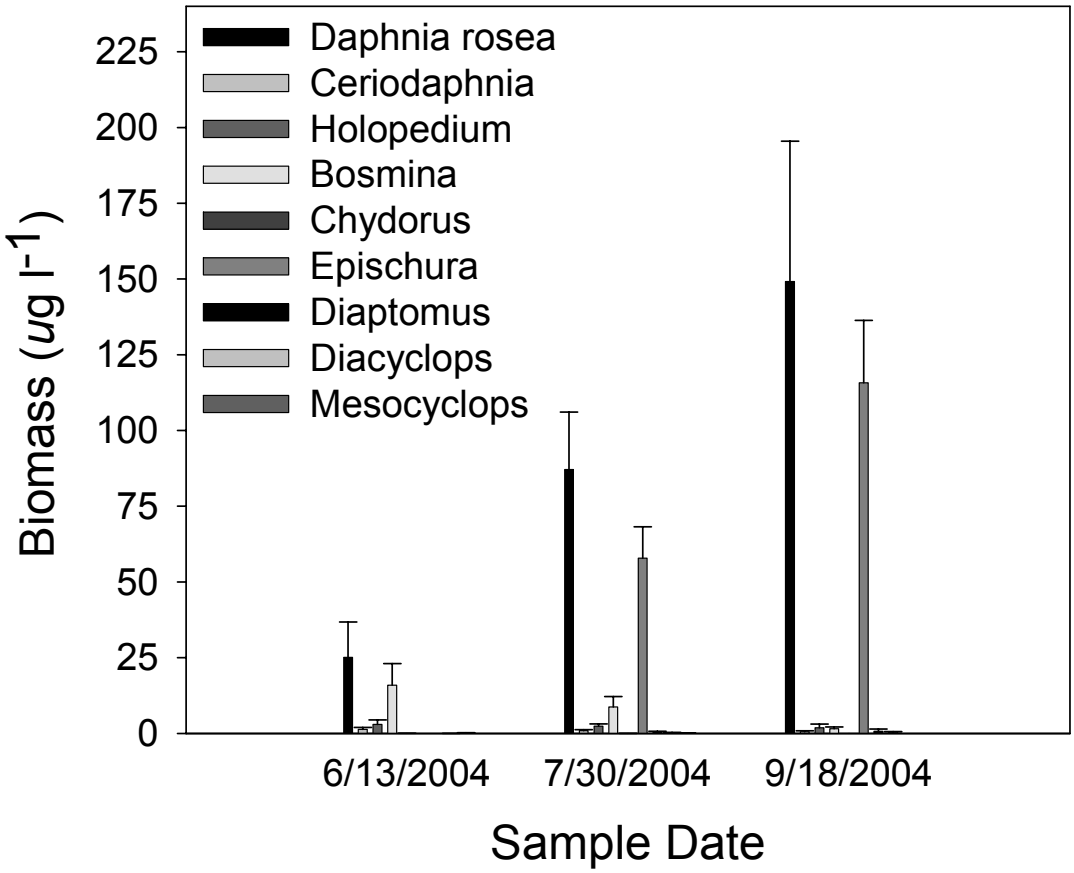

Figure 10. Species-specific zooplankton biomass in Brown's Lake, Washington, summer 2003.

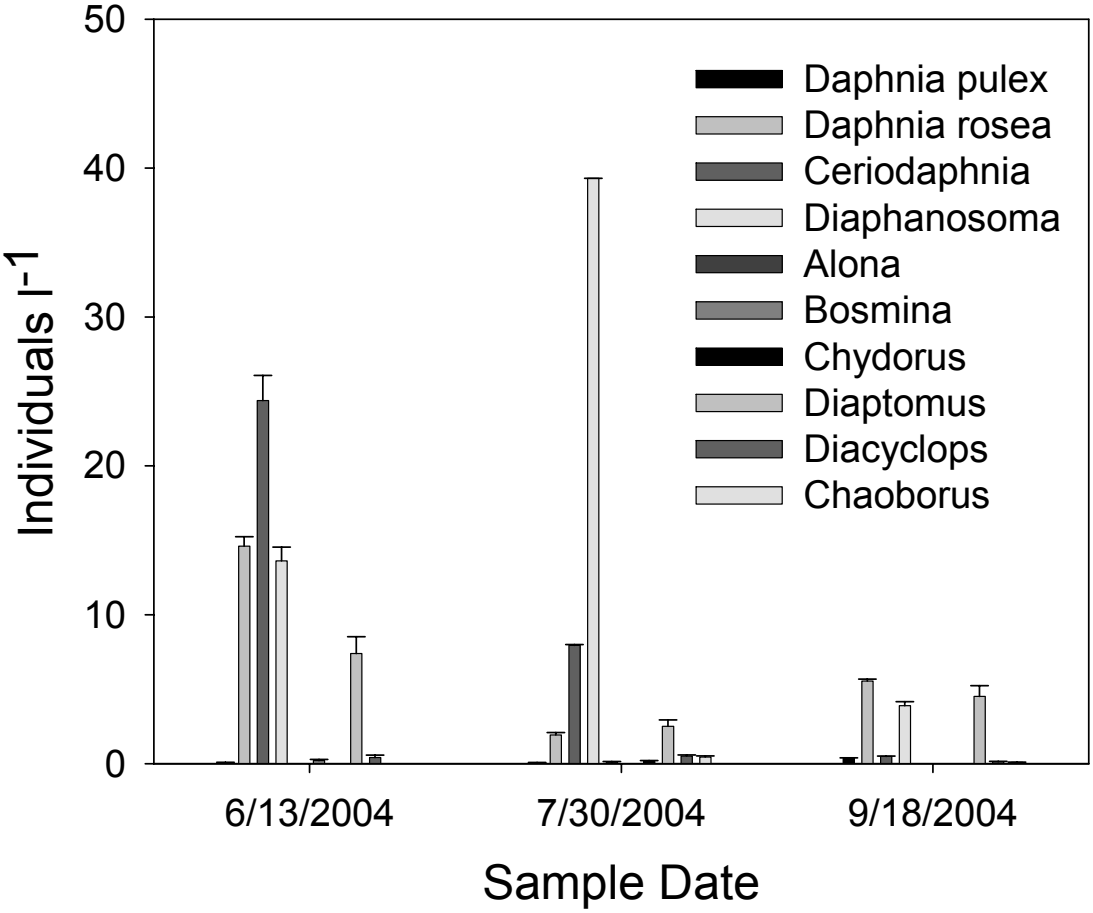

Figure 11. Species-specific zooplankton abundance within Ledbetter Lake, Washington, summer 2003.

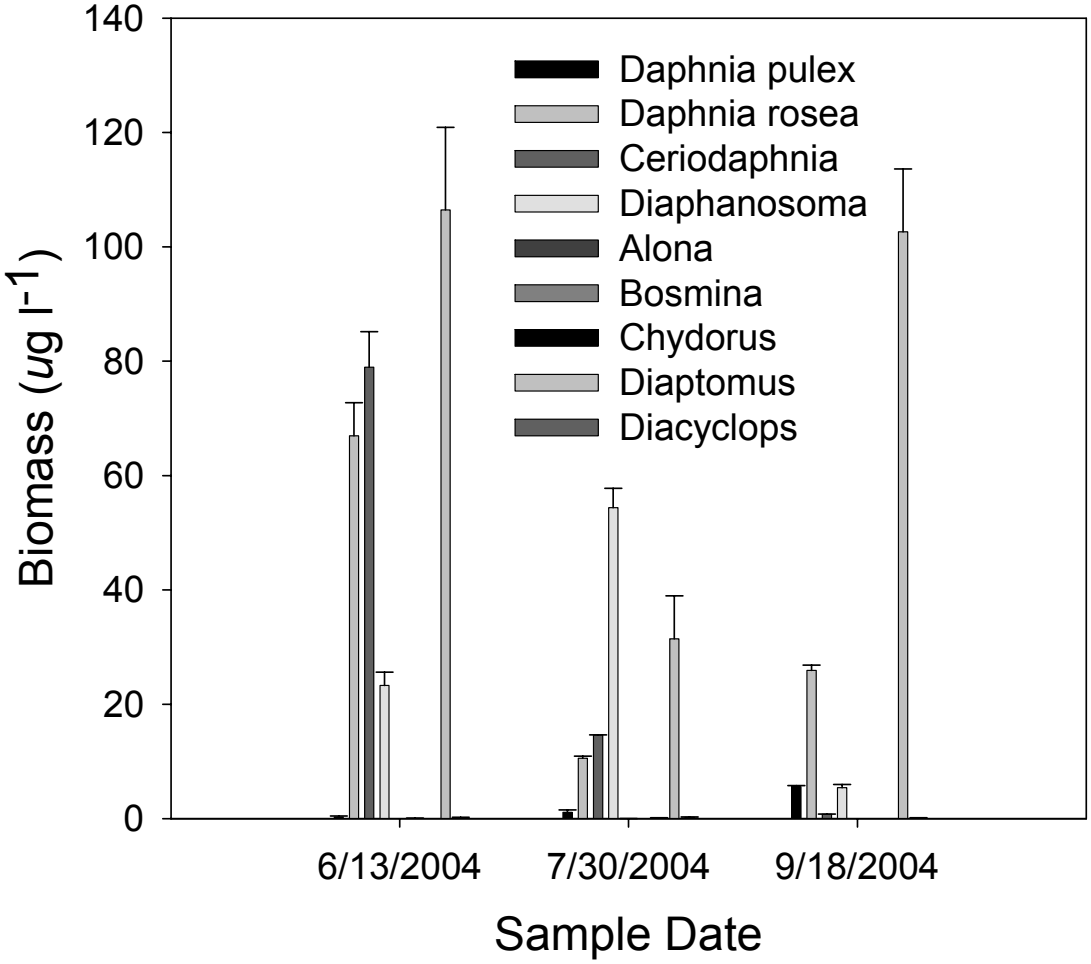

Figure 12. Zooplankton biomass in Ledbetter Lake, Washington, summer 2003.

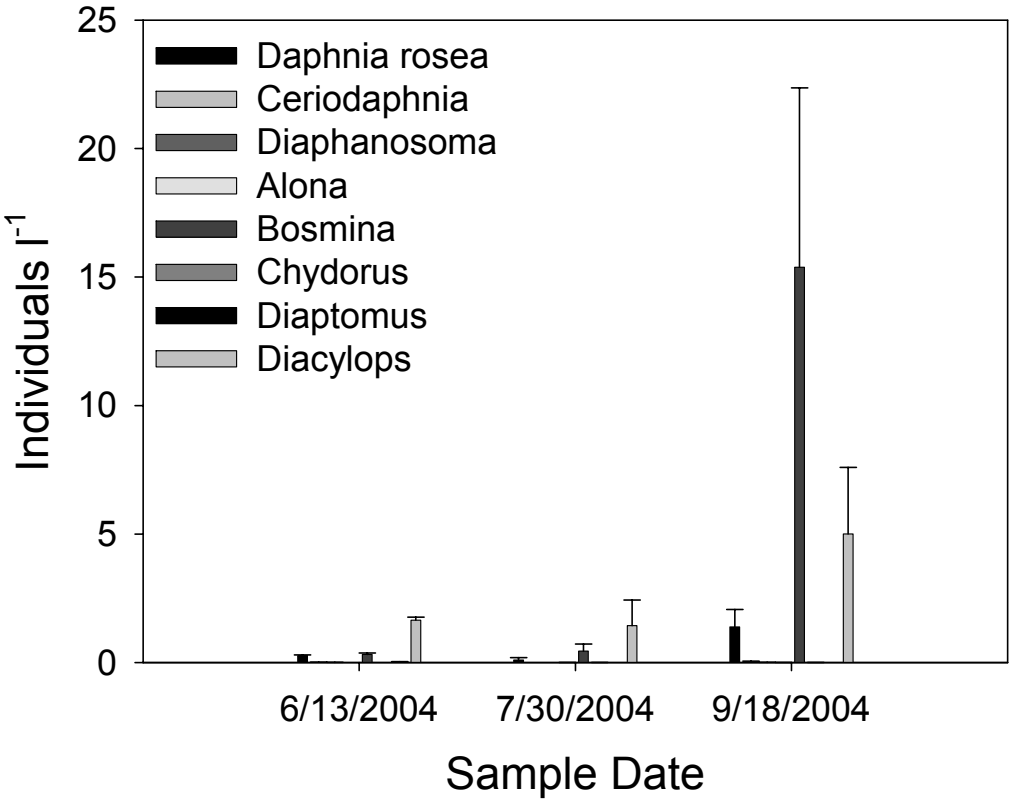

Figure 13. Species-specific zooplankton abundance, Sullivan Mill Pond, Washington, summer 2003.

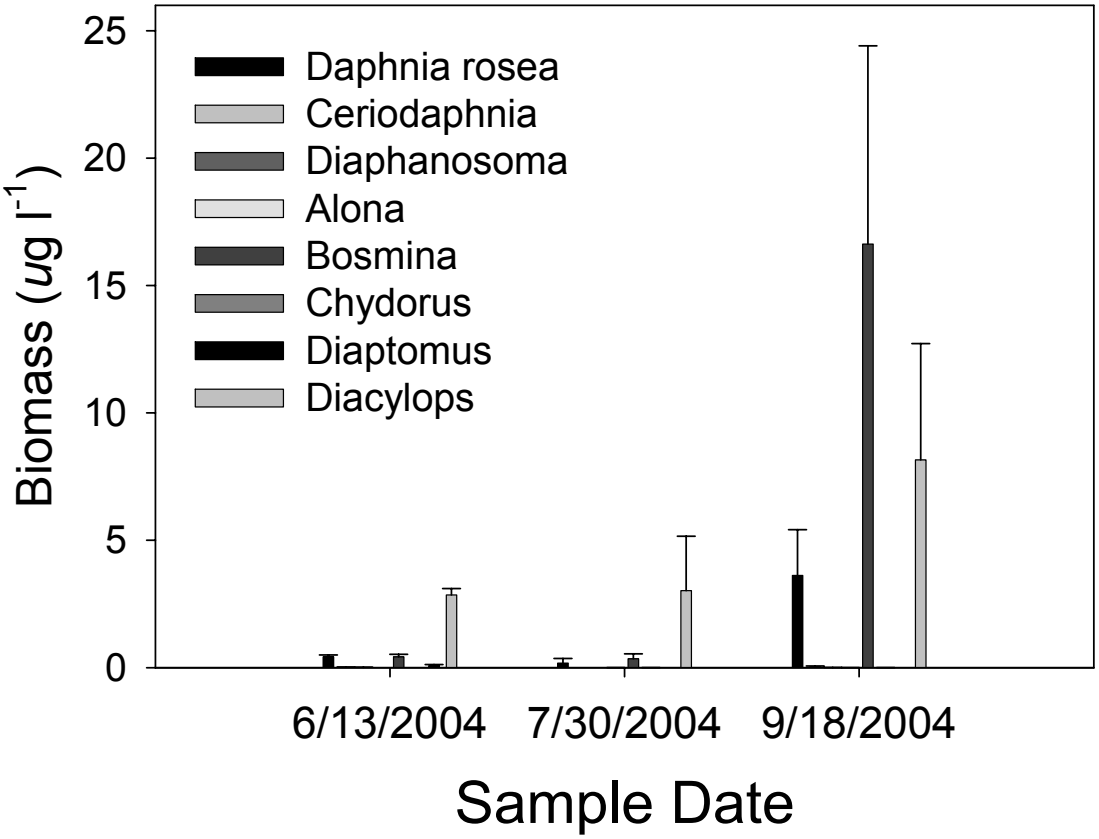

Figure 14. Species-specific zooplankton biomass within Sullivan Mill Pond, Washington, summer 2003.

Appendix 2

Stocking Records for Lakes Surveyed in 2003

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
BROWNS	PEND OREILLE	1934	CT	GENERAL	42300				
BROWNS	PEND OREILLE	1934	CT	GENERAL	20000				
BROWNS	PEND OREILLE	1934	CT	GENERAL	40000				
BROWNS	PEND OREILLE	1935	CT	GENERAL	25000				
BROWNS	PEND OREILLE	1936	CT	GENERAL	25000				
BROWNS	PEND OREILLE	1936	CT	GENERAL	25000				
BROWNS	SPOKANE	1937	CT	GENERAL	30000				
BROWNS	PEND OREILLE	1938	CT	GENERAL	23100				
BROWNS	PEND OREILLE	1938	CT	GENERAL	14400				
BROWNS	PEND OREILLE	1938	CT	GENERAL	71400				
BROWNS	PEND OREILLE	1939	CT	GENERAL	27240				
BROWNS	PEND OREILLE	1940	CT	GENERAL	2638				
BROWNS	USFWS SPOKANE	1940	CT	GENERAL	9977				
BROWNS	SALVAGE	1942	CT	GENERAL	768				
BROWNS	SPOKANE	1942	CT	GENERAL	9600				
BROWNS	PEND OREILLE	1943	CT	GENERAL	37800				
BROWNS	SPOKANE	1944	CT	GENERAL	58000				
BROWNS	SPOKANE	1945	CT	GENERAL	75000				
BROWNS	SPOKANE	1946	CT	GENERAL	74700				
BROWNS	SPOKANE	1947	CT	GENERAL	74950				
BROWNS	SPOKANE	1949	CT	GENERAL	57610				REHABILITATED 9-20-49
BROWNS	COLVILLE	1950	CT	GENERAL	24720				
BROWNS	SPOKANE	1950	CT	GENERAL	27512				
BROWNS	SPOKANE	1951	CT	GENERAL	47540	752			
BROWNS	PEND OREILLE	1952	CT	GENERAL	14746	584			
BROWNS	PEND OREILLE	1952	CT	GENERAL	5100	600			
BROWNS	PEND OREILLE	1952	CT	GENERAL	19740	564			
BROWNS	PEND OREILLE	1952	CT	GENERAL	2340	468			
BROWNS	PEND OREILLE	1953	CT	GENERAL	22000	400			
BROWNS	PEND OREILLE	1953	CT	GENERAL	28050	510			
BROWNS	PEND OREILLE	1954	CT	GENERAL	50400	450			
BROWNS	SPOKANE	1955	CT	GENERAL	35600	356			
BROWNS	SPOKANE	1958	CT	GENERAL	41600	245			REHABILITATED 8-28-58
BROWNS	SPOKANE	1959	CT	GENERAL	40500	300			
BROWNS	PEND OREILLE	1960	CT	GENERAL	20160	420			
BROWNS	PEND OREILLE	1961	CT	GENERAL	30000	600			
BROWNS	SPOKANE	1962	CT	GENERAL	20340	440			
BROWNS	SPOKANE	1963	CT	GENERAL	25200	350			

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
BROWNS	SPOKANE	1964	CT	GENERAL	25000	275			
BROWNS	SPOKANE	1965	CT	GENERAL	25500	300			
BROWNS	SPOKANE	1966	CT	GENERAL	25200	210			
BROWNS	FORD	1967	CT	GENERAL	24985	263			
BROWNS	COLVILLE	1968	CT	GENERAL	24995	250			
BROWNS	COLVILLE	1969	CT	GENERAL	25190	275			
BROWNS	COLVILLE	1970	CT	GENERAL	25110	270			
BROWNS	SPOKANE	1972	CT	GENERAL	15125	55			
BROWNS	SPOKANE	1973	CT	GENERAL	10200	30			
BROWNS	SPOKANE	1974	CT	GENERAL	5040	21			
BROWNS	SPOKANE	1975	CT	GENERAL	7018	15.7			
BROWNS	FORD	1976	CT	GENERAL	7020	30			
BROWNS	FORD	1978	CT	GENERAL	6026	46			
BROWNS	FORD	1979	CT	GENERAL	5010	30			
BROWNS	FORD	1980	CT	GENERAL	7020	45			
BROWNS	FORD	1981	CT	GENERAL	7000	35			
BROWNS	FORD	1983	CT	WESTSLOPE	7015		230	30.5	
BROWNS	FORD	1984	CT	WESTSLOPE	10010		286	35	
BROWNS	COLVILLE	1984	CT	WESTSLOPE	15000		75	200	
BROWNS	COLVILLE	1985	CT	WESTSLOPE	15120		56	270	
BROWNS	COLVILLE	1986	CT	WESTSLOPE	14960		68	220	
BROWNS	COLVILLE	1987	CT	WESTSLOPE	15120		84	180	
BROWNS	COLVILLE	1988	CT	WESTSLOPE	10000		53.2	188	
BROWNS	COLVILLE	1989	CT	WESTSLOPE	8000		32	250	
BROWNS	COLVILLE	1990	CT	WESTSLOPE	7030		37	190	
BROWNS	FORD	1992	CT	WESTSLOPE	3520		160	22	
BROWNS	COLVILLE	1993	CT	WESTSLOPE	15041		84.5	178	
BROWNS	FORD	1993	CT	WESTSLOPE	9002		325	27.7	
BROWNS	COLVILLE	1994	CT	WESTSLOPE	15051		87	173	
BROWNS	COLVILLE	1995	RB	SPOK	5115	93	55		
BROWNS	FORD	1996	CT	KING	8835	19	465		
BROWNS	COLVILLE	1997	CT	KING	19965	165	121		
BROWNS	COLVILLE	1998	CT	KING	8004	184	43.5		
BROWNS	COLVILLE	1999	CT	KING	15018	197.6	76		
BROWNS	COLVILLE	2000	CT	KING	13110	190	69		
BROWNS	COLVILLE	2001	CT	KING	10064	148	68		
BROWNS	COLVILLE	2002	CT	KING	10088	194	52		
BROWNS	COLVILLE	2003	CT	KING	10112	158	64		

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
LEDBETTER	PEND OREILLE	1933	EB	EASTERN BROOK	45000				
LEDBETTER	PEND OREILLE	1933	EB	EASTERN BROOK	16000				
LEDBETTER	PEND OREILLE	1933	LT	LAKE	7500				
LEDBETTER	PEND OREILLE	1934	EB	EASTERN BROOK	40000				
LEDBETTER	PEND OREILLE	1934	RB	RAINBOW	25000				
LEDBETTER	PEND OREILLE	1935	EB	EASTERN BROOK	25000				
LEDBETTER	PEND OREILLE	1936	S	SILVER	60000				
LEDBETTER	PEND OREILLE	1936	EB	EASTERN BROOK	25000				
LEDBETTER	PEND OREILLE	1937	EB	EASTERN BROOK	25000				
LEDBETTER	PEND OREILLE	1937	EB	EASTERN BROOK	25000				
LEDBETTER	PEND OREILLE	1939	RB	RAINBOW	19600				
LEDBETTER	PEND OREILLE	1939	RB	RAINBOW	21070				
LEDBETTER	PEND OREILLE	1940	EB	EASTERN BROOK	24279				
LEDBETTER	SPOKANE	1940	RB	RAINBOW	6290				
LEDBETTER	USFWS SPOKANE	1941	EB	EASTERN BROOK	3796				
LEDBETTER	PEND OREILLE	1941	RB	RAINBOW	3535				
LEDBETTER	SPOKANE	1944	RB	RAINBOW	7500				
LEDBETTER	PEND OREILLE	1947	EB	EASTERN BROOK	22700				REHABILITATED 8-19-46
LEDBETTER	PEND OREILLE	1948	EB	EASTERN BROOK	12210				
LEDBETTER	PEND OREILLE	1949	EB	EASTERN BROOK	20140				
LEDBETTER	PEND OREILLE	1950	EB	EASTERN BROOK	24000				
LEDBETTER	PEND OREILLE	1951	EB	EASTERN BROOK	20500	2050			
LEDBETTER	PEND OREILLE	1952	EB	EASTERN BROOK	20820	1735			
LEDBETTER	PEND OREILLE	1953	EB	EASTERN BROOK	20566	1582			
LEDBETTER	PEND OREILLE	1954	EB	EASTERN BROOK	20600	900			
LEDBETTER	PEND OREILLE	1955	EB	EASTERN BROOK	20150	650			
LEDBETTER	PEND OREILLE	1956	EB	EASTERN BROOK	20000	800			
LEDBETTER	PEND OREILLE	1957	EB	EASTERN BROOK	20048	716			
LEDBETTER	PEND OREILLE	1958	EB	EASTERN BROOK	20244	750			
LEDBETTER	PEND OREILLE	1959	EB	EASTERN BROOK	20179	348			
LEDBETTER	PEND OREILLE	1960	EB	EASTERN BROOK	14873	425			
LEDBETTER	PEND OREILLE	1961	EB	EASTERN BROOK	15000	500			
LEDBETTER	PEND OREILLE	1962	EB	EASTERN BROOK	15040	470			
LEDBETTER	SPOKANE	1963	EB	EASTERN BROOK	9940	140			
LEDBETTER	COLVILLE	1964	EB	EASTERN BROOK	15040	320			
LEDBETTER	SPOKANE	1965	EB	EASTERN BROOK	15120	140			
LEDBETTER	SPOKANE	1966	EB	EASTERN BROOK	14300	220			
LEDBETTER	SPOKANE	1967	EB	EASTERN BROOK	15295	115			

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
LEDBETTER	SPOKANE	1968	EB	EASTERN BROOK	15000	250			
LEDBETTER	COLVILLE	1969	EB	EASTERN BROOK	20100	240			
LEDBETTER	COLVILLE	1971	EB	EASTERN BROOK	10000	200			
LEDBETTER	COLVILLE	1972	EB	EASTERN BROOK	10075	160			
LEDBETTER	COLVILLE	1973	EB	EASTERN BROOK	10201	189			
LEDBETTER	COLVILLE	1974	EB	EASTERN BROOK	10122	166			
LEDBETTER	COLVILLE	1975	EB	EASTERN BROOK	10080	160			
LEDBETTER	COLVILLE	1976	EB	EASTERN BROOK	10050	150			
LEDBETTER	COLVILLE	1977	EB	EASTERN BROOK	11250	225			
LEDBETTER	COLVILLE	1978	EB	EASTERN BROOK	10200	102			
LEDBETTER	COLVILLE	1979	EB	EASTERN BROOK	10000	80			
LEDBETTER	COLVILLE	1980	EB	EASTERN BROOK	10148	86			
LEDBETTER	COLVILLE	1981	EB	EASTERN BROOK	10000	125			
LEDBETTER	COLVILLE	1982	EB	EASTERN BROOK	10032	114			
LEDBETTER	COLVILLE	1994	EB	FORD	6375	75	85		
LEDBETTER	COLVILLE	1994	RB	SPOK	2046	62	33		
LEDBETTER	COLVILLE	1995	EB	FORD	10032	66	152		
LEDBETTER	COLVILLE	1996	EB	FORD	10013	76	131.75		
LEDBETTER	COLVILLE	1997	EB	FORD	10030	85	118		
LEDBETTER	COLVILLE	1999	EB	FORD	9999	66	151.5		
LEDBETTER	COLVILLE	2000	EB	FORD	9990	45	222		
LEDBETTER	COLVILLE	2001	EB	FORD	10000	50	200		
MILL POND	PEND OREILLE	1933	EB	EASTERN BROOK	45000				
MILL POND	PEND OREILLE	1933	EB	EASTERN BROOK	18000				
MILL POND	PEND OREILLE	1933	EB	EASTERN BROOK	17000				
MILL POND	PEND OREILLE	1934	EB	EASTERN BROOK	30000				
MILL POND	PEND OREILLE	1934	EB	EASTERN BROOK	30000				
MILL POND	PEND OREILLE	1934	EB	EASTERN BROOK	15000				
MILL POND	PEND OREILLE	1935	CT	GENERAL	10000				
MILL POND	PEND OREILLE	1935	EB	EASTERN BROOK	25000				
MILL POND	PEND OREILLE	1935	EB	EASTERN BROOK	12530				
MILL POND	SPOKANE	1936	EB	EASTERN BROOK	3500				
MILL POND	SPOKANE	1936	EB	EASTERN BROOK	8000				
MILL POND	PEND OREILLE	1936	EB	EASTERN BROOK	15000				
MILL POND	PEND OREILLE	1936	EB	EASTERN BROOK	10000				
MILL POND	PEND OREILLE	1936	EB	EASTERN BROOK	9000				
MILL POND	PEND OREILLE	1937	EB	EASTERN BROOK	20000				
MILL POND	PEND OREILLE	1937	EB	EASTERN BROOK	16000				

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
MILL POND	PEND OREILLE	1939	RB	RAINBOW	55770				
MILL POND	PEND OREILLE	1939	RB	RAINBOW	20500				
MILL POND	PEND OREILLE	1941	RB	RAINBOW	9112				
MILL POND	SPOKANE	1942	RB	RAINBOW	8000				
MILL POND	SPOKANE	1943	RB	RAINBOW	24985				
MILL POND	SPOKANE	1944	RB	RAINBOW	25500				
MILL POND	SPOKANE	1945	RB	RAINBOW	10500				
MILL POND	FORD	1951	RB	RAINBOW	10845	9			
MILL POND	FORD	1951	RB	RAINBOW	8190	9			
MILL POND	SPOKANE	1952	RB	RAINBOW	17150	17.5			
MILL POND	SPOKANE	1953	RB	RAINBOW	10000	20			
MILL POND	SPOKANE	1953	RB	RAINBOW	10090	12			
MILL POND	SPOKANE	1954	RB	RAINBOW	20370	21			
MILL POND	SPOKANE	1965	RB	RAINBOW	15000	100			
MILL POND	COLVILLE	1974	RB	RAINBOW	10027	88			
MILL POND	COLVILLE	1975	RB	RAINBOW	10560	96			
MILL POND	COLVILLE	1976	RB	RAINBOW	10000	80			
MILL POND	COLVILLE	1977	RB	RAINBOW	10010	77			
MILL POND	COLVILLE	1978	RB	RAINBOW	10080	90			
MILL POND	COLVILLE	1979	RB	RAINBOW	10030	85			
MILL POND	COLVILLE	1980	RB	RAINBOW	10030	85			
MILL POND	COLVILLE	1981	RB	RAINBOW	10010	70			
MILL POND	COLVILLE	1982	RB	RAINBOW	10050	75			
MILL POND	COLVILLE	1982	RB	RAINBOW	10050		134	100	
MILL POND	COLVILLE	1983	RB	RAINBOW	5040		63	80	
MILL POND	COLVILLE	1984	RB	RAINBOW	10010		154	65	
MILL POND	COLVILLE	1985	RB	RAINBOW	10010		143	70	
MILL POND	COLVILLE	1986	RB	RAINBOW	10170		113	90	
MILL POND	COLVILLE	1987	RB	RAINBOW	10450		110	95	
MILL POND	COLVILLE	1988	RB	RAINBOW	10010		182	55	
MILL POND	COLVILLE	1989	RB	RAINBOW	10050		150	67	
MILL POND	COLVILLE	1990	RB	RAINBOW	9996		147	68	
MILL POND	COLVILLE	1991	RB	RAINBOW	9990		135	74	
MILL POND	COLVILLE	1992	RB	RAINBOW	10000		200	50	
MILL POND	COLVILLE	1993	RB	RAINBOW	10000		200	50	
MILL POND	COLVILLE	1994	RB	RAINBOW	10000		200	50	
MILL POND	COLVILLE	1994	RB	SPOK	10005	87	115		
MILL POND	COLVILLE	1995	RB	SPOK	10044	81	124		

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
MILL POND	COLVILLE	1996	RB	SPOK	10028	92	109		
MILL POND	COLVILLE	1997	RB	SPOK	9975	95	105		
MILL POND	COLVILLE	1998	RB	SPOK	9984	96	104		
MILL POND	COLVILLE	1999	RB	SPOK	10080	90	112		
MILL POND	COLVILLE	2000	RB	SPOK	10010	91	110		
MILL POND	COLVILLE	2002	RB	SPOK	10001	73	137		
SULLIVAN	COLVILLE	1947	CT	GENERAL	31990				
SULLIVAN	COLVILLE	1947	CT	GENERAL	90470				
SULLIVAN	SPOKANE	1949	CT	GENERAL	55941				
SULLIVAN	SPOKANE	1949	CT	GENERAL	713133				
SULLIVAN	SPOKANE	1959	CT	GENERAL	111000	418			
SULLIVAN	PEND OREILLE	1960	CT	GENERAL	179115	700			
SULLIVAN	FORD	1965	RB	RAINBOW	191907	73			
SULLIVAN	PEND OREILLE	1965	RB	RAINBOW	169990	850			
SULLIVAN	SPOKANE	1965	RB	RAINBOW	185100	85			
SULLIVAN	SPOKANE	1971	RB	RAINBOW	276270	100			
SULLIVAN	COLVILLE	1973	RB	RAINBOW	18966	87			
SULLIVAN	SPOKANE	1973	RB	RAINBOW	194800	150			
SULLIVAN	COLVILLE	1974	RB	RAINBOW	68103	88			
SULLIVAN	SPOKANE	1974	RB	RAINBOW	193870	95			
SULLIVAN	COLVILLE	1975	RB	RAINBOW	4930	58			
SULLIVAN	COLVILLE	1976	K	KOKANEE	197960	1800			
SULLIVAN	COLVILLE	1976	RB	RAINBOW	6250	50			
SULLIVAN	SPOKANE	1976	RB	RAINBOW	85600	80			
SULLIVAN	COLVILLE	1977	RB	RAINBOW	32956	77			
SULLIVAN	COLVILLE	1978	RB	RAINBOW	36750	75			
SULLIVAN	SPOKANE	1980	BT	BROWN	20103	18.7			
SULLIVAN	COLVILLE	1980	RB	RAINBOW	18750	75			
SULLIVAN	COLVILLE	1982	RB	RAINBOW	19600		200	98	
SULLIVAN	COLVILLE	1982	RB	RAINBOW	17346		177	98	
SULLIVAN	COLVILLE	1984	RB	RAINBOW	14300		220	65	
SULLIVAN	COLVILLE	1984	RB	RAINBOW	14300		220	65	
SULLIVAN	COLVILLE	1984	RB	RAINBOW	14300		220	65	
SULLIVAN	COLVILLE	1984	RB	RAINBOW	14300		220	65	
SULLIVAN	COLVILLE	1984	RB	RAINBOW	14300		220	65	
SULLIVAN	FORD	1984	CT	WESTSLOPE	16450		875	18.8	
SULLIVAN	FORD	1984	CT	WESTSLOPE	33600		800	42	
SULLIVAN	FORD	1984	CT	WESTSLOPE	37800		900	42	

Waterbody	Facility (Hatchery)	Year	Species Code	Species Name / Race	Number	Fish / Pound	Pounds	Mean Length	Notes
SULLIVAN	FORD	1984	CT	WESTSLOPE	16638		885	18.8	
SULLIVAN	FORD	1984	CT	WESTSLOPE	36120		860	42	
SULLIVAN	FORD	1984	CT	WESTSLOPE	16450		875	18.8	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	16000		200	80	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	16000		200	80	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	16000		200	80	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	16000		200	80	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	20000		250	80	
SULLIVAN	COLVILLE	1985	RB	RAINBOW	8000		100	80	
SULLIVAN	FORD	1985	CT	WESTSLOPE	25900		740	35	
SULLIVAN	FORD	1985	CT	WESTSLOPE	21175		605	35	
SULLIVAN	FORD	1985	CT	WESTSLOPE	25200		720	35	
SULLIVAN	FORD	1985	CT	WESTSLOPE	25900		740	35	
SULLIVAN	FORD	1985	CT	WESTSLOPE	27650		790	35	
SULLIVAN	COLVILLE	1986	RB	RAINBOW	80000		800	100	
SULLIVAN	COLVILLE	1986	RB	RAINBOW	12500		125	100	
SULLIVAN	COLVILLE	1998	RB	SPOK	18560	64	290		
SULLIVAN	COLVILLE	2002	KO	SAUK	43320	380	114		

Appendix 3

Sullivan Lake Creel Study

Sullivan Lake Creel Study

A two stage probability sampling design access point type creel survey (Malvestuto 1982, 1996; Knuth and McMullin 1996) was used to determine monthly and annual fishing pressure, catch-per-unit-effort (CPUE), and fish harvest (HPUE) by species on Sullivan Lake. Creel surveys were conducted on randomly selected dates on the north and south boat launches by the Kalispel Tribe of Indians and EWU personnel augmented creel data collection at the time fish and limnological surveys were conducted and on occasional weekends.

Creel surveys included 4 weekdays per month and 3-4 weekend days per month from May 2003 to November 2003. Days were selected using a random numbers generator. Pressure estimates were conducted every 3 hours by counting shoreline anglers and counting boat trailers at the boat launch. Anglers were interviewed at the end of each trip. Interview data consisted of number of hours fished, species harvested, species caught and released, angler residence by county, the species of preference and data on individual fish harvested (length and weight, tags). This information allowed us to determine the average weekend and weekday pressure by boat and shore anglers and the average catch rate (CPUE) effort in fish per hour by species by anglers of each group. Total fishing pressure, total catch and harvest (by species) over the seven month period were estimated by using the average fishing pressure and catch rates determined from angler interviews and expanding these numbers to account for days when no interviews were conducted.

Indices of each monthly estimate for each stratum were calculated separately (weekend vs. weekdays and boat vs. shoreline angler). All values were then combined to determine annual means. The following equations were used to expand the angler interview data.

Mean number of anglers per day of fishing was estimated by:

$$Xd = (Ad)(Bf)$$

Where:

Xd = mean number of anglers per boat per day for each stratum,
Ad = mean number of anglers per boat for each stratum per month, and
Bf = mean number of boats fishing for each stratum per month.

Number of hours available for fishing was estimated using the following equation:

$$Ns = (Ds)(Hd)$$

Where:

Ns = number of hours per weekend, weekday per month,
Ds = number of days per month (weekday or weekend), and
Hd = average number of hours per day for each stratum per month.

The number of hours sampled for each stratum per month was estimated using the equation:

$$n = \sum_{i=1}^{Ds} (H_{ci})$$

Where:

n = number of hours sampled for each stratum per month,
D_s = number of days per month within each stratum, and
H_{ci} = mean number of hours creeled per day for each stratum.

The number of shore anglers per day for each stratum per month was estimated using the equation:

$$Xd = \sum_{i=1}^{Pd} Spi$$

Where:

Xd = mean number of shore anglers per day for each stratum per month from pressure counts,
Pd = number of pressure counts conducted for each stratum per month, and
Spi = total number of shoreline anglers counted during pressure counts for each stratum per month.

The mean number of anglers (boat or shore) for each stratum per month was estimated using the equation:

$$Xs = (Xd)(Ds)$$

Where:

Xs = mean number of anglers for each stratum per month,
Xd = mean number of anglers for each stratum per day, and
Ds = number of days per month.

The standard deviation of anglers (boat or shore) for each stratum per month was estimated using the equation:

$$Ss = (Sd)(Ds)$$

Where:

Ss = standard deviation of mean number of angler hours for each stratum per month,
Sd = standard deviation of mean number of angler hours per day for each stratum per month, and
Ds = number of days per month for each stratum per month.

The mean number of angler hours per angler for each stratum was estimated using the equation:

$$H_a = \left(\frac{T_h}{A_i}\right)$$

Where:

H_a = mean number of angler hours per angler for each stratum per month,
T_h = total hours spent fishing for each stratum per month, and
A_i = total number of anglers interviewed for each stratum per month.

This data was combined to give an annual average that was used for monthly estimates because there were not enough anglers creeled.

Pressure was estimated for weekend and weekday for both shoreline and boat anglers for each month using the equation:

$$PE_s = \left(\frac{N_s}{n}\right)(X_s)(H_a)$$

Where:

PE_s = pressure estimate for each stratum per month,
N_s = number of hours for each stratum per month,
n = number of hours sampled for each stratum per month,
X_s = mean number of anglers for each stratum per month, and
H_a = mean number of angler hours per angler for each stratum per month.

The variance of the pressure estimate for each stratum per month was calculated by:

$$VPE_s = \left(\frac{N_s}{n}\right) S_s^2$$

Where:

VPE_s = variance of pressure estimate for each stratum per month,
N_s = number of hours for each stratum per month,
n = number of hours sampled for each stratum per month, and
S_s = standard deviation of mean number of angler hours for each stratum per month.

Ninety- five percent confidence intervals for each stratum per month were calculated by:

$$C.I. = PE \pm \sqrt{VPE_s 1.96}$$

Where:

C.I. = 95% confidence intervals for each stratum per month,
PE = pressure estimate for each stratum per month, and
VPE_s = variance of the pressure estimate for each stratum per month.

Fletcher (1988) and Malvestuto et al. (1978) found that there was no significant difference between incomplete and completed fishing trips, so completed and incomplete trips were used to calculate CPUE for each fish species in each stratum.
CPUE was calculated separately for fish captured and fish harvested for each month using the formula:

$$CPUE \text{ or } HPUE = \left(\frac{F}{T_h}\right)$$

Where:

CPUE = catch-per-unit-effort (includes all fish caught) of a particular fish species for each stratum per month,

HPUE = harvest-per-unit-effort (includes all fish kept) of a particular fish species for each stratum per month,
F = number of fish captured (includes harvested) for each stratum per month, and
T_h = total hours spent fishing for each stratum per month.

Harvest of fish species was determined for each stratum per month by the formula:

$$\text{Harvest} = (H_{pue})(PE_s)$$

Where:
Harvest = harvest of a particular species of fish for each stratum per month,
H_{cpue} = number of fish harvested of a particular species for each stratum month, and
PE_s = pressure estimate for each stratum.

Economic value of the Sullivan Lake fishery was estimated by multiplying the number of angler trips by an estimated amount that anglers spent per trip. Data compiled by the U.S. Fish and Wildlife Service in 1996, estimated that anglers averaged $25/fishing trip in eastern Washington (USDI 1998). This number was adjusted to account for inflation between 1996 and 2003 using the regional consumer price index. This number was multiplied by the number of angler trips to compute the May to November 2003 economic value of the Sullivan Lake fishery.

Results

A total of 61 days were surveyed which included 532 anglers catching a total of 133 fish. Angler pressure estimates are summarized in Table B-1. Angler pressure was greatest during the month of August (5978 hours of angler effort or 53% of the total 11,235 hours estimated to occur between May and November). Boat anglers accounted for most of the effort (11,093 hours compared to 142 hours for shore anglers). Effort favored weekend days (3,601 hours or about 277 hrs/day) compared to weekdays (7,762 hours or about 162 hrs/day).

The catch-per-unit-effort (CPUE) and harvest-per-unit-effort (HPUE) data is summarized in Table B-2. Since no fish were released, CPUE and HPUE were the same. Kokanee had the highest CPUE/HPUE (0.18 fish/hr) in the creel which peaked in June

(0.32 kokanee/hr) and August (0.38 kokanee/hr). Rainbow trout had the next highest CPUE/HPUE (0.02 rainbow/hr). Cutthroat trout, longnose sucker and burbot also appeared in angler creels.

Anglers harvested an estimated 3,733 fish from Sullivan Lake from May 2003 to November 2003 (Table B-3) including 3,526 kokanee, 113 rainbow trout, 71 longnose suckers, 35 cutthroat trout and 30 burbot (Table B-3). Kokanee harvest peaked during August (2,265 fish).

A total of 76 fish were measured for length (mm) during the creel surveys at Sullivan Lake 2003 (Table B-4). Kokanee (n = 71) measured an average of 234 mm (±18) and maximum of 271 mm in total length. Rainbow trout (n = 2) and cutthroat (n = 2) and burbot (n = 1) averaged 309 (± 2) mm, 293 (± 4) mm and 355 mm respectively.

A total of 181 anglers identified their county of residence. Fifty-six percent were from Spokane County and 38 percent were from Pend Oreille County (Table B-5). A few anglers from Benton, Grant, Island, King, Pierce, and Stevens Counties, Washington also fished at Sullivan Lake in 2003. Additionally, anglers from Arizona, British Columbia, Idaho, Montana, Oregon, and South Carolina were recorded.

In 1996, the U.S. Department of Fish and Wildlife Service estimated that anglers spent on average $25/fishing trip in eastern Washington (USDI). The adjusted value for 2003 according to the consumer price index was $29.32/fishing trip. Since there was a total of 3,121 trips made to Sullivan Lake at an average cost of $29.32 per fisherman, the estimated economic value of the Sullivan Lake fishery was $91,507.72 from May to November 2003.

Table B-1. Total monthly angler pressure estimates (±95% confidence intervals) by weekend (boat and shore), weekday (boat and shore), total boat, total shore, and grand total for Sullivan Lake, 2003.

Month	Weekend		Weekday		Total Boat	Total Shore	Grand Total
	Boat	Shore	Boat	Shore			
May	0	0	195 ± 30	2 ± 0	195 ± 30	2 ± 0	197 ± 30
June	1002 ± 133	23 ± 75	902 ± 119	75 ± 296	1904 ± 178	98 ± 237	2002 ± 296
July	592 ± 98	1 ± 15	1041 ± 149	11 ± 129	1633 ± 178	12 ± 130	1645 ± 220
August	1443 ± 161	0 ± 62	4511 ± 343	24 ± 89	5954 ± 378	24 ± 108	5978 ± 394
September	412 ± 44	0 ± 0	995 ± 108	6 ± 50	1407 ± 116	6 ± 50	1413 ± 127
October	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0
Total	**3449 ± 436**	**24 ± 152**	**7644 ± 749**	**118 ± 564**	**11093 ± 880**	**142 ± 525**	**11235 ± 1067**

Table B-2. Total angler CPUE (fish/hr) and HPUE (fish/hr) by species for each month at Sullivan Lake, 2003.

Species	May	Jun	Jul	Aug	Sep	Oct	Nov	Ave
Kokanee	0.18	0.32	0.14	0.38	0.25	0.00	0.00	0.18
Rainbow Trout	0.04	0.00	0.00	0.00	0.07	0.00	0.00	0.02
Cutthroat trout	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Burbot	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Longnose sucker	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.01
Total	**0.21**	**0.37**	**0.17**	**0.38**	**0.32**	**0.00**	**0.00**	**0.21**

Table B-3. Total estimated harvest (± 95 confidence intervals) by species for each month creel was performed at Sullivan Lake, 2003.

Species	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
Kokanee	35 ± 5	644 ± 95	230 ± 31	2,265 ± 149	352 ± 32	0	0	3,526 ± 312
Rainbow Trout	7 ± 1	0	5 ± 1	0	100 ± 9	0	0	113 ± 11
Cutthroat trout	0	25 ± 4	11 ± 1	0	0	0	0	35 ± 5
Burbot	0	25 ± 4	5 ± 1	0	0	0	0	30 ± 4
Longnose sucker	0	50 ± 7	21 ± 3	0	0	0	0	71 ± 10
Total	**42 ± 6**	**744 ± 110**	**272 ± 37**	**2,265 ± 149**	**452 ± 41**	**0**	**0**	**3,733 ± 336**

Table B-4. Number of fish measured, average (± standard deviation), minimum and maximum lengths (mm) of species caught by anglers at Sullivan Lake, 2003.

Species	n	Average Length	Min. Length	Max. Length
Kokanee	71	234 ± 18	195	271
Rainbow trout	2	309 ± 2	307	310
Cutthroat trout	2	293 ± 4	290	295
Burbot	1	355 ± 0	355	355
Total	**76**	**239**	**195**	**355**

Table B-5. Total number (n) and percent (%) of anglers county/state residents that fished at Sullivan Lake, 2003.

County/State	n	Percent (%)
Arizona	1	0.55
Canada	1	0.55
Idaho	6	3.20
Montana	1	0.55
Oregon	3	1.65
S. Carolina	2	1.10
WA-Benton	2	1.10
WA-Grant	4	2.20
WA-Island	1	0.55
WA-King	2	1.10
WA-Pierce	2	1.10
WA-PO	69	38.00
WA-Spokane	84	46.15
WA-Stevens	4	2.20
Total	**182**	**100**

Appendix 4

Summary of GIS/Database Administration Activities for 2003

Joint Stock Assessment Project

2003 Report on Activities

Conducted by
Jim LeMieux
Kalispel GIS Administrator

Summary

It was a challenging year for the GIS program. The completion of the unified database (UDB) in FY 2002 produced a robust RDBMS, however, this required a lot of time developing a format schema for new data. Our counterpart with the Colville Confederated Tribes resigned in the summer of 2003, leaving us without a data contact. Despite these setbacks, we have moved forward, and are preparing to develop a web-based tool to filter and extract data directly from the UDB on-line. We are continuing to support JSAP field biologists in the development and mapping of survey sample locations and report generation.

Database management

The complex nature of the UDB necessitated the development of a migration matrix to format new data tables for their eventual inclusion into the UDB. This was a difficult task, for only limited metadata was provided by the contractor to explain where each data column should reside, let alone how it should be formatted. It was requested to the contractor that a procedural manual be developed to detail the steps necessary to format each data field. A matrix now exists for most fish and habitat data fields. Several data columns are still pending, awaiting consultation with the contractor.

Map production

Numerous hard copy and electronic maps were produced for the various participants in the JSAP. These included paper maps for field surveys and soft copy maps for report generation.

GIS Administration

The administration of GIS software and related hardware continues to be a housekeeping chore necessary to stay efficient and up to date with the latest GIS technology. The ArcGIS 8.1 family of software was upgraded to Arc 8.3. This was a minor software release mainly to improve performance and bug fixes.

A new server was purchased by the Kalispel Tribe to replace the aging server in the Spokane office. This required the migration of all GIS data, SQL Server 2000 software and the UDB. This new server has put the Joint Stock project in a better position to develop an on-line clearinghouse for UDB data.

Significant tasks:

- A RFP was generated for the development of a web-based data extraction tool for the dissemination of UDB data.

- A matrix was developed to identify the correct migration path for each data column for the Kalispel habitat and fish databases. This exercise was coordinated with WDFW on their data migration matrix.

- Several survey maps were generated of the Little Spokane River watershed for WDFW (J. McLellan).

- Data was imported and Geo-coded for the 2002 KNRD fish and habitat surveys.

- Data was imported and Geo-coded for the 2002 WDFW fish and habitat survey (J. McLellan).

- Survey maps were generated of Sullivan Lake and Harvey Creek for KNRD (J. Connor).

- Survey maps were generated for the KNRD (J. Connor) 2002 and 2003 JSAP annual report.

- Attended the following Microsoft certified courses: Implementing a Database on Microsoft SQL Server 2000 and Querying Microsoft SQL Server 2000.

Setbacks

- Due to time constraints, not all JSAP related data layers were made Federal Geographic Data Committee (FGDC) compliant.
- Due to the complexities involved with formatting the UDB, 2002-03 JSAP collected data have not be uploaded into the UDB.
- Due to communication problems and the resignation of the data liaison, data obtained from the Colville Confederated Tribes was not formatted in the correct manner, nor was it parsed correctly, therefore, that data has not been considered for inclusion into the UDB.

2003 WDFW Annual Report for the Project
RESIDENT FISH STOCK STATUS
ABOVE CHIEF JOSEPH AND GRAND COULEE DAMS

Part I. Baseline Assessment of Fish Species Distribution and Densities
In the Little Spokane River Drainage, Year 3,
And
The Spokane River below Spokane Falls

Part II. Assessment of the Harvey Creek Kokanee Spawning Run

Part III. Coordination, Data Standards Development,
and Data Sharing Activities

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March 2005

2003 WDFW Annual Report for the Project
RESIDENT FISH STOCK STATUS
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March 2005

Abstract

Limited baseline fish distribution or instream habitat data had been collected on the free flowing portions of the middle Spokane River and the Little Spokane River drainage. The objectives of this study were to determine: 1) baseline fish distribution and densities in the middle Spokane River, 2) age, growth, and condition of sport fish in the middle Spokane River, 3) baseline habitat conditions and fish distribution and density in the Little Spokane River and eight tributaries, as part of a multi-year effort to survey the entire drainage, and 4) characterize the genetic structure of the wild rainbow trout populations in the middle Spokane River and tributaries of the Little Spokane River.

The portion of the free-flowing middle Spokane River examined in this study occurred between Spokane Falls and T.J. Meenach Bridge. Fish were sampled with a drift boat mounted with an electrofishing unit. Scale samples were collected from wild sport fish for age and growth analysis. Twelve species of fish were collected in the river. Bridgelip suckers had the highest overall catch-per-unit-effort (CPUE) and mountain whitefish had the highest sport fish CPUE. Ages of wild rainbow trout ranged from 1 to 5. Condition (K_{TL}) was average when compared to other populations, but mean relative weight (W_r) was lower than the national standard. Ages of mountain whitefish ranged from 1 to 6. Condition (K_{TL}) was good when compared to other populations, but mean W_r was lower than the national standard.

Little Spokane River tributaries surveyed were Little Deep, North Fork Little Deep, South Fork Little Deep, Pell, Deadman, South Fork Deadman, and Dartford Creeks. Habitat parameters were measured at each fish survey site. Fish were collected by multiple-pass backpack electrofishing. The Little Spokane River was the largest stream surveyed based on mean wetted and bankfull widths. Pell Creek was the smallest stream based on mean wetted and bankfull widths. The greatest diversity of fish was in the Little Spokane River (19 species) and the lowest was in Pell Creek (1 species). With the exception of the Little Spokane River and Deadman Creek, angling opportunities were limited due to the lack of stock and legal length trout and limited access.

The results of the DNA analysis indicated that there were several independent populations within the greater Spokane River drainage generally comprised of larger streams and their tributaries (i.e., Dragoon Creek). Hybridization with coastal rainbow trout, cutthroat trout and redband rainbow trout appeared minimal.

Acknowledgements

We thank the Kalispel Tribe for administration of the Joint Stock Assessment Project, in particular Jason Connor and Joe Maroney. We gratefully acknowledge John Whalen (WDFW) for advice and guidance in all aspects of the project design and implementation. We thank Jim Lemieux for generating maps and watershed statistics and the following individuals for their assistance with field collections: Leslie King, Chris Moan, Randy Osborne, Marc Divens, Karin Divens, Jeff Lawlor, Heather Woller, and Chris Donley (WDFW), Dr. Al Scholz, Derek Rader, Bret Nine, Connie Fox, and Holly McLellan (Eastern Washington University). We also thank Jim Shaklee, Sewall Young, Janet Loxterman, and Maureen Small (WDFW Genetics Lab) for conducting microsatellite DNA analysis. We would also like to thank John Sneva and Lucinda Morrow (WDFW Fish Aging Lab) for conducting the scale analysis. We thank Chris Donley, Curt Vail, and John Whalen (WDFW), as well as Holly McLellan and Dr. Al Scholz (EWU) for reviewing this report.

Funding for this project was provided by the U.S. Department of Energy, Bonneville Power Administration, Project No. 199700400, through a sub-contract with the Kalispel Tribe of Indians. A portion of the funding for the DNA analysis of the samples from the middle and upper Spokane River rainbow populations was provided by Avista Utlilities.

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Introduction

Project Background

The Joint Stock Assessment Project (JSAP), developed in 1997, is a cooperative project of the Washington Department of Fish and Wildlife (WDFW), Kalispel Tribe of Indians, Spokane Tribe of Indians, and Colville Confederated Tribes. The objective of the JSAP is to assess fish stocks and associated habitats, and generate a management plan(s) for protection, mitigation, and enhancement of resident fish in the blocked area watersheds above Chief Joseph and Grand Coulee Dams. In order to identify data gaps and effectively house stock assessment data, the participants developed a central database of fisheries related data for the blocked area that is accessible to all blocked area managers. Initial development of the database involved collecting all existing data. Using the historical database, data gaps were identified and new investigations were initiated to fill those gaps.

The Little Spokane River drainage was identified as a high priority watershed for 2001-2003. In addition, the Spokane River between Spokane Falls and Nine Mile Dam, which we call the middle Spokane River, was identified as a priority in 2002 and 2003. This document describes survey results for the middle Spokane River and the third year of sampling in the Little Spokane River drainage.

History of the Spokane and Little Spokane Rivers

When the first Europeans arrived in the region, the fish communities of the Spokane and Little Spokane River systems were comprised of chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), resident trout (*O.* spp.), whitefish (*Prosopium* spp.), and suckers (*Catostomus* spp.) (Scholz et al. 1985). There was reportedly a small run of sockeye salmon (*O. nerka*) that migrated up the Little Spokane River to Chain Lake (WDFW Region 1 lake management file, 1956). Prior to the construction of Little Falls Dam in 1911, the fish resources in the Spokane River system provided a subsistence fishery for local Native American tribes and a nationally recognized sport fishery for the early white settlers (Scholz et al. 1985).

The species composition of the Spokane River and its tributaries began to change following the completion of Little Falls Dam, which prevented salmon and steelhead from

returning to the system. There were also numerous introductions of non-indigenous fish species, which further changed the species composition (WDFW, unpublished hatchery records, A. Scholz, EWU, personal communication). Human impacts, such as timber harvest, agriculture, and commercial and residential development, are assumed to have had negative impacts on the remaining fish populations. However, prior to 2001 little instream habitat or fish data had been collected on the middle Spokane River or Little Spokane River systems.

The most substantial fisheries related work on the Spokane River was completed on the upper stretches near the Idaho/Washington border (Bailey and Saltes 1982; Bennett and Underwood 1988; Underwood and Bennett 1992; Johnson 1997), Long Lake (Pfeiffer 1985; Bennett and Hatch 1989; Bennett and Hatch 1991; Osborne et al. 2003), and the Spokane Arm of Lake Roosevelt (e.g. Peone et al. 1990; Griffith and Scholz 1990; McLellan 1998; Cichosz et al. 1999). The results from the previous fisheries work on the middle Spokane River was summarized in McLellan (2003b).

Prior to 2001, there had been little instream habitat or fish distribution data collected on the Little Spokane River or its tributaries. The only habitat information consisted of standardized stream assessment surveys (3 sites) conducted by the Washington Department of Ecology (WDOE) and temperature monitoring conducted by the Spokane County Conservation District (SCCD). The majority of the fish surveys in the Little Spokane River system occurred on the lakes (Zook 1978; Mongillo and Hallock 1995; Hallock and Mongillo 1998; Polacek and Baldwin 1999; Phillips and Divens 2000; Divens et al. 2001; 2002a; 2002b). The fish population data collected on the free flowing portions of the drainage consisted of work on the lower 27.0 km of the Little Spokane River, with the exception of various single site electrofishing surveys conducted on the upper Little Spokane River and eleven of its tributaries. All of the previous instream habitat and fish survey work in the Little Spokane River drainage was summarized in McLellan (2003a).

In 2001 and 2002, the WDFW Joint Stock Assessment Project personnel completed standardized surveys of thirteen tributaries of the Little Spokane River (McLellan 2003a and 2003b). Fish distribution data from those surveys were included with the previous data to develop a table of known fish occurrences in the Little Spokane River drainage, as of the spring of 2003 (Table 1).

Spokane and Little Spokane River Stocking Histories

Fish have been planted in the Spokane and Little Spokane River basins over the last 110 years. Several species of fish were planted, including rainbow trout, brown trout, cutthroat trout, eastern brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), steelhead, kokanee, bass (*Micropterus* spp.), crappie (*Pomoxis* spp.), yellow perch, and catfish (*Ameiurus* spp.) (WDFW, unpublished hatchery records; A. Scholz, EWU, personal communication). The unpublished WDFW plant records for the Spokane River from 1933 through 2002 were provided in McLellan (2003b). The stocking regime for the middle Spokane River in 2003 was 2,500 brown trout planted in Nine Mile Reservoir.

The unpublished WDFW plant records for the Little Spokane River drainage from 1933 through 2001 were provided in McLellan (2003a). The stocking regime for the Little Spokane River drainage in 2003 included approximately 15,000 brown trout and 47,678 rainbow trout in Diamond Lake, 21,635 eastern brook trout and 7,500 rainbow trout in Sacheen Lake, 7,500 rainbow trout in Horseshoe Lake, 3,000 rainbow trout in Fan Lake, and 5,000 brown trout in Eloika Lake.

Table 1. Updated list of fish species reported to occur within the Little Spokane River system.

Common Name	Species Name	Location	Source
Salmonidae			
Brown Trout	*Salmo trutta*	Beaver Creek[2]	McLellan (2003b)
		Dragoon Creek	McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Eloika Lake	Divens et al. (2001)
		Little Spokane River	Hartung and Meier (1980); EWU, unpubl. data 2001
		Otter Creek	McLellan (2003a)
		Sacheen Lake	WDFW, unpubl. data 2000
		Spring Creek	McLellan (2003b)
		WB Dragoon Creek	McLellan (2003b)
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
		Wethey Creek	WDFW, unpubl. data 2002
Eastern Brook Trout	*Salvelinus fontinalis*	Bear Creek	McLellan (2003a)
		Beaver Creek[1]	McLellan (2003a)
		Beaver Creek[2]	McLellan (2003b)
		Buck Creek	EWU, unpubl. data 2000; McLellan (2003a)
		Deer Creek	WDFW, unpubl. data 1978; EWU, unpubl. data 1999; McLellan (2003a)
		Dragoon Creek	EWU, unpubl. data 2001; McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Heel Creek	McLellan (2003a)
		Little Deer Creek	EWU, unpubl. data 1999; McLellan (2003b)
		Little Spokane River	EWU, unpubl. data 1999
		Mud Creek	Lines (1982)
		Otter Creek	WDFW, unpubl. data 1974; McLellan (2003a)
		Sacheen Lake	Divens et al. (2002b)
		S. Fork Deadman Creek	EWU, unpubl. data 1999
		Spring Creek	McLellan (2003b)
		Spring Heel Creek	McLellan (2003a)
		Trout Lake	WDFW, unpubl. data 1993
		WB Dragoon Creek	McLellan (2003b)
		Wethey Creek	WDFW, unpubl. data 2002
Lake Trout	*Salvelinus namaycush*	Horseshoe Lake	WDFW, unpubl. data 1993, 1995, 1997
Kokanee	*Oncorhynchus nerka*	Buck Creek	EWU, unpubl. data 2000

Common Name	Species Name	Location	Source
		Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Horseshoe Lake	WDFW, unpubl. data 1993, 1995, 1997
		Little Spokane River	EWU, unpubl. data 2000
Rainbow Trout	*Oncorhynchus mykiss*	Bear Creek	McLellan (2003a)
		Beaver Creek[1]	McLellan (2003a)
		Beaver Creek[2]	McLellan (2003b)
		Buck Creek	EWU, unpubl. data 2000; McLellan (2003a)
		Chain Lake	Polacek and Baldwin (1999)
		Dartford Creek	WDFW, unpubl. data 1986, 1992
		Deadman Creek	EWU, unpubl. data 1999
		Deer Creek	EWU, unpubl. data 1999; McLellan (2003a)
		Diamond Lake	Phillips and Divens (2000)
		Dragoon Creek	EWU, unpubl. data 2001; McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Eloika Lake	Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Horseshoe Lake	WDFW, unpubl. data 1993
		Little Deep Creek	EWU, unpubl. data 1999
		Little Deer Creek	EWU, unpubl. data 1999; McLellan (2003b)
		Little Spokane River	Hartung and Meier (1980, 1995); Peden (1987); Pfeiffer (1988); EWU, unpubl. data 1999, 2001
		Otter Creek	WDFW, unpubl. data 1974; McLellan (2003a)
		Spring Creek	McLellan (2003b)
		Trout Lake	WDFW, unpubl. data 1993
		WB Dragoon Creek	McLellan (2003b)
		WB Little Spokane River	McLellan (2003a)
		Wethey Creek	WDFW, unpubl. data 2002
Mountain Whitefish	*Prosopium williamsoni*	Bear Creek	McLellan (2003a)
		Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Dragoon Creek	McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Horseshoe Lake	WDFW, unpubl. data 1993
		Little Spokane River	Hartung and Meier (1980, 1995); Pfeiffer (1988); EWU, unpubl. data 2001
		Otter Creek	McLellan (2003a)
		WB Little Spokane River	McLellan (2003a)

Common Name	Species Name	Location	Source
		Wethey Creek	WDFW, unpubl. data 2002
Pygmy Whitefish	*Prosopium coulteri*	Horseshoe Lake	Mongillo and Hallock (1995); Hallock and Mongillo (1998)
		Little Spokane River	Hartung and Meier (1980)
Esocidae			
Grass Pickerel	*Esox americanus vermiculatus*	Buck Creek	EWU, unpubl. data 2000
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Little Spokane River	Hartung and Meier (1980, 1995)
		WB Little Spokane River	McLellan (2003a)
Cyprinidae			
Carp	*Cyprinus carpio*	Little Spokane River	Hartung and Meier (1980)
Chiselmouth	*Acrocheilus alutaceus*	Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Dragoon Creek	McLellan (2003b)
		Little Spokane River	Hartung and Meier (1980, 1995); Peden (1987); Pfeiffer (1988); EWU, unpubl. data 1999, 2001
		WB Dragoon Creek	McLellan (2003b)
Longnose Dace	*Rhinichthys cataractae*	Bear Creek	McLellan (2003a)
		Deadman Creek	EWU, unpubl. data 1999
		Deer Creek	McLellan (2003a)
		Dragoon Creek	McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Little Deep Creek	EWU, unpubl. data 1999
		Little Spokane River	Hartung and Meier (1980, 1995); Peden (1987); EWU, unpubl. data 2001
		WB Dragoon Creek	McLellan (2003b)
		WB Little Spokane River	McLellan (2003a)
Northern Pikeminnow	*Ptychocheilus oregonensis*	Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Dragoon Creek	Lines (1982); EWU, unpubl. data 2001; McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Little Spokane River	Hartung and Meier (1980, 1995); Pfeiffer (1988); EWU, unpubl. data 1999, 2001
Redside Shiner	*Richardsonius balteatus*	Beaver Creek[2]	McLellan (2003b)
		Chain Lake	Polacek and Baldwin (1999)
		Deadman Creek	EWU, unpubl. data 1999
		Dragoon Creek	Lines (1982); McLellan (2003b)
		Little Deep Creek	EWU, unpubl. data 1999

Common Name	Species Name	Location	Source
		Little Spokane River	Hartung and Meier (1980; 1995); Peden (1987); Pfeiffer (1988); EWU, unpubl. data 1999, 2001
		WB Dragoon Creek	McLellan (2003b)
Speckled Dace	*Rhinichthys osculus*	Bear Creek	McLellan (2003a)
		Beaver Creek[2]	McLellan (2003b)
		Deadman Creek	EWU, unpubl. data 1999
		Dragoon Creek	EWU, unpubl. data 2001; McLellan (2003b)
		Little Deep Creek	EWU, unpubl. data 1999
		Little Spokane River	EWU, unpubl. data 1999
		Otter Creek	McLellan (2003a)
		WB Dragoon Creek	McLellan (2003b)
Tench	*Tinca tinca*	Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Little Spokane River	Hartung and Meier (1980)
		Sacheen Lake	Divens et al. (2002b)
		Trout Lake	WDFW, unpubl. data 1993
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Catostomidae			
Bridgelip Sucker	*Catostomus columbianus*	Bear Creek	McLellan (2003a)
		Beaver Creek[2]	McLellan (2003b)
		Deadman Creek	EWU, unpubl. data 1999
		Dragoon Creek	EWU, unpubl. data 2001; McLellan (2003b)
		Little Deep Creek	EWU, unpubl. data 1999
		Little Spokane River	Hartung and Meier (1980, 1995); EWU, unpubl. data 2001
		WB Dragoon Creek	McLellan (2003b)
Largescale Sucker	*Catostomus macrocheilus*	Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Dragoon Creek	McLellan (2003b)
		Little Spokane River	Hartung and Meier (1980, 1995); Peden (1987); Pfeiffer (1988); EWU, unpubl. data 2001
Longnose Sucker	*Catostomus catostomus*	Horseshoe Lake	WDFW, unpubl. data 1993
		Little Spokane River	Hartung and Meier (1980)
		Little Spokane River	Pfeiffer (1988)
		Trout Lake	WDFW, unpubl. data 1993
White Sucker	*Catostomus commersi*	Little Spokane River	Hartung and Meier (1995)
Centrarchidae			

Common Name	Species Name	Location	Source
Black Crappie	*Pomoxis nigromaculatus*	Chain Lakes	WDFW, unpubl. data 1993
		Diamond Lake	Phillips and Divens (2000)
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Little Spokane River	Hartung and Meier (1980)
		Sacheen Lake	Divens et al. (2002b)
Bluegill	*Lepomis macrochirus*	Horseshoe Lake	WDFW, unpubl. data 1995
		Little Spokane River	Hartung and Meier (1980)
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Green Sunfish	*Lepomis cyanellus*	Bear Creek	McLellan (2003a)
		Diamond Lake	Phillips and Divens (2000)
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Horseshoe Lake	WDFW, unpubl. data 1995
		Sacheen Lake	Divens et al. (2002b)
		Trout Lake	WDFW, unpubl. data 1993
Largemouth Bass	*Micropterus salmoides*	Diamond Lake	Phillips and Divens (2000)
		Dry Creek	McLellan (2003a)
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Little Spokane River	Hartung and Meier (1980); Pfeiffer (1988)
		Sacheen Lake	Divens et al. (2002b)
		Spring Heel Creek	McLellan (2003a)
		Trout Lake	WDFW, unpubl. data 1993
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Pumpkinseed	*Lepomis gibbosus*	Diamond Lake	Phillips and Divens (2000)
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Horseshoe Lake	WDFW, unpubl. data 1993
		Little Spokane River	Hartung and Meier (1980, 1995)
		Sacheen Lake	Divens et al. (2002b)
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Smallmouth Bass	*Micropterus dolomieui*	Eloika Lake	Zook (1978)
Percidae			
Yellow Perch	*Perca flavescens*	Chain Lake	WDFW, unpubl. data 1993; Polacek and Baldwin (1999)
		Diamond Lake	Phillips and Divens (2000)

Common Name	Species Name	Location	Source
		Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Horseshoe Lake	WDFW, unpubl. data 1993, 1995
		Little Spokane River	Hartung and Meier (1980)
		Sacheen Lake	Divens et al. (2001)
		Trout Lake	WDFW, unpubl. data 1993
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Ameiurus			
Black Bullhead	*Ameiurus melas*	Eloika Lake	Divens et al. (2001)
Brown Bullhead	*Ameiurus nebulosus*	Diamond Lake	Phillips and Divens (2000)
		Dragoon Creek	McLellan (2003b)
		Eloika Lake	Divens et al. (2001)
		Little Spokane River	Hartung and Meier (1980); EWU, unpubl. data 1999
		Sacheen Lake	Divens et al. (2002b)
		Trout Lake	WDFW, unpubl. data 1993
Yellow Bullhead	*Ameiurus natalis*	Eloika Lake	Zook (1978); Divens et al. (2001)
		Fan Lake	Divens et al. (2002a)
		Horseshoe Lake	WDFW, unpubl. data 1995
		Spring Heel Creek	McLellan (2003a)
		WB Little Spokane River	EWU, unpubl. data 1999; McLellan (2003a)
Cottidae			
Sculpin spp.	*Cottus* spp.	Buck Creek	EWU, unpubl. data 2000
		Dragoon Creek	Lines (1982); EWU, unpubl. data 2001
		Little Spokane River	EWU, unpubl. data 1999
		Wethey Creek	WDFW, unpubl. data 2002
Mottled Sculpin	*Cottus bairdi*	Beaver Creek[2]	McLellan (2003b)
		Deer Creek	McLellan (2003a)
		Dragoon Creek	McLellan (2003b)
		Dry Creek	McLellan (2003a)
		Little Spokane River	Hartung and Meier (1980, 1995); Peden (1987)
		Otter Creek	McLellan (2003a)
		Spring Creek	McLellan (2003b)
		WB Dragoon Creek	McLellan (2003b)
		WB Little Spokane River	McLellan (2003a)
Slimy Sculpin	*Cottus cognatus*	Bear Creek	McLellan (2003a)
		Buck Creek	McLellan (2003a)

Common Name	Species Name	Location	Source
Torrent Sculpin	*Cottus rotheus*	Dragoon Creek	McLellan (2003b)
		Dry Creek	McLellan (2003a)
		WB Dragoon Creek	McLellan (2003b)

[1]Beaver Creek; tributary to the West Branch Little Spokane River.
[2]Beaver Creek; tributary to Dragoon Creek.

Study Area

Spokane River

The Spokane River originates at the outlet of Lake Coeur d'Alene, Idaho and flows west through the city of Spokane, Washington. Just west of Spokane, it bends and flows north to Tum Tum, Washington, where it bends west and flows to its confluence with the Columbia River. Seven hydropower projects have been constructed on the Spokane River between Lake Coeur d'Alene and the Columbia River. The dams, in order from most upstream, are Post Falls, Upriver, Upper Falls, Monroe Street, Nine Mile, Long Lake, and Little Falls.

The focus of this study was the 16.3 km free-flowing section between the Monroe Street Dam (river kilometer, rkm 119.1) and T.J. Meenach Bridge (rkm 105.7). The free-flowing section was characterized as having pool-riffle-run sequences, characteristic of lotic systems (Kleist 1987). The mean daily discharge of the middle Spokane River during water year (WY) 2003 (Oct. 1, 2002 to Sep. 30, 2003) measured below Monroe Street Dam, (rkm 117.2) was 135.3 m^3/s [4,779.1 cubic feet/sec (cfs)] (USGS, Spokane, unpublished data). The only notable tributary of the middle Spokane River in the study area was Latah Creek, (also known as Hangman Creek) (rkm 116.5). During WY 2003, Latah Creek contributed an average of 2.9% (3.9 m^3/s; 138.8 cfs) of the mean daily discharge of the middle Spokane River (USGS, Spokane, unpublished data). There was also a location of groundwater inflow near T.J. Meenach Bridge. The 25-year mean discharges for the middle Spokane River and Latah Creek were 175.2 m^3/s (6,186.2 cfs) and 6.0 m^3/s (213.3 cfs).

The free-flowing portion of the middle Spokane River is open to fishing year-round and is managed as a selective trout fishery. Angling gear is limited to unscented artificial flies or lures with a single barbless hook and anglers are not allowed to fish from any floating device equipped with a motor. The daily bag limit for trout is one with a minimum length of 208 mm (8 inches). Only hatchery rainbow trout can be retained. Hatchery rainbow trout are marked with a clipped adipose fin. The other game fish are managed with general statewide bag limits and minimum size restrictions.

Little Spokane River

The Little Spokane River is located in eastern Washington, north of the city of Spokane. It has two main branches, the east (hereafter referred to as the Little Spokane River) and the west. The headwaters of both branches occur in Pend Oreille County, southeast of Newport, WA. McLellan (2003a) provided a detailed description of the Little Spokane River system. The mean daily discharge of the Little Spokane River during WY 2003 measured at Dartford (rkm 17.5) was 7.7 m^3/s (272.4 cfs) and at the Indian Painted Rocks (rkm 6.3) was 14.5 m^3/s (512.3 cfs) (USGS, Spokane, unpublished data).

The Little Spokane River and eight of its tributaries were surveyed in 2003. The tributaries were Burping Brook, Dartford, Deadman, Little Deep, North Fork Little Deep, Pell, South Fork Deadman, and South Fork Little Deep Creeks (Table 2).

All of the streams surveyed in 2003 were managed under the Statewide General Freshwater Regulations for Streams, Rivers and Beaver Ponds. The statewide regulations permitted angling from June 1st through October 31st. Harvest regulations were two trout, 208 mm (8 in.) or longer, except eastern brook trout, which had a bag limit of 5, with no minimum size. However, anglers were allowed to harvest 5 trout total, of which only two could be species other than eastern brook trout. General statewide bag limits and minimum size restrictions applied to all other game fish species.

Table 2. Characteristics of the tributaries surveyed in 2003. Elevations are in meters above mean sea level.

Stream	Order	Length (Km)	Headwater Elevation (m)	Mouth Elevation (m)
Burping Brook	2	2.4	1,566	1,003
Dartford Creek	3	7.6	580	487
Deadman Creek	4	33.8	1,494	497
Little Deep Creek	3	15.6	609	499
Little Spokane River	6	72.7	667	471
North Fork Little Deep Creek	2	8.0	1,254	609
Pell Creek	1	7.4	943	610
South Fork Deadman Creek	2	8.7	1,383	747
South Fork Little Deep Creek	2	3.9	1,408	609

Study Objectives

The objectives of the 2003 study were as follows:

- Determine the fish species present in the free-flowing middle Spokane River between Monroe Street Dam and T.J. Meenach Bridge.
- Calculate relative abundances and catch-per-unit effort as indices of abundance for each fish species in the free-flowing middle Spokane River between Monroe Street Dam and T.J. Meenach Bridge.
- Determine the age structure and growth of the wild sport fish populations in the free-flowing middle Spokane River between Monroe Street Dam and T.J. Meenach Bridge.
- Calculate indices of condition for game fish in the free-flowing middle Spokane River between Monroe Street Dam and T.J. Meenach Bridge.
- Quantify instream habitat at fish sample sites in the Little Spokane River and eight tributaries: Burping Brook and Dartford, Deadman, Little Deep, North Fork Little Deep, Pell, South Fork Deadman, and South Fork Little Deep Creeks.
- Determine the fish species present in the Little Spokane River and the previous eight tributaries.
- Estimate relative abundances, population sizes, and densities of each fish species in the Little Spokane River and and the previous eight tributaries.
- Characterize the population structure of wild rainbow trout in the Spokane River and the Little Spokane River and its tributaries, using microsatellite DNA techniques.

Methods

Spokane River

The free-flowing stretch of the Spokane River, between Spokane Falls and T.J. Meenach Bridge, was sampled on May 21, June 17, and July 22 (Figures 1 through 3). Sampling was conducted during the day using a drift boat mounted with a Smith-Root 2.5 GPP electrofishing unit, except for the July survey, which began at dusk. Electrofishing settings were: voltage = low (50-500), percent = 50, pulse rate = 60 pulses/second Direct Current (DC), and amperage = 1.5 to 2.0. Mean daily discharge on May 21, June 17, and July 22 was 209.0 m^3/s (7,380 cfs), 103.1 m^3/s (3,640 cfs), and 27.9 m^3/s (986 cfs) (USGS, Spokane, unpublished data). The entire stretch of the river was sampled and shoreline sample sections were systematically chosen by alternating them on subsequent sample dates beginning with the shorelines opposite those randomly selected for the 2002 survey (McLellan 2003a). However, sampling was occasionally limited to the navigable portions of the channel.

Each fish collected was identified to species, measured (total length, TL; mm), and recorded. During the July sample on the middle river, the bridgelip and largescale suckers were only counted, due to warm water temperatures and a crowded live-well. Scale samples and weights (g) were obtained from a subset of sport fish. For the purposes of this report, sport fish species were defined as those species that are most commonly targeted by anglers in the study area, such as trout (*Oncorhynchus* spp., *Salmo* spp. and *Salvelinus* spp.), landlocked salmon (*Oncorhynchus* spp.), mountain whitefish, bass (*Micropterus* spp.), sunfish (*Lepomis* spp. and *Pomoxis* spp.), perch, walleye (*Sander vitreum*), and catfish (*Ameiurus* spp.). Sport fish are not to be confused with game fish, which are listed in state RCW 77.08.020 and WAC 232.12.019. Game fish include all of the sport fish species listed above, as well as suckers *(Catostomus* spp.), northern pikeminnow, and peamouth (*Mylocheilus caurinus*) that are not commonly sought after by sport anglers in the study area. Catch-per-unit-effort (CPUE) was determined for each fish species collected (number of fish/hour). The CPUE for each fish species was calculated, using all fish, as an index of relative density. Randomly chosen sample sections can contribute to high variability among samples, therefore, 80 percent confidence intervals (CI) were calculated for each mean CPUE by species and by sampling method. Species composition by number (relative abundance) was calculated from fish collected by dividing the number of individuals of each species captured by the total number of fish of all species captured, and multiplying by 100.

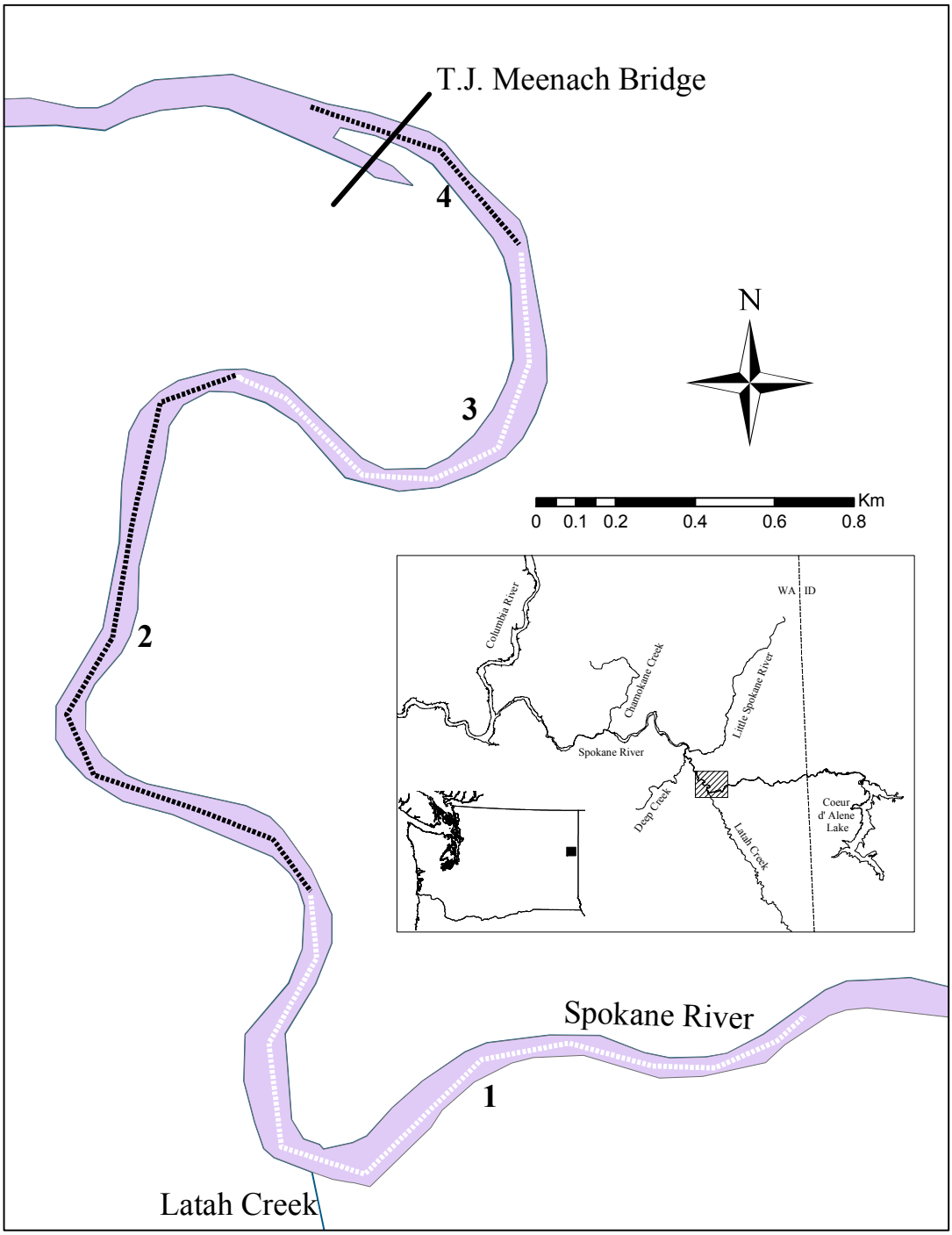

Figure 1. Electrofishing transects surveyed in May on the Spokane River. Dotted lines indicate transects. Line colors alternate between transects.

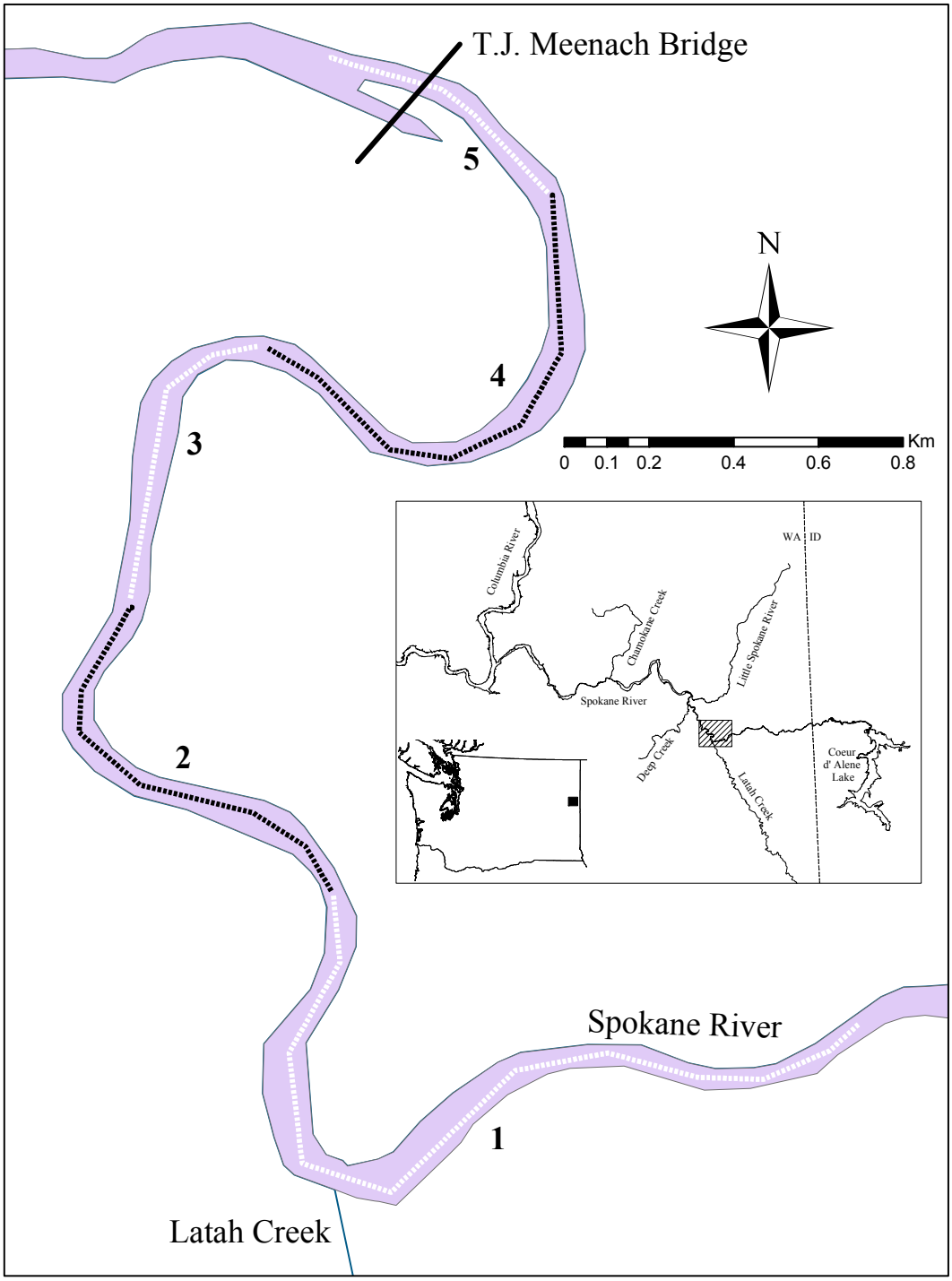

Figure 2. Electrofishing transects surveyed in June on the Spokane River. Dotted lines indicate transects. Line colors alternate between transects.

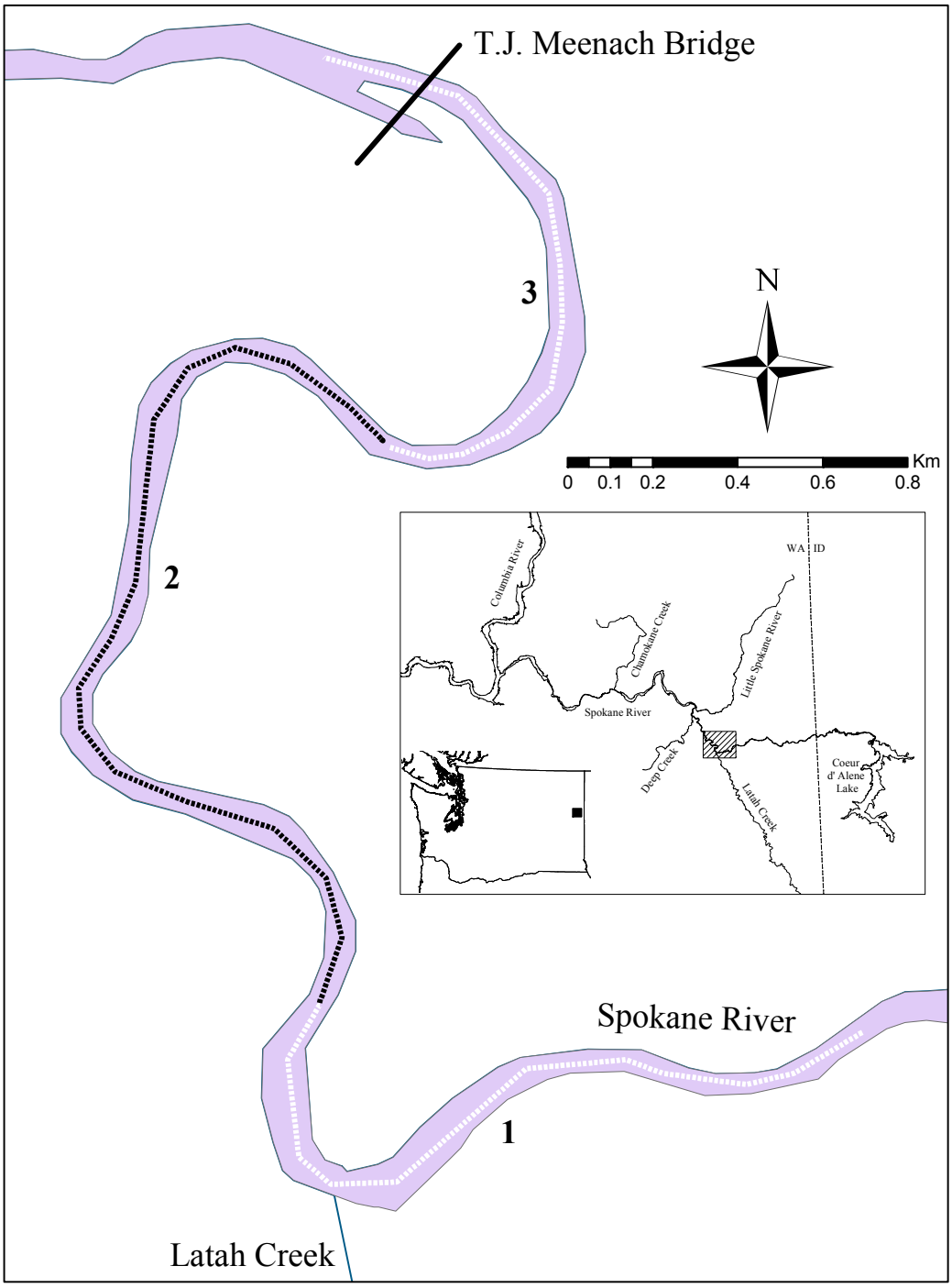

Figure 3. Electrofishing transects surveyed in July on the Spokane River. Dotted lines indicate transects. Line colors alternate between transects.

Proportional stock density (PSD) was calculated for each sport fish species collected. The PSD's were calculated by dividing the number of fish ≥ the minimum quality length by the number of fish ≥ the minimum stock length, and multiplying by 100 (Anderson and Neuman 1996). Stock length was defined as the minimum length of fish with recreational value (20-26% of world record) and quality length was defined as the minimum size of fish that anglers would like to catch (36-41% of world record) (Gabelhouse 1984). Relative stock densities were calculated to provide a proportion of stock length fish that were longer than quality length fish, relative to the world record. The three categories used for RSD were preferred, memorable, and trophy (Gabelhouse 1984). Preferred length was the minimum length of fish anglers would prefer to catch (45-55% of world record). Memorable length was the minimum length of fish anglers would remember catching (59-64% of world record). Trophy length was the minimum length of fish worthy of acknowledgement (74-80% of world record). RSD's were calculated by dividing the number of fish ≥ a specific length by the number of fish ≥ the minimum stock length, and multiplying by 100 (Anderson and Neuman 1996). Stock, quality, preferred, memorable, and trophy lengths were provided for fish collected (Table 3). Eighty percent confidence intervals were calculated, assuming a normal distribution, as an indication of precision.

Age and growth was evaluated from scale samples. Scale samples were sent to the WDFW Fish Aging Lab in Olympia for analysis. The direct proportional method was used to back-calculate the total length at the formation of each annulus of mountain whitefish (Devries and Frie 1996). The back-calculation equation was,

$$L_i = \left(\frac{L_c - a}{S_c} \right) S_i + a$$

where, L_i was the back-calculated TL of the fish at the formation of the ith annulus, L_c was the TL of the fish at capture, S_c was the length from the focus to the outermost edge of the scale at capture, S_i was the length from focus of the scale to the outer edge of the ith annulus, and a was the y-intercept of the body length-scale length regression line. The direct proportional method assumed the intercept value, a, was equal to 0. Back-calculations were not completed for rainbow trout due to the high number of scales that were reabsorbed.

The relative weight (W_r) index was used to evaluate the condition of sport fish collected in the middle Spokane River. The index was calculated as,

$$W_r = \frac{W}{W_s} x100$$

where, W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length calculated with the standard weight (W_s) equation (Murphy and Willis 1991). The W_s equations were obtained from Andersen and Neuman (1996) and Bister et al. (2000). When available, the lotic W_s equation was used. A W_r value of 100 generally indicates that a fish is in good condition (Anderson and Gutreuter 1983; Anderson and Neuman 1996).

In addition to relative weights, condition factors (K_{TL}) were calculated as an index of how fish add weight in relation to increasing length (Anderson and Neuman 1996). Mean condition factor was calculated for all sport fish age 1 or older and ≥100 mm TL using the formula,

$$K_{TL} = \left(\frac{W}{TL^3}\right) \times 10^5$$

where, W is the weight (g) and TL is the total length (mm) of an individual fish.

Table 3. Length categories used for PSD and RSD calculations. The lengths listed represent total lengths (mm; Anderson and Neuman 1996). Numbers in parentheses are the percent of the world record (Gabelhouse 1984).

	Standard Length Categories				
Species	**Stock (20-26)**	**Quality (36-41)**	**Preferred (45-55)**	**Memorable (59-64)**	**Trophy (74-80)**
Brown trout	150	230	300	380	460
Cutthroat trout	200	350	450	600	750
Rainbow trout	250	400	500	650	800

Little Spokane River/Tributaries

Habitat Surveys

Each stream was stratified into reaches using a USGS topographic map (1:24,000 scale) (Figure 4; Appendix B). Reaches were defined as portions of streams with similar gradient between confluences with tributaries and road crossings. Each reach was divided into 100 m survey sections that were numbered consecutively moving upstream from the mouth. We randomly selected 10% of the survey sections in each reach to be sampled for habitat and fish distribution (Figure 5; Appendix C). Platts et al. (1983) recommended sampling 10% of a stream's length for baseline surveys of habitat and fish distribution.

Stream habitat surveys were always completed following fish sampling. Habitat surveys consisted of two parts, the survey section measurements and transect measurements. Survey section measurements were those that were measured for the entire length of the 100 m survey section and included counts of the total numbers of primary pools (PP) and acting large woody debris (LWD), as well as measurements of stream channel gradient (%) and water and air temperatures (°C). Total numbers of PP's and LWD were used to estimate their mean densities per reach, as well as the entire stream. Densities were calculated as the number of PP per km and the number of LWD per 100 m. A PP was defined as a pool that was longer or wider than the mean wetted width of the survey section. The length (0.1 m), width (0.1 m), maximum depth (cm), and tailout depth (cm) were measured in each primary pool that occurred within each survey section (KNRD 1997). The residual pool depth was calculated by summing the maximum and tailout depths and dividing by two (KNRD 1997). Acting LWD were considered any piece of organic debris with a diameter > 10 cm and a length > 1 m that intruded into the stream (KNRD 1997). Exposed root wads of live trees were only counted if they were intruding the stream. Large debris dams causing one particular effect on the stream were counted as a single piece of LWD (KNRD 1997). Stream channel gradient was defined as the change in vertical elevation per unit horizontal distance of the channel (Platts et al. 1983; KNRD 1997). Gradient was measured with a clinometer (Suunto Corp.). Water temperatures were measured in the middle of the thalweg. Air temperatures were measured away from the water's surface and out of direct sunlight. Mean values and standard deviations of each parameter were calculated for each reach and stream.

Transect measurements consisted of those that were measured along a line that was perpendicular to the stream flow. The number of transects sampled was determined using a modified version of the protocol described by Simonson et al. (1994). Simonson et al. (1994) reported that estimates spaced a minimum of two mean stream widths apart within a survey section 35 mean stream widths long were within 5% of the true value 95% of the time. The first transect occurred at the downstream end of the fish survey section and subsequent transects were measured in an upstream direction. The spacing of the subsequent transects was based on a visual estimate of the mean stream (wetted) width of the survey section. If the mean stream width was < 5 m, transects were spaced two or three times the mean stream width apart and the total number of transects was determined by how many occurred in a distance of 35 times the mean stream width or 100 meters, which ever was shorter. If the mean stream width was ≥ 5 m, transects were spaced every 10 m for 100 m. Unlike the protocol suggested by Simonson et al. (1994), the habitat transects were limited to the 100 m survey sections due to the large number of private landowners and the reduced precision was considered acceptable for the baseline survey.

Habitat parameters were measured or visually estimated along each transect. Parameters included habitat type, habitat width, wetted width, bankfull width, mean depth, maximum depth, percent composition of each substrate type, and percent embeddedness. Mean values and standard deviations of each habitat parameter were calculated for each reach and stream.

Habitat types were divided into three categories: pool, riffle, and run. Pools were defined as portions of the stream with reduced current velocity and usually deeper than a riffle (KNRD 1997). A riffle was a shallow rapid where the water flowed swiftly over completely or partially submerged obstructions to produce surface agitation (KNRD 1997). Runs were stream segments with intermediate characteristics between pools and riffles (Platts et al. 1983).

The wetted width of a stream was defined as the distance from the edge of the water on each shoreline, perpendicular to the flow of the stream. If the channel was braided, the wetted width of each braid was measured and summed to provide a total wetted width. Wetted width was measured to the nearest tenth of a meter. If a transect had two segments of a similar habitat type, their widths were summed to provide a single width for that habitat type.

The bankfull (or channel) width was defined as the cross section of the stream valley containing the stream that was distinct from the surrounding area due to breaks in the general slope of the land, lack of terrestrial vegetation, and changes in the composition of the substrate

material (Platts et al. 1983). The bankfull width contained the stream bottom and stream bank and a bankfull flow fills the channel with water to the point just prior to its spreading onto the flood plain (Platts et al. 1983). The bankfull width was measured to the nearest tenth of a meter.

Mean stream depth was determined from summing the depth measurements (cm) taken at ¼, ½, and ¾ the wetted width along the transect line and dividing them by four to account for the zero depth values at each shoreline (Platts et al. 1983). Maximum stream depths (cm) were measured at each transect. The maximum depths provide the thalweg depth, or the line connecting the deepest points along the streambed (KNRD 1997).

The percent composition of each substrate type along each transect line was estimated visually (Table 4). The percent embeddedness was visually estimated along the transect line. Embeddedness was defined as the percentage of the surface area of larger substrate particles (cobble, rubble, and boulder) that were surrounded by fine particles (sand and smaller) (Platts et al. 1983).

Definite and potential, natural and human-made fish barriers were identified on each stream surveyed. Natural fish barriers were described as falls or chutes. Falls were vertical overflow portions of the stream (Powers and Orsborn 1985). Chutes were defined as steep, sloping, open channels with high velocities (Powers and Orsborn 1985). Human-made barriers consisted of culverts and dams. A falls or culvert was determined to be a definite barrier if it had a vertical height of 3.4 m (11.0 ft), which exceeded the maximum leaping height of the healthiest steelhead (610-792 mm TL) with a maximum burst speed of 8.1 m/s (26.5 ft/s) (Powers and Orsborn 1985). We assumed the swimming abilities of steelhead exceeded those of resident trout. A good takeoff pool is required for fish to leap any height, so a relatively low fall without a good take off pool may act as a total barrier (Powers and Orsborn 1985). Waterfalls with vertical heights ≥ 1.5 m, without a plunge pool were considered a potential barrier. Culverts with a vertical height of ≥ 2.5 m were reported as potential barriers because they lacked landing pools. The lack of good landing pools reduces the chance of passage (Powers and Orsborn 1985). A chute was considered a potential barrier if it had a smooth bedrock substrate and a slope ≥ 25% and a length ≥ 15.0 m. Brook trout were found to ascend a 14.5 m long chute with 22% slope (Adams et al. 2000).

Stream temperatures (^{o}C) were recorded with Tidbit® temperature loggers (Onset Corp., MA) between May 29 and December 16. The temperature-logging interval was every two hours.

The loggers were fixed with identification tags and were attached to logs or root wads near the stream bottom, out of direct sunlight. Loggers were placed near the mouth of all of the streams monitored (Figure 6). Two additional loggers were set in the middle and upper reaches of Deadman Creek. The Little Spokane River had five additional loggers spaced out between the lower and upper reaches, at the Indian Painted Rocks USGS gaging station, Wandermere USGS gaging station, Chattaroy USGS gaging station, Elk, and Scotia (Figure 6). Mean temperatures and standard deviations were calculated for the complete recording period and for the period from May 29 to October 28, which was approximately the same time period measured in 2002, for comparisons.

Table 4. Description of substrate classification used for stream habitat assessments (modified from KNRD 1997).

Substrate Type	**Description**
Bedrock	Large masses of solid rock
Boulder	>30.5 cm (>12.0 in.)
Rubble	15.2 - 30.5 cm (6.0 in. - 12.0 in.)
Cobble	7.6 - 15.2 cm (3.0 in. - 6.0 in.)
Gravel	0.6 - 7.6 cm (0.25 in. - 3.0 in.)
Sand	<0.6 cm (<0.25 in.)
Silt	Fine sediments with little grittiness.
Muck	Decomposed organic material, usually black in color.
Organic Debris	Undecomposed herbaceous material.

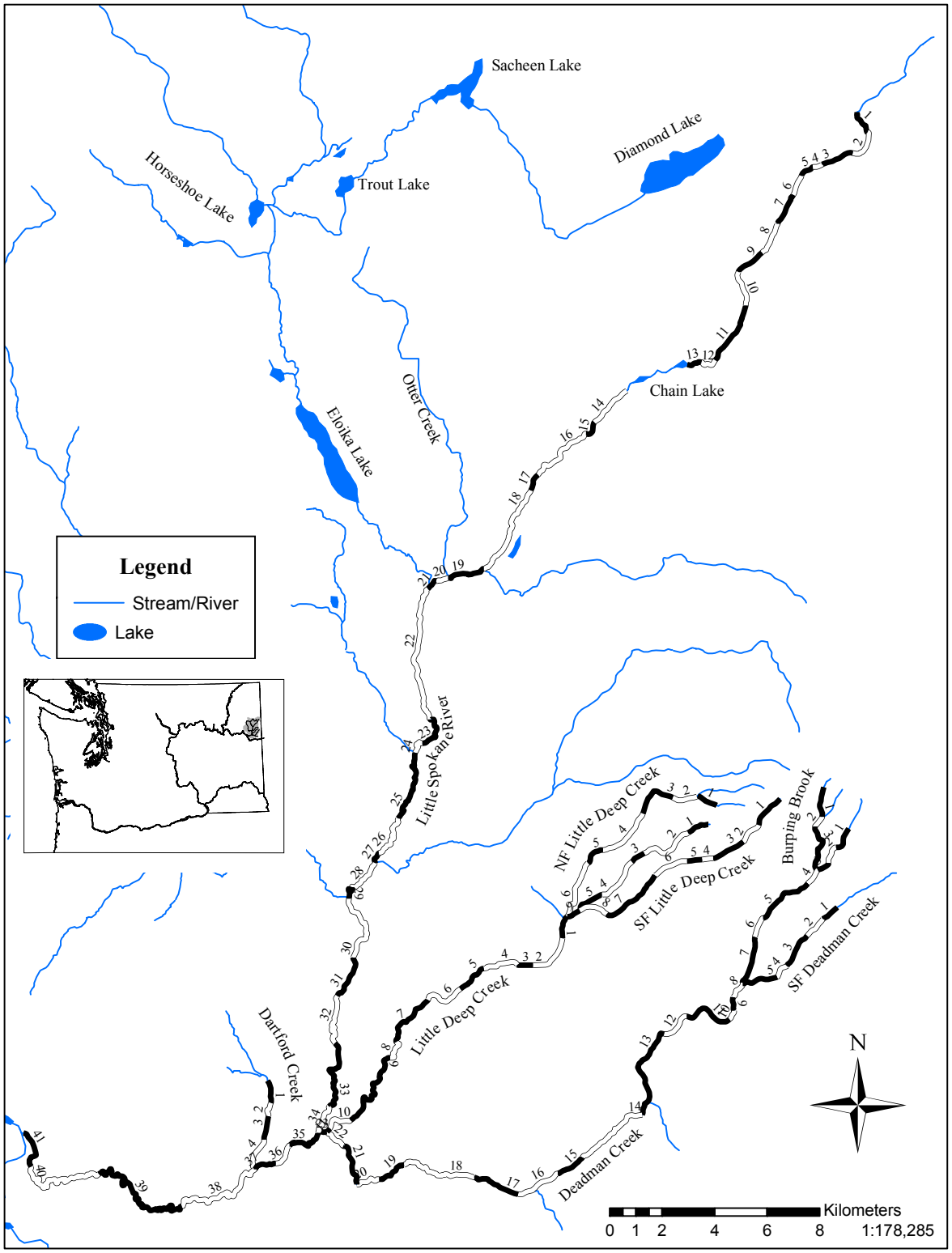

Figure 4. Habitat and fish stratified sampling reaches on the Little Spokane River, Burping Brook, and Dartford, Deadman, Little Deep, North Fork Little Deep, Pell, South Fork Deadman, and South Fork Little Deep Creeks.

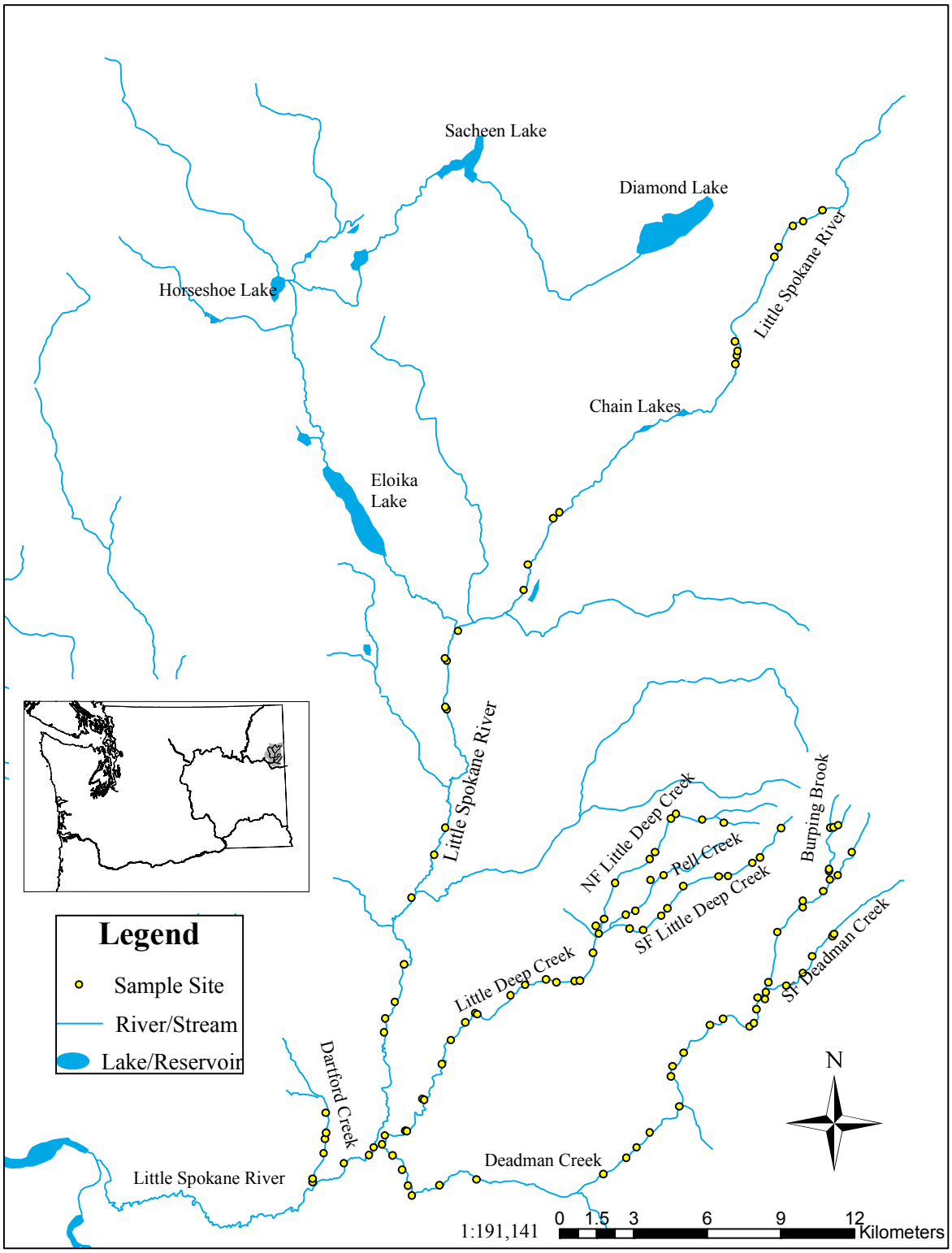

Figure 5. Randomly selected habitat and fish sample sites on the Little Spokane River, Burping Brook, and Dartford, Deadman, Little Deep, North Fork Little Deep, Pell, South Fork Deadman, and South Fork Little Deep Creeks.

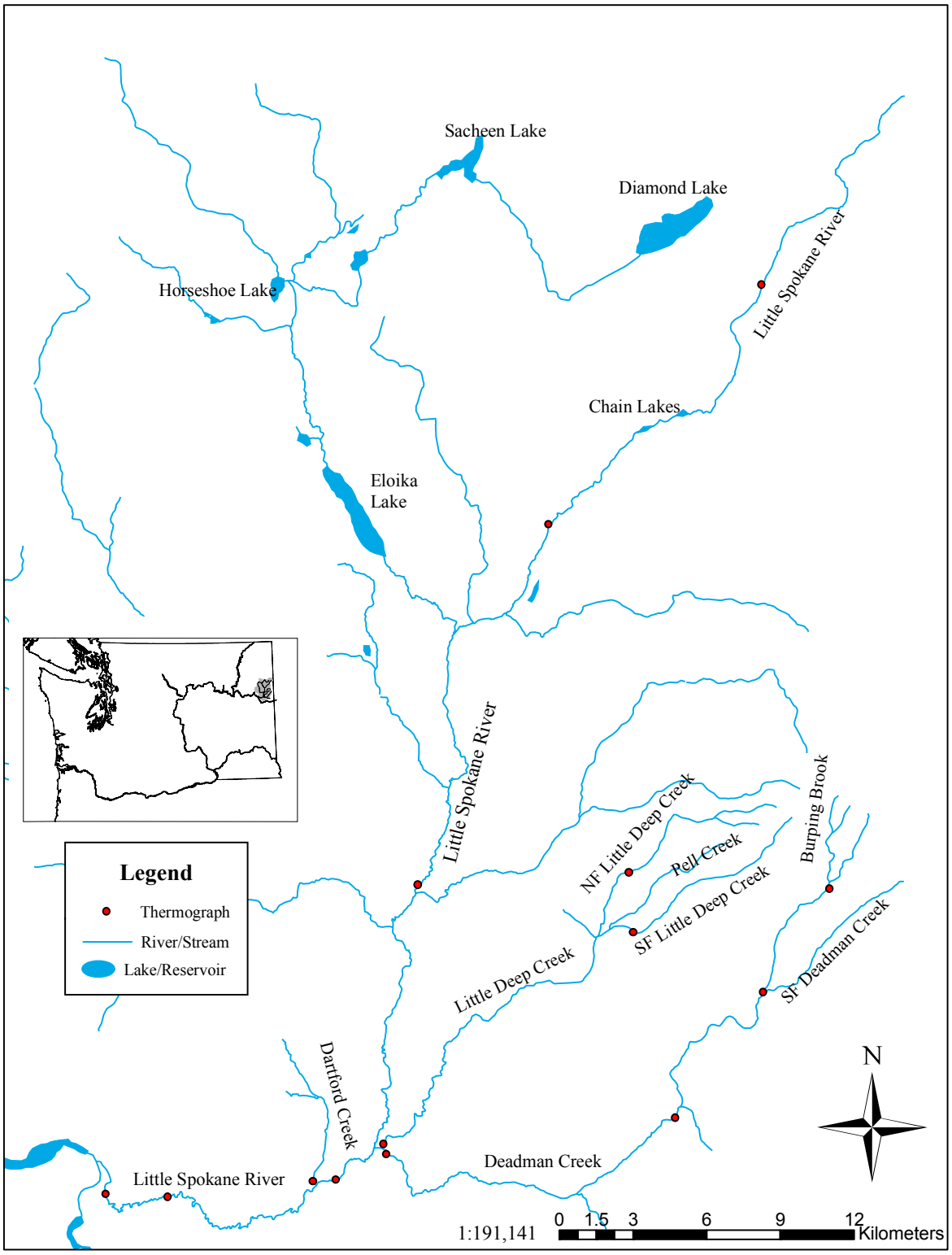

Figure 6. Locations of thermographs in the Little Spokane River drainage, 2003.

Fish Surveys

Fish presence, relative abundance, population size, and density were determined from backpack electrofishing data collected at each survey section. A multiple-pass removal-depletion sampling strategy was used for fish collection (White et al. 1982; Platts et al. 1983), except for the Little Spokane River surveys. The Little Spokane River surveys were single pass because of water conditions that prevented completely blocking the stream, such as deep water, high velocities, and dense vegetation. During the multiple-pass surveys, two passes were completed, unless a greater than 50% depletion of each species of salmonids was not achieved, in which case additional passes were completed until a greater than 50% reduction was achieved. Block nets (1.22 m x 15.24 m; 0.64 cm mesh) were placed across the stream at the downstream and upstream ends of the survey section prior to electrofishing. The 100 m distance between the block nets was measured with a hip chain (string box), while walking parallel to the stream on the bank. Electrofishing was conducted beginning at the downstream end, moving upstream, while attempting to electrofish the stream consistently on each pass. Effort was standardized on subsequent passes to ensure consistency. All fish collected on each pass were identified, counted, measured to the nearest mm total length (TL), and released outside of the blocked survey section. A sub-sample of sculpins from what appeared to be different species were collected from each stream for identification. The sculpins were fixed in 95% ethanol and keyed using Hallock (2003).

The relative abundance of fish in each stream was calculated by dividing the total number of fish of a particular species caught by the total number of all species caught, and multiplying it by 100. Length-frequency distributions were developed for each game fish species collected in each stream, when 25 or more individuals were collected.

In order to assess harvest potential, the proportion of the populations of eastern brook trout that were of stock length and brown and rainbow trout that were of legal length for harvest (208 mm; 8 in.) were calculated. Stock length for lotic eastern brook trout was 130 mm TL (Anderson and Neumann 1996).

Population estimates were calculated for each species of fish at each survey section using the CAPTURE model Zippin M_b (Otis et al. 1978; White et al. 1982), except the Little Spokane River surveys. Fish < 50 mm TL were excluded because they were observed passing through the mesh of the block nets. Densities (number of fish/100 m^2) were calculated by dividing the

population estimate in a survey section, by the surface area (m^2) of the survey site, which was multiplied by 100. The surface area of the survey section was determined by multiplying the mean wetted width (m) of the survey section by its the length (m). Population estimates were not calculated for the surveys of the Little Spokane River, so densities were calculated using the total number of fish captured on the single pass.

Population Characterization with DNA Analysis

Tissue samples were collected from wild rainbow trout populations for microsatellite DNA analysis. When sampling the stream populations, tissue was obtained from a maximum of 5 individuals per site, at a randomly selected subset of the fish survey sites. When insufficient sample sizes were obtained in upstream sites, more than 5 fish were sampled at some lower sites or fish were sampled from the next closest site. Tissue samples were collected from the first 59 wild rainbow trout captured in the middle Spokane River. Personnel from Parametrix, Inc. collected 41 tissue samples from wild rainbow trout, while conducting rainbow trout research on the Spokane River. In addition, tissue samples were collected from 70 (Parametrix n=31; WDFW n=39) wild rainbow trout from the upper Spokane River (above Upriver Dam; rkm 129.1) for comparisons to the middle Spokane River and Little Spokane River populations.

Tissue was obtained by either clipping the left ventral or adipose fin. Each sample was preserved in absolute ethanol and assigned a unique identification code that was printed on waterproof paper and placed in the sample vial. The WDFW Genetics Laboratory conducted the microsatellite DNA analysis and statistical tests (see Appendix M). Three hypotheses were tested: 1) the rainbow trout in sampled streams comprise one single, interbreeding population, 2) the rainbow trout in the sampled streams are genetically indistinguishable from one or more hatchery strain (Spokane Hatchery stock or Phalon Lake conservation stock), and 3) the rainbow trout in the sampled streams are interior redband strain (*O. mykiss gairdneri*, represented by Phalon Lake stock) not coastal strain (*O. m. irideus*, represented by Spokane Hatchery stock).

Results

Spokane River

Twelve species of fish were collected in the free-flowing Spokane River (Table 5). Catch-per-unit-effort (CPUE) and relative abundance were calculated for each species and month (Table 6; Appendix D). Bridgelip suckers were the most abundant species, based on CPUE (108.4 fish/hr; SD=28.8) and relative abundance (44.8%; n=296) (Table 6). Mountain whitefish were the most abundant sport fish species, based on CPUE (72.2 fish/hr; SD=10.4), and relative abundance (29.7%; n=196) (Table 6). Six (6.8%) of the 88 rainbow trout captured were of hatchery origin.

Proportional stock densities (PSD) and relative stock densities (RSD) were calculated for each sport fish species collected (Table 7). Sample sizes were too small for interpretation.

Ages of wild rainbow trout ranged from 1 to 5. Mountain whitefish from the free-flowing stretch ranged in age from 1 to 6. Mean back-calculated total lengths at the formation of each annulus were calculated for mountain whitefish (Table 8).

The mean W_r of rainbow trout was 89 (SD=12). The mean and the majority (84.5%; n=71) of individual rainbow trout W_r values were below the national standard (Figure 7). The mean W_r of the mountain whitefish was 88 (SD=12). Similar to the rainbow trout, mean and the majority (88.2%; n=60) of the individual mountain whitefish W_r values were below national standard (Figure 7). Mean total length, weight, W_r, and K_{TL} was calculated for each sport fish species collected in the free-flowing and reservoir sections (Table 9).

Table 5. Common and scientific names of fish species captured in the free-flowing Spokane River, 2003.

Common Name	Species Name
Salmonidae	
Brown trout	*Salmo trutta* Linnaeus
Cutthroat trout	*Onchorhynchus clarki* (Mitchell)
Rainbow trout	*Oncorhynchus mykiss* (Walbaum)
Mountain whitefish	*Prosopium williamsoni* (Girard)
Cyprinidae	
Chiselmouth	*Acrocheilus alutaceus* Agassiz and Pickering
Longnose dace	*Rhinichthys cataractae* (Valenciennes)
Northern pikeminnow	*Ptychocheilus oregonensis* (Richardson)
Redside shiner	*Richardsonius balteatus* (Richardson)
Catostomidae	
Bridgelip sucker	*Catostomus columbianus* (Eigenmann and Eigenmann)
Largescale sucker	*Catostomus macrocheilus* (Girard)
Cottidae	
Sculpin spp.	*Cottus* spp.

Table 6. Total (May-July, 2003) relative abundance, catch per unit effort (CPUE; ± 80% CI), mean total length (± SD), and size range of fish captured in the middle Spokane River between Spokane Falls and T.J. Meenach Bridge (total effort = 2.74 hours; 13 sites).

Species	n	Relative Abundance (%)	CPUE (#/hour)	Mean Total Length (mm)	Size Range (mm)
Brown trout	1	0.2	0.6 (± 0.7)	332	332
Cutthroat trout	1	0.2	1.4 (± 1.8)	352	352
Rainbow trout	88	13.3	39.9 (± 13.6)	333 (± 59)	135-413
Mountain whitefish	196	29.7	72.2 (± 10.4)	332 (± 33)	221-426
Sculpins	2	0.3	0.8 (± 0.7)	72 (± 12)	63-80
Chiselmouth	1	0.2	0.3 (± 0.3)	175	175
Longnose dace	3	0.5	0.9 (± 0.8)	73 (± 10)	63-82
Northern pikeminnow	6	0.9	2.6 (± 1.6)	389 (± 145)	142-585
Redside shiner	3	0.5	0.9 (± 0.8)	100 (± 12)	88-112
Bridgelip sucker	296	44.8	108.4 (± 28.8)	324 (± 75)[1]	87-462[1]
Largescale sucker	63	9.5	21.3 (± 5.5)	427 (± 89)[1]	94-562[1]

[1]Bridgelip and largescale suckers were not measured during the July sample, so the means and standard deviations were calculated with May and June data only.

Table 7. Annual PSD and RSD values (± 80% CI) of sport fish collected in the Spokane River in 2003.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
Brown trout	1	100	100	0	0
Cutthroat trout	1	100	0	0	0
Rainbow trout	78	6.4 (3.6)	0	0	0

Table 8. Mean back-calculated total lengths (± standard deviation) at the formation of each annulus for mountain whitefish collected in the free-flowing section of the middle Spokane River during 2003.

		Mean Total Length at the Formation of Each Annulus					
Cohort	**n**	**1**	**2**	**3**	**4**	**5**	**6**
2002	1	162 (nc)					
2001	1	147 (nc)	282 (nc)				
2000	10	168 (± 13)	252 (± 17)	297 (± 20)			
1999	20	178 (± 22)	270 (± 27)	306 (± 24)	337 (± 25)		
1998	17	189 (± 25)	279 (± 22)	309 (± 25)	333 (± 30)	358 (± 31)	
1997	2	154 (± 0)	283 (± 14)	311 (± 9)	332 (± 12)	361 (± 9)	381 (± 9)
Grand Mean	51	178 (± 23)	270 (± 25)	306 (± 23)	335 (± 26)	358 (± 30)	381 (± 9)
Mean Annual Growth		178 (± 23)	92 (± 25)	36 (± 11)	27 (± 10)	26 (± 9)	20 (± 0)

Table 9. Mean total length (TL), weight, relative weight (W_r), and condition factor (K_{TL}) (± SD) of all sport fish species collected in the Spokane River in 2003.

Species	**n**	**TL (mm)**	**Weight (g)**	**W_r**	**K_{TL}**
Brown trout	1	332	400	102	1.09
Cutthroat trout	1	352	450	97	1.03
Rainbow trout	84	333 (± 59)[1]	376 (± 146)	89 (± 12)	0.97 (± 0.13)
Mountain whitefish	68	339 (± 34)[1]	345 (± 84)	87 (± 13)	0.88 (± 0.13)

[1]Only includes lengths of fish that were also weighed.

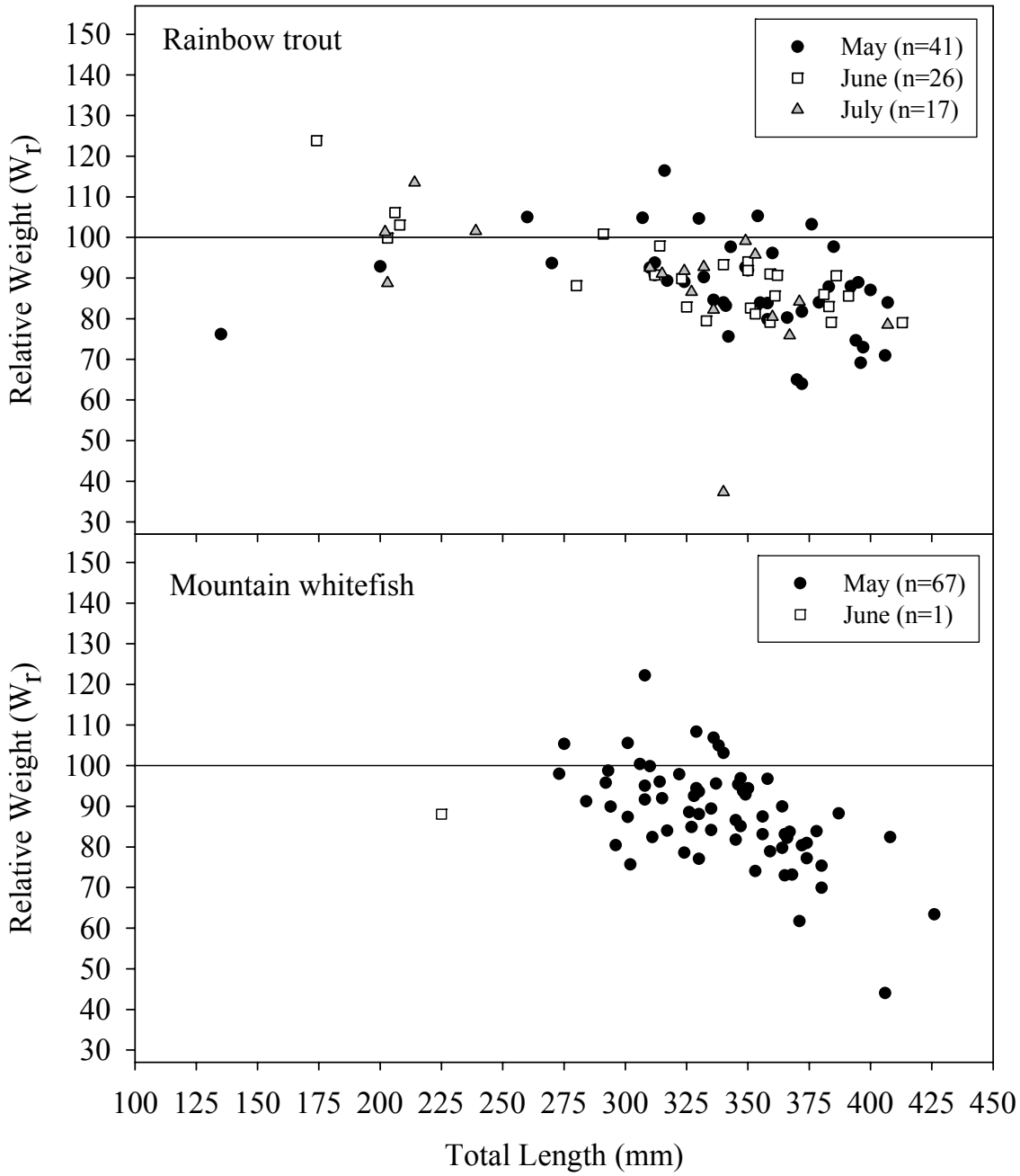

Figure 7. Relative weights of rainbow trout and mountain whitefish collected in the free-flowing Spokane River. The national standard of 100 generally indicates good condition.

Little Spokane River

Burping Brook

Burping Brook was divided into three reaches that were sampled on August 4 (Figure 4; Appendix B). A total of five sites were surveyed (Figure 5; Appendix C). The mean and standard deviation (SD) of each habitat parameter was calculated for the stream, as well as each reach (Table 10; Appendix E). The mean wetted width of Burping Brook was 1.7 m (SD=0.7) and the mean depth was 6 cm (SD=3) (Table 10). The dominant habitat and substrate types were riffle (84%) and sand (37%), respectively (Table 10).

Eastern brook and rainbow trout were the only two species of fish collected in Burping Brook (Table 11). Eastern brook trout were the most abundant species, based on relative abundance (99.4%; n=163) (Table 11). The percentage of the eastern brook trout population that was of stock length was 28.8% (n=47) (Figure 8). The rainbow trout was shorter than the legal length for harvest.

Population estimates, their corresponding standard errors and 95% confidence intervals, as well as densities were calculated for eastern brook and rainbow trout (Table 12).

Table 10. Mean values (± SD) of habitat parameters measured and counted in Burping Brook.

Sample Sizes		**Riffle Habitat**	
No. Reaches	3	No. Riffles	72
No. Sections	5	Riffle Width (m)	1.7 (± 0.7)
No. Transects	84	Riffle Occurrence (%)	84
		Pool Habitat	
Transect Measurements		No. Pools	9
Wetted Width (m)	1.7 (± 0.7)	Pool Width (m)	1.6 (± 0.5)
Bankfull Width (m)	3.1 (± 1.1)	Pool Occurrence (%)	10
Depth (cm)	6 (± 3)	**Run Habitat**	
Maximum Depth (cm)	14 (± 6)	No. Runs	5
		Run Width (m)	1.4 (± 0.5)
Survey Section Measurements		Run Occurrence (%)	6
Gradient (%)	11.6 (± 6.1)		
Water Temperature (^{o}C)	12.4 (± 2.7)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	16.1 (± 2.3)	Organic	5 (± 10)
No. LWD/100 m	43 (± 22)	Muck	0 (± 0)
No. PP/km	4 (± 5)	Silt	7 (± 10)
		Sand	37 (± 19)
Primary Pools (PP)		Gravel	17 (± 17)
No. PP	2	Cobble	14 (± 14)
PP Width (m)	2.2 (± 0.2)	Rubble	10 (± 13)
PP Length (m)	2.3 (± 1.1)	Boulder	11 (± 20)
PP Max. Depth (cm)	33 (± 4)	Bedrock	0 (± 0)
PP Residual Depth (cm)	19 (± 3)	Embeddedness (%)	58 (± 20)

Table 11. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in Burping Brook.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
No Fish				
2				
Eastern brook trout	20	100.0	108 (± 35)	53-157
3				
Eastern brook trout	143	99.3	92 (± 44)	42-184
Rainbow trout	1	0.7	169	169
Total				
Eastern brook trout	163	99.4	94 (± 43)	42-184
Rainbow trout	1	0.6	169	169

Table 12. Population estimates (N), their corresponding standard errors (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in Burping Brook.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
3	5	66	2.2080	65	75	31
3	6	53	5.1541	50	74	26
2	19	20	0.4899	20	20	16
Rainbow trout						
3	5	1	0.0000	1	1	<1

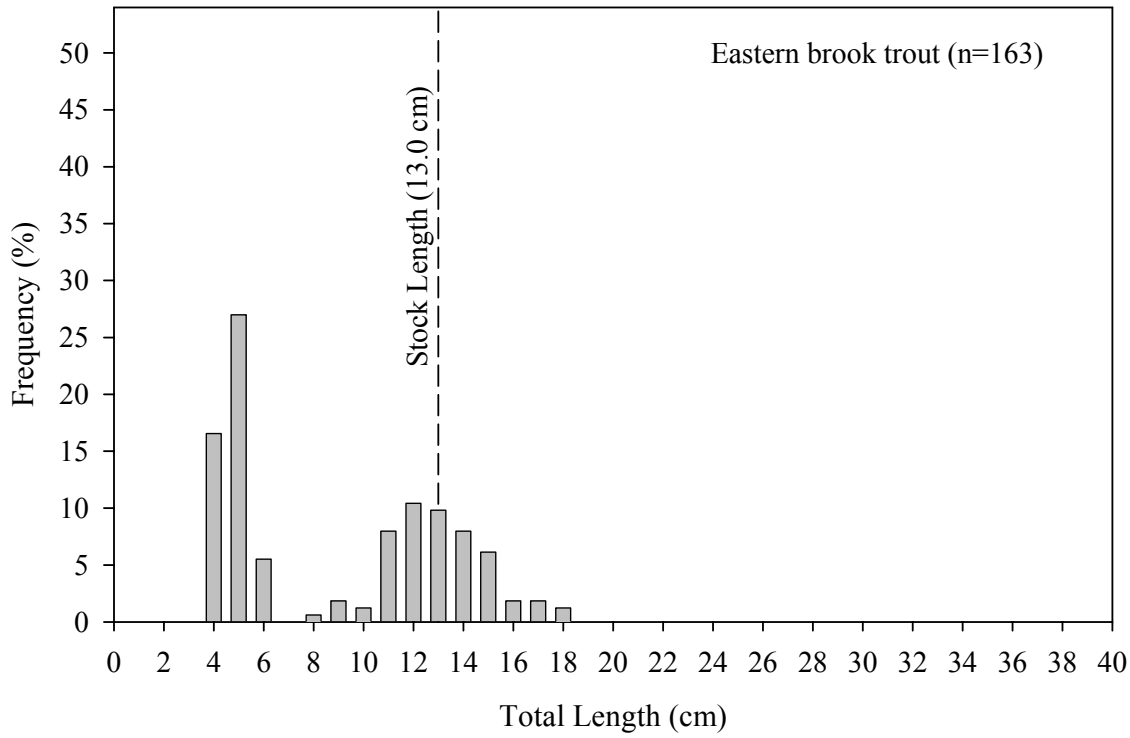

Figure 8. Length-frequency distribution of eastern brook trout collected in Burping Brook.

Dartford Creek

Dartford Creek was divided into five reaches that were sampled on August 6 and 7 (Figure 4; Appendix B). A total of five sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 13; Appendix F). The mean wetted width was 2.1 m (SD=0.7) and the mean depth was 12 cm (SD=4) (Table 13). The dominant habitat and substrate types were riffle (86%) and sand (29%), respectively (Table 13).

There was a potential fish passage barrier on Dartford Creek at rkm 0.2. The barrier did not meet the barrier criteria listed in the methods, but it was suspected to limit the distribution of smaller fish encountered in the stream. The barrier consisted of a square concrete culvert that was 3.6 m wide. The depth of the water in the culvert was 3.0 cm and it was uniform across its width. The vertical jumping height required for a fish to enter the culvert was 1.7 m and the horizontal distance that would have to be traveled during the leap was 2.2 m. There was a large plunge pool below the culvert.

Daily average, maximum, and minimum temperatures were determined for Dartford Creek (Figure 9). The mean temperature of Dartford Creek was 10.31 °C (SD=3.68), with a maximum of 16.30 °C on July 23 and a minimum of 0.00 °C on November 22. The mean temperature between May 29 and October 28, the same time period monitored in 2001 and 2002, was 12.09 °C (SD=2.02).

Three species of fish were collected in Dartford Creek: eastern brook trout, rainbow trout, and longnose dace (Table 14). Rainbow trout were the most abundant species, based on relative abundance (98.2%; n=1,010) (Table 14). The percentage of the eastern brook trout population that was of stock length was 20.0% (n=3) (Figure 10). None of the rainbow trout were of legal length for harvest (Figure 10).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each of the species collected (Table 15).

Table 13. Mean values (± SD) of habitat parameters measured and counted in Dartford Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	5	No. Riffles	74
No. Sections	5	Riffle Width (m)	2.0 (± 0.7)
No. Transects	85	Riffle Occurrence (%)	86
		Pool Habitat	
Transect Measurements		No. Pools	7
Wetted Width (m)	2.1 (± 0.7)	Pool Width (m)	2.3 (± 0.7)
Bankfull Width (m)	2.8 (± 1.0)	Pool Occurrence (%)	8
Depth (cm)	12 (± 4)	**Run Habitat**	
Maximum Depth (cm)	21 (± 6)	No. Runs	5
		Run Width (m)	1.8 (± 0.3)
Survey Section Measurements		Run Occurrence (%)	6
Gradient (%)	2.5 (± 1.6)		
Water Temperature (^{o}C)	13.8 (± 1.3)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	19.0 (± 2.3)	Organic	2 (± 5)
No. LWD/100 m	13 (± 17)	Muck	0 (± 1)
No. PP/km	14 (± 11)	Silt	16 (± 16)
		Sand	49 (± 29)
Primary Pools (PP)		Gravel	12 (± 14)
No. PP	7	Cobble	10 (± 17)
PP Width (m)	2.7 (± 0.6)	Rubble	3 (± 6)
PP Length (m)	3.7 (± 1.0)	Boulder	4 (± 12)
PP Max. Depth (cm)	42 (± 11)	Bedrock	4 (± 18)
PP Residual Depth (cm)	30 (± 7)	Embeddedness (%)	75 (± 20)

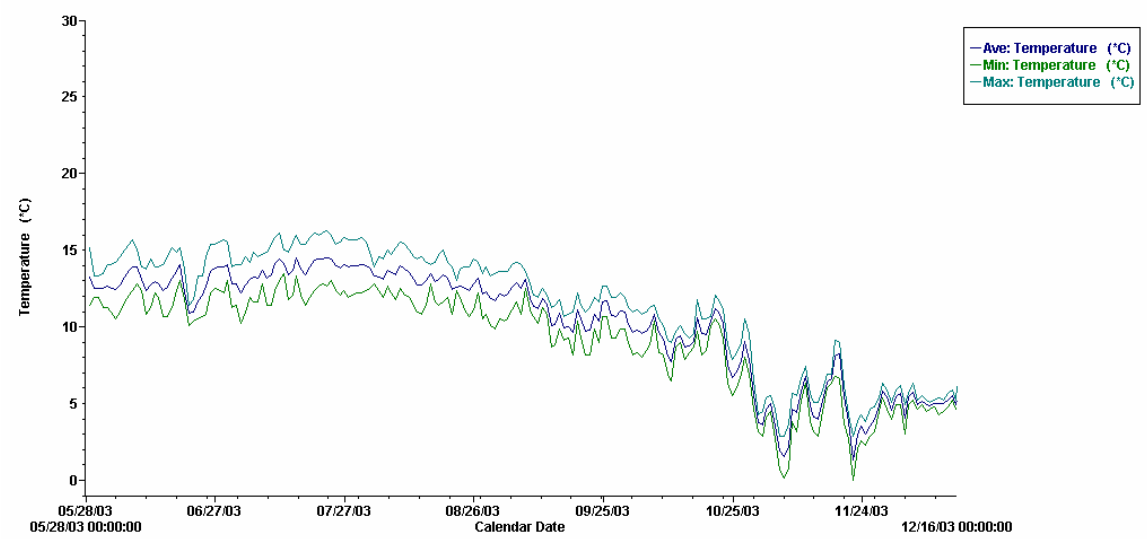

Figure 9. Mean, minimum, and maximum daily temperatures recorded on lower Dartford Creek.

Table 14. Relative abundances (R.A.), mean total length (TL; ± SD), and size range of each species of fish collected in Dartford Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
Rainbow trout	259	100.0	76 (± 32)	32-193
2				
Rainbow trout	70	100.0	88 (± 48)	40-203
3				
Rainbow trout	112	100.0	89 (± 39)	42-201
4				
Rainbow trout	96	100.0	100 (± 34)	45-204
5				
Eastern brook trout	15	3.1	98 (± 27)	73-161
Rainbow trout	473	96.3	74 (± 30)	40-183
Longnose dace	3	0.6	122 (± 15)	109-138
Total				
Eastern brook trout	15	1.5	98 (± 27)	73-161
Rainbow trout	1,010	98.2	80 (± 34)	32-204
Longnose dace	3	0.3	122 (± 15)	109-138

Table 15. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in Dartford Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
5	2	15	0.5812	15	15	9
Longnose dace						
5	2	3	0.0000	3	3	2
Rainbow trout						
5	2	420	8.3404	409	442	264
4	3	96	2.8268	94	107	53
3	20	117	8.6480	108	145	43
2	23	54	1.8857	54	63	22
1	30	243	11.6877	228	276	137

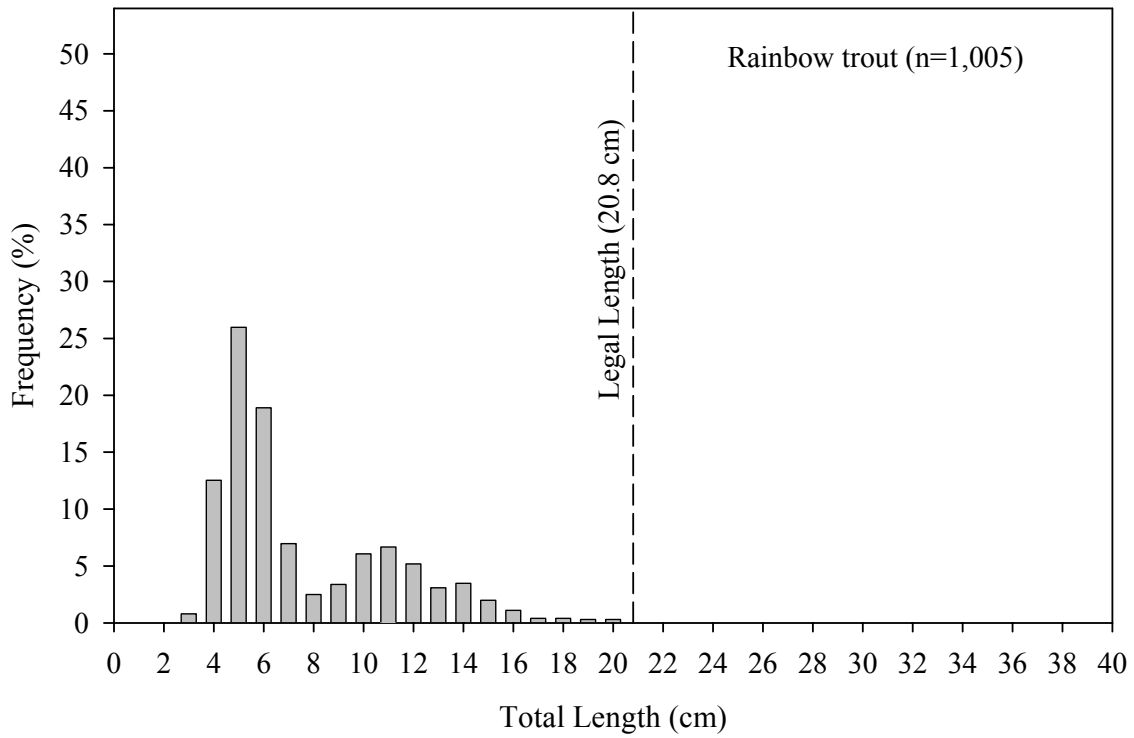

Figure 10. Length-frequency distribution of rainbow trout collected in Dartford Creek.

Deadman Creek

Deadman Creek was divided into 23 reaches that were sampled between July 7 and 28 (Figure 4; Appendix B). A total of 30 sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 16; Appendix G). The mean wetted width was 3.7 m (SD=1.3) and the mean depth was 15 cm (SD=9) (Table 16). The dominant habitat and substrate types were riffle (61%) and sand (31%), respectively (Table 16).

Daily average, maximum, and minimum temperatures were determined for sites in lower, middle, and upper Deadman Creek (Figures 11 through 13). The mean temperature (± SD) at each recording site was calculated for study period, as well as for the period between May 29 and October 28 for comparisons to 2002 (Table 17).

Ten species of fish were collected in Deadman Creek (Table 18). A total of seven sculpins were collected, preserved for identification: three from site 250 (reach 7) and four from site 9 (reach 22). All were identified as mottled sculpins. Sculpin were the most abundant

species, based on relative abundance (27.0%; n=1,210) (Table 18). Rainbow trout were the most abundant sport fish species, based on relative abundance (18.8%; n=842). The percentage of the eastern brook trout population that was of stock length was 47.9% (n=58) (Figure 14). The percentage of the rainbow trout population that was of legal length for harvest was 6.2% (n=52) (Figure 14).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each species of fish collected (Table 19).

Table 16. Mean values (± SD) of habitat parameters measured and counted in Deadman Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	21	No. Riffles	252
No. Sections	30	Riffle Width (m)	3.4 (± 1.4)
No. Transects	395	Riffle Occurrence (%)	61
		Pool Habitat	
Transect Measurements		No. Pools	68
Wetted Width (m)	3.7 (± 1.3)	Pool Width (m)	3.3 (± 1.5)
Bankfull Width (m)	5.4 (± 1.6)	Pool Occurrence (%)	16
Depth (cm)	15 (± 9)	**Run Habitat**	
Maximum Depth (cm)	30 (± 16)	No. Runs	94
		Run Width (m)	3.8 (± 1.1)
Survey Section Measurements		Run Occurrence (%)	23
Gradient (%)	3.5 (± 2.3)		
Water Temperature (^{o}C)	14.6 (± 3.0)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	22.3 (± 4.5)	Organic	0 (± 3)
No. LWD/100 m	17 (± 13)	Muck	0 (± 2)
No. PP/km	21 (± 18)	Silt	14 (± 24)
		Sand	31 (± 24)
Primary Pools (PP)		Gravel	13 (± 17)
No. PP	62	Cobble	17 (± 19)
PP Width (m)	4.1 (± 1.5)	Rubble	12 (± 15)
PP Length (m)	5.6 (± 3.6)	Boulder	11 (± 19)
PP Max. Depth (cm)	57 (± 25)	Bedrock	1 (± 7)
PP Residual Depth (cm)	38 (± 16)	Embeddedness (%)	70 (± 23)

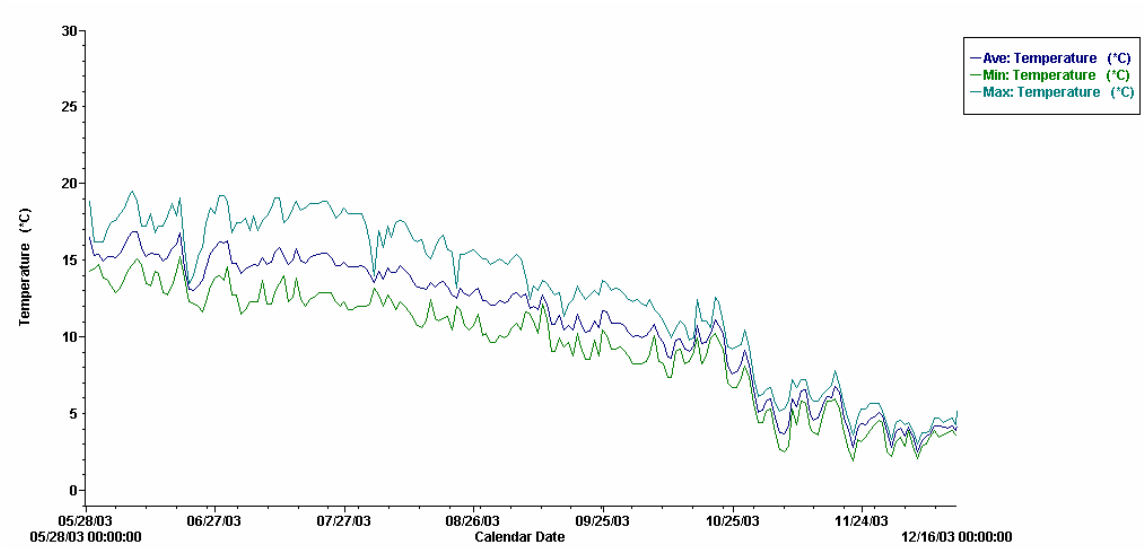

Figure 11. Mean, minimum, and maximum daily temperatures recorded on lower Deadman Creek.

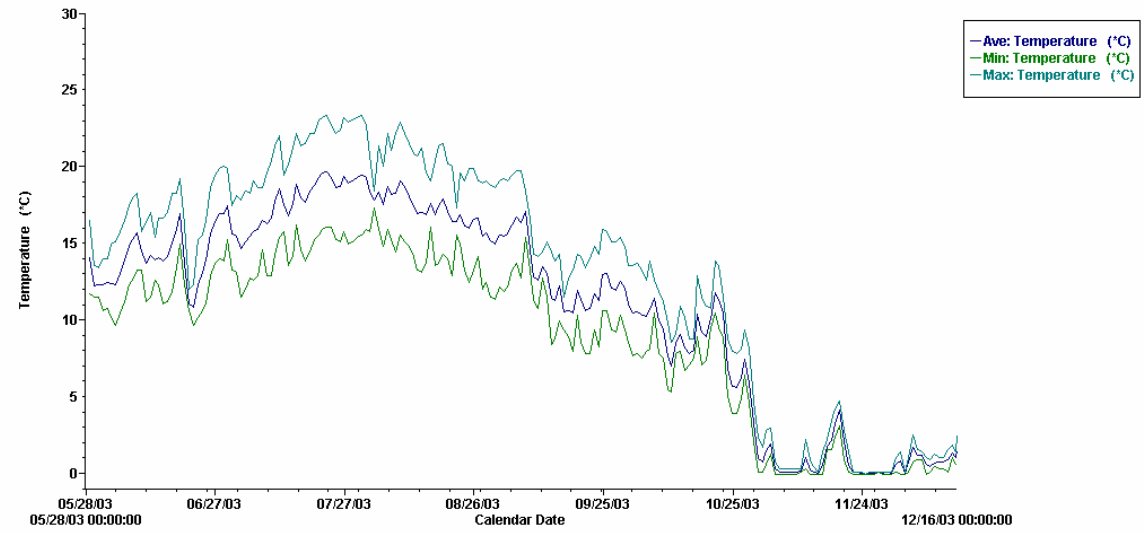

Figure 12. Mean, minimum, and maximum daily temperatures recorded on middle Deadman Creek.

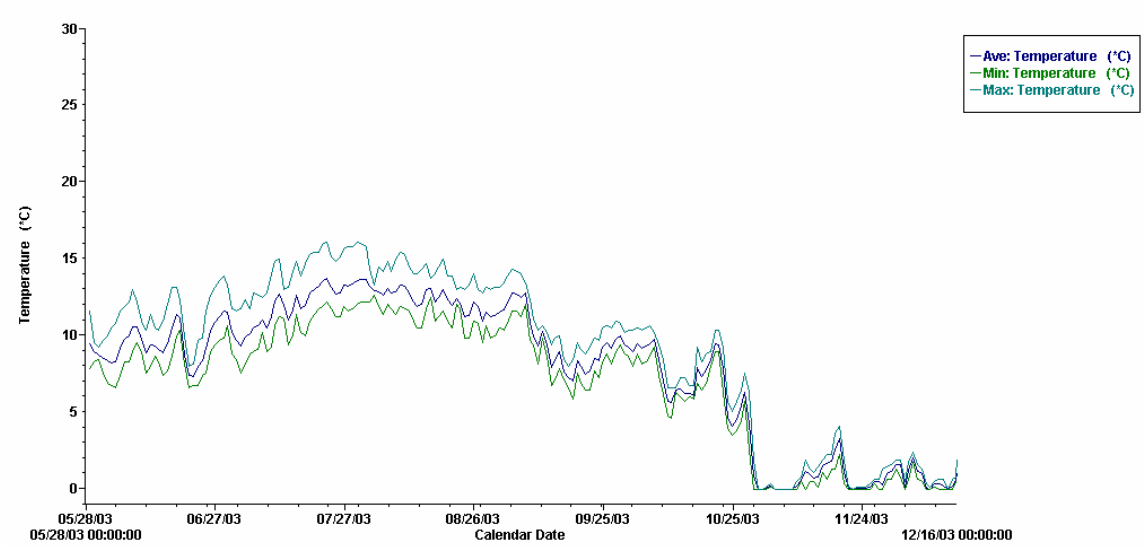

Figure 13. Mean, minimum, and maximum daily temperatures recorded on upper Deadman Creek.

Table 17. Mean (± SD), minimum, and maximum temperatures (^{o}C) at each site on Deadman Creek during the study period and mean temperatures (± SD; ^{o}C) between May 29 and October 28.

Location	Average	Minimum	Date(s) of Min.	Maximum	Date(s) of Max.	Average (Oct 28)
Lower	11.03 (± 4.34)	1.88	11/22	19.51	6/8	13.06 (± 2.70)
Middle	11.05 (± 6.75)	-0.06	11/4-12/9 (23 days)	23.36	7/23,31	14.30 (± 3.99)
Upper	7.86 (± 4.63)	-0.06	10/30-12/15 (28 days)	16.04	7/23,30	10.17 (± 2.47)

Table 18. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in Deadman Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
Rainbow trout	2	100.0	147 (± 37)	121-173
2				
Eastern brook trout	25	53.2	132 (± 21)	95-202
Rainbow trout	22	46.8	102 (± 50)	36-189
3				
Eastern brook trout	16	40.0	129 (± 30)	99-188
Rainbow trout	24	60.0	78 (± 40)	29-166
4				
Eastern brook trout	36	48.6	129 (± 21)	87-164
Rainbow trout	38	51.4	99 (± 41)	33-171
5				
Eastern brook trout	31	30.4	129 (± 26)	87-198
Rainbow trout	66	64.7	109 (± 31)	45-168
Sculpin spp.	5	4.9	101 (± 35)	38-125

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
6				
Eastern brook trout	10	11.0	114 (± 51)	49-212
Rainbow trout	55	60.4	109 (± 32)	50-208
Sculpin spp.	26	28.6	71 (± 21)	30-101
7				
Eastern brook trout	2	1.7	139 (± 65)	93-185
Rainbow trout	63	52.9	119 (± 34)	66-215
Sculpin spp.	54	45.4	65 (± 18)	37-103
8				
Rainbow trout	42	64.6	120 (± 38)	57-241
Sculpin spp.	23	35.4	73 (± 22)	38-109
9				
Rainbow trout	59	74.7	126 (± 35)	72-214
Sculpin spp.	20	25.3	69 (± 23)	38-105
10				
Rainbow trout	41	73.2	129 (± 35)	81-197
Sculpin spp.	15	26.8	69 (± 17)	46-109
11				
Rainbow trout	140	69.3	124 (± 46)	42-227
Sculpin spp.	62	30.7	68 (± 21)	40-110
12				
Rainbow trout	25	25.0	98 (± 49)	44-210
Sculpin spp.	75	75.0	79 (± 17)	42-118
13				
Rainbow trout	54	7.1	115 (± 58)	42-232
Sculpin spp.	311	40.7	66 (± 17)	41-122
Redside shiner	303	39.6	79 (± 13)	42-122
Speckled dace	53	6.9	69 (± 14)	38-99
Bridgelip sucker	44	5.8	156 (± 25)	95-201
14				
Rainbow trout	11	1.4	192 (± 47)	123-257
Sculpin spp.	178	23.2	67 (± 16)	22-120
Redside shiner	259	33.8	67 (± 16)	31-110
Speckled dace	265	34.6	60 (± 11)	35-99
Bridgelip sucker	54	7.0	117 (± 26)	45-172
15				
Rainbow trout	1	0.5	228 (nc)	228
Sculpin spp.	4	2.1	71 (± 15)	61-93
Redside shiner	54	28.0	48 (± 11)	38-80
Speckled dace	130	67.4	54 (± 9)	36-78
Bridgelip sucker	4	2.1	73 (± 24)	48-103
16				
No Sample				
17				
No Sample				
18				
Rainbow trout	11	4.5	65 (± 43)	34-190
Sculpin spp.	12	4.9	66 (± 26)	24-96
Redside shiner	171	70.1	55 (± 17)	33-100
Speckled dace	36	14.8	58 (± 11)	43-81
Bridgelip sucker	14	5.7	114 (± 13)	77-126
19				

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Rainbow trout	1	0.5	158 (nc)	158
Sculpin spp.	7	3.3	67 (± 37)	26-106
Redside shiner	155	72.4	72 (± 11)	43-109
Speckled dace	24	11.2	66 (± 9)	44-82
Bridgelip sucker	27	12.6	124 (± 22)	74-159
20				
Rainbow trout	19	5.7	140 (± 92)	55-319
Sculpin spp.	80	23.9	59 (± 9)	25-84
Chiselmouth	7	2.1	90 (± 63)	45-192
Longnose dace	5	1.5	54 (± 4)	50-59
Northern pikeminnow	2	0.6	118 (± 21)	103-132
Redside shiner	146	43.6	73 (± 7)	48-98
Speckled dace	2	0.6	53 (± 8)	47-59
Bridgelip sucker	74	22.1	108 (± 23)	50-157
21				
Rainbow trout	84	13.3	124 (± 58)	52-262
Mountain whitefish	3	0.5	104 (± 9)	94-112
Sculpin spp.	178	28.3	64 (± 18)	25-117
Chiselmouth	4	0.6	93 (± 10)	78-100
Longnose dace	140	22.2	80 (± 15)	48-114
Northern pikeminnow	1	0.2	112 (nc)	112
Redside shiner	100	15.9	78 (± 8)	60-119
Speckled dace	17	2.7	78 (± 13)	54-100
Bridgelip sucker	103	16.3	128 (± 25)	64-209
22				
Eastern brook trout	2	1.1	186 (± 8)	180-191
Rainbow trout	35	18.9	160 (± 73)	48-349
Mountain whitefish	2	1.1	109 (± 1)	108-109
Sculpin spp.	72	38.9	69 (± 13)	26-96
Longnose dace	32	17.3	77 (± 17)	46-105
Redside shiner	1	0.5	81 (nc)	81
Speckled dace	1	0.5	79 (nc)	79
Bridgelip sucker	40	21.6	141 (± 26)	90-188
23				
Rainbow trout	38	23.3	174 (± 75)	54-330
Mountain whitefish	7	4.3	121 (± 34)	97-195
Sculpin spp.	88	54.0	54 (± 23)	25-117
Longnose dace	6	3.7	72 (± 16)	58-92
Redside shiner	2	1.2	97 (± 8)	91-102
Bridgelip sucker	22	13.5	121 (± 19)	88-149
Total				
Eastern brook trout	122	2.7	129 (± 28)	49-212
Rainbow trout	842	18.8	121 (± 52)	29-349
Mountain whitefish	12	0.3	115 (± 26)	94-195
Sculpin spp.	1,210	27.0	66 (± 19)	22-125
Chiselmouth	11	0.2	91 (± 49)	45-192
Longnose dace	183	4.1	78 (± 16)	46-114
Northern pikeminnow	3	0.1	116 (± 15)	103-132
Redside shiner	1,191	26.6	70 (± 16)	31-122
Speckled dace	528	11.8	60 (± 12)	35-100
Bridgelip sucker	382	8.5	126 (± 28)	45-209

Table 19. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in Deadman Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
22	9	2	0.0000	2	2	<1
7	250	1	0.0000	1	1	<1
7	252	1	0.0000	1	1	<1
6	272	9	0.8012	9	9	3
5	288	25	1.7601	25	34	9
5	289	7	0.9476	7	7	2
4	299	40	4.4440	37	59	13
3	306	16	0.5610	16	16	6
2	310	27	2.5542	26	39	14
Rainbow trout						
23	2	40	2.2807	39	50	8
22	9	39	5.0611	35	60	8
21	19	60	1.6687	60	68	13
21	26	25	1.3835	25	34	5
20	30	20	2.0637	20	31	4
19	43	1	0.0000	1	1	<1
18	64	6	0.0000	6	6	1
15	123	1	0.0000	1	1	<1
14	133	2	0.0000	2	2	1
14	138	6	0.0000	6	6	1
14	148	3	0.7454	3	3	1
13	163	3	0.0000	3	3	1
13	181	12	0.6667	12	12	2
13	184	5	0.5292	5	5	1
13	193	25	2.4404	24	36	7
12	210	18	0.2485	18	18	5
11	218	58	2.1653	57	67	13
11	229	77	4.0896	74	92	21
10	232	41	1.1568	41	48	12
9	239	59	1.0751	59	66	14
8	243	46	4.2390	43	63	12
7	250	25	0.9192	25	25	5
7	252	38	1.2525	38	46	13
6	272	57	3.3644	55	71	17
5	288	38	5.0006	34	58	14
5	289	30	1.7321	30	39	10
4	299	31	3.8977	29	49	10
3	306	16	0.9002	16	16	6
2	310	15	0.9547	15	15	8
1	322	16	4.5372	14	39	13
Mountain whitefish						
23	2	7	0.4286	7	7	1
22	9	2	0.0000	2	2	<1
21	26	3	0.7454	3	3	1
Sculpins						
23	2	156	183.4458	62	1117	33
22	9	206	199.0266	86	1175	43
21	19	136	41.0865	98	286	29
21	26	92	15.6442	77	147	17

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
20	30	215	243.6841	83	1458	42
19	43	4	0.6124	4	4	1
18	64	9	0.8012	9	9	2
15	123	4	0.6124	4	4	1
14	133	101	32.9123	72	227	26
14	138	152	102.8433	79	609	38
14	148	69	40.7210	42	256	19
13	163	126	59.2509	79	368	38
13	181	80	16.5222	65	141	16
13	184	69	20.5717	52	151	17
13	193	171	73.0326	105	448	47
12	210	101	23.4440	79	185	28
11	218	36	7.0962	32	67	8
11	229	14	2.0456	14	26	4
10	232	21	15.5175	14	106	6
9	239	15	6.6123	13	51	3
8	243	20	4.8906	18	44	5
7	250	16	1.4412	16	25	3
7	252	22	3.2499	21	38	7
6	272	35	26.4185	22	127	10
5	288	3	0.2659	3	3	1
5	289	1	0.0000	1	1	<1
Chiselmouth						
21	26	4	0.6124	4	4	1
20	30	5	1.2000	5	5	1
Longnose dace						
21	26	90	25.1943	68	185	16
Northern pikeminnow						
21	19	1	0.0000	1	1	<1
Redside shiner						
22	9	1	0.0000	1	1	<1
21	26	136	21.8569	112	207	25
20	30	192	23.3178	164	262	38
19	43	156	5.6737	150	174	42
18	64	93	11.7653	82	133	21
14	133	58	7.7244	52	87	15
14	138	41	0.8709	41	41	10
14	148	119	5.6141	113	137	33
13	163	308	96.8029	206	634	93
13	181	40	9.5550	33	80	8
13	184	14	0.6061	14	14	3
13	193	106	5.9067	100	125	29
Speckled dace						
21	19	14	2.0456	14	26	3
19	43	22	0.4636	22	22	6
18	64	39	23.8685	25	157	9
14	133	70	6.4016	65	93	18
14	138	92	13.4242	79	139	23
14	148	101	9.2382	92	132	28
13	163	49	2.7539	48	61	15
Bridgelip suckers						
23	2	22	0.9959	22	22	5
22	9	43	3.6014	41	58	9
21	19	14	0.2857	14	14	3

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
21	26	101	7.7184	93	127	18
19	43	29	2.8433	28	43	8
18	64	20	10.1883	15	73	5
14	133	9	0.3685	9	9	2
14	138	19	1.1402	19	26	5
14	148	25	2.2999	25	37	7
13	163	16	9.8535	12	70	5
13	193	26	2.8107	25	39	7

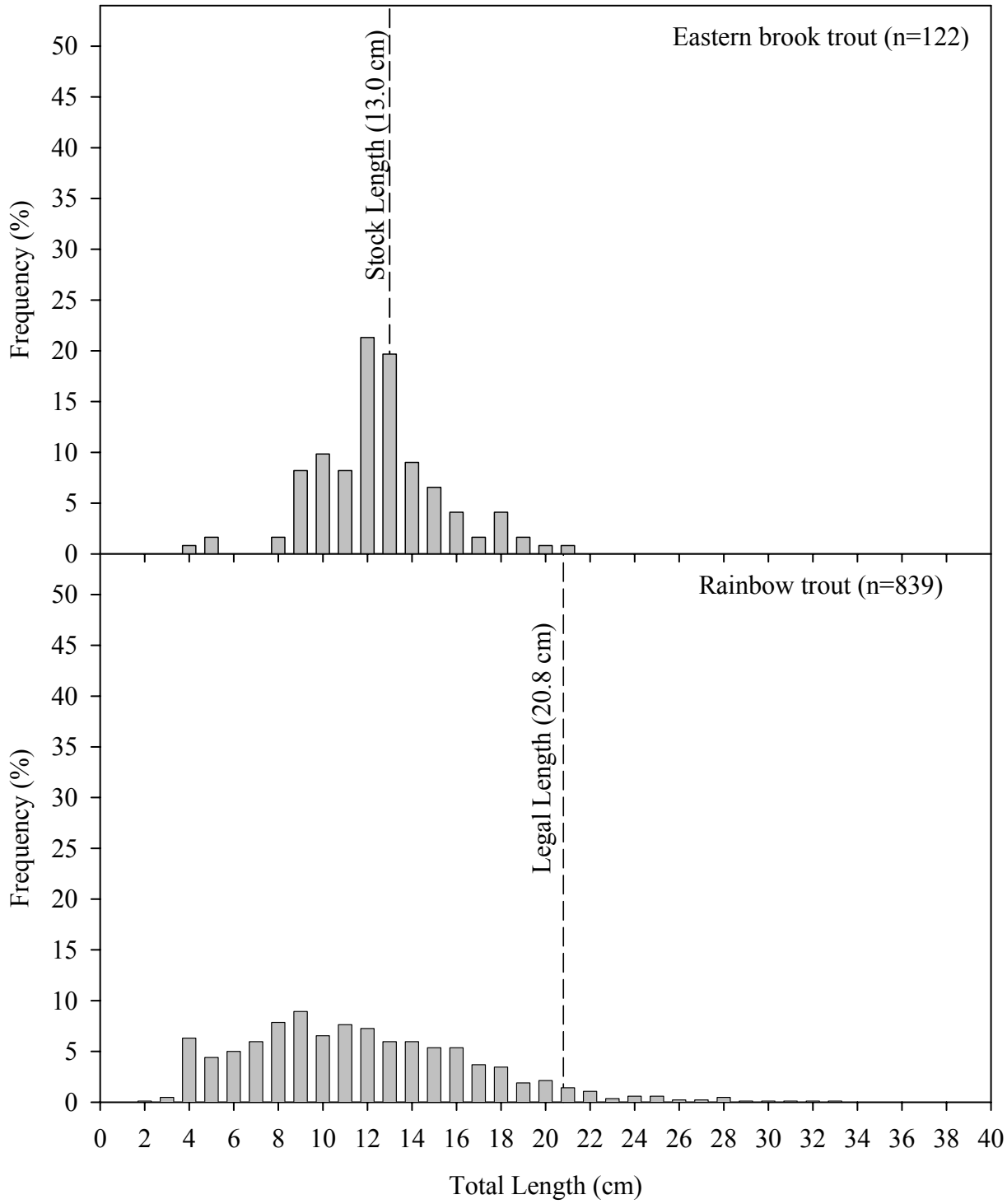

Figure 14. Length-frequency distributions of eastern brook and rainbow trout in Deadman Creek.

Little Deep Creek

Little Deep Creek was divided into 11 reaches that were sampled between June 3 and 12 (Figure 4; Appendix B). A total of 18 sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 19; Appendix H). The mean wetted width was 2.8 m (SD=0.7) and the mean depth was 19 cm (SD=10) (Table 20). The dominant habitat and substrate types were riffle (43%) and sand (40%), respectively (Table 20).

Daily average, maximum, and minimum temperatures were determined for lower, Little Deep Creek (Figure 15). The mean temperature was 10.29 °C (SD=4.43), with a maximum of 19.07 °C on June 8 and a minimum of –0.11 °C on November 6. The mean temperature between May 29 and October 28, the same time period monitored in 2001 and 2002, was 12.39 °C (SD=2.61).

Seven species of fish were collected in Little Deep Creek: rainbow trout, mountain whitefish, sculpins, longnose dace, redside shiners, speckled dace, and bridgelip suckers (Table 21). Five sculpins, collected at site 5 (reach 10), were preserved for identification. All were identified as torrent sculpins. Speckled dace were the most abundant species, based on relative abundance (24.5%; n=423) (Table 21). Rainbow trout were the most abundant sport fish species, based on relative abundance (20.0%; n=346) (Table 20). The percentage of the rainbow trout population that was of legal length for harvest was 4.1% (n=14) (Figure 16).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each of the species collected (Table 22).

Table 20. Mean values (± SD) of habitat parameters measured and counted in Little Deep Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	11	No. Riffles	137
No. Sections	18	Riffle Width (m)	2.7 (± 0.9)
No. Transects	297	Riffle Occurrence (%)	43
		Pool Habitat	
Transect Measurements		No. Pools	53
Wetted Width (m)	2.8 (± 0.7)	Pool Width (m)	2.7 (± 1.0)
Bankfull Width (m)	4.0 (± 1.3)	Pool Occurrence (%)	17
Depth (cm)	19 (± 10)	**Run Habitat**	
Maximum Depth (cm)	35 (± 18)	No. Runs	125
		Run Width (m)	2.5 (± 0.6)
Survey Section Measurements		Run Occurrence (%)	40
Gradient (%)	1.1 (± 0.3)		
Water Temperature (^{o}C)	13.2 (± 2.3)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	20.5 (± 4.4)	Organic	0 (± 2)
No. LWD/100 m	15 (± 15)	Muck	0 (± 2)
No. PP/km	13 (± 11)	Silt	28 (± 29)
		Sand	40 (± 29)
Primary Pools (PP)		Gravel	15 (± 22)
No. PP	24	Cobble	11 (± 19)
PP Width (m)	3.7 (± 0.8)	Rubble	4 (± 9)
PP Length (m)	5.6 (± 1.9)	Boulder	2 (± 7)
PP Max. Depth (cm)	68 (± 19)	Bedrock	0 (± 0)
PP Residual Depth (cm)	46 (± 12)	Embeddedness (%)	77 (± 24)

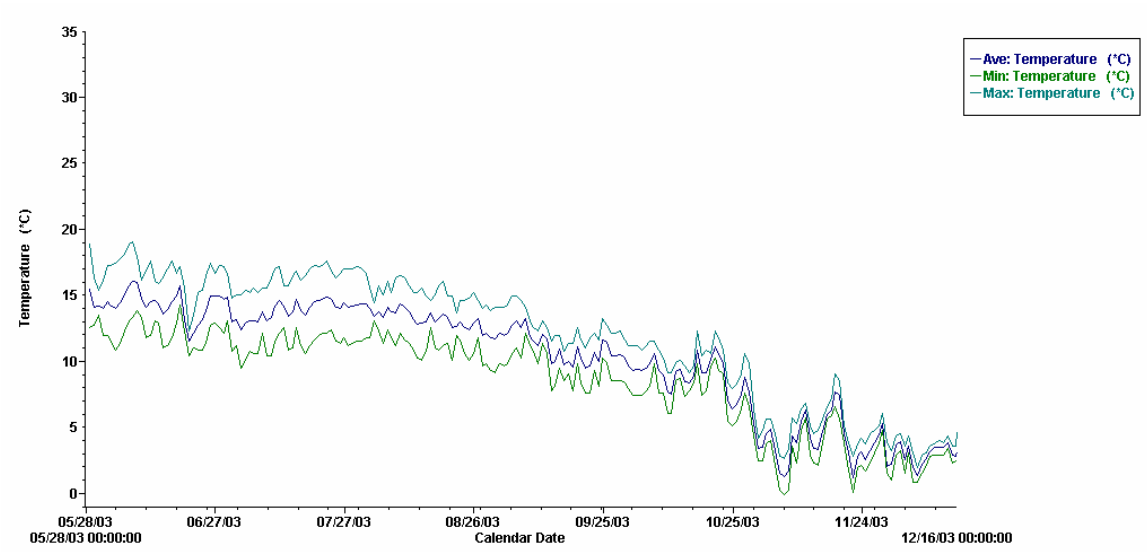

Figure 15. Mean, minimum, and maximum daily temperatures recorded on Little Deep Creek.

Table 21. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in Little Deep Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
Rainbow trout	40	78.4	117 (± 32)	81-232
Longnose dace	1	2.0	90 (nc)	90
Redside shiner	5	9.8	100 (± 15)	86-117
Speckled dace	1	2.0	70 (nc)	70
Bridgelip sucker	4	7.8	76 (± 66)	37-174
2				
Rainbow trout	76	73.1	116 (± 30)	75-201
Redside shiner	9	8.7	85 (± 16)	60-100
Speckled dace	14	13.5	66 (± 12)	43-86
Bridgelip sucker	5	4.8	131 (± 122)	58-347
3				
Rainbow trout	33	25.0	131 (± 39)	89-240
Longnose dace	4	3.0	99 (± 20)	82-128
Redside shiner	55	41.7	83 (± 15)	47-103
Speckled dace	25	18.9	51 (± 15)	30-83
Bridgelip sucker	15	11.4	64 (± 22)	39-106
4				
Rainbow trout	40	27.6	133 (± 40)	88-251
Redside shiner	47	32.4	77 (± 23)	26-118
Speckled dace	34	23.4	50 (± 19)	28-93
Bridgelip sucker	24	16.6	59 (± 27)	35-134
5				
Rainbow trout	14	25.0	142 (± 42)	81-214
Longnose dace	1	1.8	51 (nc)	51
Redside shiner	24	42.9	60 (± 28)	25-119
Speckled dace	10	17.9	60 (± 17)	30-80
Bridgelip sucker	7	12.5	55 (± 37)	32-133
6				
Rainbow trout	58	38.7	143 (± 36)	90-225
Longnose dace	6	4.0	49 (± 8)	36-57
Redside shiner	23	15.3	69 (± 29)	26-113
Speckled dace	22	14.7	54 (± 25)	26-97
Bridgelip sucker	41	27.3	64 (± 26)	29-110
7				
Rainbow trout	23	16.2	125 (± 31)	86-188
Redside shiner	56	39.4	87 (± 24)	32-122
Speckled dace	57	40.1	60 (± 19)	23-101
Bridgelip sucker	6	4.2	63 (± 17)	44-90
8				
Rainbow trout	8	4.9	141 (± 32)	106-202
Longnose dace	5	3.1	69 (± 24)	50-106
Redside shiner	26	16.0	74 (± 18)	34-108
Speckled dace	77	47.2	65 (± 16)	37-130
Bridgelip sucker	47	28.8	66 (± 24)	38-118
9				
Rainbow trout	18	2.9	156 (± 42)	92-239
Sculpin spp.	107	17.5	72 (± 20)	43-131

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Longnose dace	134	21.9	60 (± 23)	36-128
Redside shiner	26	15.9	74 (± 18)	34-108
Speckled dace	182	29.8	64 (± 14)	36-92
Bridgelip sucker	73	11.9	76 (± 23)	37-149
10				
Rainbow trout	22	39.3	137 (± 40)	64-220
Mountain whitefish	3	5.4	66 (± 8)	60-75
Sculpin spp.	28	50.0	86 (± 20)	43-118
Longnose dace	3	5.4	98 (± 8)	89-103
11				
Rainbow trout	14	12.1	138 (± 28)	92-187
Sculpin spp.	73	62.9	74 (± 22)	46-164
Longnose dace	27	23.3	78 (± 18)	43-104
Speckled dace	1	0.9	48 (nc)	48
Bridgelip sucker	1	0.9	40 (nc)	40
Total				
Rainbow trout	346	20.0	131 (± 37)	64-251
Mountain whitefish	3	0.2	66 (± 8)	60-75
Sculpin spp.	208	12.1	75 (± 21)	43-164
Longnose dace	181	10.5	64 (± 23)	36-128
Redside shiner	342	19.8	77 (± 22)	25-122
Speckled dace	423	24.5	61 (± 17)	23-130
Bridgelip sucker	223	12.9	69 (± 32)	29-347

Table 22. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in Little Deep Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m2)
Rainbow trout						
11	2	14	0.6061	14	14	5
10	5	24	2.6827	23	37	10
9	15	4	0.6124	4	4	1
9	16	10	0.3464	10	10	3
9	36	2	0.0000	2	2	1
9	37	2	0.0000	2	2	1
8	56	8	0.3953	8	8	3
7	71	10	0.7483	10	10	4
7	80	13	1.0059	13	13	5
6	85	45	13.2738	35	100	16
6	86	26	1.3176	26	35	12
5	104	14	0.9583	14	14	5
4	114	23	0.9683	23	23	7
4	122	18	2.5277	18	32	6
3	127	36	3.5094	34	51	13
2	134	46	4.2390	43	63	14
2	136	34	0.9804	34	37	10
1	150	42	2.7698	41	54	15
Sculpins						
11	2	112	31.7207	83	229	44

9	15	105	67.0455	59	407	28
Longnose dace						
9	16	23	1.6427	23	32	7
9	37	24	10.6245	18	77	11
3	127	4	0.0000	4	4	1
1	150	1	0.0000	1	1	<1
Redside shiner						
9	15	13	0.2979	13	13	3
9	16	29	5.1111	26	52	9
9	36	24	4.9724	22	48	10
9	37	30	4.6238	27	51	13
8	56	28	6.5083	24	58	12
6	85	8	0.5123	8	8	3
6	86	6	0.4714	6	6	3
5	104	12	0.3118	12	12	4
4	114	9	0.3685	9	9	3
3	127	56	3.9483	53	71	20
2	134	3	0.0000	3	3	1
2	136	6	1.0541	6	6	2
1	150	5	0.5292	5	5	2
Speckled dace						
9	16	2	0.0000	2	2	1
9	36	136	79.6964	77	479	56
9	37	195	147.8629	94	863	86
8	56	103	36.5155	71	245	43
7	80	39	10.8335	32	86	16
6	86	5	1.2000	5	5	2
5	104	8	2.5125	8	23	3
4	122	12	2.9527	12	29	4
3	127	11	1.0198	11	11	4
2	134	6	0.4714	6	6	2
2	136	6	0.0000	6	6	2
1	150	1	0.0000	1	1	<1
Bridgelip suckers						
9	15	8	0.8660	8	8	2
9	16	28	1.2073	28	36	9
9	36	33	31.4799	19	206	14
8	56	46	21.5541	32	145	19
7	80	4	0.6124	4	4	2
6	85	17	1.0436	17	22	6
6	86	5	0.0000	5	5	2
4	114	2	0.0000	2	2	1
4	122	9	1.4304	9	18	3
2	136	2	0.0000	2	2	1
1	150	2	0.0000	2	2	1

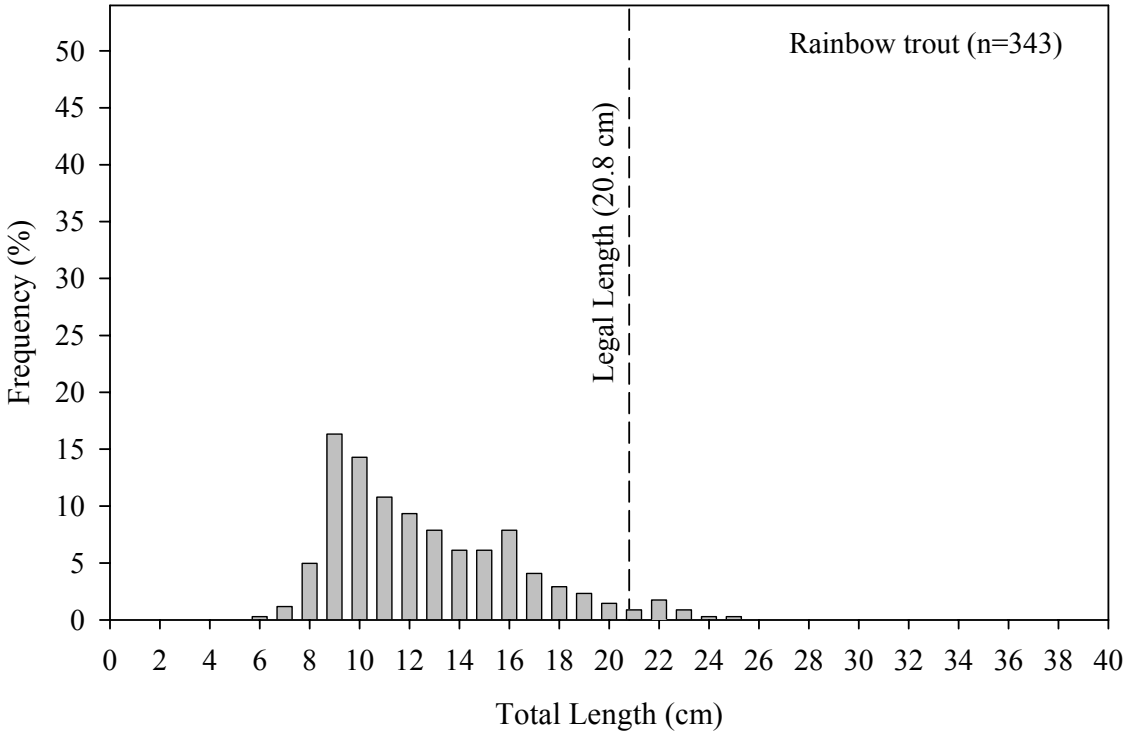

Figure 16. Length-frequency distribution of rainbow trout in Little Deep Creek.

Little Spokane River

Little Spokane River was divided into 41reaches (Figure 4; Appendix B). Sampling was conducted in 23 reaches between September 3 and October 1. The remaining 18 reaches were not sampled, because landowner permission could not be obtained. A total of 28 sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 23; Appendix I). The mean wetted width was 11.9 m (SD=4.5) and the mean depth was 47 cm (SD=16) (Table 23). The dominant habitat and substrate types were run (74%) and sand (43%), respectively (Table 23).

There were two fish passage barriers on the Little Spokane River upstream of Chain Lake (Figure 17). The upper most barrier was a waterfall (rkm 69.4) and it was a complete barrier. The vertical height of the waterfall was estimated to be 4.27 m (A. Scholz, EWU, personal communication).

The second barrier was a concrete railroad culvert located at rkm 68.7 and it was considered a potential barrier. The culvert was 41.0 m long, 5.5 m wide, and had a gradient of

2.5%. The water depth in the culvert was 16 cm. The vertical leaping height needed to enter the culvert was 1.3 m. The plunge pool was 109 cm deep and 5.5 m wide. Below the plunge pool there was a steep, high velocity section that ran over riprap substrate.

Daily average, maximum, and minimum temperatures were determined at six sites on the Little Spokane River: near the mouth, Indian Painted Rocks, Wandermere, Chattaroy, Elk, and Scotia (Figures 18 through 23). The mean temperature (± SD) at each recording site was calculated for study period, as well as for the period between May 29 and October 28 for comparisons to 2002 (Table 24).

Nineteen species of fish were collected in the Little Spokane River (Table 25). Sixteen sculpins were preserved for identification. The five sculpins from site 174 (reach 38), the three from site 292 (reach 31), and the four from site 432 (reach 23) were identified as mottled sculpins. The four from site 704 (reach 3) were identified as slimy sculpins. Eastern brook trout were the most abundant species, based on relative abundance (34.0%; n=474) (Table 25). The percentage of the eastern brook trout population that was of stock length was 25.5% (n=121) (Figure 24). The percentages of brown and rainbow trout populations that were of legal length for harvest was 100.0% (n=1) and 14.2% (n=26), respectively (Figure 24).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each species of fish collected (Table 26).

Table 23. Mean values (± SD) of habitat parameters measured and counted in Little Spokane River.

Sample Sizes		**Riffle Habitat**	
No. Reaches	21	No. Riffles	67
No. Sections	28	Riffle Width (m)	13.4 (± 5.2)
No. Transects	280	Riffle Occurrence (%)	24
		Pool Habitat	
Transect Measurements		No. Pools	5
Wetted Width (m)	11.9 (± 4.5)	Pool Width (m)	8.3 (± 3.3)
Bankfull Width (m)	13.7 (± 4.9)	Pool Occurrence (%)	2
Depth (cm)	47 (± 16)	**Run Habitat**	
Maximum Depth (cm)	81 (± 27)	No. Runs	210
		Run Width (m)	11.4 (± 4.2)
Survey Section Measurements		Run Occurrence (%)	74
Gradient (%)	1.7 (± 1.2)		
Water Temperature (^{o}C)	12.6 (± 2.1)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	15.8 (± 3.8)	Organic	12 (± 18)
No. LWD/100 m	12 (± 8)	Muck	2 (± 7)
No. PP/km	1 (± 3)	Silt	12 (± 17)
		Sand	43 (± 27)
Primary Pools (PP)		Gravel	6 (± 11)
No. PP	2	Cobble	10 (± 17)
PP Width (m)	10.3 (± 5.4)	Rubble	6 (± 12)
PP Length (m)	15.8 (± 1.1)	Boulder	8 (± 18)
PP Max. Depth (cm)	126 (± 3)	Bedrock	0 (± 2)
PP Residual Depth (cm)	101 (± 5)	Embeddedness (%)	82 (± 21)

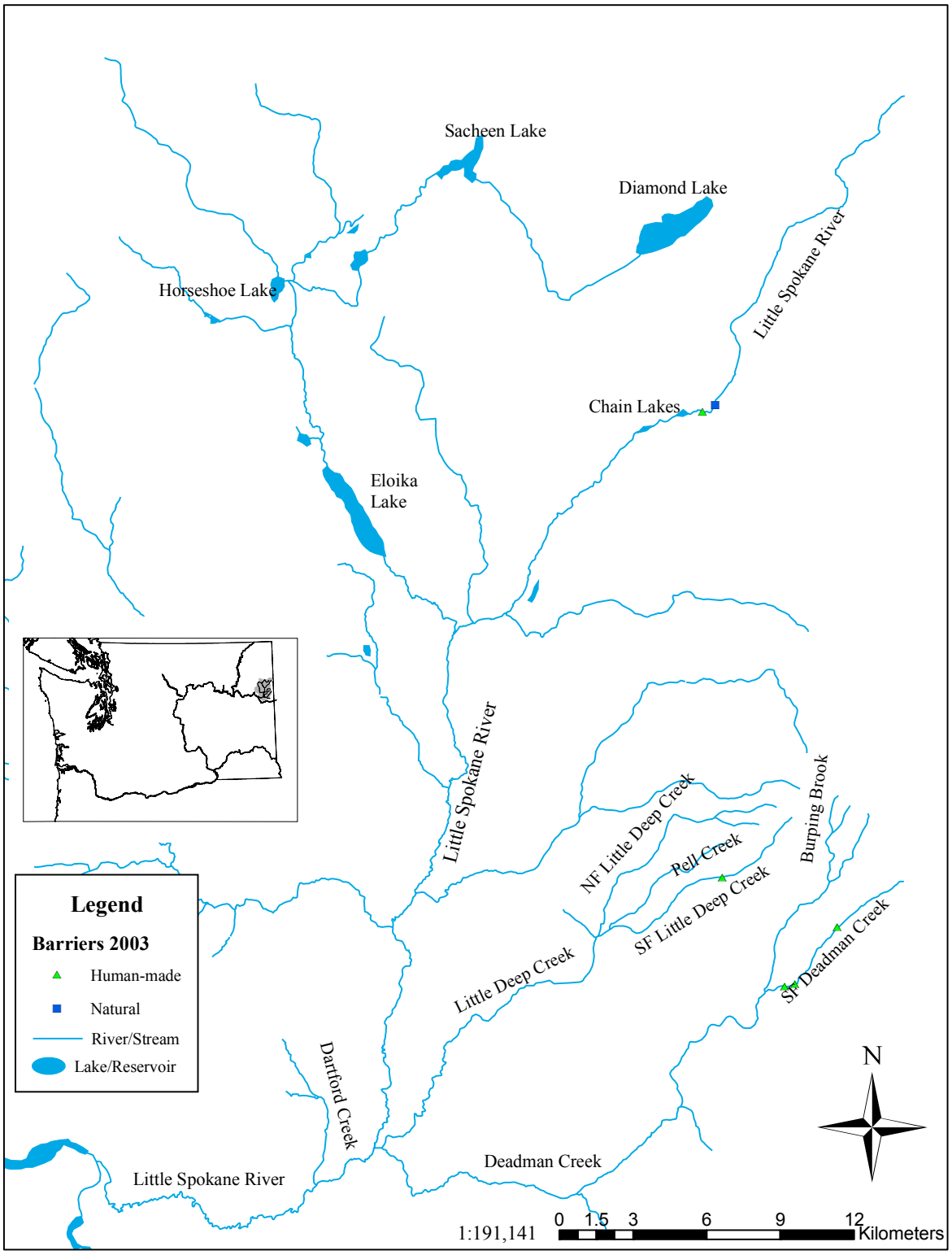

Figure 17. The locations of potential and definite fish passage barriers identified in 2003.

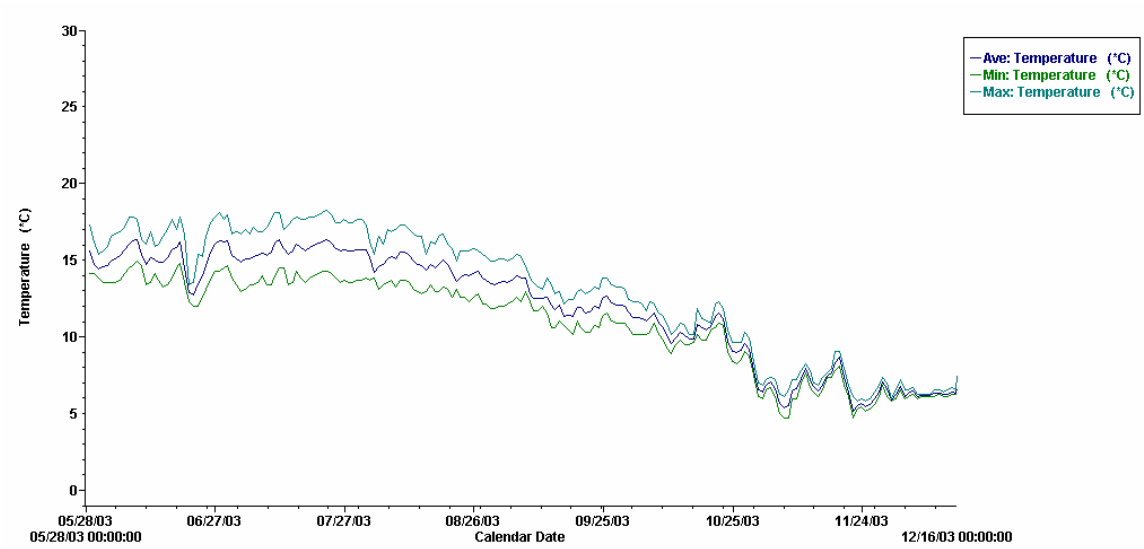

Figure 18. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River near it mouth.

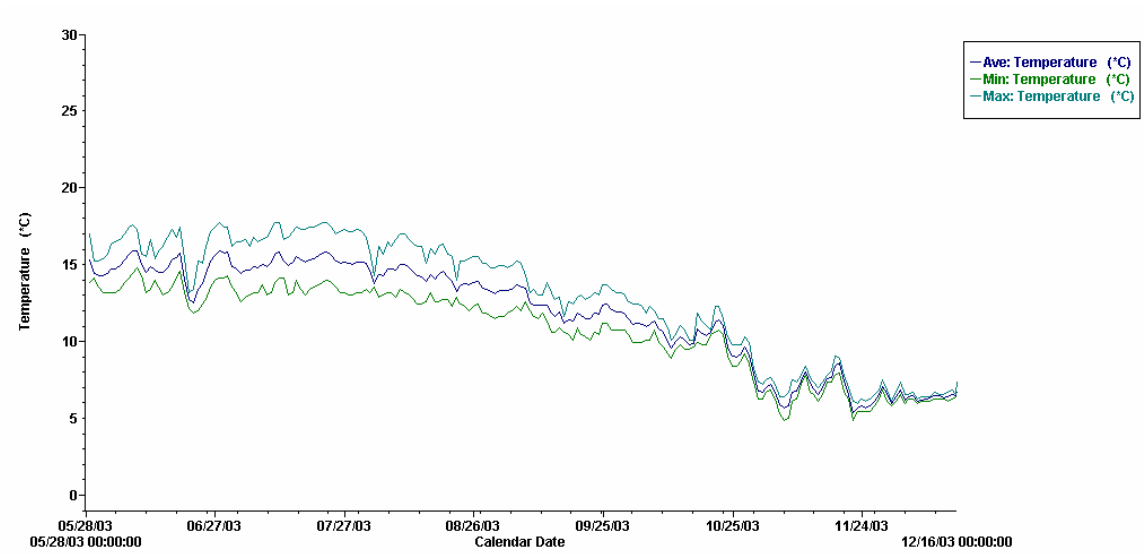

Figure 19. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River at Indian Painted Rocks.

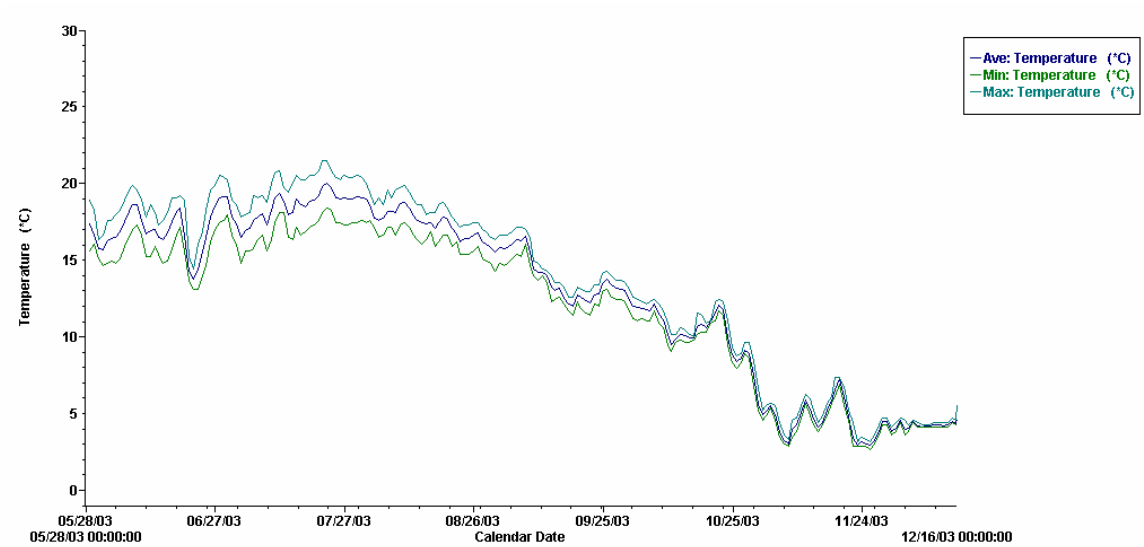

Figure 20. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River at Wandermere.

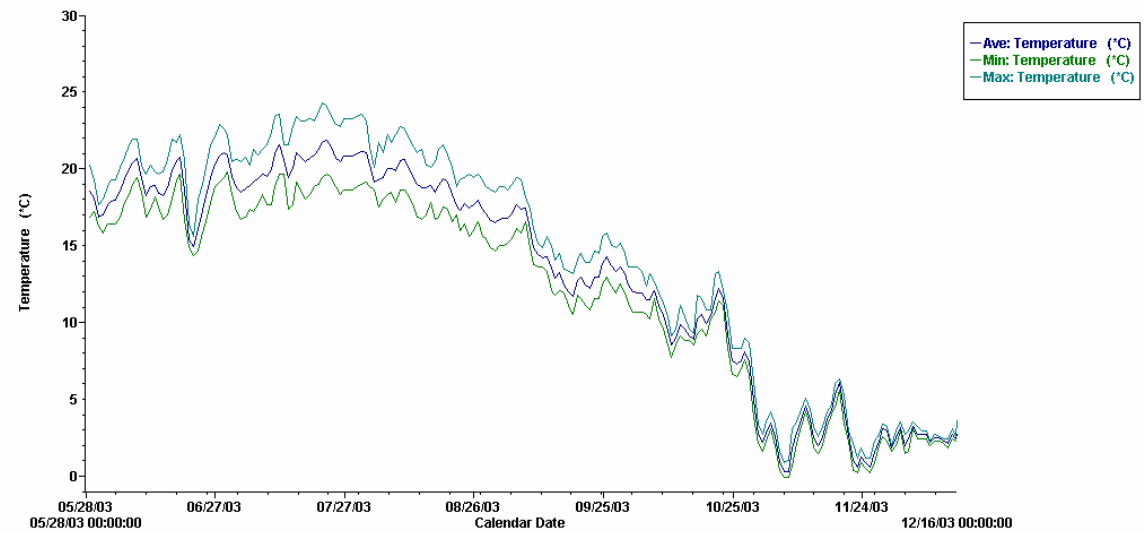

Figure 21. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River at Chattaroy.

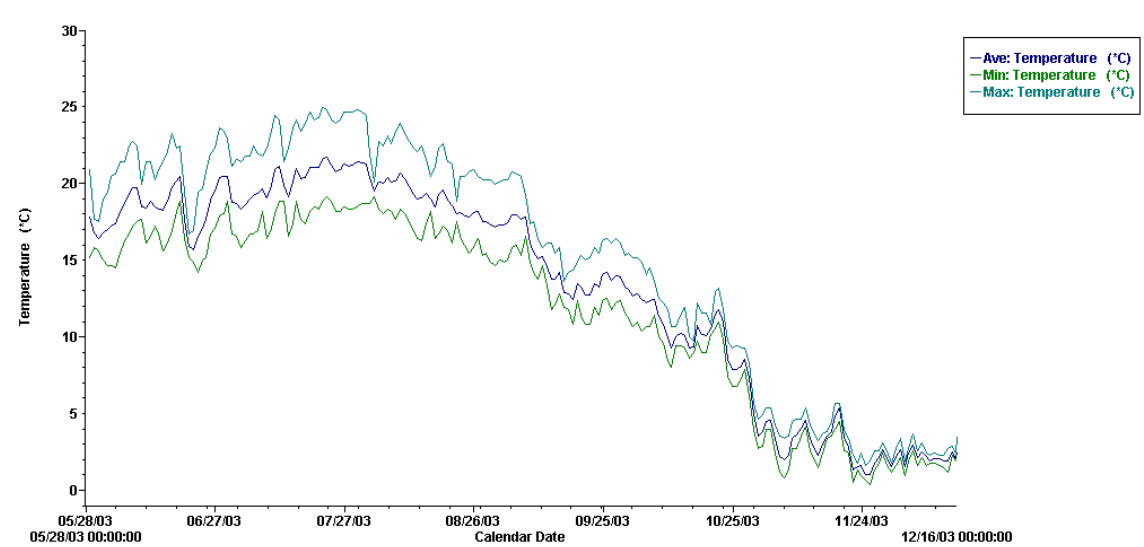

Figure 22. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River at Elk.

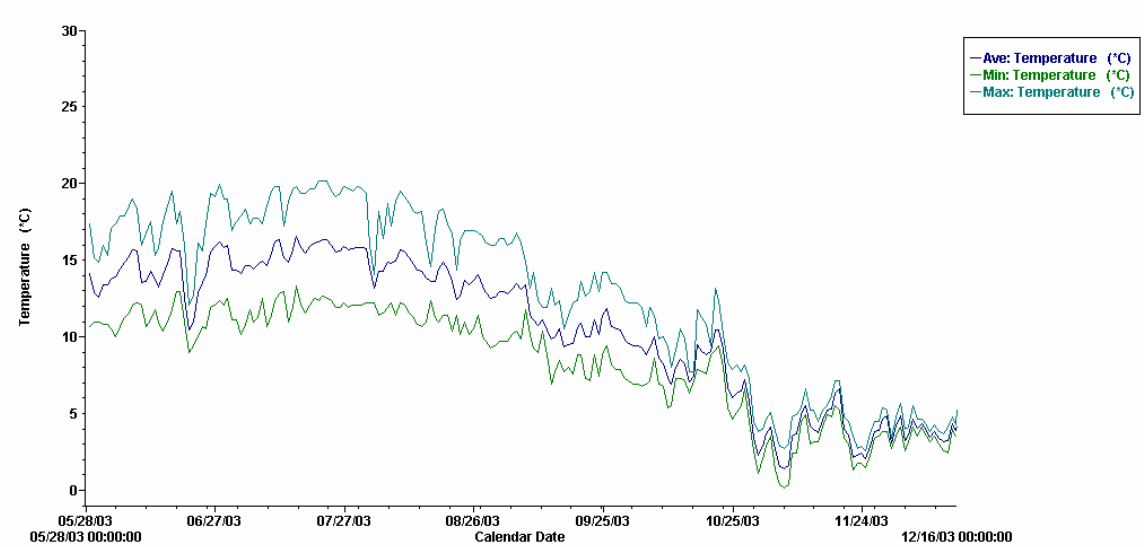

Figure 23. Mean, minimum, and maximum daily temperatures recorded on the Little Spokane River at Scotia.

Table 24. Mean (± SD), minimum, and maximum temperatures (^{o}C) at each site on the Little Spokane River during the study period and mean temperatures (± SD; ^{o}C) between May 29 and October 28.

Location	Average	Minimum	Date(s) of Min.	Maximum	Date(s) of Max.	Average (Oct 28)
Lower	12.00 (± 3.68)	4.68	11/6,7,22	18.29	7/23	13.74 (± 2.27)
Painted Rocks	11.81 (± 3.46)	4.85	11/6,22	17.77	6/28,7/11,12,22,23	13.44 (± 2.13)
Wandermere	12.94 (± 5.48)	2.68	11/26	21.52	7/22,23	15.61 (± 3.11)
Chattaroy	13.24 (± 6.99)	-0.11	11/6,7	24.27	7/22	16.62 (± 4.09)
Elk	13.37 (± 6.96)	0.34	11/26	24.99	7/22	16.74 (± 4.06)
Scotia	10.57 (± 4.89)	0.17	11/6	20.14	7/21-23	12.74 (± 3.39)

Table 25. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in Little Spokane River.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
No Sample				
2				
No Sample				
3				
Eastern brook trout	53	76.8	113 (± 40)	66-242
Sculpin spp.	16	23.2	48 (± 17)	32-84
4				
Eastern brook trout	112	78.9	131 (± 43)	81-253
Rainbow trout	3	2.1	227 (± 25)	206-255
Sculpin spp.	26	18.3	66 (± 24)	36-114
Bluegill	1	0.7	70 (nc)	70
5				
Eastern brook trout	109	72.2	116 (± 38)	71-234
Sculpin spp.	20	13.2	55 (± 20)	37-92
Speckled dace	21	13.9	49 (± 12)	28-77
Bluegill	1	0.7	61 (nc)	61
6				
Eastern brook trout	28	75.7	139 (± 62)	74-264
Sculpin spp.	1	2.7	83 (nc)	83
Speckled dace	8	21.6	47 (± 17)	26-70
7				
Eastern brook trout	54	85.7	116 (± 32)	70-242
Sculpin spp.	4	6.3	71 (± 20)	47-95
Speckled dace	5	7.9	61 (± 14)	42-79
8				
No Sample				
9				
No Sample				
10				
Eastern brook trout	68	47.2	117 (± 43)	65-277
Rainbow trout	58	40.3	119 (± 47)	54-267
Sculpin spp.	7	4.9	58 (± 15)	47-90

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Speckled dace	11	7.6	53 (± 7)	43-68
11				
Eastern brook trout	48	43.6	114 (± 33)	67-217
Rainbow trout	42	38.2	137 (± 49)	60-279
Sculpin spp.	7	6.4	79 (± 16)	51-98
Speckled dace	13	11.8	50 (± 6)	41-64
12				
No Sample				
13				
No Sample				
14				
No Sample				
15				
No Sample				
16				
Eastern brook trout	1	0.6	204 (nc)	204
Rainbow trout	24	14.5	162 (± 52)	78-244
Mountain whitefish	2	1.2	140 (± 10)	133-147
Sculpin spp.	31	18.8	58 (± 15)	35-87
Chiselmouth	9	5.5	127 (± 33)	71-154
Northern pikeminnow	10	6.1	121 (± 33)	75-174
Redside shiner	57	34.5	79 (± 16)	55-112
Speckled dace	3	1.8	73 (± 7)	69-81
Bridgelip sucker	19	11.5	163 (± 26)	107-215
Largescale sucker	9	5.5	170 (± 29)	133-212
17				
No Sample				
18				
Rainbow trout	13	21.7	176 (± 74)	81-318
Mountain whitefish	2	3.3	133 (± 13)	124-142
Sculpin spp.	16	26.7	72 (± 10)	42-87
Chiselmouth	3	5.0	147 (± 12)	135-158
Longnose dace	2	3.3	96 (± 1)	95-96
Northern pikeminnow	2	3.3	142 (± 64)	97-187
Redside shiner	5	8.3	93 (± 17)	79-115
Tench	1	1.7	129 (nc)	129
Bridgelip sucker	8	13.3	173 (± 12)	146-187
Largescale sucker	4	6.7	169 (± 9)	158-181
Largemouth bass	4	6.7	92 (± 7)	82-97
19				
No Sample				
20				
No Sample				
21				
Sculpin spp.	10	71.4	59 (± 18)	35-85
Speckled dace	1	7.1	32 (nc)	32
Largescale sucker	1	7.1	146 (nc)	146
Yellow perch	2	14.3	73 (± 8)	67-78
22				
Sculpin spp.	8	22.9	54 (± 22)	33-82
Northern pikeminnow	4	11.4	152 (± 8)	142-162
Speckled dace	1	2.9	53 (nc)	53

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Bridgelip sucker	7	20.0	141 (± 39)	55-166
Largescale sucker	5	14.3	151 (± 46)	76-193
Pumpkinseed	1	2.9	103 (nc)	103
Grass pickerel	5	14.3	198 (± 41)	152-264
Yellow perch	2	5.7	128 (± 5)	124-131
Yellow bullhead	2	5.7	45 (± 4)	42-47
23				
Eastern brook trout	1	1.2	109 (nc)	109
Rainbow trout	15	18.1	168 (± 49)	88-298
Mountain whitefish	4	4.8	138 (± 10)	127-152
Sculpin spp.	18	21.7	57 (± 19)	37-90
Chiselmouth	2	2.4	52 (± 1)	51-52
Longnose dace	7	8.4	87 (± 17)	60-101
Northern pikeminnow	10	12.0	54 (± 6)	43-66
Redside shiner	4	4.8	74 (± 29)	50-113
Bridgelip sucker	13	15.7	165 (± 21)	134-193
Largescale sucker	4	4.8	190 (± 13)	173-200
Yellow perch	5	6.0	137 (± 18)	113-152
24				
No Sample				
25				
No Sample				
26				
Sculpin spp.	7	35.0	50 (± 15)	37-80
Chiselmouth	3	15.0	149 (± 13)	134-159
Northern pikeminnow	9	45.0	58 (± 41)	33-167
Largescale sucker	1	5.0	183 (nc)	183
27				
Mountain whitefish	1	2.4	147 (nc)	147
Sculpin spp.	8	19.0	56 (± 18)	43-87
Tench	5	11.9	118 (± 47)	41-151
Bridgelip sucker	16	38.1	89 (± 53)	47-191
Largescale sucker	9	21.4	114 (± 60)	60-223
Pumpkinseed	1	2.4	85 (nc)	85
Grass pickerel	1	2.4	166 (nc)	166
Yellow perch	1	2.4	147 (nc)	147
28				
No Sample				
29				
Rainbow trout	2	7.1	148 (± 9)	141-154
Sculpin spp.	15	53.6	58 (± 20)	33-90
Chiselmouth	2	7.1	127 (± 39)	99-154
Longnose dace	2	7.1	99 (± 18)	86-111
Northern pikeminnow	1	3.6	95 (nc)	95
Redside shiner	1	3.6	46 (nc)	46
Bridgelip sucker	2	7.1	149 (± 50)	113-184
Largescale sucker	3	10.7	107 (± 97)	50-219
30				
No Sample				
31				
Sculpin spp.	12	70.6	45 (± 13)	34-73
Longnose dace	3	17.6	49 (± 1)	48-50

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Redside shiner	1	5.9	35 (nc)	35
Largescale sucker	1	5.9	68 (nc)	68
32				
Rainbow trout	2	7.1	163 (± 1)	162-163
Sculpin spp.	12	42.9	57 (± 15)	39-79
Longnose dace	1	3.6	54 (nc)	54
Northern pikeminnow	2	7.1	51 (± 3)	49-53
Redside shiner	2	7.1	33 (± 7)	28-38
Bridgelip sucker	6	21.4	77 (± 18)	64-112
Largescale sucker	2	7.1	94 (± 29)	73-114
Pumpkinseed	1	3.6	81 (nc)	81
33				
Sculpin spp.	12	60.0	54 (± 18)	37-87
Northern pikeminnow	5	25.0	67 (± 22)	48-94
Bridgelip sucker	3	15.0	113 (± 64)	60-184
34				
No Sample				
35				
No Sample				
36				
Rainbow trout	3	5.5	320 (± 53)	260-362
Mountain whitefish	2	3.6	234 (± 4)	231-236
Sculpin spp.	2	3.6	76 (± 8)	70-82
Chiselmouth	5	9.1	82 (± 5)	78-90
Redside shiner	28	50.9	60 (± 19)	30-105
Bridgelip sucker	3	5.5	132 (± 45)	89-178
Largescale sucker	12	21.8	109 (± 20)	62-136
37				
Brown trout	1	1.3	321 (nc)	321
Rainbow trout	8	10.4	166 (± 24)	118-190
Sculpin spp.	13	16.9	66 (± 17)	35-95
Chiselmouth	28	36.4	111 (± 17)	84-143
Longnose dace	3	3.9	61 (± 18)	40-73
Northern pikeminnow	3	3.9	176 (± 28)	143-194
Redside shiner	12	15.6	85 (± 27)	41-116
Bridgelip sucker	8	10.4	167 (± 31)	127-205
Largescale sucker	1	1.3	154 (nc)	154
38				
Rainbow trout	14	42.4	131 (± 42)	85-222
Mountain whitefish	7	21.2	268 (± 33)	224-301
Sculpin spp.	8	24.2	67 (± 19)	44-97
Longnose dace	1	3.0	54 (nc)	54
Bridgelip sucker	1	3.0	115 (nc)	115
Largescale sucker	2	6.1	91 (± 45)	59-123
39				
No Sample				
40				
No Sample				
41				
No Sample				
Total				
Brown trout	1	0.1	321 (nc)	321

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
Eastern brook trout	474	34.0	121 (± 42)	65-277
Rainbow trout	184	13.2	145 (± 58)	54-362
Mountain whitefish	18	1.3	199 (± 67)	124-301
Sculpin spp.	253	18.2	59 (± 19)	32-114
Chiselmouth	52	3.7	114 (± 28)	51-159
Longnose dace	19	1.4	75 (± 23)	40-111
Northern pikeminnow	46	3.3	93 (± 50)	33-194
Redside shiner	110	7.9	74 (± 22)	28-116
Speckled dace	63	4.5	52 (± 12)	26-81
Tench	6	0.4	120 (± 43)	41-151
Bridgelip sucker	86	6.2	139 (± 48)	47-215
Largescale sucker	54	3.9	135 (± 49)	50-223
Bluegill	2	0.1	66 (± 6)	61-70
Largemouth bass	4	0.3	92 (± 7)	82-97
Pumpkinseed	3	0.2	90 (± 12)	81-103
Grass pickerel	6	0.4	193 (± 39)	152-264
Yellow perch	10	0.7	123 (± 30)	67-152
Yellow bullhead	2	0.1	45 (± 4)	42-47

Table 26. Density estimates for each species of fish collected at each site in the Little Spokane River.

Reach	Site	N	Density (#/100 m^2)
Bluegill			
5	687	1	<1
4	693	1	<1
Bridgelip suckers			
38	174	1	<1
37	181	8	1
36	196	3	<1
33	260	3	<1
32	275	6	<1
29	332	2	<1
27	355	16	1
23	431	5	<1
23	432	8	<1
22	451	2	<1
22	452	5	<1
18	500	8	1
16	535	14	2
16	539	5	1
Brown trout			
37	181	1	<1
Chiselmouth			
37	181	28	2
36	196	5	<1
29	332	2	<1
26	367	3	<1
23	432	2	<1
18	513	3	<1
16	535	8	1
16	539	1	<1

Reach	Site	N	Density (#/100 m^2)
Sculpins			
38	174	8	<1
37	181	13	1
36	196	2	<1
33	260	12	1
32	267	6	<1
32	275	6	<1
31	292	12	1
29	332	15	1
27	355	8	1
26	367	7	1
23	431	4	<1
23	432	14	1
22	451	3	<1
22	452	5	<1
21	466	10	1
18	500	8	1
18	513	8	1
16	535	9	1
16	539	22	3
11	619	2	<1
11	622	5	1
10	624	2	<1
10	630	5	1
7	668	4	<1
6	674	1	<1
5	687	20	2
4	693	26	3
3	704	16	1
Eastern brook trout			
23	432	1	<1
16	539	1	<1
11	619	43	7
11	622	5	1
10	624	30	5
10	630	38	5
7	668	54	5
6	674	28	3
5	687	109	9
4	693	112	15
3	704	53	4
Grass pickerel			
27	355	1	<1
22	451	3	<1
22	452	2	<1
Largemouth bass			
18	513	4	1
Longnose dace			
38	174	1	<1
37	181	3	<1
32	267	1	<1
31	292	3	<1
29	332	2	<1
23	431	1	<1

Reach	Site	N	Density (#/100 m^2)
23	432	6	<1
18	500	2	<1
Largescale suckers			
38	174	2	<1
37	181	1	<1
36	196	12	1
32	267	1	<1
32	275	1	<1
31	292	1	<1
29	332	3	<1
27	355	9	1
26	367	1	<1
23	431	4	<1
22	452	5	<1
21	466	1	<1
18	500	1	<1
18	513	3	<1
16	535	8	1
16	539	1	<1
Northern pikeminnow			
37	181	3	<1
33	260	5	<1
32	275	2	<1
29	332	1	<1
26	367	9	1
23	431	10	1
22	451	2	<1
22	452	2	<1
18	500	1	<1
18	513	1	<1
16	535	6	1
16	539	4	<1
Pumpkinseed			
32	267	1	<1
27	355	1	<1
22	452	1	<1
Rainbow trout			
38	174	14	1
37	181	8	1
36	196	3	<1
32	267	2	<1
29	332	2	<1
23	432	15	1
18	500	12	2
18	513	1	<1
16	535	8	1
16	539	16	2
11	619	12	2
11	622	30	5
10	624	15	2
10	630	43	5
4	693	3	<1
Redside shiner			
37	181	12	1

Reach	Site	N	Density (#/100 m^2)
36	196	28	2
32	267	2	<1
31	292	1	<1
29	332	1	<1
23	431	3	<1
23	432	1	<1
18	513	5	1
16	535	50	6
16	539	7	1
Speckled dace			
22	451	1	<1
21	466	1	<1
16	535	3	<1
11	619	4	1
11	622	9	1
10	624	7	1
10	630	4	1
7	668	5	<1
6	674	8	1
5	687	21	2
Tench			
27	355	5	<1
18	500	1	<1
Mountain whitefish			
38	174	7	<1
36	196	2	<1
27	355	1	<1
23	432	4	<1
18	500	1	<1
18	513	1	<1
16	539	2	<1
Yellow bullhead			
22	452	2	<1
Yellow perch			
27	355	1	<1
23	431	5	<1
22	451	1	<1
22	452	1	<1
21	466	2	<1

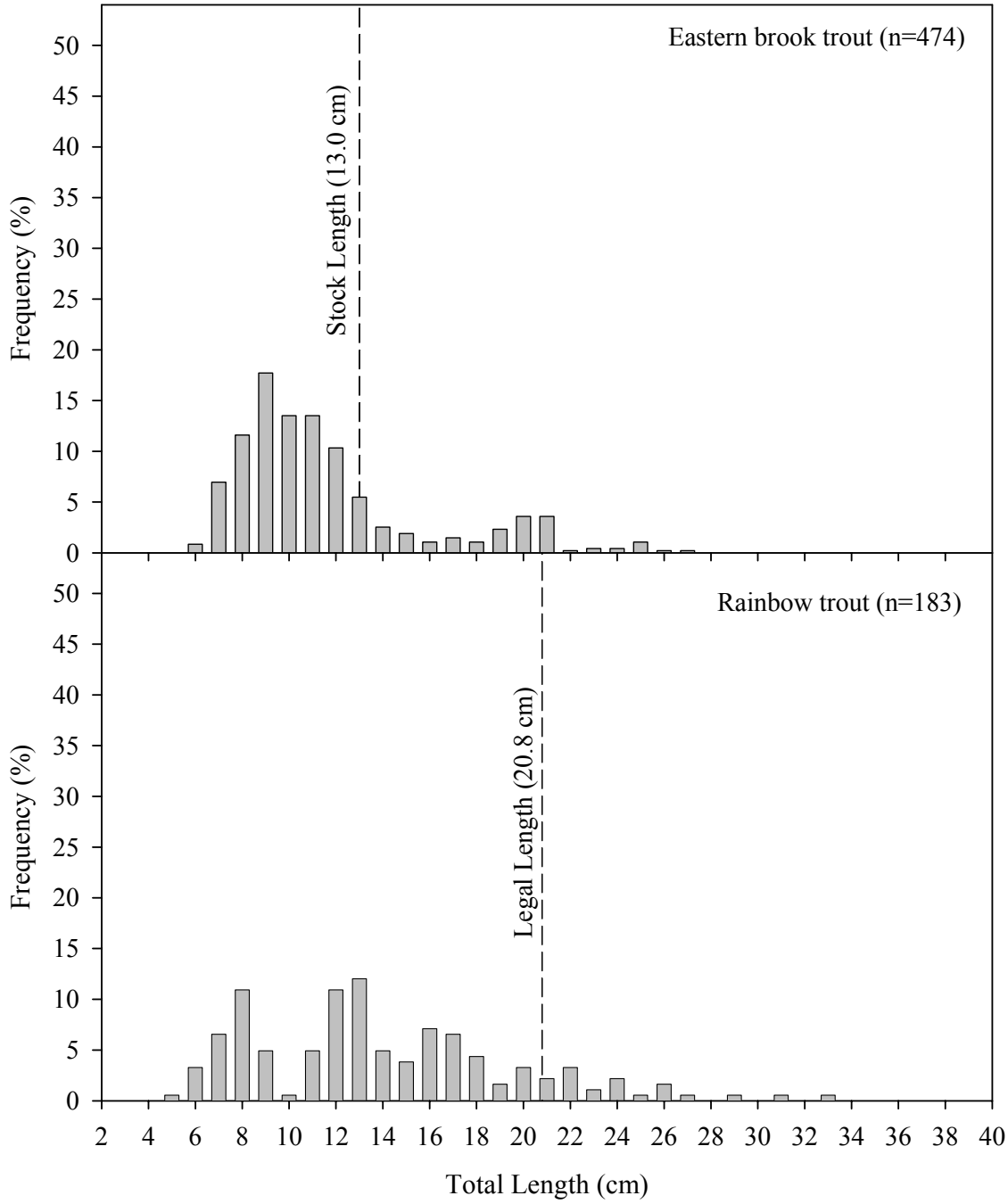

Figure 24. Length-frequency distributions of eastern brook and rainbow trout in the Little Spokane River.

North Fork Little Deep Creek

North Fork Little Deep Creek was divided into 6 reaches that were sampled between June 16 and 23 (Figure 4; Appendix B). A total of 9 sites were surveyed (Figure 5; Appendix C). The

mean of each habitat parameter was calculated for the stream, as well as each reach (Table 27; Appendix J). The mean wetted width was 1.6 m (SD=0.6) and the mean depth was 9 cm (SD=5) (Table 27). The dominant habitat and substrate types were riffle (67%) and gravel (34%), respectively (Table 27).

Daily average, maximum, and minimum temperatures were determined for North Fork Little Deep Creek (Figure 25). The mean temperature was 10.36 °C (SD=6.22), with a maximum of 22.69 °C on July 23 and a minimum of 0.05 °C on November 1, 4, 5, 7-15, 28, and 29.

Five species of fish were collected in North Fork Little Deep Creek (Table 28). Rainbow trout were the most abundant species, based on relative abundance (41.1%; n=157) (Table 28). The percentage of the eastern brook trout population that was of stock length was 13.6% (n=3) (Figure 26). None of the rainbow trout were of legal length for harvest (Figure 26).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each of the species collected (Table 29).

Table 27. Mean values (± SD) of habitat parameters measured and counted in North Fork Little Deep Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	6	No. Riffles	106
No. Sections	9	Riffle Width (m)	1.5 (± 0.6)
No. Transects	153	Riffle Occurrence (%)	67
		Pool Habitat	
Transect Measurements		No. Pools	16
Wetted Width (m)	1.6 (± 0.6)	Pool Width (m)	1.4 (± 0.6)
Bankfull Width (m)	2.8 (± 1.3)	Pool Occurrence (%)	10
Depth (cm)	9 (± 5)	**Run Habitat**	
Maximum Depth (cm)	16 (± 8)	No. Runs	37
		Run Width (m)	1.5 (± 0.4)
Survey Section Measurements		Run Occurrence (%)	23
Gradient (%)	2.4 (± 1.0)		
Water Temperature (^{o}C)	14.1 (± 3.1)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	22.1 (± 4.6)	Organic	1 (± 6)
No. LWD/100 m	25 (± 11)	Muck	3 (± 11)
No. PP/km	4 (± 5)	Silt	23 (± 30)
		Sand	25 (± 21)
Primary Pools (PP)		Gravel	34 (± 32)
No. PP	4	Cobble	6 (± 10)
PP Width (m)	2.4 (± 0.5)	Rubble	4 (± 8)
PP Length (m)	2.3 (± 1.3)	Boulder	4 (± 12)
PP Max. Depth (cm)	36 (± 17)	Bedrock	0 (± 1)
PP Residual Depth (cm)	26 (± 12)	Embeddedness (%)	65 (± 29)

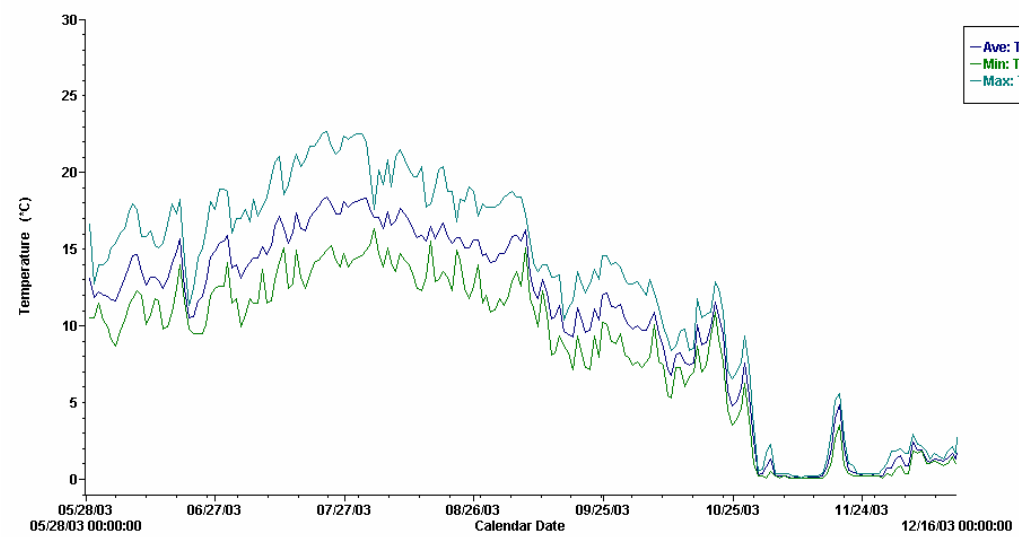

Figure 25. Mean, minimum, and maximum daily temperatures recorded on North Fork Little Deep Creek.

Table 28. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in North Fork Little Deep Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
No Fish				
2				
Eastern brook trout	18	33.3	106 (± 15)	87-151
Rainbow trout	36	66.7	91 (± 39)	34-203
3				
Eastern brook trout	3	6.0	139 (± 44)	107-189
Rainbow trout	47	94.0	100 (± 27)	64-191
4				
Eastern brook trout	1	2.0	203 (nc)	203
Rainbow trout	50	98.0	109 (± 21)	76-156
5				
Rainbow trout	10	100.0	129 (± 21)	109-178
6				
Rainbow trout	14	6.5	128 (± 27)	94-189
Redside shiner	23	10.6	65 (± 22)	29-111
Speckled dace	127	58.5	49 (± 12)	30-88
Bridgelip sucker	53	24.4	48 (± 17)	28-99
Total				
Eastern brook trout	22	5.8	115 (± 30)	87-203
Rainbow trout	157	41.1	105 (± 30)	34-203
Redside shiner	23	6.0	65 (± 22)	29-111
Speckled dace	127	33.2	49 (± 12)	30-88
Bridgelip sucker	53	13.9	48 (± 17)	28-99

Table 29. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in North Fork Little Deep Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
3	64	3	0.7454	3	3	2
2	72	18	1.2224	18	36	12
Rainbow trout						
6	6	3	0.0000	3	3	2
6	9	11	0.3278	11	11	8
5	27	10	0.3464	10	10	5
4	41	27	0.8765	27	27	16
4	45	23	0.7024	23	23	14
3	61	22	3.2499	21	38	12
3	64	30	4.2249	28	49	16
2	72	35	4.1802	33	54	23
6	9	18	0.5212	18	18	13
Speckled dace						
6	6	42	2.7698	41	54	32
6	9	8	0.3953	8	8	6
Bridgelip suckers						
6	9	13	1.0059	13	13	9

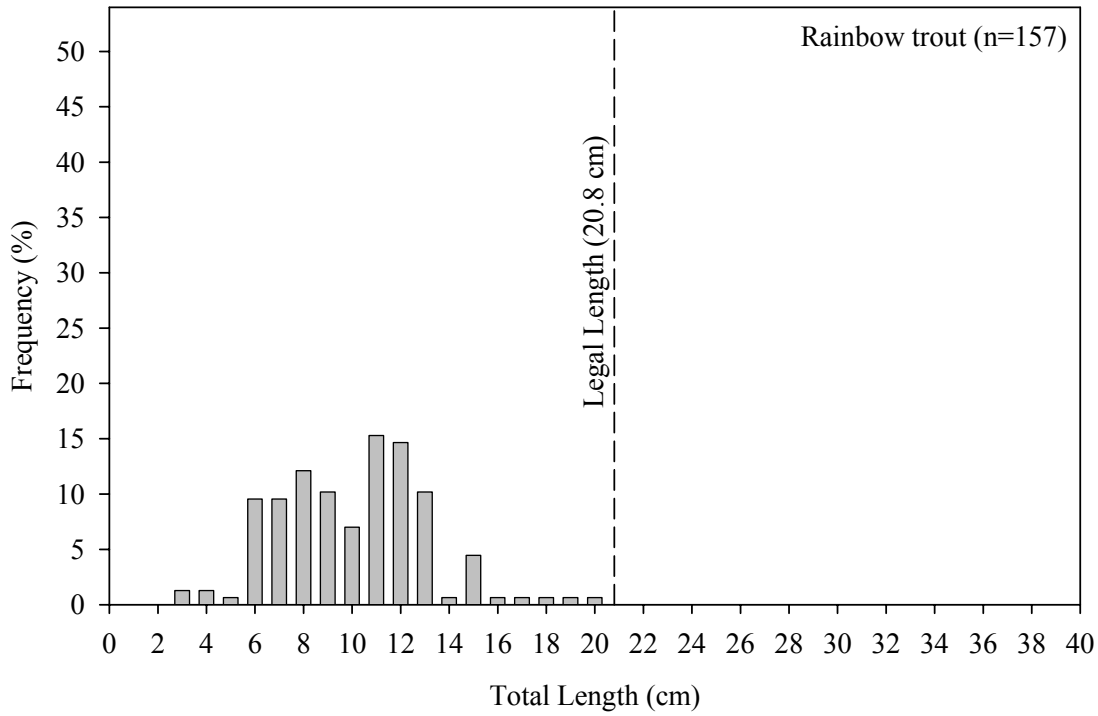

Figure 26. Length-frequency distribution of rainbow trout in North Fork Little Deep Creek.

Pell Creek

Pell Creek was divided into five reaches (Figure 4; Appendix B). Reaches 3, 4, and 5 were sampled on July 2. There was no water in reaches 1 or 2 during the study period. A total of 4 sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 30; Appendix K). The mean wetted width was 2.8 m (SD=0.7) and the mean depth was 19 cm (SD=10) (Table 30). The dominant habitat and substrate types were riffle (43%) and sand (40%), respectively (Table 30).

Rainbow trout were the only fish species collected in Pell Creek (Table 31). None of the rainbow trout were of legal length for harvest. The estimated abundance (± 95% CI) of rainbow trout >50 mm TL at site 26 (Reach 4) was 3 (± 3) and the estimated density was <1 fish/100m^2.

Table 30. Mean values (± SD) of habitat parameters measured and counted in Pell Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	3	No. Riffles	51
No. Sections	4	Riffle Width (m)	1.1 (± 0.4)
No. Transects	68	Riffle Occurrence (%)	73
		Pool Habitat	
Transect Measurements		No. Pools	9
Wetted Width (m)	1.2 (± 0.4)	Pool Width (m)	1.3 (± 0.5)
Bankfull Width (m)	2.8 (± 0.8)	Pool Occurrence (%)	13
Depth (cm)	5 (± 3)	**Run Habitat**	
Maximum Depth (cm)	10 (± 6)	No. Runs	10
		Run Width (m)	1.2 (± 0.1)
Survey Section Measurements		Run Occurrence (%)	14
Gradient (%)	4.3 (± 2.2)		
Water Temperature (^{o}C)	13.0 (± 1.1)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	21.0 (± 6.4)	Organic	1 (± 3)
No. LWD/100 m	20 (± 8)	Muck	1 (± 6)
No. PP/km	8 (± 5)	Silt	18 (± 22)
		Sand	30 (± 24)
Primary Pools (PP)		Gravel	25 (± 21)
No. PP	3	Cobble	14 (± 18)
PP Width (m)	2.1 (± 0.2)	Rubble	6 (± 11)
PP Length (m)	3.2 (± 0.3)	Boulder	1 (± 2)
PP Max. Depth (cm)	34 (± 4)	Bedrock	6 (± 22)
PP Residual Depth (cm)	20 (± 2)	Embeddedness (%)	54 (± 24)

Table 31. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in Pell Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
No Sample				
2				
No Sample				
3				
Rainbow trout	1	100.0	91 (nc)	91
4				
Rainbow trout	12	100.0	58 (± 34)	35-119
5				
No Fish				
Total				
Rainbow trout	13	100.0	61 (± 34)	35-119

South Fork Deadman Creek

South Fork Deadman Creek was divided into five reaches that were sampled between July 28 and August 11 (Figure 4; Appendix B). A total of six sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 32; Appendix L). The mean wetted width was 2.0 m (SD=0.7) and the mean depth was 7 cm (SD=3) (Table 32). The dominant habitat and substrate types were riffle (81%) and sand (35%), respectively (Table 32).

There was one complete and two potential barriers on South Fork Deadman Creek (Figure 17). The complete barrier was a concrete dam located just downstream from the Wallis Road crossing (rkm 1.6). The dam was not examined up close because landowner permission could not be obtained. The approximate height of the dam was 2.0 m.

The first potential barrier was a culvert at the Elliot Road crossing (rkm 4.0). The culvert did not meet the criteria of a fish passage barrier described in the methods; however, a log was lodged at the top of the culvert that required a fish to complete a 40 cm vertical leap. The culvert was 1.2 m in diameter, 9.8 m long, with a gradient of 4.0%, and the water depth in culvert at the time of the survey was 6 cm.

The second potential barrier was a smooth steel pipe (culvert) encased in concrete located at rkm 1.0. Similar to the first barrier, it did not meet the criteria of a fish passage barrier described in the methods; however, a boards were placed at the upstream end of the culvert that required a fish to complete a 40 cm vertical leap. The boards were held in place by steel brackets

designed to allow damming of the stream. The culvert diameter was 1.4 m, 9.2 m long, with a gradient of 5.0%, and the water depth in culvert at the time of the survey was 6 cm.

Daily average, maximum, and minimum temperatures were determined for South Fork Deadman Creek (Figure 27). The mean temperature was 8.79 °C (SD=5.42), with a maximum of 17.86 °C on July 23 and a minimum of –0.02 °C on October 30-November 17, 20-December 1, 4, and 9-14.

Three species of fish were collected in South Fork Deadman Creek (Table 33). Five sculpins, collected at site 2 (reach 5), were preserved for identification and all were identified as mottled sculpins. Rainbow trout were the most abundant species, based on relative abundance (59.8%; n=277) (Table 31). The percentage of the eastern brook trout population that was of stock length was 14.4% (n=40) (Figure 28). None of the rainbow trout were of legal length for harvest (Figure 28).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each of the species collected (Table 34).

Table 32. Mean values (± SD) of habitat parameters measured and counted in South Fork Deadman Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	5	No. Riffles	85
No. Sections	6	Riffle Width (m)	1.9 (± 0.7)
No. Transects	101	Riffle Occurrence (%)	81
		Pool Habitat	
Transect Measurements		No. Pools	15
Wetted Width (m)	2.0 (± 0.7)	Pool Width (m)	1.9 (± 0.7)
Bankfull Width (m)	3.5 (± 0.9)	Pool Occurrence (%)	14
Depth (cm)	7 (± 3)	**Run Habitat**	
Maximum Depth (cm)	15 (± 5)	No. Runs	5
		Run Width (m)	1.9 (± 0.5)
Survey Section Measurements		Run Occurrence (%)	5
Gradient (%)	4.3 (± 2.0)		
Water Temperature (^{o}C)	13.8 (± 1.2)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	19.3 (± 5.4)	Organic	0 (± 3)
No. LWD/100 m	23 (± 7)	Muck	0 (± 0)
No. PP/km	10 (± 9)	Silt	5 (± 7)
		Sand	35 (± 17)
Primary Pools (PP)		Gravel	28 (± 19)
No. PP	6	Cobble	18 (± 17)
PP Width (m)	2.5 (± 0.3)	Rubble	7 (± 8)
PP Length (m)	4.2 (± 1.6)	Boulder	7 (± 11)
PP Max. Depth (cm)	31 (± 5)	Bedrock	0 (± 0)
PP Residual Depth (cm)	20 (± 3)	Embeddedness (%)	56 (± 15)

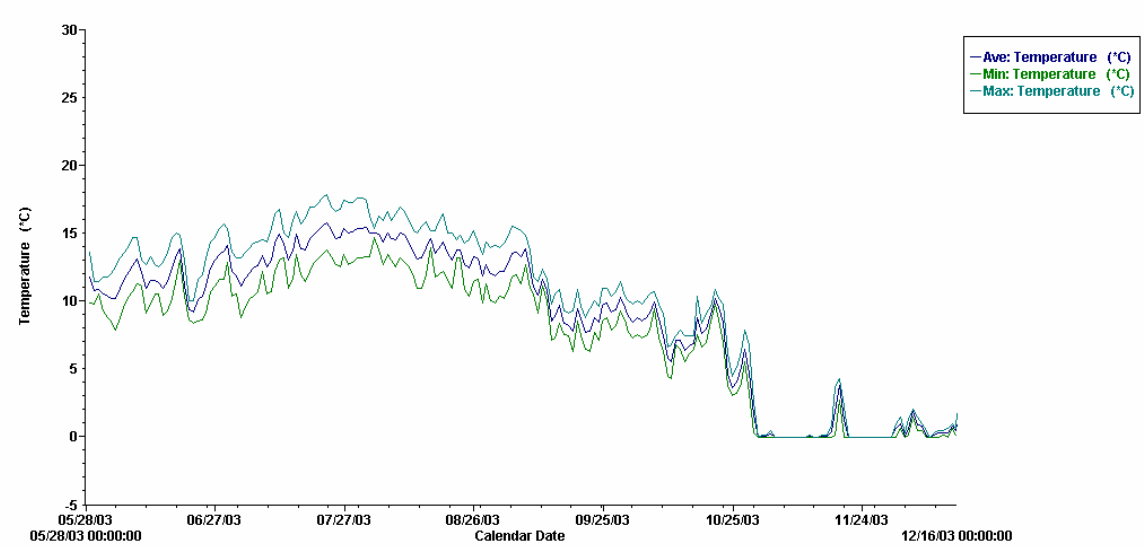

Figure 27. Mean, minimum, and maximum daily temperatures recorded on South Fork Deadman Creek.

Table 33. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in South Fork Deadman Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
Eastern brook trout	79	98.8	81 (± 39)	38-193
Rainbow trout	1	1.3	131 (nc)	131
2				
Eastern brook trout	69	94.5	73 (± 34)	36-154
Rainbow trout	4	5.5	121 (± 13)	111-140
3				
Eastern brook trout	63	87.5	81 (± 41)	40-197
Rainbow trout	9	12.5	86 (± 43)	31-147
4				
Eastern brook trout	56	77.8	78 (± 46)	37-204
Rainbow trout	16	22.2	120 (± 32)	73-179
5				
Eastern brook trout	10	6.0	98 (± 60)	53-205
Rainbow trout	132	79.5	79 (± 40)	29-203
Sculpin spp.	24	14.5	69 (± 14)	48-88
Total				
Eastern brook trout	277	59.8	79 (± 41)	36-205
Rainbow trout	162	35.0	85 (± 41)	29-203
Sculpin spp.	24	5.2	69 (± 14)	48-88

Table 34. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in South Fork Deadman Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
5	10	10	0.7483	10	10	5
4	20	52	7.1570	46	79	28
3	25	59	6.9455	53	85	33
2	37	51	6.3138	46	75	22
1	39	61	1.9908	61	71	26
Rainbow trout						
5	2	38	2.4706	37	49	21
5	10	53	1.9291	53	62	27
4	20	16	0.9002	16	16	9
3	25	6	0.4714	6	6	3
2	37	4	0.6124	4	4	2
1	39	1	0.0000	1	1	<1
Sculpins						
5	10	5	1.2000	5	5	3

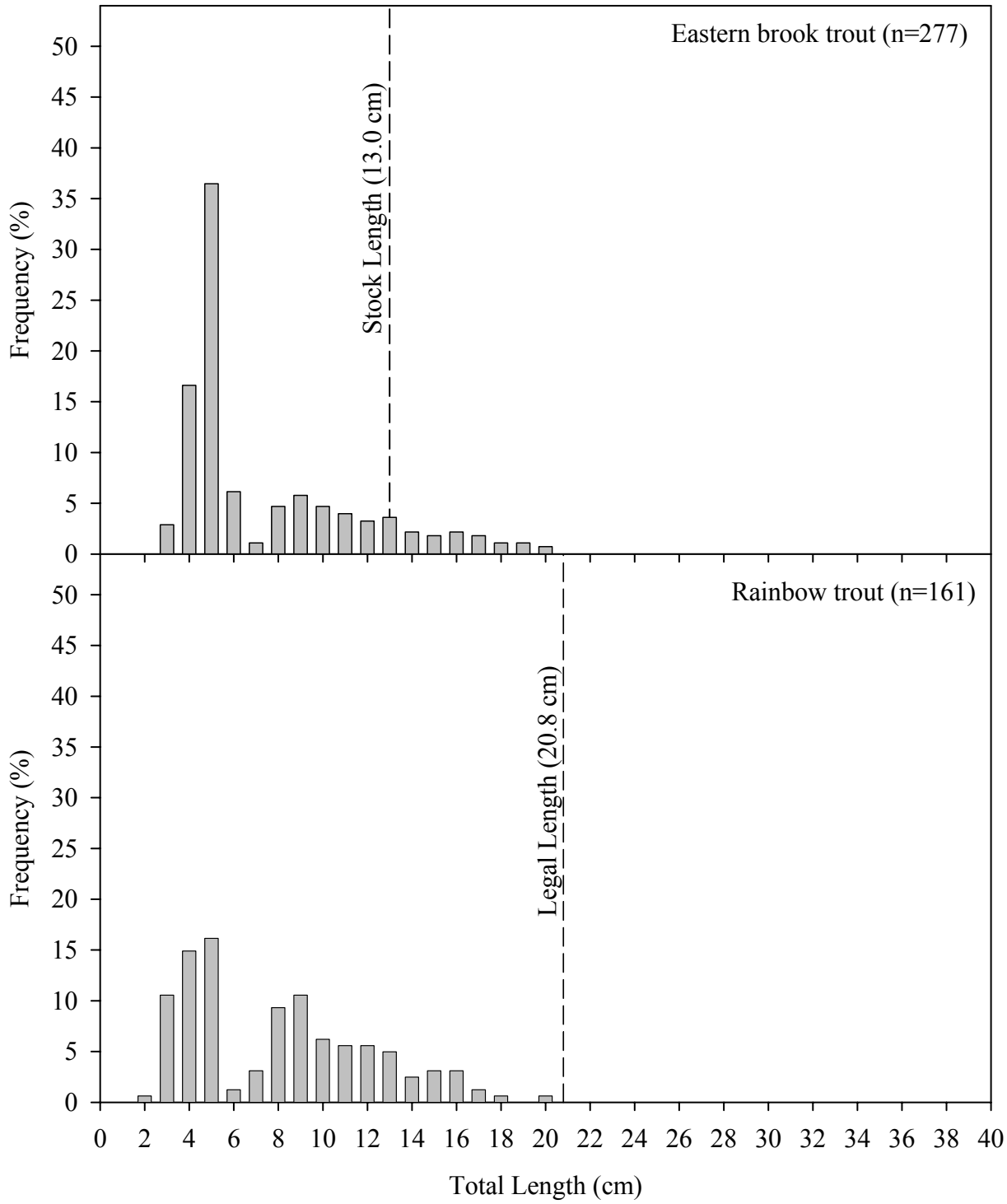

Figure 28. Length-frequency distributions of eastern brook and rainbow trout in South Fork Deadman Creek.

South Fork Little Deep Creek

South Fork Little Deep Creek was divided into nine reaches that were sampled between June 24 and 30 (Figure 4; Appendix B). A total of 11 sites were surveyed (Figure 5; Appendix C). The mean of each habitat parameter was calculated for the stream, as well as each reach (Table 35; Appendix M). The mean wetted width was 1.9 m (SD=0.8) and the mean depth was 9 cm (SD=5) (Table 35). The dominant habitat and substrate types were riffle (74%) and sand and gravel (both 25%), respectively (Table 35).

There was a complete fish passage barrier on South Fork Little Deep Creek at rkm 7.0 (reach 4) (Figure 17). The barrier consisted of a concrete dam that had a vertical height of 2.2 m.

Daily average, maximum, and minimum temperatures were determined for South Fork Little Deep Creek (Figure 29). The mean temperature was 9.86 °C (SD=5.83), with a maximum of 19.72 °C on July 23 and a minimum of –0.19 °C on November 11.

Four species of fish were collected in South Fork Little Deep Creek (Table 36). Rainbow trout were the most abundant species, based on relative abundance (97.7%; n=548) (Table 36). The percentage of the eastern brook trout population that was of stock length was 100.0% (n=2). None of the rainbow trout were of legal length for harvest (Figure 30).

Population estimates, their corresponding standard errors and 95% confidence intervals, and densities were calculated for each of the species collected (Table 37).

Table 35. Mean values (± SD) of habitat parameters measured and counted in South Fork Little Deep Creek.

Sample Sizes		**Riffle Habitat**	
No. Reaches	9	No. Riffles	149
No. Sections	11	Riffle Width (m)	1.8 (± 0.8)
No. Transects	186	Riffle Occurrence (%)	74
		Pool Habitat	
Transect Measurements		No. Pools	43
Wetted Width (m)	1.9 (± 0.8)	Pool Width (m)	1.9 (± 0.7)
Bankfull Width (m)	3.2 (± 1.1)	Pool Occurrence (%)	21
Depth (cm)	9 (± 5)	**Run Habitat**	
Maximum Depth (cm)	18 (± 9)	No. Runs	10
		Run Width (m)	2.1 (± 0.7)
Survey Section Measurements		Run Occurrence (%)	5
Gradient (%)	5.0 (± 3.3)		
Water Temperature (^{o}C)	11.5 (± 2.8)	**Substrate Composition (%)**	
Air Temperature (^{o}C)	18.4 (± 3.7)	Organic	0 (± 2)
No. LWD/100 m	25 (± 8)	Muck	0 (± 1)
No. PP/km	17 (± 15)	Silt	13 (± 22)
		Sand	25 (± 20)
Primary Pools (PP)		Gravel	25 (± 23)
No. PP	19	Cobble	14 (± 17)
PP Width (m)	2.5 (± 0.6)	Rubble	13 (± 17)
PP Length (m)	3.5 (± 1.6)	Boulder	8 (± 18)
PP Max. Depth (cm)	41 (± 12)	Bedrock	2 (± 13)
PP Residual Depth (cm)	27 (± 7)	Embeddedness (%)	48 (± 22)

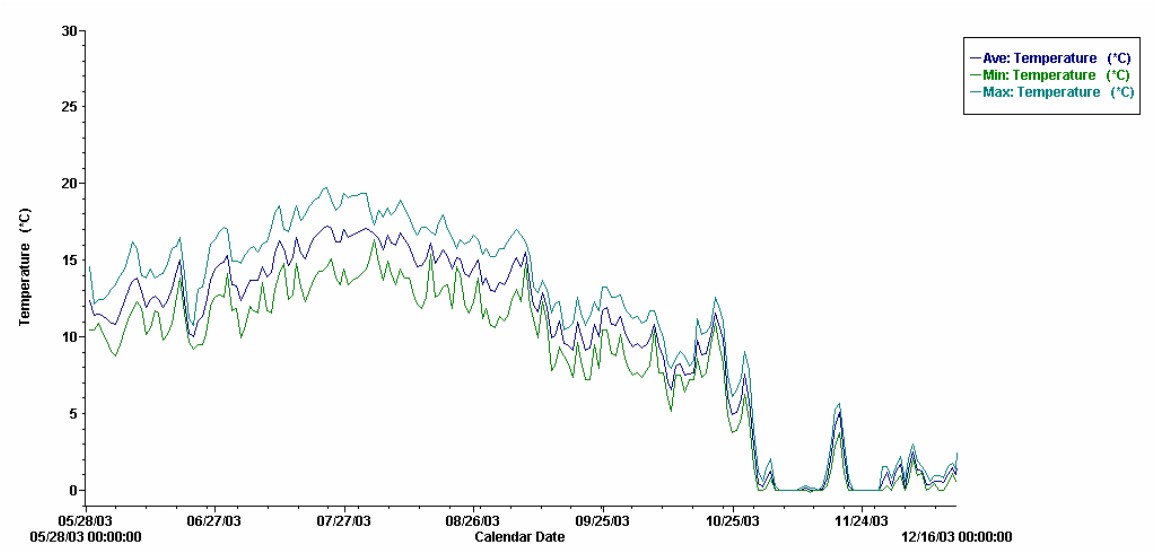

Figure 29. Mean, minimum, and maximum daily temperatures recorded on South Fork Little Deep Creek.

Table 36. Relative abundances (R.A.), mean total lengths (TL; ± SD), and size ranges of each species of fish collected in South Fork Little Deep Creek.

Reach	n	R. A. (%)	Mean TL (mm)	TL Range (mm)
1				
Rainbow trout	1	100.0	124 (nc)	124
2				
Rainbow trout	27	100.0	97 (± 22)	56-145
3				
Rainbow trout	18	100.0	105 (± 23)	67-150
4				
Rainbow trout	50	100.0	104 (± 31)	45-181
5				
Rainbow trout	87	100.0	88 (± 35)	43-203
6				
Rainbow trout	59	100.0	93 (± 31)	55-184
7				
Rainbow trout	168	100.0	97 (± 28)	55-186
8				
Eastern brook trout	2	2.0	160 (± 1)	159-160
Rainbow trout	98	98.0	103 (± 29)	24-201
9				
Rainbow trout	40	78.4	109 (± 25)	82-187
Redside shiner	5	9.8	87 (± 6)	78-94
Speckled dace	6	11.8	81 (± 13)	59-92
Total				
Eastern brook trout	2	0.4	160 (± 1)	159-160
Rainbow trout	548	97.7	98 (± 30)	24-203
Redside shiner	5	0.9	87 (± 6)	78-94
Speckled dace	6	1.1	81 (± 13)	59-92

Table 37. Population estimates (N), their corresponding standard error (SE) and 95% confidence intervals, and density estimates for each species of fish collected at each site in South Fork Little Deep Creek.

Reach	Site	N	SE	Lower 95% CI	Upper 95% CI	Density (#/100 m^2)
Eastern brook trout						
8	12	2	0.0000	2	2	1
Rainbow trout						
9	2	40	0.6928	40	40	20
8	12	99	3.0465	97	111	47
7	20	37	1.2893	37	45	16
7	31	42	2.0522	42	52	22
7	37	94	3.3224	91	106	48
6	45	60	1.3532	60	67	33
5	61	80	2.0572	79	89	44
4	67	53	5.1541	50	74	19
3	77	18	0.8165	18	18	9
2	80	27	0.6383	27	27	14
Redside shiner						
9	2	5	0.5292	5	5	2
Speckled dace						
9	2	6	0.0000	6	6	3

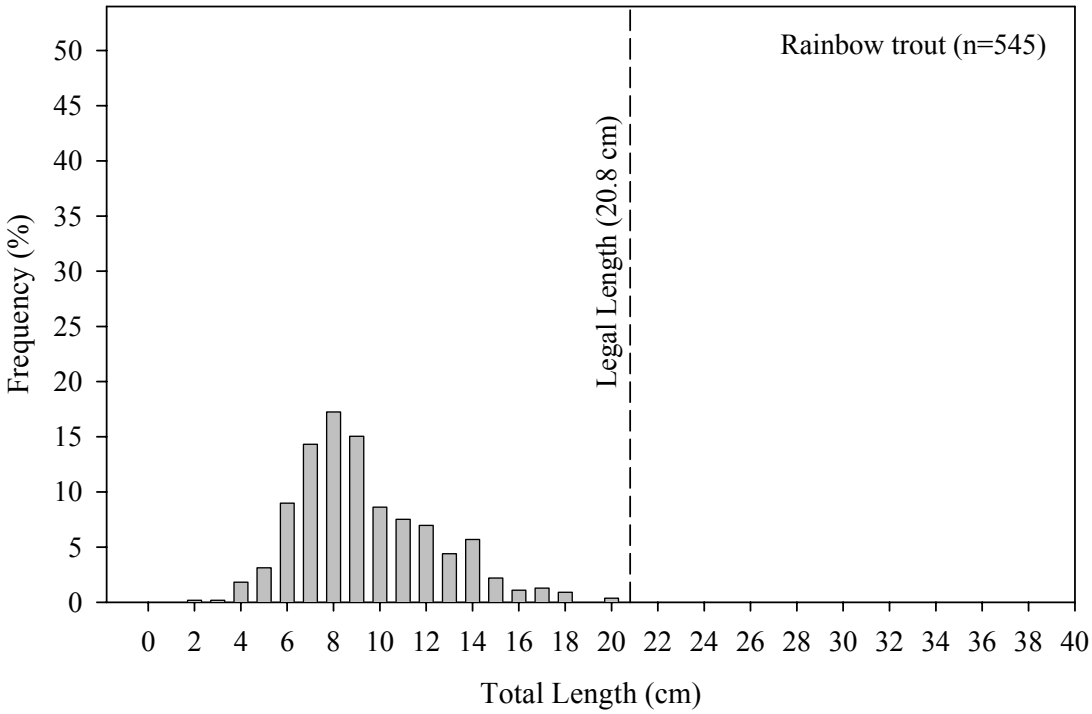

Figure 30. Length-frequency distribution of rainbow trout in South Fork Little Deep Creek.

Population Characterization with DNA Analysis

The rainbow trout populations in Dartford, Deadman, Little Deep, North Fork Little Deep, South Fork Deadman, and South Fork Little Deep Creeks, the Little Spokane River, and the middle and upper Spokane River were sampled for microsatellite DNA analysis. Fin tissue samples were collected from a subsample of individuals from each population (Table 38). The results of the microsatellite DNA analysis data (Appendix N) suggest several independent populations within the greater Spokane River drainage: Spokane River mainstem (upper and middle Spokane River and Middle Spokane R.), Deadman Cr., Deer Cr., Little Deep Cr., Otter Cr., Dragoon Cr., Dartford Cr., Buck Cr., Upper Little Spokane and Lower Little Spokane. Tributaries within these drainages were genetically linked (eg. SFDeadman and Deadman Cr.), such that genetic structure followed geographic structure with collections from tributaries within

the same drainage most closely related. Introgression by coastal rainbow trout, cutthroat trout and redband rainbow trout appeared minimal.

Table 38. List of rainbow trout fin tissue collections for microsatellite DNA analysis and the mean length of the fish in each collection (± SD).

Collection Name	No. of Samples	Mean TL (mm)
Spokane River		
upper Spokane River (mainstem rkm 135 to 155)[a]	70	405 (± 46)
middle Spokane River (mainstem rkm 103 to 119)[b]	100	365 (± 57)
Little Spokane River		
upper Little Spokane River (mainstem above rkm 69)	40	170 (± 47)
lower Little Spokane River (mainstem below rkm 69)	63	183 (± 52)
Dartford Creek	51	152 (± 23)
Dartford Creek (below barrier rkm 0.2)	30	139 (± 22)
Deadman Creek	100	175 (± 52)
Little Deep Creek	50	165 (± 31)
North Fork Little Deep Creek	50	133 (± 22)
South Fork Deadman Creek	50	130 (± 25)
South Fork Little Deep Creek	60	144 (± 22)

[a]Parametrix/Avista Utilities provided 31 of the samples.
[b]Parametrix/Avista Utilities provided 41 of the samples.

Discussion

Spokane River

Surveys of the free-flowing stretch of the middle Spokane River between Monroe Street Dam and T.J. Meenach Bridge conducted in 2002 were repeated in 2003, in an effort to get a better representation of the species composition in that stretch of the river. Effort was increased by adding surveys in May and June. There were four species captured in 2003 that were not collected in 2002: brown trout, cutthroat trout, chiselmouth, and sculpins. These species were likely present in 2002, but at low enough densities that they were not detected by random chance. Similar to 2002, bridgelip suckers and mountain whitefish had the highest CPUE's and relative abundances for all fish and game fish, respectively. Both rainbow trout and mountain whitefish had higher CPUE's and relative abundances in 2003, but the CPUE and relative abundance of bridgelip suckers was lower (Table 39). The mean total lengths of rainbow trout and mountain whitefish in were relatively similar to those in 2002 (Table 39).

The fish species collected in 2003 had all been collected in previous sampling efforts in this stretch of the river (Pfeiffer 1985; Kleist 1987; Peden 1987; Johnson 1993; Maret 1999; McLellan 2003b). Two species that were previously reported, but were not encountered in 2003 were Umatilla dace (Peden 1987) and white sturgeon (Johnson 1993). The densities of these species were likely so low the odds of detection were minimal. Conclusions could not be drawn from the observed differences in species composition indices, such as CPUE or relative abundance, because none of the studies used standardized methods. For a more complete description of the previous surveys and a discussion of the differences see McLellan (2003b).

Mountain whitefish growth in the free-flowing stretch of the middle Spokane River was high when compared to other northwest populations (Table 40). The oldest mountain whitefish collected in the Spokane River was age 6, unlike the other northwest populations that have individuals from age 6 to age 8 (Table 40).

The K_{TL} of rainbow trout from the middle Spokane River was average when compared to those from other northwest rainbow trout populations (Table 41). The K_{TL} of mountain whitefish in the Spokane River was between those reported for Pend Oreille River reservoirs (Table 42).

Table 39. A comparison of relative abundance, catch per unit effort (CPUE; ± 80% CI), and mean total length (± SD) of fish captured in the middle Spokane River between Spokane Falls and T.J. Meenach Bridge in 2002 and 2003. The total effort in 2002 was 0.98 hours (6 sites) and the total effort in 2003 was 2.74 hours (13 sites).

	2002[a]				2003			
Species	**n**	**Relative Abundance (%)**	**CPUE (#/hour)**	**Mean Total Length (mm)**	**n**	**Relative Abundance (%)**	**CPUE (#/hour)**	**Mean Total Length (mm)**
Brown trout					1	0.2	0.57 (± 0.73)	332
Cutthroat trout					1	0.2	1.41 (± 1.80)	352
Rainbow trout	28	11.7	28.3 (± 5.5)	310 (± 65)	88	13.3	39.91 (± 13.58)	333 (± 59)
Mountain whitefish	28	11.7	30.9 (± 12.0)	329 (± 26)	196	29.7	72.16 (± 10.36)	332 (± 33)
Sculpins					2	0.3	0.82 (± 0.71)	72 (± 12)
Chiselmouth					1	0.2	0.25 (± 0.33)	175
Longnose dace	2	0.8	2.0 (± 2.6)	80 (± 15)	3	0.5	0.92 (± 0.81)	73 (± 10)
Northern pikeminnow	1	0.4	1.0 (± 1.3)	417 (nc)	6	0.9	2.56 (± 1.62)	389 (± 145)
Redside shiner	2	0.8	1.8 (± 1.5)	104 (± 7)	3	0.5	0.88 (± 0.78)	100 (± 12)
Bridgelip sucker	155	64.9	158.5 (± 17.3)	303 (± 89)	296	44.8	108.40 (± 28.83)	324 (± 75)[1]
Largescale sucker	23	9.6	24.3 (± 8.7)	435 (± 52)	63	9.5	21.29 (± 5.47)	427 (± 89)[1]

[a]From McLellan (2003b).
[b]Bridgelip and largescale suckers were not measured in July. Means calculated with May and June data (bridgelip suckers n=188; largescale suckers n=40).

Table 40. Comparison of mean back-calculated total lengths (mm) of mountain whitefish in northwest rivers and reservoirs.

		Mean Total Length (mm) at Each Annulus								
Location	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Source**
Montana Rivers	1,212	86	180	246	292	328	353	368	419	Carlander (1969)
Madison River, WY	36	130	226	305	348	388	429			Carlander (1969)
Box Canyon Reservoir, WA 1988-90	1,540	149	206	250	285	341	381	413	435	Ashe and Scholz (1992)
Boundary Reservoir, WA 2000	35	75	177	248	278	317	324	343		McLellan (2001)
Spokane River, WA 2002	24	175	278	316	345					McLellan (2003b)
Nine Mile Reservoir, WA 2002	11	164	253	304	328	352				McLellan (2003b)
Spokane River, WA 2003	51	178	270	306	335	358	381			Current study

Table 41. Comparison of rainbow trout condition factors (K_{TL}) from northwest rivers and reservoirs.

Location	n	K_{TL}	Source
Deer Lake, WA 1985	32	1.08	Scholz et al. (1988)
Loon Lake, WA 1985	15	0.93	Scholz et al. (1988)
Box Canyon Reservoir, WA 1988-90	29	0.93	Ashe and Scholz (1992)
Lake Roosevelt, WA 1997	35	1.22	Cichosz et al. (1999)
Rock Lake, WA 1999	266	0.98	McLellan (2000)
Boundary Reservoir, WA 2000	15	0.95	McLellan (2001)
Spokane River, WA 2002	26	0.96	McLellan (2003b)
Nine Mile Reservoir, WA 2002	101	0.95	McLellan (2003b)
Spokane River, WA 2003	84	0.97	Current study

Table 42. Comparison of mountain whitefish condition factors (K_{TL}) from northwest rivers and reservoirs.

Location	n	K_{TL}	Source
Box Canyon Reservoir, WA 1988-90 (weighted mean)	-	0.76	Ashe and Scholz (1992)
Boundary Reservoir, WA 2000	35	0.83	McLellan (2001)
Spokane River, WA 2002	24	0.80	McLellan (2003b)
Spokane River, WA 2003	68	0.89	Current study

Little Spokane River

Burping Brook

Burping Brook was the steepest stream surveyed and it had the most LWD. The dominant substrate in Burping Brook was sand, which was similar to the rest of the streams surveyed, except North Fork Little Deep Creek, which was dominated by gravel. Burping Brook occurred entirely within Mount Spokane State Park, but roads that were built near the headwaters likely contributed to elevated levels of sand substrate (Marcus et al. 1990, and references within). Large amounts of fine substrates (sand and smaller) may limit trout growth, over-winter survival, and reproduction by filling the interstitial spaces between larger substrate particles, subsequently decreasing macroinvertebrate production and prey availability (Alexander and Hansen 1986), winter concealment cover for juveniles (Griffith and Smith 1993; Meyer and Griffith 1997), and embryo survival (Tappel and Bjornn 1983; Phillips et al. 1975).

Despite no records of fish being stocked in Burping Brook, eastern brook trout and rainbow trout were collected in the stream. The fish in Burping Brook likely emigrated from Deadman Creek. Brook and rainbow trout were collected in Deadman Creek near the confluence with Burping Brook.

Brook trout were present throughout Burping Brook, but only one rainbow trout was collected (reach 3). Rainbow trout likely failed to establish a population due to habitat conditions, either directly from unsuitability or indirectly through interspecific competition. Several factors have been suggested to influence the competitive interactions of brook, brown, and rainbow trout. Brook trout have been suggested to have a competitive advantage at higher elevations, in colder water temperatures, higher gradients, and narrower streams (Larson and Moore 1985; Cunjak and Green 1986; Bozek and Hubert 1992; Larscheid and Hubert 1992; Larson et al. 1995). Magoulick and Wilzbach (1998) reported that brook trout were more aggressive, captured more prey, and grew better than rainbow trout regardless of temperature or macrohabitat.

There appeared to be two size/age classes of brook trout in Burping Brook. The largest size class was between 4 and 6 cm, which likely represented mostly age 0 fish. A second size class was apparent between 8 and 18 cm. The wide length range of the second size/age class may have been the result of variable second year growth or it was comprised of fish from multiple age classes. The lack of subsequent size classes suggested that growth was slow, or that

fish were leaving the population (immigration or mortality). The relatively steep decline in frequency between the first two size/age classes, suggested that first year survival was low. First year survival may have been lower than indicated by the length-frequency distribution, because the proportions of fish of each age may not have been represented equally in each size class. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

Angler opportunities were limited on Burping Brook, due to limited access and low densities of stock size brook trout and legal size rainbow trout. All of the land adjacent to the stream was within the Mount Spokane State Park, but access was limited foot travel through difficult terrain. The proportion of brook trout that were of stock length was relatively high (28.8%), indicating that some angling opportunity did exist. However, the stock length for lotic brook trout is 130 mm (5.1 inches), which is 78 mm (2.9 inches) shorter than the minimum legal size for other trout and 70 mm shorter than the stock length for lentic brook trout (200 mm). No brook trout in the sample were 200 mm or longer. Rainbow trout densities were too low to provide an angling opportunity.

Dartford Creek

Dartford Creek was the fourth largest stream surveyed based on wetted width and mean depth. Similar to Burping Brook the dominant substrate was sand, which was likely the result of road construction and residential development along the stream. Road construction and riparian disturbances (from development) can increase sediment load to streams (Marcus et al. 1990, and references within).

The maximum summer temperature of Dartford Creek (16.30 ^{o}C) was lower than the maximum for Class A coldwater streams (18 ^{o}C), as described in the Washington Administrative Code (WAC) Chapter 173-201A, and was within the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977). The mean temperature of Dartford Creek between May 29 and October 28, 2003 was 0.58 ^{o}C warmer than during the same time period in 2002 (Table 43).

There were no records of fish introductions to Dartford Creek. The origin and genetic composition of the current population is in question. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the

tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in Dartford Creek, so it was assumed that steelhead were historically present. However, substantial numbers of rainbow trout were planted in the Little Spokane River (WDFW unpublished hatchery records) and the lack of passage barriers provided the opportunity for them to hybridize with fish in Dartford Creek. Nonetheless, the preliminary genetic results indicate that the rainbow trout in Dartford Creek have had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

The distribution of brook trout and longnose dace was limited to reach 5 and below. The reason for the lack of brook trout and longnose dace upstream was likely related to the culvert at rkm 0.2.

The rainbow trout length frequency distribution had two distinct size/age classes. A third, less distinct size/age class, was visible at 14 cm. There appeared to be a relatively substantial overlap in the lengths of different age classes. The number of fish after age 0 declined sharply, with densities of older fish declining at a moderate rate. The sharp decline in fish between ages 0 and 1 may have been the result of low first year survival or emigration. Adult rainbow trout from the Little Spokane River may use the lower portion of Dartford Creek for spawning, and a portion of the juveniles may migrate to the Little Spokane River between ages 0 and 1. Survival may have been higher than indicated by the length-frequency distribution, because the proportions of fish of each age may not have been represented equally in each size class. The life history strategies of rainbow trout in Dartford Creek should be determined to allow for improved management. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

Angler opportunities were limited on Dartford Creek, due to limited access and a lack of legal size trout. All of the land adjacent to the stream was privately owned and several landowners, although not directly asked, expressed that they did not permit access to anglers. None of the rainbow trout captured were of the legal length for harvest.

Similar to our results, two previous single site electrofishing surveys of Dartford Creek above the barrier culvert resulted in collections of rainbow trout (WDFW, unpublished data).

Table 43. Comparison of the mean (± SD) temperatures (^{o}C) recorded at each of the sites monitored in 2002 and 2003.

Stream	Location	2002[a]		2003	
		n	Average	n	Average
Dartford Creek	Lower	1,741	11.51 (± 2.70)	1,837	12.09 (± 2.02)
Deadman Creek	Lower	1,741	12.74 (± 3.46)	1,837	13.06 (± 2.70)
Deadman Creek	Upper	1,741	8.72 (± 3.04)	1,837	10.17 (± 2.47)
Little Deep Creek	Lower	1,741	12.05 (± 3.70)	1,836	12.39 (± 2.61)
Little Spokane River	Lower	1,741	13.29 (± 2.70)	1,837	13.74 (± 2.27)
Little Spokane River	Painted Rocks	1,741	12.98 (± 2.53)	1,837	13.44 (± 2.13)
Little Spokane River	Wandermere	1,741	14.50 (± 3.88)	1,837	15.61 (± 3.11)
Little Spokane River	Elk	1,741	15.83 (± 4.73)	1,837	16.74 (± 4.06)
Little Spokane River	Scotia	1,741	11.76 (± 3.82)	1,837	12.74 (± 3.39)

[a]2002 values from McLellan 2003b.

Deadman Creek

Deadman Creek was the largest tributary of the Little Spokane River surveyed based on wetted width (3.7 m) and bankfull width (5.4 m). Deadman Creek had the highest density of primary pools of all of the streams surveyed.

The maximum summer temperature measured at the lower and middle Deadman Creek sites (19.51 and 23.36 ^{o}C) exceeded the maximum for Class A coldwater streams (18 ^{o}C), as described in the WAC Chapter 173-201A. The summer maximum temperature recorded at middle Deadman Creek also exceeded the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977). The middle reaches of Deadman Creek were low gradient (≤ 1.6%) and flowed through active agricultural areas and portions were almost stagnant by late summer. Cold groundwater recharge in the lower reaches likely resulted in the lower observed temperatures at the lower monitoring site. The summer maximum temperature at the upper Deadman Creek site (16.04 ^{o}C) was below the maximum for Class A coldwater streams. The mean temperatures at the lower and upper Deadman Creek sites between May 29 and October 28, 2003 were 0.32 and 1.45 ^{o}C warmer than during the same time period in 2002 (Table 43).

Eastern brook trout were primarily isolated to six of the uppermost seven reaches of the stream (reaches 2-7), with the exception of two captured in reach 22. Densities varied upstream of reach 7 (2 to 14 fish/100 m^2), but were relatively low in reaches 7 and 22 (≤ 1 fish/100 m^2). Rainbow trout were present throughout the stream. Densities of rainbow trout varied in reaches

1-7 and 20-23, but typically exceeded 10 fish/100 m^2. Rainbow trout densities in the middle reaches (12-20) were generally low (≤ 2 fish/100 m^2) with the exception of one site 193 (reach 13), which had a density of 7 fish/100 m^2.

Rainbow trout appeared to dominate brook trout in Deadman Creek. In four of the seven reaches where brook trout and rainbow trout were both collected, rainbow trout had higher densities. In one reach (3) they had equal densities and in reaches 2 and 4 brook trout had higher densities. Interestingly, brook trout were not captured in reach 1. The results of this study were similar to those in other areas in that brook trout were isolated to the headwater areas of the stream; however they were different in that rainbow trout still appeared to maintain a competitive dominance or equality in the upper reaches.

In southern Appalachian streams, introduced rainbow trout occupied low reaches and confined brook trout to upper reaches, with a small zone of sympatry in intermediate reaches (Larson and Moore 1985; Larson et al. 1995). Bozek and Hubert (1992) observed the same general distribution in Wyoming streams and classified brook trout as high elevation, low gradient, narrow stream species and classified brown and rainbow trout as low elevation, low gradient, wide stream species. Brook trout have been suggested to have a competitive advantage at higher elevations, in colder water temperatures, higher gradients, and narrower streams (Larson and Moore 1985; Cunjak and Green 1986; Bozek and Hubert 1992; Larscheid and Hubert 1992; Larson et al. 1995). The low densities of salmonids in the middle reaches of Deadman Creek were likely due to the high temperatures.

The reasons for the limited distribution of mountain whitefish were unknown, but may have been to the high temperatures in the middle reaches of Deadman Creek. Mountain whitefish generally occupy streams with mean temperatures ranging from 9 to 11 ^{o}C (Wydoski and Whitney 1979).

The upper most extent of the distribution of redside shiners, speckled dace, and bridgelip suckers was reach 13. Their distribution appeared to be related, in part, to gradient. The gradient of Deadman Creek upstream of reach 13 was ≥ 3.0% and the gradient from reach 13 downstream was ≤ 3.0%.

There were no apparent size/age classes in the length-frequency distribution of eastern brook trout. Otolith analysis is needed to determine the age structure, survival rates, and growth rates of the population.

There were no apparent size/age classes in the length-frequency distribution of rainbow trout. Otolith analysis is needed to determine the age structure, survival rates, and growth rates of the population.

The origin of the brook trout population in Deadman Creek was likely the result of past stocking efforts. Brook trout were planted by WDFW on three occasions between 1934 and 1941 (WDFW, unpublished hatchery records).

The origin of the rainbow trout population in Deadman Creek was unknown. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in Dartford Creek, so it was assumed that steelhead were historically present. However, rainbow trout were planted in Deadman Creek on several occasions between 1934 and 1955 and in the Little Spokane River as recently as 2002 (WDFW, unpublished hatchery records). The preliminary genetic results indicated that the rainbow trout in Deadman Creek have had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

Eastern Washington University conducted three single site electrofishing surveys on Deadman Creek in 1999 (EWU, unpublished data). Similar to this study, they collected rainbow trout, longnose dace, redside shiners, speckled dace, bridgelip suckers and sculpins. They likely did not collect all of the species that were observed in this study because of their small number of sample sites.

There were angler opportunities on Deadman Creek, particularly in the upper reaches. State Highway 206 ran along the upper third of the stream into Mount Spokane State Park and anglers were observed accessing the stream directly from the highway. The headwaters of Deadman Creek also fell within the boundaries of Mount Spokane State Park. There was also a Spokane County Conservation Futures property (Feryn Property), along the middle reaches of the stream, where anglers could gain access. However, trout densities in the middle reaches were low. The remainder of the land adjacent to the stream was privately owned and many landowners, although not directly asked, expressed that they did not permit access to anglers. The proportion of brook trout that were of stock length was relatively high (47.9%), indicating that the stream may have some angling value. However, the stock length for lotic brook trout is

130 mm (5.1 inches), which is 78 mm (2.9 inches) shorter than the minimum legal size for other trout and 70 mm shorter than the stock length for lentic brook trout (200 mm). Two brook trout in the sample were 200 mm or longer. The proportion of rainbow trout that were legal length for harvest was 6.7%, which was relatively high compared to other streams in the area (McLellan 2003a and 2003b).

Little Deep Creek

Little Deep Creek was the second largest tributary of the Little Spokane River surveyed based on wetted and bankfull widths and it was the deepest. Little Deep Creek also had the lowest gradient. A portion of Little Deep Creek (reaches 7 and 8) goes dry in the late summer of most years. According to land owners, Little Deep Creek has gone completely dry above reach 9 in previous years.

The maximum summer temperature of Little Deep Creek (19.07 ^{o}C) was higher than the maximum for Class A coldwater streams (18 ^{o}C), as described in the Washington Administrative Code (WAC) Chapter 173-201A, but was within the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977). The mean temperature of Little Deep Creek between May 29 and October 28, 2003 was 0.34 ^{o}C warmer than during the same time period in 2002 (Table 43).

There were no records of any fish introductions to Little Deep Creek. The origin and genetic composition of the current rainbow trout population is in question. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in Little Deep Creek, so it was assumed that steelhead were historically present. However, substantial numbers of rainbow trout were planted in the Little Spokane River (WDFW unpublished hatchery records) and the lack of passage barriers provided the opportunity for them to hybridize with fish in Little Deep Creek. However, the preliminary genetic results indicated that the rainbow trout in Little Deep Creek have had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

One large (347 mm) bridgelip sucker was collected in reach 2, which was approximately 13.4 km upstream from the mouth. The large size suggested that the fish migrated from the

Little Spokane River. The presence of only one large fish, not in spawning condition, did not support the idea of an adfluvial bridgelip sucker run.

There were no distinct size/age classes in the length frequency distribution of rainbow trout. Otoliths need to be analyzed to determine age, growth, and survival characteristics.

Angler opportunities were limited Little Deep Creek, due to few access opportunities and low densities of legal size trout. All of the land adjacent to the stream was privately owned and it was unknown if any landowners would grant access to anglers. The proportion of rainbow trout that were of legal length for harvest was low (4.1%).

Eastern Washington University conducted a single electrofishing survey on Little Deep Creek near Woolard Road in 1999 (EWU, unpublished data). Similar to this study, they collected rainbow trout, longnose dace, redside shiners, speckled dace, and bridgelip suckers. Mountain whitefish and sculpins were also captured in the current study, but they were downstream of the EWU sampling location.

Little Spokane River

The Little Spokane River was the largest stream surveyed based on wetted width, bankfull width, and mean depth. The Little Spokane River was more than 3 times the wetted width of the next largest stream. It was dominated by run habitat, unlike the rest of the streams, which were dominated by riffle habitat. The Little Spokane River had the lowest mean densities of LWD and primary pools and the second lowest mean gradient.

The maximum summer temperature measured at five of the six sites monitored on the Little Spokane River (18.29 to 24.99 ^{o}C) exceeded the maximum for Class A coldwater streams (18 ^{o}C), as described in the WAC Chapter 173-201A. The exception was at the Indian Painted Rocks site (17.77 ^{o}C).

Mean and maximum water temperatures in the Little Spokane River increased between Scotia and Elk and then declined at successive downstream monitoring sites to the Indian Painted Rocks. Mean and maximum water temperatures increased again between the Indian Painted Rocks and the mouth. The increase in temperature between Scotia and Elk was likely the result of warm surface waters from Chain Lake flowing down the Little Spokane River. The decreasing temperatures between Elk and the Indian Painted Rocks were likely the result of cold

groundwater inflow that occurs near Wandermere (Hartung and Meier 1980; 1995) and inflow from colder tributary streams.

Maximum temperatures exceeded the upper avoidance levels reported for adult brown, brook, and rainbow trout (19, 20, and 20 ^{o}C, respectively) in the Little Spokane River from Wandermere upstream (Coutant 1977; Garrett and Bennett 1995). Maximum temperatures in the Little Spokane River at Chattaroy exceeded 20.0 ^{o}C on 71 days. Maximum temperatures in the Little Spokane River at Elk exceeded 20.0 ^{o}C on 89 days, which was higher than the 59 and 64 days in 2001 and 2002. The maximum temperature of the Little Spokane River at Scotia exceeded 20.0 ^{o}C on three days, which was similar to the four days in 2002. Summer maximum temperatures may limit salmonid production in the Little Spokane River, between Wandermere and Chain Lake.

The mean temperatures of Little Spokane River measured near the mouth, Indian Painted Rocks, Wandermere, Elk, and Scotia between May 29 and October 28, 2003 were virtually the same as they were during the same time period in 2002 (Table 43).

Fourteen of the 19 species of fish captured in this study, were only collected downstream of reach 11. The upper 11 reaches occurred upstream of a natural barrier above Chain Lake. Densities of fish in the Little Spokane River were generally low (≤ 1 fish/100 m^2), with the exception of trout densities in the upper 11 reaches. Eastern brook trout were collected at two sites downstream of Chain Lake, but they were predominantly confined to the uppermost 11 reaches. Rainbow trout, speckled dace, and sculpins were captured both above and below reach 11. Bluegills were only captured above reach 11.

The results of this study, particularly the density estimates, should be interpreted with caution. The single pass electrofishing method, without block nets, that was used likely biased the density estimates by allowing fish to enter or leave during the study. In addition, high velocities, deep water, and thick vegetation limited the efficiency of fish capture. The survey of the river was not complete, because landowners did not grant access to some of the reaches.

There were two apparent size/age classes in the length-frequency distribution of eastern brook trout. The first size class was relatively wide (6 to 15 cm). The second size class was 20 to 21 cm. The large width of the first size class suggested that there were multiple ages represented; however, the wide space between the first and second size groups, as well as the presence of fish to 27 cm, suggested that growth was relatively fast. The observed distribution

was likely the result of sampling bias. Otolith analysis is needed to determine the age structure, survival rates, and growth rates of the population.

There were several apparent size/age classes in the length-frequency distribution of rainbow trout. The length-frequency distribution was developed from a relatively low number of fish over a wide geographic area and likely from multiple populations. Considering these facts, the data was not interpreted. Otolith analysis is needed to determine the age structure, survival rates, and growth rates of the population.

The origins of the current rainbow trout populations in Little Spokane River were unknown. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), so there was the possibility of some remnant native stock present in the river. The likelihood of a pure redband stock was remote due the long history of fish stocking in the Little Spokane River, as well as its tributaries. Since the early 1900's, there have been various state federal, and private fish culture facilities operating on the Little Spokane River primarily located in the lower reaches near Wandermere, Waikiki Springs, and Galbraith Springs (Crawford 1979). Since 1933, there have been over 10.1 million rainbow trout and steelhead planted in the Little Spokane River drainage by WDFW (WDFW, unpublished hatchery records). Despite the low probability that genetically pure redband rainbow trout remained in the river, the upper and lower populations were analyzed using microsatellite DNA techniques. The preliminary genetic results indicated that the rainbow trout in both the upper and lower portions of the Little Spokane River have had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

The majority of the existing fish population data that was collected on the free flowing portions of the drainage consisted of electrofishing on the lower 27.0 km of the Little Spokane River. Detailed descriptions of the studies were presented in McLellan (2003a). There were 26 species reported in all of the previous work combined (Hartung and Meier 1980 and 1995; Pfeiffer 1988; EWU, unpublished data) (Table 1). The seven species that were not also collected in this study were kokanee, pygmy whitefish, carp, longnose sucker, white sucker, black crappie, and brown bullhead. All of these fish, with the exception of white suckers, were reported in waters that connected to the Little Spokane River (Hartung and Meier 1980 and 1995; Mongillo and Hallock 1995; Hallock and Mongillo 1998; Polacek and Baldwin 1999; Osborne et al. 2003; EWU, unpublished data). They were likely missed in 2003 due to sampling bias or random

chance as a result of low densities. The pygmy whitefish were collected in 1980 (Hartung and Meier 1980). Pygmy whitefish were confirmed to inhabit Horseshoe Lake in the early 1990's, but are now considered extirpated (Mongillo and Hallock 1995; Hallock and Mongillo 1998). The white suckers were likely misidentified. Yellow bullhead was the only species captured in 2003 that was not previously reported to occur. Yellow bullheads were captured in other parts of the drainage (Zook 1978; Divens et al. 2001; Divens et al. 2002a; McLellan 2003a; Osborne et al. 2003; EWU, unpublished data; WDFW, unpublished data).

There was angler opportunity on Little Spokane River, but the majority of the river falls within private land ownership. The fact that the landowners also own the stream bottom makes the landowner-angler relationship rather tenuous. The only public access in the upper reaches was the Elk Community Park. The majority of the public access occurs in the lower 27.0 km and the largest piece of public property along the lower river is Riverside State Park. There are additional smaller pieces of state and county property within the lower 27.0 km where anglers can access the stream. The proportion of brook trout that were of stock length was relatively high (25.5%). The stock length for lotic brook trout is 130 mm (5.1 inches), which is 78 mm (2.9 inches) shorter than the minimum legal size for other trout and 70 mm shorter than the stock length for lentic brook trout (200 mm). However, the proportion of brook trout that were 200 mm or longer was 9.7% (n=46), indicating that the upper river has relatively good angling value. The proportions of brown and rainbow trout that were legal length for harvest were 100.0% and 14.2%, which was high when compared to other streams in the area (McLellan 2003a and 2003b).

North Fork Little Deep Creek

North Fork Little Deep Creek was the second smallest stream surveyed based on wetted width and the smallest based on bankfull width (tied with Pell Creek). Unlike the other streams surveyed in 2003, the dominant substrate in North Fork Little Deep Creek was gravel.

The maximum summer temperature of North Fork Little Deep Creek (22.69 ^{o}C) exceeded the maximum for Class A coldwater streams (18 ^{o}C), as described in the Washington Administrative Code (WAC) Chapter 173-201A, and the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977).

There were no records of any fish introductions to North Fork Little Deep Creek. The origin and genetic composition of the current rainbow trout population is in question. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in North Fork Little Deep Creek, so it was assumed that steelhead were historically present. The preliminary genetic results indicated that the rainbow trout in the North Fork Little Deep and Little Deep Creeks make up a single population, which has had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

The distribution of brook trout was limited to reaches 2, 3, and 4, which was similar to the distribution pattern observed in other areas (McLellan 2003b). For a discussion on the factors related to brook and rainbow trout distributions see McLellan (2003b).

The rainbow trout length frequency distribution did not have any distinct size/age classes. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

Angler opportunities were limited on North Fork Little Deep Creek, due to limited access and a lack of legal size trout. The headwaters of the stream ran through Mount Spokane State Park and Inland Empire Paper Company property; however, there were no fish captured in the headwaters. All of the land adjacent to the stream where fish were present was privately owned and several landowners, although not directly asked, expressed that they did not permit access to anglers. Three brook trout (13.6%) were of stock length. None of the rainbow trout captured were of the legal length for harvest.

Pell Creek

Pell Creek was the smallest stream surveyed based on wetted width, bankfull width, and mean depth. Angler opportunities were limited on Pell Creek, due a lack of legal size trout. None of the rainbow trout captured were of the legal length for harvest.

South Fork Deadman Creek

The maximum summer temperature of South Fork Deadman Creek (17.86 ^{o}C) was lower than the maximum for Class A coldwater streams (18 ^{o}C), as described in the Washington Administrative Code (WAC) Chapter 173-201A, and was within the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977).

The brook and rainbow trout were collected throughout the stream, but densities of rainbow trout progressively increased in lower reaches. Brook trout densities declined in reach 5, to a level lower than that of rainbow trout. The general distribution pattern has been observed in several other locations (McLellan 2003b). For a discussion on the possible factors related to brook and rainbow trout distributions see McLellan (2003b).

There were no records of any fish introductions to South Fork Deadman Creek. The brook trout likely emigrated from Deadman Creek.

The origin and genetic composition of the current rainbow trout population was in question. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in South Fork Deadman Creek, so it was assumed that steelhead were historically present. However, substantial numbers of rainbow trout were planted in Deadman Creek (WDFW unpublished hatchery records) and the lack of passage barriers provided the opportunity for them to hybridize with fish in South Fork Deadman Creek. The preliminary genetic results indicated that the rainbow trout in the South Fork Deadman and Deadman Creeks make up a single population, which has had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

The brook trout length frequency distribution had one size/age class between 3 and 7 cm (age 0). The lack of other size classes suggested that growth was slow after age 0. The steep decline in the number of fish after age 0 indicated that first year survival was low or that fish were immigrating. Adult brook trout from Deadman Creek may use South Fork Deadman Creek for spawning, and a portion of the juveniles may migrate out to Deadman Creek between ages 0 and 1. The fluvial life history pattern hypothesis was supported by the lack of age 0 brook trout in Deadman Creek. The gradual decline in the number fish per cm length category after age 0

indicates high survival. Survival may have been lower than indicated by the length-frequency distribution, because the proportions of fish of each age may not have been represented equally in each size class. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

The rainbow trout length frequency distribution had two distinct size/age classes. The lack of distinct size classes after age 1 (second size class), suggested that growth was slow. The slope of the moderate decline in the numbers of fish between the two size/age classes and subsequent cm length category indicated survival was moderate across all ages. Survival may have been lower than indicated by the length-frequency distribution, because the proportions of fish of each age may not have been represented equally in each size class. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

Angler opportunities were limited on South Fork Deadman Creek, due to limited access and a lack of legal size trout. The majority of the land adjacent to the stream was privately owned and several landowners, although not directly asked, expressed that they did not permit access to anglers. The proportion of the brook trout population that was of stock length was 14.4%, indicating some angling potential. However, the stock length for lotic brook trout is 130 mm (5.1 inches), which is 78 mm (2.9 inches) shorter than the minimum legal size for other trout and 70 mm shorter than the stock length for lentic brook trout (200 mm). Two brook trout in the sample were 200 mm or longer. None of the rainbow trout captured were of the legal length for harvest.

Eastern Washington University conducted a single backpack electrofishing survey on the South Fork Deadman Creek in 1999 and they reported only collecting brook trout (EWU, unpublished data). Rainbow trout were collected throughout South Fork Deadman Creek during this survey, but the densities were low in the area EWU surveyed (rkm 4.0), so they likely missed them by random chance. Sculpins were only collected in reach 5 in the current study, which was more than 3.0 km downstream from the EWU sample site.

South Fork Little Deep Creek

The maximum summer temperature of South Fork Little Deep Creek (19.72 ^{o}C) exceeded the maximum for Class A coldwater streams (18 ^{o}C), as described in the Washington

Administrative Code (WAC) Chapter 173-201A, but was within the preferred ranges of brown, eastern brook, and rainbow trout (15 to 21 ^{o}C) (Coutant 1977).

There were no records of any fish introductions to South Fork Little Deep Creek. The two brook trout collected in reach 9 likely emigrated from the North Fork Little Deep Creek.

The origin and genetic composition of the current rainbow trout population is in question. Historically, steelhead migrated up the Little Spokane River to spawn (Scholz et al. 1985), but it is unclear as to which, if any, of the tributaries they used for spawning, with the exception of Deer Creek (A. Scholz, EWU, personal communication). There were no known historic barriers to fish movements in South Fork Little Deep Creek, so it was assumed that steelhead were historically present. The preliminary genetic results indicated that the rainbow trout in the South Fork Little Deep and Little Deep Creeks make up a single population, which has had little influence from the Spokane Hatchery stock of rainbow trout, suggesting they are native redband rainbow trout (Appendix N).

The rainbow trout length frequency distribution did not have any distinct size/age classes. Otolith analysis is needed to determine the age structure and growth and survival rates of the population.

Angler opportunities were limited on South Fork Little Deep Creek, due to limited access and a lack of stock and legal size trout. The majority of the land adjacent to the stream was privately owned and several landowners, although not directly asked, expressed that they did not permit access to anglers. The headwaters were within Mount Spokane State Park, but access was limited to foot travel over extremely difficult terrain. Only two brook trout were captured in the stream and none of the rainbow trout captured were of the legal length for harvest.

Recommendations

- Determine the origins and stock composition of the wild rainbow trout population in the middle Spokane River.
- Re-evaluate stocking programs and management goals for the middle Spokane River once the DNA studies are complete.
- Identify habitat restoration opportunities in the Little Spokane River system, particularly related to decreasing sediment loading, with statistically defensible evaluation plans. Particular emphasis should be given to restoration projects along Dartford Creek (reaches 1 and 2), Deadman Creek (reaches 13, 14, 15, and 18), Little Deep Creek (reaches 3, 4, 5, and 7), the Little Spokane River (reaches 3, 4, 5, 6, 7, 10, 21, and 22), NF Little Deep Creek (reaches 5 and 6) where substrate embeddedness levels were ≥ 90% and fine sediments (sand or smaller, including organics) comprised ≥ 75%. Large amounts of fine substrates (sand and smaller) may limit trout growth, over-winter survival, and reproduction by filling the interstitial spaces between larger substrate particles, subsequently decreasing macroinvertebrate production and prey availability (Alexander and Hansen 1986), winter concealment cover for juveniles (Griffith and Smith 1993; Meyer and Griffith 1997), and embryo survival (Tappel and Bjornn 1983; Phillips et al. 1975).
- Identify the human-made fish migration barriers in the Little Spokane River system that should be removed or improved to restore fish passage.
- Collect otoliths from each salmonid population in the Little Spokane River system to determine age structures, growth rates, and survival rates.
- Identify the life history strategies of fish populations in the Little Spokane River system.
- Microsatellite DNA characterization of the rainbow trout populations in the Spokane and Little Spokane River systems that have not been evaluated to determine purity and distinction from other stocks.

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Appendices

Appendix A.

Table A1. Coordinates of the 2003 middle Spokane River electrofishing sample sections. Lat.=north latitude; Long.=north longitude; DD=decimal degrees; S=start; E=end.

Date	Section #	S_Lat. (DD)	S_Lon. (DD)	E_Lat. (DD)	E_Lon. (DD)	Time	Effort (sec.)
05/21/2003	1	47.65996	117.43887	47.66333	117.45493	10:30	1,090
05/21/2003	2	47.66333	117.45493	47.67468	117.45880	11:30	1,200
05/21/2003	3	47.67468	117.45880	47.67792	117.44915	12:00	642
05/21/2003	4	47.67792	117.44915	47.67792	117.44915	12:55	523
06/17/2003	1	47.65996	117.43887	47.65669	117.45488	19:30	535
06/17/2003	2	47.65669	117.45488	47.66333	117.45493	20:15	712
06/17/2003	3	47.66333	117.45493	47.66333	117.45493	20:35	197
06/17/2003	4	47.66333	117.45493	47.67468	117.45880	21:00	488
06/17/2003	5	47.67468	117.45880	47.67792	117.44915	21:30	1,045
06/17/2003	6	47.67792	117.44915	47.67792	117.44915	22:00	709
07/22/2003	1	47.65996	117.43887	47.66065	117.45529	19:30	1,120
07/22/2003	2	47.66065	117.45529	47.67351	117.45484	20:15	807
07/22/2003	3	47.67351	117.45484	47.68122	117.45652	21:00	800

Appendix B.

Table B1. Coordinates of the starting and ending locations and the lengths of the stream reaches surveyed in 2003. Lat.=north latitude; Long.=north longitude; DD=decimal degrees; S=start; E=end.

Stream	Reach	Start_Lat. (DD)	Start_Long. (DD)	End_Lat. (DD)	End_Long. (DD)	Length (m)
Burping Brook	1	47.91471	117.12718	47.90417	117.12789	1,166
Burping Brook	2	47.90417	117.12789	47.89921	117.13085	487
Burping Brook	3	47.89921	117.13085	47.88626	117.13074	1,925
Dartford Creek	1	47.81289	117.40999	47.80563	117.40824	869
Dartford Creek	2	47.80563	117.40824	47.80091	117.40941	588
Dartford Creek	3	47.80091	117.40941	47.79303	117.41204	900
Dartford Creek	4	47.79303	117.41204	47.78447	117.41733	1,097
Dartford Creek	5	47.78447	117.41733	47.78271	117.41494	181
Deadman Creek	1	47.90054	117.11369	47.89416	117.12029	969
Deadman Creek	2	47.89416	117.12029	47.88840	117.12450	711
Deadman Creek	3	47.88840	117.12450	47.88626	117.13074	517
Deadman Creek	4	47.88626	117.13074	47.88193	117.13482	646
Deadman Creek	5	47.88193	117.13482	47.86987	117.15819	2,311
Deadman Creek	6	47.86987	117.15819	47.86316	117.16218	796
Deadman Creek	7	47.86316	117.16218	47.84727	117.16830	1,862
Deadman Creek	8	47.84727	117.16830	47.84286	117.17268	710
Deadman Creek	9	47.84286	117.17268	47.83781	117.17258	536
Deadman Creek	10	47.83781	117.17258	47.83512	117.17431	388
Deadman Creek	11	47.83512	117.17431	47.83584	117.19643	2,037
Deadman Creek	12	47.83584	117.19643	47.82971	117.20754	1,202
Deadman Creek	13	47.82971	117.20754	47.80226	117.21904	3,775
Deadman Creek	14	47.80226	117.21904	47.78739	117.24928	3,053
Deadman Creek	15	47.78739	117.24928	47.78159	117.26152	1,159
Deadman Creek	16	47.78159	117.26152	47.77431	117.28137	1,764
Deadman Creek	17	47.77431	117.28137	47.78008	117.30438	1,889

Stream	Reach	Start_Lat. (DD)	Start_Long. (DD)	End_Lat. (DD)	End_Long. (DD)	Length (m)
Deadman Creek	18	47.78008	117.30438	47.78455	117.33994	3,063
Deadman Creek	19	47.78455	117.33994	47.77946	117.35235	1,205
Deadman Creek	20	47.77946	117.35235	47.77864	117.36497	997
Deadman Creek	21	47.77864	117.36497	47.79067	117.37100	1,754
Deadman Creek	22	47.79067	117.37100	47.79556	117.37996	872
Deadman Creek	23	47.79556	117.37996	47.79549	117.38444	318
Little Deep Creek	1	47.87019	117.25679	47.86266	117.26029	898
Little Deep Creek	2	47.86266	117.26029	47.85310	117.27447	1,749
Little Deep Creek	3	47.85310	117.27447	47.85324	117.28313	601
Little Deep Creek	4	47.85324	117.28313	47.85207	117.29975	1,406
Little Deep Creek	5	47.85207	117.29975	47.84540	117.31167	1,249
Little Deep Creek	6	47.84540	117.31167	47.84141	117.32868	1,665
Little Deep Creek	7	47.84141	117.32868	47.82663	117.34477	2,261
Little Deep Creek	8	47.82663	117.34477	47.82140	117.34710	921
Little Deep Creek	9	47.82140	117.34710	47.79995	117.36725	3,698
Little Deep Creek	10	47.79995	117.36725	47.79714	117.37823	1,058
Little Deep Creek	11	47.79714	117.37823	47.79556	117.37996	166
Little Spokane River	1	48.14663	117.11123	48.13954	117.10628	949
Little Spokane River	2	48.13954	117.10628	48.13245	117.11221	1,253
Little Spokane River	3	48.13245	117.11221	48.12863	117.12757	1,266
Little Spokane River	4	48.12863	117.12757	48.12787	117.13270	388
Little Spokane River	5	48.12787	117.13270	48.12532	117.13905	569
Little Spokane River	6	48.12532	117.13905	48.11866	117.14328	794
Little Spokane River	7	48.11866	117.14328	48.10790	117.15262	1,278
Little Spokane River	8	48.10790	117.15262	48.09879	117.15898	1,287
Little Spokane River	9	48.09879	117.15898	48.09217	117.17200	1,181
Little Spokane River	10	48.09217	117.17200	48.08038	117.16802	1,396
Little Spokane River	11	48.08038	117.16802	48.06169	117.18288	2,468
Little Spokane River	12	48.06169	117.18288	48.06010	117.18933	699
Little Spokane River	13	48.06010	117.18933	48.05976	117.19670	587
Little Spokane River	14	48.05127	117.22753	48.04072	117.24401	1,764
Little Spokane River	15	48.04072	117.24401	48.03589	117.24830	666
Little Spokane River	16	48.03589	117.24830	48.02202	117.27304	2,747
Little Spokane River	17	48.02202	117.27304	48.01658	117.27673	681
Little Spokane River	18	48.01658	117.27673	47.98933	117.30081	3,752
Little Spokane River	19	47.98933	117.30081	47.98637	117.31912	1,499
Little Spokane River	20	47.98637	117.31912	47.98492	117.32474	477
Little Spokane River	21	47.98492	117.32474	47.98238	117.32925	457
Little Spokane River	22	47.98238	117.32925	47.96950	117.33376	5,412
Little Spokane River	23	47.96950	117.33376	47.93755	117.32716	1,473
Little Spokane River	24	47.93755	117.32716	47.92936	117.33136	701
Little Spokane River	25	47.92936	117.33136	47.92633	117.33565	3,026
Little Spokane River	26	47.92633	117.33565	47.90389	117.34375	1,925
Little Spokane River	27	47.90389	117.34375	47.89164	117.35366	441
Little Spokane River	28	47.89164	117.35366	47.88834	117.35570	1,425
Little Spokane River	29	47.88834	117.35570	47.87981	117.36682	690
Little Spokane River	30	47.87981	117.36682	47.87603	117.36917	2,927
Little Spokane River	31	47.87603	117.36917	47.85578	117.36694	1,748
Little Spokane River	32	47.85578	117.36694	47.84251	117.37486	2,242
Little Spokane River	33	47.84251	117.37486	47.82610	117.37591	3,174
Little Spokane River	34	47.82610	117.37591	47.80471	117.37834	1,282
Little Spokane River	35	47.80471	117.37834	47.79549	117.38444	1,560
Little Spokane River	36	47.79549	117.38444	47.79115	117.39849	951
Little Spokane River	37	47.79115	117.39849	47.78461	117.40500	918
Little Spokane River	38	47.78461	117.40500	47.78261	117.41600	4,441

Stream	Reach	Start_Lat. (DD)	Start_Long. (DD)	End_Lat. (DD)	End_Long. (DD)	Length (m)
Little Spokane River	39	47.78261	117.41600	47.76994	117.45266	5,898
Little Spokane River	40	47.76994	117.45266	47.78083	117.49500	4,514
Little Spokane River	41	47.78083	117.49500	47.78309	117.52922	1,622
NF Little Deep Creek	1	47.91123	117.19171	47.90799	117.18114	825
NF Little Deep Creek	2	47.90799	117.18114	47.91085	117.20366	970
NF Little Deep Creek	3	47.91085	117.20366	47.90575	117.21923	1,735
NF Little Deep Creek	4	47.90575	117.21923	47.89281	117.23900	2,191
NF Little Deep Creek	5	47.89281	117.23900	47.88874	117.24695	849
NF Little Deep Creek	6	47.88874	117.24695	47.87019	117.25679	2,315
Pell Creek	1	47.90183	117.18506	47.89894	117.19552	875
Pell Creek	2	47.89894	117.19552	47.89191	117.21797	2,151
Pell Creek	3	47.89191	117.21797	47.88898	117.22409	573
Pell Creek	4	47.88898	117.22409	47.87758	117.23922	1,806
Pell Creek	5	47.87758	117.23922	47.87201	117.25151	1,097
SF Deadman Creek	1	47.87380	117.11987	47.86957	117.12676	691
SF Deadman Creek	2	47.86957	117.12676	47.86382	117.13508	907
SF Deadman Creek	3	47.86382	117.13508	47.85422	117.14463	1,427
SF Deadman Creek	4	47.85422	117.14463	47.84982	117.15050	601
SF Deadman Creek	5	47.84982	117.15050	47.84727	117.16830	1,392
SF Little Deep Creek	1	47.91147	117.14770	47.90169	117.15953	1,321
SF Little Deep Creek	2	47.90169	117.15953	47.89597	117.16749	913
SF Little Deep Creek	3	47.89597	117.16749	47.89015	117.18275	1,325
SF Little Deep Creek	4	47.89015	117.18275	47.88984	117.18836	418
SF Little Deep Creek	5	47.88984	117.18836	47.88909	117.19602	584
SF Little Deep Creek	6	47.88909	117.19602	47.88451	117.21255	1,367
SF Little Deep Creek	7	47.88451	117.21255	47.87105	117.23693	2,536
SF Little Deep Creek	8	47.87105	117.23693	47.87211	117.25046	1,156
SF Little Deep Creek	9	47.87211	117.25046	47.87019	117.25679	526

Appendix C.

Table C1. Coordinates of the starting locations of the habitat and fish survey sections and the transect spacing distance for the habitat surveys. Lat.=north latitude; Long.=north longitude; DD=decimal degrees.

Stream	Reach	Site #	Start_Lat (DD)	Start_Lon (DD)	Transect Spacing (m)
Burping Brook	3	5	47.88996	117.13003	6.0
Burping Brook	3	6	47.89068	117.12992	4.0
Burping Brook	2	19	47.90583	117.12827	3.0
Burping Brook	2	23	47.90580	117.12661	4.0
Burping Brook	1	26	47.90654	117.12388	3.0
Dartford Creek	5	2	47.78382	117.41764	4.0
Dartford Creek	4	3	47.78487	117.41748	4.0
Dartford Creek	3	20	47.79935	117.41001	5.0
Dartford Creek	2	23	47.80166	117.40928	4.0
Dartford Creek	1	30	47.80885	117.40890	4.0
Deadman Creek	23	2	47.79559	117.38360	8.0
Deadman Creek	22	9	47.79244	117.37353	10.0
Deadman Creek	21	19	47.78706	117.36882	10.0
Deadman Creek	21	26	47.78107	117.36584	10.0
Deadman Creek	20	30	47.77734	117.36400	9.0
Deadman Creek	19	43	47.78076	117.34875	8.0
Deadman Creek	18	64	47.78234	117.32856	8.0

Stream	Reach	Site #	Start_Lat (DD)	Start_Lon (DD)	Transect Spacing (m)
Deadman Creek	15	123	47.78242	117.25956	7.0
Deadman Creek	14	133	47.78803	117.24683	8.0
Deadman Creek	14	138	47.79164	117.24092	8.0
Deadman Creek	14	148	47.79704	117.23340	8.0
Deadman Creek	13	163	47.80603	117.21696	8.0
Deadman Creek	13	181	47.81718	117.22063	8.0
Deadman Creek	13	184	47.82077	117.21964	7.0
Deadman Creek	13	193	47.82555	117.21334	8.0
Deadman Creek	12	210	47.83542	117.19839	6.0
Deadman Creek	11	218	47.83745	117.19119	7.0
Deadman Creek	11	229	47.83423	117.17677	8.0
Deadman Creek	10	232	47.83534	117.17433	6.0
Deadman Creek	9	239	47.84044	117.17272	8.0
Deadman Creek	8	243	47.84464	117.17187	8.0
Deadman Creek	7	250	47.84402	117.16778	7.0
Deadman Creek	7	252	47.85014	117.16575	7.0
Deadman Creek	6	272	47.86842	117.15954	7.0
Deadman Creek	5	288	47.87696	117.14520	6.0
Deadman Creek	5	289	47.87945	117.14503	7.0
Deadman Creek	4	299	47.88256	117.13365	6.0
Deadman Creek	3	306	47.88678	117.12976	6.0
Deadman Creek	2	310	47.88820	117.12543	4.0
Deadman Creek	1	322	47.89648	117.11729	2.0
Little Deep Creek	11	2	47.79663	117.37903	5.0
Little Deep Creek	10	5	47.79972	117.37725	5.0
Little Deep Creek	9	15	47.80117	117.36626	6.0
Little Deep Creek	9	16	47.80107	117.36533	6.0
Little Deep Creek	9	36	47.81260	117.35616	5.0
Little Deep Creek	9	37	47.81232	117.35513	5.0
Little Deep Creek	8	56	47.82509	117.34476	5.0
Little Deep Creek	7	71	47.83375	117.33928	5.0
Little Deep Creek	7	80	47.84007	117.33112	5.0
Little Deep Creek	6	85	47.84329	117.32571	6.0
Little Deep Creek	6	86	47.84282	117.32452	5.0
Little Deep Creek	5	104	47.84933	117.30587	6.0
Little Deep Creek	4	114	47.85277	117.29766	6.0
Little Deep Creek	4	122	47.85463	117.28649	6.0
Little Deep Creek	3	127	47.85342	117.28089	6.0
Little Deep Creek	2	134	47.85359	117.27083	6.0
Little Deep Creek	2	136	47.85364	117.26805	6.0
Little Deep Creek	1	150	47.86356	117.26027	5.0
Little Spokane River	38	174	47.79415	117.41083	10.0
Little Spokane River	37	181	47.79018	117.40013	10.0
Little Spokane River	36	196	47.79290	117.38628	10.0
Little Spokane River	33	260	47.83755	117.37558	10.0
Little Spokane River	32	267	47.84261	117.37459	10.0
Little Spokane River	32	275	47.84853	117.36900	10.0
Little Spokane River	31	292	47.86212	117.36326	10.0
Little Spokane River	29	332	47.88657	117.35776	10.0
Little Spokane River	27	355	47.90183	117.34448	10.0
Little Spokane River	26	367	47.91168	117.33771	10.0
Little Spokane River	23	431	47.95489	117.33433	10.0
Little Spokane River	23	432	47.95576	117.33504	10.0
Little Spokane River	22	451	47.97272	117.33328	10.0
Little Spokane River	22	452	47.97363	117.33437	10.0

Stream	Reach	Site #	Start_Lat (DD)	Start_Lon (DD)	Transect Spacing (m)
Little Spokane River	21	466	47.98342	117.32660	10.0
Little Spokane River	18	500	47.99739	117.28985	10.0
Little Spokane River	18	513	48.00665	117.28709	10.0
Little Spokane River	16	535	48.02339	117.27232	10.0
Little Spokane River	16	539	48.02534	117.26857	10.0
Little Spokane River	11	619	48.07692	117.16928	10.0
Little Spokane River	11	622	48.07997	117.16823	10.0
Little Spokane River	10	624	48.08178	117.16771	10.0
Little Spokane River	10	630	48.08529	117.16900	10.0
Little Spokane River	7	668	48.11558	117.14563	10.0
Little Spokane River	6	674	48.11907	117.14304	10.0
Little Spokane River	5	687	48.12676	117.13474	10.0
Little Spokane River	4	693	48.12813	117.12900	10.0
Little Spokane River	3	704	48.13196	117.11828	10.0
NF Little Deep Creek	6	6	47.87341	117.25828	3.0
NF Little Deep Creek	6	9	47.87582	117.25349	4.0
NF Little Deep Creek	5	27	47.88885	117.24655	4.0
NF Little Deep Creek	4	41	47.89708	117.22718	3.0
NF Little Deep Creek	4	45	47.89952	117.22422	3.0
NF Little Deep Creek	3	61	47.91154	117.21482	4.0
NF Little Deep Creek	3	64	47.91321	117.21205	3.0
NF Little Deep Creek	2	72	47.91060	117.19785	4.0
NF Little Deep Creek	1	86	47.90924	117.18616	3.0
Pell Creek	5	11	47.87710	117.24148	3.0
Pell Creek	4	16	47.87833	117.23630	3.0
Pell Creek	4	26	47.88942	117.22741	3.0
Pell Creek	3	33	47.89091	117.22011	3.0
SF Deadman Creek	5	2	47.84657	117.16712	4.0
SF Deadman Creek	5	10	47.84864	117.15602	4.0
SF Deadman Creek	4	20	47.85303	117.14671	5.0
SF Deadman Creek	3	25	47.85897	117.14123	4.0
SF Deadman Creek	2	37	47.86609	117.12983	6.0
SF Deadman Creek	1	39	47.86678	117.12878	4.0
SF Little Deep Creek	9	2	47.87046	117.25664	4.0
SF Little Deep Creek	8	12	47.87191	117.23983	4.0
SF Little Deep Creek	7	20	47.87107	117.23264	4.0
SF Little Deep Creek	7	31	47.87605	117.22229	4.0
SF Little Deep Creek	7	37	47.87877	117.21878	4.0
SF Little Deep Creek	6	45	47.88674	117.20965	3.0
SF Little Deep Creek	5	61	47.88965	117.19031	4.0
SF Little Deep Creek	4	67	47.88956	117.18509	6.0
SF Little Deep Creek	3	77	47.89400	117.17148	4.0
SF Little Deep Creek	2	80	47.89603	117.16723	3.0
SF Little Deep Creek	1	97	47.90637	117.15517	3.0

Appendix D.

Table D1. Relative abundance, catch per unit effort (CPUE; ± 80% CI), mean total length (± SD), and size range of fish captured in the middle Spokane River between Spokane Falls and T.J. Meenach Bridge on May 21, 2003 (total effort = 0.96 hours; 4 sites).

Species	n	Relative Abundance (%)	CPUE (#/hour)	Mean Total Length (mm)	Size Range (mm)
Rainbow trout	38	19.7	39.8 (± 21.5)	343 (± 56)	135-407
Mountain whitefish	65	33.7	72.5 (± 19.6)	340 (± 32)	273-426
Sculpins	1	0.5	1.4 (± 1.8)	63	63
Chiselmouth	1	0.5	0.8 (± 1.1)	175	175
Northern pikeminnow	3	1.6	3.4 (± 2.5)	313 (± 151)	142-427
Bridgelip sucker	54	28.0	60.4 (± 12.6)	362 (± 58)	153-462
Largescale sucker	31	16.1	29.8 (± 10.4)	422 (± 84)	152-562

Table D2. Relative abundance, catch per unit effort (CPUE; ± 80% CI), mean total length (± SD), and size range of fish captured in the middle Spokane River between Spokane Falls and T.J. Meenach Bridge on June 17, 2003 (total effort = 1.02 hours; 6 sites).

Species	n	Relative Abundance (%)	CPUE (#/hour)	Mean Total Length (mm)	Size Range (mm)
Brown trout	1	0.4	1.2 (± 1.6)	332	332
Cutthroat trout	1	0.4	3.05 (± 3.9)	352	352
Rainbow trout	33	12.5	48.3 (± 26.5)	329 (± 59)	174-413
Mountain whitefish	64	24.2	61.5 (± 10.9)	327 (± 33)	221-383
Sculpins	1	0.4	0.8 (± 1.1)	80	80
Longnose dace	3	1.1	2.0 (± 1.6)	73 (± 10)	63-82
Northern pikeminnow	3	1.1	3.3 (± 3.1)	465 (± 110)	369-585
Redside shiner	2	0.8	1.2 (± 1.5)	100 (± 17)	88-112
Bridgelip sucker	134	50.6	126.0 (± 41.8)	309 (± 76)	87-439
Largescale sucker	23	8.7	20.6 (± 8.4)	433 (± 96)	94-541

Table D3. Relative abundance, catch per unit effort (CPUE; ± 80% CI), mean total length (± SD), and size range of fish captured in the middle Spokane River between Spokane Falls and T.J. Meenach Bridge on July 22, 2003 (total effort = 0.76 hours; 3 sites).

Species	n	Relative Abundance (%)	CPUE (#/hour)	Mean Total Length (mm)	Size Range (mm)
Rainbow trout	17	8.4	23.3 (± 5.7)	315 (± 62)	202-407
Mountain whitefish	67	33.2	93.0 (± 29.8)	330 (± 34)	227-388
Redside shiner	1	0.5	1.5 (± 1.9)	101	101
Bridgelip sucker	108	53.5	137.1 (± 94.2)	-	-
Largescale sucker	9	4.5	11.4 (± 7.3)	-	-

Appendix E.

Table E1. Mean values (± SD) of habitat parameters measured along transects on Burping Brook.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	1.4 (± 0.6)	2.8 (± 0.6)	5 (± 3)	11 (± 5)
2	2	34	1.4 (± 0.6)	2.9 (± 1.4)	5 (± 2)	12 (± 5)
3	2	33	2.1 (± 0.6)	3.4 (± 0.8)	8 (± 3)	18 (± 6)
Total	**5**	**84**	**1.7 (± 0.7)**	**3.1 (± 1.1)**	**6 (± 3)**	**14 (± 6)**

Table E2. Mean values (± SD) of habitat parameters measured and counted at each survey section on Burping Brook.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	20.0 (nc)	9.5 (nc)	15.0 (nc)	36 (nc)	10 (nc)
2	2	12.5 (± 4.9)	11.0 (± 0.0)	14.3 (± 1.1)	67 (± 5)	5 (± 7)
3	2	6.5 (± 0.7)	15.3 (± 1.1)	18.5 (± 0.7)	23 (± 6)	0 (± 0)
Total	**5**	**11.6 (± 6.1)**	**12.4 (± 2.7)**	**16.1 (± 2.3)**	**43 (± 22)**	**4 (±5)**

Table E3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on Burping Brook.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	1	2.0 (nc)	1.5 (nc)	35 (nc)	21 (nc)
2	1	2.3 (nc)	3.0 (nc)	30 (nc)	17 (nc)
3	0	-	-	-	-
Total	**2**	**2.2 (± 0.2)**	**2.3 (± 1.1)**	**33 (± 4)**	**19 (± 3)**

Table E4. Mean width (± SD) and percent occurrence of each habitat type observed on Burping Brook.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	14	1.4 (± 0.6)	82	1	0.8 (nc)	6	2	1.6 (± 0.6)	12
2	28	1.3 (± 0.5)	78	2	1.4 (± 0.6)	5	6	1.4 (± 0.4)	17
3	30	2.1 (± 0.6)	91	2	1.8 (± 0.1)	6	1	2.7 (nc)	3
Total	**72**	**1.7 (± 0.7)**	**84**	**5**	**1.4 (± 0.5)**	**6**	**9**	**1.6 (± 0.5)**	**10**

Table E5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on Burping Brook.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
1	17	63 (± 23)	11 (± 11)	0 (± 0)	14 (± 11)	36 (± 18)	12 (± 18)	10 (± 17)	4 (± 8)	12 (± 22)	0 (± 0)
2	34	62 (± 25)	7 (± 13)	0 (± 0)	8 (± 11)	45 (± 22)	20 (± 21)	9 (± 9)	4 (± 6)	8 (± 21)	0 (± 0)
3	33	52 (± 13)	0 (± 0)	0 (± 0)	2 (± 4)	28 (± 14)	15 (± 9)	22 (± 14)	20 (± 15)	13 (± 19)	0 (± 0)
Total	**84**	**58 (± 20)**	**5 (± 10)**	**0 (± 0)**	**7 (± 10)**	**37 (± 19)**	**17 (± 17)**	**14 (± 14)**	**10 (± 13)**	**11 (± 20)**	**0 (± 0)**

Appendix F.

Table F1. Mean values (± SD) of habitat parameters measured along transects on Dartford Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	1.8 (± 0.4)	2.7 (± 0.7)	10 (± 4)	19 (± 6)
2	1	17	2.4 (± 0.6)	3.2 (± 0.6)	10 (± 3)	19 (± 4)
3	1	17	2.7 (± 0.8)	4.0 (± 0.9)	10 (± 4)	20 (± 6)
4	1	17	1.8 (± 0.6)	2.2 (± 0.8)	13 (± 5)	23 (± 9)
5	1	17	1.6 (± 0.3)	1.9 (± 0.4)	14 (± 4)	23 (± 5)
Total	**5**	**85**	**2.1 (± 0.7)**	**2.8 (± 1.0)**	**12 (± 4)**	**21 (± 6)**

Table F2. Mean values (± SD) of habitat parameters measured and counted at each survey section on Dartford Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	1.5 (nc)	14.0 (nc)	17.5 (nc)	0 (nc)	0 (nc)
2	1	2.0 (nc)	13.0 (nc)	16.0 (nc)	32 (nc)	10 (nc)
3	1	3.0 (nc)	13.0 (nc)	20.0 (nc)	31 (nc)	10 (nc)
4	1	5.0 (nc)	13.0 (nc)	22.0 (nc)	0 (nc)	20 (nc)
5	1	1.0 (nc)	16.0 (nc)	19.5 (nc)	0 (nc)	30 (nc)
Total	**5**	**2.5 (± 1.6)**	**13.8 (± 1.3)**	**19.0 (± 2.3)**	**13 (± 17)**	**14 (± 11)**

Table F3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on Dartford Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	0	-	-	-	-
2	1	2.1 (nc)	4.0 (nc)	38 (nc)	27 (nc)
3	1	3.1 (nc)	3.9 (nc)	62 (nc)	41(nc)
4	2	2.9 (± 0.5)	4.7 (± 0.8)	46 (± 3)	33 (± 3)
5	3	2.8 (± 0.8)	2.8 (± 0.3)	33 (± 6)	24 (± 5)
Total	**7**	**2.7 (± 0.6)**	**3.7 (± 1.0)**	**42 (± 11)**	**30 (± 7)**

Table F4. Mean width (± SD) and percent occurrence of each habitat type observed on Dartford Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	15	1.8 (± 0.5)	88	2	1.6 (± 0.2)	12	0	-	0
2	16	2.4 (± 0.6)	94	0	-	0	1	2.1 (nc)	6
3	16	2.7 (± 0.8)	89	0	-	0	2	2.1 (± 1.4)	11
4	12	1.6 (± 0.5)	70	2	2.1 (± 0.1)	12	3	2.5 (± 0.7)	18
5	15	1.5 (± 0.3)	88	1	1.8 (nc)	6	1	2.4 (nc)	6
Total	**74**	**2.0 (± 0.7)**	**86**	**5**	**1.8 (± 0.3)**	**6**	**7**	**2.3 (± 0.7)**	**8**

Table F5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed in Dartford Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	n	Embeddedness (%)	Organic	Muck	Silt	Sand	Gravel	Cobble	Rubble	Boulder	Bedrock
1	17	96 (± 12)	6 (± 8)	0 (± 0)	15 (± 13)	75 (± 15)	2 (± 3)	1 (± 2)	0 (± 0)	0 (± 0)	0 (± 0)
2	17	90 (± 8)	2 (± 4)	1 (± 2)	10 (± 9)	74 (± 13)	13 (± 12)	1 (± 2)	0 (± 1)	0 (± 0)	0 (± 0)
3	17	69 (± 12)	0 (± 0)	0 (± 0)	17 (± 14)	45 (± 18)	13 (± 12)	13 (± 12)	6 (± 10)	4 (± 8)	3 (± 12)
4	17	62 (± 23)	0 (± 0)	0 (± 0)	11 (± 15)	21 (± 21)	20 (± 22)	15 (± 21)	3 (± 4)	13 (± 23)	16 (± 36)
5	17	73 (± 19)	2 (± 4)	0 (± 0)	26 (± 22)	29 (± 24)	12 (± 10)	22 (± 23)	4 (± 8)	4 (± 7)	0 (± 0)
Total	**85**	**75 (± 20)**	**2 (± 5)**	**0 (± 1)**	**16 (± 16)**	**49 (± 29)**	**12 (± 14)**	**10 (± 17)**	**3 (± 6)**	**4 (± 12)**	**4 (± 18)**

Appendix G.

Table G1. Mean values (± SD) of habitat parameters measured along transects on Deadman Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	1.3 (± 0.4)	2.0 (± 0.4)	6 (± 3)	12 (± 5)
2	1	17	1.9 (± 0.5)	3.0 (± 0.4)	7 (± 2)	16 (± 5)
3	1	15	2.7 (± 0.7)	4.3 (± 0.9)	7 (± 2)	16 (± 3)
4	1	15	3.2 (± 0.9)	4.9 (± 1.5)	10 (± 4)	22 (± 7)
5	2	29	2.9 (± 0.8)	4.8 (± 1.1)	13 (± 4)	26 (± 9)
6	1	14	3.4 (± 1.1)	4.7 (± 0.8)	12 (± 3)	25 (± 5)
7	2	29	3.8 (± 1.2)	5.6 (± 1.8)	10 (± 5)	23 (± 8)
8	1	12	3.7 (± 1.0)	5.3 (± 1.4)	13 (± 3)	25 (± 6)
9	1	12	4.4 (± 0.6)	5.9 (± 1.1)	13 (± 6)	24 (± 9)
10	1	16	3.4 (± 0.7)	5.0 (± 0.7)	12 (± 8)	26 (± 11)
11	2	26	4.1 (± 1.3)	6.0 (± 1.3)	15 (± 7)	31 (± 11)
12	1	16	3.6 (± 0.8)	5.8 (± 0.7)	11 (± 3)	23 (± 4)
13	4	50	4.0 (± 1.3)	6.2 (± 1.3)	17 (± 10)	36 (± 20)
14	3	36	3.8 (± 1.1)	6.3 (± 1.5)	16 (± 6)	34 (± 12)
15	1	14	3.3 (± 0.5)	4.4 (± 1.0)	31 (± 12)	57 (± 20)
18	1	12	4.4 (± 1.1)	5.8 (± 0.9)	26 (± 9)	50 (± 16)
19	1	12	3.7 (± 0.5)	5.5 (± 0.8)	22 (± 13)	40 (± 20)
20	1	11	5.1 (± 0.9)	6.5 (± 1.0)	19 (± 10)	35 (± 18)
21	2	20	5.1 (± 0.8)	6.8 (± 1.1)	16 (± 11)	30 (±16)
22	1	10	4.8 (± 1.4)	6.4 (± 1.0)	25 (± 15)	47 (± 23)
23	1	12	4.7 (± 1.2)	6.8 (± 1.7)	21 (± 8)	40 (± 19)
Total	**30**	**395**	**3.7 (± 1.3)**	**5.4 (± 1.6)**	**15 (± 9)**	**30 (± 16)**

Table G2. Mean values (± SD) of habitat parameters measured and counted at each survey section on Deadman Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	8.0 (nc)	13.0 (nc)	24.0 (nc)	60 (nc)	70 (nc)
2	1	5.0 (nc)	10.0 (nc)	16.0 (nc)	15 (nc)	50 (nc)
3	1	9.0 (nc)	10.0 (nc)	15.0 (nc)	20 (nc)	10 (nc)
4	1	4.0 (nc)	11.0 (nc)	19.0 (nc)	21 (nc)	50 (nc)
5	2	4.5 (± 0.7)	10.8 (± 1.1)	16.5 (± 3.5)	17 (± 4)	20 (± 14)
6	1	6.0 (nc)	10.5 (nc)	15.0 (nc)	17 (nc)	20 (nc)
7	2	5.0 (± 1.4)	15.5 (± 0.7)	26.5 (± 3.5)	14 (± 7)	15 (± 7)
8	1	5.0 (nc)	12.0 (nc)	18.0 (nc)	5 (nc)	0 (nc)
9	1	6.0 (nc)	13.5 (nc)	26.0 (nc)	6 (nc)	30 (nc)
10	1	6.0 (nc)	15.0 (nc)	22.0 (nc)	6 (nc)	0 (nc)
11	2	5.5 (± 0.7)	13.5 (± 2.1)	21.5 (± 7.8)	8 (± 1)	25 (± 7)
12	1	3.0 (nc)	15.0 (nc)	21.0 (nc)	2 (nc)	0 (nc)
13	4	1.6 (± 0.3)	15.8 (± 0.5)	22.5 (± 3.0)	27 (± 10)	33 (± 17)
14	3	1.2 (± 0.3)	16.8 (± 0.8)	23.0 (± 1.0)	23 (± 4)	10 (± 10)
15	1	1.0 (nc)	15.0 (nc)	24.0 (nc)	1 (nc)	20 (nc)
18	1	0.5 (nc)	20.0 (nc)	29.0 (nc)	30 (nc)	0 (nc)
19	1	1.0 (nc)	22.0 (nc)	25.0 (nc)	24 (nc)	20 (nc)
20	1	1.0 (nc)	19.5 (nc)	30.5 (nc)	26 (nc)	10 (nc)
21	2	2.5 (± 0.7)	14.5 (± 0.7)	22.0 (± 4.2)	12 (± 8)	10 (± 0)
22	1	1.5 (nc)	17.0 (nc)	27.0 (nc)	6 (nc)	10 (nc)
23	1	3.0 (nc)	13.0 (nc)	24.0 (nc)	3 (nc)	30 (nc)
Total	**30**	**3.5 (± 2.3)**	**14.6 (± 3.0)**	**22.3 (± 4.5)**	**17 (± 13)**	**21 (± 18)**

Table G3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on Deadman Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	7	1.7 (± 0.2)	2.1 (± 0.5)	27 (± 5)	19 (± 4)
2	5	2.5 (± 0.3)	2.3 (± 0.4)	32 (± 4)	22 (± 3)
3	1	2.1 (nc)	5.1 (nc)	24 (nc)	18 (nc)
4	5	3.7 (± 0.8)	3.3 (± 1.1)	31 (± 5)	23 (± 3)
5	4	3.3 (± 0.3)	4.4 (± 3.2)	50 (± 14)	34 (± 9)
6	2	4.1 (± 0.8)	4.3 (± 0.1)	47 (± 2)	31 (± 3)
7	3	4.1 (± 0.9)	4.6 (± 1.0)	52 (± 15)	34 (± 4)
8	0	-	-	-	-
9	3	5.0 (± 1.5)	3.8 (± 0.5)	46 (± 12)	30 (± 7)
10	0	-	-	-	-
11	5	5.8 (± 1.9)	5.6 (± 3.2)	59 (± 20)	40 (± 11)
12	0	-	-	-	-
13	13	4.7 (± 1.1)	6.2 (± 1.9)	72 (± 16)	48 (± 11)
14	3	4.7 (± 0.2)	7.9 (± 1.9)	85 (± 17)	52 (± 9)
15	2	4.0 (± 0.3)	8.0 (± 3.3)	100 (± 5)	63 (± 11)
18	0	-	-	-	-
19	2	3.9 (± 0.0)	7.8 (± 0.7)	86 (± 6)	59 (± 1)
20	1	5.3 (nc)	15.3 (nc)	102 (nc)	69 (nc)
21	2	5.7 (± 0.1)	13.0 (± 6.9)	77 (± 1)	58 (± 12)
22	1	5.6 (nc)	15.3 (nc)	103 (nc)	66 (nc)
23	3	5.9 (± 1.3)	10.0 (± 3.2)	75 (± 21)	51 (± 11)
Total	**62**	**4.1 (± 1.5)**	**5.6 (± 3.6)**	**57 (± 25)**	**38 (± 16)**

Table G4. Mean width (± SD) and percent occurrence of each habitat type observed on Deadman Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	12	1.2 (± 0.5)	70	1	1.3 (nc)	6	4	1.5 (± 0.3)	24
2	14	1.8 (± 0.5)	82	0	-	0	3	2.3 (± 0.6)	18
3	14	2.5 (± 0.6)	82	0	-	0	3	1.7 (± 0.3)	18
4	12	3.1 (± 1.1)	75	1	2.6 (nc)	6	3	2.7 (± 1.0)	19
5	23	2.8 (± 0.8)	76	5	2.9 (± 0.9)	17	2	2.7 (± 0.1)	7
6	12	3.1 (± 1.1)	75	1	3.0 (nc)	6	3	2.4 (± 1.1)	19
7	25	3.9 (± 1.3)	83	0	-	0	5	2.8 (± 0.6)	17
8	11	3.5 (± 1.3)	79	1	2.8 (nc)	7	2	1.4 (± 0.0)	14
9	11	4.4 (± 0.6)	92	0	-	0	1	4.4 (nc)	8
10	16	3.3 (± 0.7)	94	0	-	0	1	2.3 (nc)	6
11	18	4.1 (± 1.4)	64	2	3.8 (± 0.4)	7	8	3.3 (± 1.7)	29
12	16	3.6 (± 0.8)	100	0	-	0	0	-	0
13	22	3.8 (± 1.4)	41	20	3.7 (± 1.0)	38	11	3.9 (± 1.7)	21
14	15	3.7 (± 1.4)	39	17	3.7 (± 0.7)	45	6	3.3 (± 1.2)	16
15	0	-	0	12	3.2 (± 0.5)	86	2	3.9 (± 0.4)	14
18	0	-	0	12	4.4 (± 1.1)	100	0	-	0
19	2	3.2 (± 0.1)	15	7	3.5 (± 1.1)	54	4	3.3 (± 0.8)	31
20	1	5.6 (nc)	9	9	5.0 (± 1.0)	82	1	5.3 (nc)	9
21	16	5.0 (± 0.9)	80	1	4.9 (± nc)	5	3	5.5 (± 0.4)	15
22	4	4.7 (± 1.8)	40	4	5.0 (± 1.4)	40	2	4.6 (± 1.4)	20
23	8	4.0 (± 1.2)	61	1	5.2 (nc)	8	4	4.9 (± 0.8)	31
Total	**252**	**3.4 (± 1.4)**	**61**	**94**	**3.8 (± 1.1)**	**23**	**68**	**3.3 (± 1.5)**	**16**

Table G5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on Deadman Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
1	17	55 (± 31)	2 (± 10)	0 (± 0)	4 (± 8)	39 (± 31)	31 (± 25)	8 (± 9)	7 (± 16)	8 (± 14)	0 (± 0)
2	17	58 (± 14)	1 (± 5)	0 (± 0)	0 (± 0)	17 (± 12)	16 (± 12)	38 (± 22)	10 (± 9)	18 (± 28)	0 (± 0)
3	15	69 (± 12)	0 (± 0)	0 (± 0)	2 (± 4)	19 (± 13)	16 (± 10)	24 (± 13)	20 (± 16)	10 (± 20)	9 (± 27)
4	15	62 (± 10)	0 (± 1)	0 (± 0)	3 (± 6)	32 (± 19)	25 (± 12)	15 (± 11)	18 (± 13)	7 (± 8)	0 (± 0)
5	29	74 (± 11)	0 (± 0)	0 (± 0)	0 (± 2)	25 (± 20)	16 (± 11)	14 (± 9)	20 (± 14)	24 (± 28)	0 (± 0)
6	14	51 (± 14)	0 (± 0)	0 (± 0)	2 (± 4)	16 (± 11)	7 (± 7)	24 (± 14)	26 (± 15)	25 (± 20)	0 (± 0)
7	29	63 (± 15)	0 (± 0)	0 (± 0)	1 (± 3)	22 (± 15)	13 (± 11)	36 (± 22)	16 (± 8)	11 (± 16)	0 (± 0)
8	12	59 (± 18)	0 (± 0)	0 (± 0)	3 (± 3)	21 (± 14)	6 (± 4)	16 (± 12)	29 (± 14)	33 (± 20)	0 (± 0)
9	12	50 (± 15)	0 (± 0)	0 (± 0)	1 (± 3)	22 (± 13)	8 (± 5)	30 (± 14)	22 (± 11)	18 (± 19)	0 (± 0)
10	16	50 (± 20)	0 (± 0)	0 (± 0)	2 (± 4)	13 (± 12)	7 (± 3)	27 (± 19)	22 (± 13)	23 (± 20)	6 (± 25)
11	26	55 (± 11)	1 (± 4)	0 (± 0)	1 (± 2)	23 (± 15)	6 (± 8)	11 (± 7)	22 (± 16)	36 (± 23)	0 (± 0)
12	16	53 (± 12)	0 (± 0)	0 (± 0)	1 (± 2)	21 (± 18)	6 (± 3)	22 (± 15)	32 (± 22)	18 (± 16)	0 (± 0)
13	50	99 (± 6)	0 (± 1)	0 (± 1)	14 (± 16)	56 (± 23)	30 (± 28)	0 (± 1)	0 (± 0)	0 (± 0)	0 (± 0)
14	36	100 (± 0)	0 (± 0)	1 (± 2)	43 (± 23)	54 (± 23)	2 (± 7)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
15	14	100 (± 0)	0 (± 0)	5 (± 7)	73 (± 27)	22 (± 28)	0 (± 1)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
18	12	100 (± 0)	0 (± 1)	2 (± 4)	85 (± 8)	13 (± 5)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
19	12	83 (± 22)	5 (± 8)	0 (± 1)	21 (± 16)	60 (± 15)	10 (± 17)	4 (± 4)	0 (± 1)	0 (± 0)	0 (± 0)
20	11	73 (± 19)	0 (± 0)	0 (± 0)	16 (± 10)	57 (± 19)	12 (± 13)	14 (± 11)	0 (± 2)	0 (± 0)	0 (± 0)
21	20	58 (± 13)	0 (± 0)	0 (± 0)	6 (± 13)	13 (± 6)	3 (± 2)	53 (± 9)	17 (± 6)	8 (± 7)	0 (± 0)
22	10	66 (± 13)	0 (± 0)	0 (± 0)	18 (± 19)	18 (± 16)	2 (± 3)	43 (± 26)	11 (± 7)	4 (± 4)	0 (± 0)
23	12	56 (± 16)	0 (± 0)	0 (± 0)	20 (± 21)	19 (± 15)	29 (± 19)	21 (± 14)	6 (± 7)	5 (± 8)	0 (± 0)
Total	**395**	**70 (± 23)**	**0 (± 3)**	**0 (± 2)**	**14 (± 24)**	**31 (± 24)**	**13 (± 17)**	**17 (± 19)**	**12 (± 15)**	**11 (± 19)**	**1 (± 7)**

Appendix H.

Table H1. Mean values (± SD) of habitat parameters measured along transects on Little Deep Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	2.8 (± 0.5)	4.5 (± 0.9)	17 (± 8)	33 (± 17)
2	2	32	3.4 (± 0.8)	5.0 (± 1.3)	18 (± 9)	33 (± 15)
3	1	16	2.7 (± 0.5)	4.0 (± 0.7)	16 (± 7)	31 (± 11)
4	2	32	3.2 (± 0.7)	4.6 (± 1.4)	18 (± 9)	34 (± 14)
5	1	16	2.7 (± 0.6)	4.1 (± 0.8)	11 (± 3)	25 (± 8)
6	2	33	2.5 (± 0.6)	3.5 (± 0.6)	30 (± 16)	55 (± 27)
7	2	34	2.4 (± 0.4)	3.5 (± 0.8)	21 (± 8)	39 (± 13)
8	1	17	2.4 (± 0.3)	2.6 (± 0.4)	29 (± 9)	47 (± 14)
9	4	66	2.9 (± 0.9)	4.0 (± 1.4)	16 (± 9)	27 (± 13)
10	1	17	2.3 (± 0.5)	4.2 (± 1.7)	17 (± 7)	28 (± 10)
11	1	17	2.6 (± 0.5)	4.2 (± 0.8)	15 (± 7)	28 (± 13)
Total	**18**	**297**	**2.8 (± 0.7)**	**4.0 (± 1.3)**	**19 (± 10)**	**35 (± 18)**

Table H2. Mean values (± SD) of habitat parameters measured and counted at each survey section on Little Deep Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	1.0 (nc)	11.5 (nc)	17.0 (nc)	37 (nc)	30 (nc)
2	2	1.3 (± 0.4)	11.3 (± 1.1)	15.3 (± 1.8)	27 (± 16)	25 (± 7)
3	1	0.5 (nc)	16.0 (nc)	26.0 (nc)	9 (nc)	20 (nc)
4	2	1.0 (± 0.0)	14.5 (± 0.7)	15.8 (± 1.8)	34 (± 11)	15 (± 7)
5	1	1.0 (nc)	14.5 (nc)	25.0 (nc)	14 (nc)	0 (nc)
6	2	1.0 (± 0.0)	10.8 (± 1.4)	22.3 (± 2.3)	3 (± 0)	15 (± 7)
7	2	1.0 (± 0.0)	12.5 (± 3.5)	20.8 (± 1.1)	2 (± 3)	10 (± 14)
8	1	1.0 (nc)	18.5 (nc)	24.5 (nc)	0 (nc)	0 (nc)
9	4	1.1 (± 0.5)	13.5 (± 0.9)	22.6 (± 5.5)	14 (± 17)	8 (± 10)
10	1	1.0 (nc)	12.0 (nc)	15.5 (nc)	19 (nc)	0 (nc)
11	1	1.5 (nc)	15.0 (nc)	20.5 (nc)	2 (nc)	30 (nc)
Total	**18**	**1.1 (± 0.3)**	**13.2 (± 2.3)**	**20.5 (± 4.4)**	**15 (± 15)**	**13 (± 11)**

Table H3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on Little Deep Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	3	4.2 (± 1.0)	5.8 (± 1.2)	62 (± 12)	41 (± 9)
2	5	3.7 (± 0.5)	4.8 (± 1.0)	64 (± 10)	43 (± 7)
3	2	3.8 (± 0.7)	4.5 (± 0.4)	73 (± 23)	42 (± 13)
4	3	4.2 (± 1.1)	6.2 (± 0.5)	80 (± 26)	53 (± 15)
5	0	-	-	-	-
6	3	3.0 (± 0.5)	8.1 (± 4.3)	95 (± 24)	63 (± 19)
7	2	3.2 (± 0.5)	5.3 (± 0.8)	60 (± 8)	48 (± 7)
8	0	-	-	-	-
9	3	4.3 (± 0.2)	5.9 (± 1.3)	56 (± 7)	38 (± 2)
10	0	-	-	-	-
11	3	3.2 (± 1.3)	4.4 (± 1.2)	56 (± 11)	42 (± 9)
Total	**24**	**3.7 (± 0.8)**	**5.6 (± 1.9)**	**68 (± 19)**	**46 (± 12)**

Table H4. Mean width (± SD) and percent occurrence of each habitat type observed on Little Deep Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	11	2.4 (± 1.0)	58	3	2.8 (± 0.3)	16	5	2.4 (± 0.9)	26
2	14	3.1 (± 0.9)	38	9	3.0 (± 0.7)	24	14	3.0 (± 0.9)	38
3	4	2.8 (± 0.2)	25	6	2.6 (± 0.3)	37	6	2.9 (± 0.8)	38
4	11	2.5 (± 1.1)	30	19	2.9 (± 0.8)	51	7	2.5 (± 1.4)	19
5	13	2.4 (± 0.6)	72	2	3.3 (± 0.3)	11	3	1.9 (± 1.4)	17
6	8	2.3 (± 0.5)	24	20	2.6 (± 0.7)	61	5	2.9 (± 0.6)	15
7	6	2.4 (± 0.3)	17	25	2.3 (± 0.5)	69	5	2.1 (± 0.8)	14
8	1	2.5 (nc)	6	16	2.4 (± 0.3)	94	0	-	0
9	45	3.0 (± 1.0)	67	20	2.3 (± 0.5)	29	3	3.1 (± 1.4)	4
10	11	2.4 (± 0.6)	65	5	2.3 (± 0.5)	29	1	1.8 (nc)	6
11	13	2.5 (± 0.4)	76	0	-	0	4	2.6 (± 0.5)	24
Total	**137**	**2.7 (± 0.9)**	**43**	**125**	**2.5 (± 0.6)**	**40**	**53**	**2.7 (± 1.0)**	**17**

Table H5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on Little Deep Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
1	17	71 (± 32)	0 (± 0)	1 (± 2)	20 (± 19)	52 (± 20)	27 (± 21)	1 (± 2)	0 (± 0)	0 (± 0)	0 (± 0)
2	32	81 (± 30)	0 (± 0)	0 (± 0)	12 (± 11)	56 (± 25)	32 (± 26)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
3	16	97 (± 9)	0 (± 0)	0 (± 0)	20 (± 8)	77 (± 8)	1 (± 2)	0 (± 0)	0 (± 0)	2 (± 5)	0 (± 0)
4	31	97 (± 14)	1 (± 4)	2 (± 5)	43 (± 26)	51 (± 26)	4 (± 8)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
5	16	94 (± 12)	0 (± 0)	1 (± 3)	41 (± 29)	55 (± 31)	2 (± 3)	0 (± 1)	0 (± 0)	0 (± 0)	0 (± 0)
6	33	84 (± 28)	0 (± 0)	0 (± 0)	59 (± 33)	29 (± 30)	2 (± 4)	1 (± 4)	3 (± 8)	7 (± 18)	0 (± 0)
7	34	100 (± 0)	0 (± 0)	0 (± 0)	24 (± 23)	57 (± 24)	18 (± 26)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
8	17	85 (± 6)	0 (± 0)	0 (± 0)	72 (± 15)	7 (± 9)	1 (± 2)	14 (± 7)	6 (± 6)	1 (± 3)	0 (± 0)
9	66	57 (± 18)	0 (± 1)	0 (± 1)	15 (± 21)	20 (± 16)	17 (± 20)	34 (± 21)	10 (± 13)	3 (± 5)	0 (± 0)
10	17	76 (± 11)	0 (± 1)	0 (± 0)	9 (± 9)	40 (± 26)	46 (± 25)	4 (± 4)	1 (± 2)	0 (± 0)	0 (± 0)
11	17	58 (± 12)	1 (± 5)	0 (± 1)	7 (± 17)	26 (± 22)	6 (± 5)	41 (± 23)	17 (± 17)	1 (± 2)	0 (± 0)
Total	**296**	**77 (± 24)**	**0 (± 2)**	**0 (± 2)**	**28 (± 29)**	**40 (± 29)**	**15 (± 22)**	**11 (± 19)**	**4 (± 9)**	**2 (± 7)**	**0 (± 0)**

Appendix I.

Table I1. Mean values (± SD) of habitat parameters measured along transects on the Little Spokane River.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
3	1	10	14.6 (± 2.4)	16.8 (± 2.3)	40 (± 7)	63 (± 12)
4	1	10	7.7 (± 1.1)	8.5 (± 1.2)	42 (± 11)	67 (± 20)
5	1	10	12.3 (± 2.3)	13.7 (± 2.8)	31 (± 4)	61 (± 13)
6	1	10	11.1 (± 5.8)	13.8 (± 6.6)	49 (± 11)	84 (± 25)
7	1	10	12.0 (± 3.0)	15.3 (± 2.4)	47 (± 6)	77 (± 27)
10	2	20	7.1 (± 1.8)	8.3 (± 1.8)	47 (± 9)	79 (± 15)
11	2	20	6.4 (± 1.1)	7.9 (± 1.1)	38 (± 12)	62 (± 18)
16	2	20	8.7 (± 2.0)	10.8 (± 2.5)	38 (± 14)	69 (± 25)
18	2	20	6.6 (± 1.3)	7.5 (± 1.5)	53 (± 9)	88 (± 13)
21	1	10	7.5 (± 0.7)	8.2 (± 1.0)	59 (± 13)	103 (± 23)
22	2	20	12.0 (± 1.4)	12.8 (± 1.4)	58 (± 13)	103 (± 25)
23	2	20	17.1 (± 1.7)	18.5 (± 2.3)	55 (± 23)	88 (± 29)
26	1	10	13.3 (± 2.1)	15.4 (± 1.6)	54 (± 18)	108 (± 33)
27	1	10	13.3 (± 1.3)	14.7 (± 1.2)	66 (± 13)	120 (± 30)
29	1	10	12.0 (± 2.2)	15.3 (± 3.1)	33 (± 5)	59 (± 9)
31	1	10	18.0 (± 2.3)	20.1 (± 2.1)	33 (± 11)	60 (± 20)
32	2	20	17.1 (± 2.6)	18.7 (± 1.8)	49 (± 16)	82 (± 25)
33	1	10	11.6 (± 1.8)	13.4 (± 2.0)	65 (± 13)	109 (± 17)
36	1	10	16.2 (± 1.8)	18.4 (± 2.7)	45 (± 18)	90 (± 12)
37	1	10	15.7 (± 1.7)	18.4 (± 2.1)	40 (± 7)	65 (± 9)
38	1	10	18.4 (± 2.4)	21.6 (± 2.6)	32 (± 7)	67 (± 21)
Total	**28**	**280**	**11.9 (± 4.5)**	**13.7 (± 4.9)**	**47 (± 16)**	**81 (± 27)**

Table I2. Mean values (± SD) of habitat parameters measured and counted at each survey section on the Little Spokane River.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
3	1	2.0 (nc)	11.0 (nc)	17.0 (nc)	30 (nc)	0 (nc)
4	1	1.5 (nc)	11.0 (nc)	17.0 (nc)	9 (nc)	0 (nc)
5	1	1.0 (nc)	12.0 (nc)	24.0 (nc)	13 (nc)	0 (nc)
6	1	1.5 (nc)	11.5 (nc)	11.0 (nc)	3 (nc)	0 (nc)
7	1	1.0 (nc)	8.0 (nc)	14.0 (nc)	6 (nc)	0 (nc)
10	2	1.0 (± 0.0)	11.0 (± 2.8)	10.5 (± 0.7)	10 (± 8)	0 (± 0)
11	2	3.3 (± 1.1)	14.0 (± 0.0)	11.5 (± 0.7)	12 (± 1)	0 (± 0)
16	2	2.0 (± 0.0)	13.0 (± 0.7)	15.0 (± 1.4)	12 (± 3)	5 (± 7)
18	2	2.0 (± 0.0)	14.0 (± 1.4)	13.0 (± 0.0)	23 (± 8)	5 (± 7)
21	1	2.0 (nc)	14.0 (nc)	21.0 (nc)	16 (nc)	0 (nc)
22	2	1.0 (± 0.0)	16.0 (± 0.0)	18.5 (± 0.7)	11 (± 4)	0 (± 0)
23	2	4.0 (± 4.2)	14.8 (± 1.1)	17.5 (± 2.1)	9 (± 13)	0 (± 0)
26	1	1.0 (nc)	14.0 (nc)	23.0 (nc)	3 (nc)	0 (nc)
27	1	0.5 (nc)	13.5 (nc)	15.0 (nc)	6 (nc)	0 (nc)
29	1	2.0 (nc)	11.0 (nc)	10.0 (nc)	4 (nc)	0 (nc)
31	1	1.0 (nc)	11.0 (nc)	19.0 (nc)	23 (nc)	0 (nc)
32	2	1.3 (± 0.4)	10.0 (± 0.0)	14.5 (± 0.7)	14 (± 12)	0 (± 0)
33	1	1.0 (nc)	12.0 (nc)	17.0 (nc)	12 (nc)	0 (nc)
36	1	1.5 (nc)	15.0 (nc)	16.0 (nc)	5 (nc)	0 (nc)
37	1	1.5 (nc)	12.0 (nc)	20.0 (nc)	8 (nc)	0 (nc)
38	1	2.0 (nc)	11.0 (nc)	16.0 (nc)	22 (nc)	0 (nc)
Total	**28**	**1.7 (± 1.2)**	**12.6 (± 2.1)**	**15.8 (± 3.8)**	**12 (± 8)**	**1 (± 3)**

Table I3. Mean width (± SD) and percent occurrence of each habitat type observed on the Little Spokane River.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
3	0	-	-	-	-
4	0	-	-	-	-
5	0	-	-	-	-
6	0	-	-	-	-
7	0	-	-	-	-
10	0	-	-	-	-
11	0	-	-	-	-
16	1	14.1 (nc)	16.6 (nc)	124 (nc)	98 (nc)
18	1	6.4 (nc)	15.0 (nc)	128 (nc)	105 (nc)
21	0	-	-	-	-
22	0	-	-	-	-
23	0	-	-	-	-
26	0	-	-	-	-
27	0	-	-	-	-
29	0	-	-	-	-
31	0	-	-	-	-
32	0	-	-	-	-
33	0	-	-	-	-
36	0	-	-	-	-
37	0	-	-	-	-
38	0	-	-	-	-
Total	**2**	**10.3 (± 5.4)**	**15.8 (± 1.1)**	**126 (± 3)**	**101 (± 5)**

Table I4. Mean width (± SD) and percent occurrence of each habitat type observed on the Little Spokane River.

Reach	Riffle			Run			Pool		
	n	**Width (m)**	**Occurrence (%)**	**n**	**Width (m)**	**Occurrence (%)**	**n**	**Width (m)**	**Occurrence (%)**
3	0	-	0	10	14.6 (± 2.4)	100	0	-	0
4	0	-	0	10	7.7 (± 1.1)	100	0	-	0
5	0	-	0	10	12.3 (± 2.3)	100	0	-	0
6	0	-	0	10	11.1 (± 5.8)	100	0	-	0
7	0	-	0	10	12.0 (± 3.0)	100	0	-	0
10	0	-	0	20	7.1 (± 1.8)	100	0	-	0
11	6	5.8 (± 1.1)	30	13	6.7 (± 1.0)	65	1	6.6 (nc)	5
16	13	8.3 (± 2.3)	62	5	7.5 (± 0.5)	24	3	9.6 (± 3.8)	14
18	4	5.9 (± 1.8)	20	15	6.9 (± 1.2)	75	1	5.8 (nc)	5
21	0	-	0	10	7.5 (± 0.7)	100	0	-	0
22	0	-	0	20	12.0 (± 1.4)	100	0	-	0
23	10	17.8 (± 2.2)	50	10	16.4 (± 0.4)	50	0	-	0
26	0	-	0	10	13.3 (± 2.1)	100	0	-	0
27	0	-	0	10	13.3 (± 1.3)	100	0	-	0
29	5	12.2 (± 2.9)	50	5	11.7(± 1.3)	50	0	-	0
31	6	17.5 (± 2.8)	60	4	18.8 (± 1.5)	40	0	-	0
32	3	14.4 (± 1.7)	15	17	17.5 (± 2.4)	85	0	-	0
33	0	-	0	10	11.6 (± 1.8)	100	0	-	0
36	5	16.1 (± 2.7)	45	6	13.6 (± 4.1)	55	0	-	0
37	5	15.5 (± 0.7)	50	5	15.9 (± 2.4)	50	0	-	0
38	10	18.4 (± 2.4)	100	0	-	0	0	-	0
Total	**67**	**13.4 (± 5.2)**	**24**	**210**	**11.4 (± 4.2)**	**74**	**5**	**8.3 (± 3.3)**	**2**

Table I5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on the Little Spokane River.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
3	10	97 (± 7)	8 (± 10)	0 (± 0)	40 (± 12)	46 (± 17)	2 (± 4)	2 (± 2)	3 (± 4)	2 (± 3)	0 (± 0)
4	10	90 (± 14)	52 (± 27)	0 (± 0)	21 (± 14)	20 (± 15)	6 (± 4)	1 (± 2)	1 (± 2)	1 (± 3)	0 (± 0)
5	10	100 (± 0)	32 (± 20)	4 (± 2)	38 (± 14)	27 (± 9)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
6	10	99 (± 3)	39 (± 21)	5 (± 8)	26 (± 21)	30 (± 18)	0 (± 0)	0 (± 0)	1 (± 2)	0 (± 0)	0 (± 0)
7	10	100 (± 0)	31 (± 21)	16 (± 9)	38 (± 17)	17 (± 17)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
10	20	95 (± 9)	25 (± 16)	1 (± 3)	4 (± 6)	48 (± 29)	21 (± 27)	1 (± 2)	1 (± 2)	1 (± 2)	0 (± 0)
11	20	84 (± 15)	7 (± 5)	0 (± 1)	4 (± 6)	61 (± 23)	6 (± 9)	11 (± 13)	8 (± 12)	3 (± 9)	0 (± 0)
16	20	74 (± 17)	3 (± 5)	0 (± 1)	7 (± 13)	39 (± 26)	6 (± 4)	9 (± 8)	18 (± 14)	18 (± 15)	0 (± 0)
18	20	87 (± 23)	15 (± 18)	4 (± 5)	3 (± 5)	58 (± 27)	2 (± 3)	2 (± 3)	3 (± 5)	14 (± 23)	0 (± 0)
21	10	100 (± 0)	6 (± 4)	18 (± 21)	0 (± 0)	77 (± 23)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
22	20	95 (± 10)	16 (± 10)	1 (± 2)	5 (± 6)	73 (± 13)	2 (± 5)	0 (± 0)	0 (± 0)	2 (± 5)	2 (± 7)
23	20	69 (± 32)	13 (± 19)	3 (± 5)	0 (± 0)	43 (± 29)	0 (± 0)	1 (± 2)	1 (± 2)	40 (± 41)	0 (± 0)
26	10	84 (± 18)	2 (± 2)	2 (± 2)	16 (± 10)	60 (± 20)	9 (± 8)	2 (± 3)	2 (± 3)	9 (± 16)	0 (± 0)
27	10	86 (± 15)	5 (± 7)	2 (± 3)	26 (± 18)	43 (± 17)	3 (± 3)	18 (± 20)	2 (± 3)	3 (± 3)	0 (± 0)
29	10	47 (± 18)	1 (± 2)	1 (± 2)	2 (± 2)	12 (± 5)	11 (± 4)	38 (± 18)	20 (± 12)	18 (± 16)	0 (± 0)
31	10	66 (± 8)	1 (± 3)	0 (± 0)	2 (± 4)	34 (± 18)	19 (± 11)	12 (± 6)	24 (± 8)	8 (± 8)	0 (± 0)
32	20	78 (± 19)	2 (± 3)	1 (± 2)	26 (± 26)	24 (± 12)	9 (± 9)	22 (± 23)	13 (± 21)	3 (± 3)	0 (± 0)
33	10	92 (± 8)	1 (± 2)	0 (± 0)	20 (± 10)	69 (± 11)	3 (± 4)	4 (± 5)	2 (± 3)	3 (± 3)	0 (± 0)
36	10	71 (± 10)	2 (± 3)	0 (± 0)	15 (± 10)	24 (± 7)	16 (± 8)	42 (± 8)	2 (± 3)	0 (± 0)	0 (± 0)
37	10	62 (± 8)	0 (± 0)	0 (± 0)	5 (± 2)	17 (± 5)	11 (± 4)	45 (± 11)	20 (± 12)	4 (± 3)	0 (± 0)
38	10	66 (± 11)	1 (± 2)	0 (± 0)	1 (± 2)	30 (± 11)	9 (± 7)	35 (± 14)	20 (± 17)	7 (± 7)	0 (± 0)
Total	**280**	**82 (± 21)**	**12 (± 18)**	**2 (± 7)**	**12 (± 17)**	**43 (± 27)**	**6 (± 11)**	**10 (± 17)**	**6 (± 12)**	**8 (± 18)**	**0 (± 2)**

Appendix J.

Table J1. Mean values (± SD) of habitat parameters measured along transects on North Fork Little Deep Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	0.8 (± 0.2)	1.6 (± 0.3)	4 (± 2)	8 (± 4)
2	1	17	1.6 (± 0.6)	2.4 (± 0.7)	6 (± 2)	14 (± 4)
3	2	34	1.9 (± 0.6)	3.1 (± 1.0)	6 (± 2)	13 (± 3)
4	2	34	1.7 (± 0.6)	3.0 (± 0.9)	7 (± 3)	15 (± 6)
5	1	17	2.1 (± 0.5)	5.0 (± 1.4)	13 (± 4)	24 (± 8)
6	2	34	1.4 (± 0.4)	2.1 (± 0.5)	13 (± 5)	22 (± 8)
Total	**9**	**153**	**1.6 (± 0.6)**	**2.8 (± 1.3)**	**9 (± 5)**	**16 (± 8)**

Table J2. Mean values (± SD) of habitat parameters measured and counted at each survey section on North Fork Little Deep Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	4.0 (nc)	12.0 (nc)	14.0 (nc)	25 (nc)	0 (nc)
2	1	2.0 (nc)	11.0 (nc)	18.0 (nc)	29 (nc)	0 (nc)
3	2	3.0 (± 0.0)	13.0 (± 0.0)	20.3 (± 2.5)	32 (± 1)	5 (± 7)
4	2	3.0 (± 0.0)	14.5 (± 0.7)	21.0 (± 1.4)	32 (± 9)	10 (± 0)
5	1	2.0 (nc)	18.0 (nc)	29.0 (nc)	24 (nc)	0 (nc)
6	2	1.0 (± 0.0)	15.5 (± 6.4)	23.0 (± 5.7)	12 (± 16)	5 (± 7)
Total	**9**	**2.4 (± 1.0)**	**14.1 (± 3.1)**	**21.1 (± 4.6)**	**25 (± 11)**	**4 (± 5)**

Table J3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on North Fork Little Deep Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	0	-	-	-	-
2	0	-	-	-	-
3	1	2.4 (nc)	1.2 (nc)	22 (nc)	18 (nc)
4	2	2.2 (± 0.8)	2.0 (± 0.2)	31 (± 1)	22 (± 2)
5	0	-	-	-	-
6	1	2.8 (nc)	4.1 (nc)	61 (nc)	43 (nc)
Total	**4**	**2.4 (± 0.5)**	**2.3 (± 1.3)**	**36 (± 17)**	**26 (± 12)**

Table J4. Mean width (± SD) and percent occurrence of each habitat type observed on North Fork Little Deep Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	16	0.8 (± 0.2)	94	0	-	0	1	0.8 (nc)	6
2	16	1.5 (± 0.5)	89	0	-	0	2	1.3 (± 0.2)	11
3	31	1.8 (± 0.6)	89	0	-	0	4	1.5 (± 0.8)	11
4	31	1.6 (± 0.6)	82	0	-	0	7	1.1 (± 0.3)	18
5	6	2.3 (± 0.7)	35	10	1.9 (± 0.4)	59	1	1.6 (nc)	6
6	6	1.3 (± 0.1)	18	27	1.3 (± 0.3)	79	1	2.8 (nc)	3
Total	**106**	**1.5 (± 0.6)**	**67**	**37**	**1.5 (± 0.4)**	**23**	**16**	**1.4 (± 0.6)**	**10**

Table J5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on North Fork Little Deep Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
1	17	37 (± 15)	1 (± 2)	0 (± 0)	10 (± 21)	18 (± 13)	56 (± 29)	9 (± 16)	5 (± 11)	1 (± 5)	0 (± 0)
2	17	42 (± 19)	0 (± 0)	0 (± 0)	8 (± 9)	21 (± 21)	38 (± 28)	15 (± 16)	10 (± 16)	9 (± 15)	0 (± 0)
3	34	52 (± 22)	2 (± 12)	0 (± 0)	2 (± 5)	20 (± 19)	52 (± 29)	8 (± 9)	6 (± 8)	10 (± 19)	0 (± 0)
4	34	55 (± 20)	0 (± 0)	0 (± 0)	5 (± 8)	31 (± 21)	51 (± 24)	6 (± 6)	3 (± 5)	4 (± 9)	0 (± 2)
5	17	100 (± 0)	1 (± 3)	6 (± 9)	44 (± 20)	49 (± 19)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
6	34	99 (± 4)	1 (± 4)	13 (± 19)	65 (± 22)	16 (± 20)	4 (± 6)	1 (± 3)	0 (± 2)	0 (± 0)	0 (± 0)
Total	**153**	**65 (± 29)**	**1 (± 6)**	**3 (± 11)**	**23 (± 30)**	**25 (± 21)**	**34 (± 32)**	**6 (± 10)**	**4 (± 8)**	**4 (± 12)**	**0 (±1)**

Appendix K.

Table K1. Mean values (± SD) of habitat parameters measured along transects on Pell Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
3	1	17	1.2 (± 0.3)	3.3 (± 0.7)	5 (± 2)	10 (± 3)
4	2	34	1.3 (± 0.4)	2.8 (± 0.8)	5 (± 3)	9 (± 6)
5	1	17	1.0 (± 0.4)	2.1 (± 0.4)	6 (± 4)	10 (± 7)
Total	**4**	**68**	**1.2 (± 0.4)**	**2.8 (± 0.8)**	**5 (± 3)**	**10 (± 6)**

Table K2. Mean values (± SD) of habitat parameters measured and counted at each survey section on Pell Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
3	1	5.0 (nc)	11.5 (nc)	16.0 (nc)	17 (nc)	0 (nc)
4	2	5.0 (± 2.8)	13.3 (± 0.4)	23.5 (± 9.2)	16 (± 0)	10 (± 0)
5	1	2.0 (nc)	14.0 (nc)	21.0 (nc)	32 (nc)	10 (nc)
Total	**4**	**4.3 (± 2.2)**	**13.0 (± 1.1)**	**21.0 (± 6.4)**	**20 (± 8)**	**8 (±5)**

Table K3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on Pell Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
3	0	-	-	-	-
4	2	2.0 (± 0.3)	3.3 (± 0.3)	35 (± 6)	21 (± 3)
5	1	2.2 (nc)	2.9 (nc)	32 (nc)	19 (nc)
Total	**3**	**2.1 (± 0.2)**	**3.2 (± 0.3)**	**34 (± 4)**	**20 (± 2)**

Table K4. Mean width (± SD) and percent occurrence of each habitat type observed on Pell Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
3	10	1.2 (± 0.4)	59	4	1.1 (± 0.2)	23	3	1.1 (± 0.2)	18
4	26	1.2 (± 0.4)	72	6	1.2 (± 0.1)	17	4	1.3 (± 0.5)	11
5	15	0.9 (± 0.2)	88	0	-	0	2	1.7 (± 0.7)	12
Total	**51**	**1.1 (± 0.4)**	**73**	**10**	**1.2 (± 0.1)**	**14**	**9**	**1.3 (± 0.5)**	**13**

Table K5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on Pell Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
3	17	63 (± 13)	0 (± 0)	0 (± 0)	21 (± 22)	33 (± 25)	19 (± 12)	19 (± 20)	8 (± 12)	1 (± 2)	0 (± 0)
4	34	47 (± 24)	1 (± 4)	0 (± 0)	16 (± 23)	18 (± 17)	26 (± 23)	19 (± 18)	7 (± 13)	1 (± 3)	12 (± 30)
5	17	100 (± 0)	0 (± 0)	3 (± 12)	18 (± 20)	51 (± 24)	29 (± 22)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
Total	**68**	**54 (± 24)**	**1 (± 3)**	**1 (± 6)**	**18 (± 22)**	**30 (± 24)**	**25 (± 21)**	**14 (± 18)**	**6 (± 11)**	**1 (± 2)**	**6 (± 22)**

Appendix L.

Table L1. Mean values (± SD) of habitat parameters measured along transects on South Fork Deadman Creek.

Reach	**No. Sections**	**No. Transects**	**Wet Width (m)**	**Bankfull Width (m)**	**Mean Depth (cm)**	**Mean Max. Depth (cm)**
1	1	17	2.4 (± 0.8)	3.9 (± 1.4)	7 (± 3)	14 (± 4)
2	1	16	2.3 (± 0.6)	3.6 (± 0.6)	6 (± 2)	16 (± 5)
3	1	17	1.8 (± 0.6)	2.7 (± 0.5)	7 (± 3)	15 (± 6)
4	1	17	1.9 (± 0.5)	3.6 (± 0.6)	6 (± 2)	15 (± 4)
5	2	34	1.9 (± 0.7)	3.7 (± 0.8)	7 (± 3)	15 (± 6)
Total	**6**	**101**	**2.0 (± 0.7)**	**3.5 (± 0.9)**	**7 (± 3)**	**15 (± 5)**

Table L2. Mean values (± SD) of habitat parameters measured and counted at each survey section on South Fork Deadman Creek.

Reach	**No. Sections**	**Gradient (%)**	**Water Temp. (°C)**	**Air Temp. (°C)**	**No. LWD/100 m**	**No. PP/km**
1	1	6.0 (nc)	15.0 (nc)	27.0 (nc)	33 (nc)	10 (nc)
2	1	6.0 (nc)	12.0 (nc)	16.0 (nc)	30 (nc)	0 (nc)
3	1	6.0 (nc)	14.0(nc)	23.0 (nc)	22 (nc)	20 (nc)
4	1	2.0 (nc)	15.0 (nc)	22.0 (nc)	19 (nc)	0 (nc)
5	2	3.0 (± 1.4)	13.5 (± 0.7)	14.0 (± 0.0)	18 (± 1)	15 (± 7)
Total	**6**	**4.3 (± 2.0)**	**13.8 (± 1.2)**	**19.3 (± 5.4)**	**23 (± 7)**	**10 (± 9)**

Table L3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on South Fork Deadman Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	1	2.1 (nc)	3.4 (nc)	25 (nc)	14 (nc)
2	0	-	-	-	-
3	2	2.6 (± 0.4)	2.9 (± 1.0)	33 (± 2)	20 (± 1)
4	0	-	-	-	-
5	3	2.6 (± 0.2)	5.2 (± 1.5)	31 (± 6)	21 (± 2)
Total	**6**	**2.5 (± 0.3)**	**4.2 (± 1.6)**	**31 (± 5)**	**20 (± 3)**

Table L4. Mean width (± SD) and percent occurrence of each habitat type observed on South Fork Deadman Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	15	2.4 (± 0.9)	88	0	-	0	2	2.0 (± 0.2)	12
2	15	2.2 (± 0.6)	83	0	-	0	3	1.2 (± 0.4)	17
3	14	1.5 (± 0.5)	78	0	-	0	4	2.3 (± 0.8)	22
4	15	1.8 (± 0.5)	83	1	1.3 (nc)	6	2	1.3 (± 0.1)	11
5	26	1.8 (± 0.7)	76	4	2.1 (± 0.4)	12	4	2.2 (± 0.5)	12
Total	**85**	**1.9 (± 0.7)**	**81**	**5**	**1.9 (± 0.5)**	**5**	**15**	**1.9 (± 0.7)**	**14**

Table L5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on South Fork Deadman Creek.

Reach	n	Embeddedness (%)	Mean Composition (%) of Each Substrate Type								
			Organic	Muck	Silt	Sand	Gravel	Cobble	Rubble	Boulder	Bedrock
1	17	59 (± 15)	1 (± 2)	0 (± 0)	6 (± 7)	33 (± 19)	29 (± 19)	14 (± 11)	9 (± 6)	8 (± 7)	0 (± 0)
2	16	56 (± 14)	0 (± 0)	0 (± 0)	5 (± 8)	34 (± 13)	21 (± 11)	28 (± 17)	6 (± 7)	5 (± 7)	0 (± 0)
3	17	54 (± 17)	0 (± 0)	0 (± 0)	4 (± 6)	26 (± 16)	24 (± 19)	23 (± 21)	6 (± 7)	16 (± 18)	0 (± 0)
4	17	53 (± 12)	0 (± 0)	0 (± 0)	4 (± 6)	33 (± 16)	38 (± 19)	13 (± 9)	8 (± 13)	5 (± 7)	0 (± 0)
5	34	57 (± 16)	1 (± 5)	0 (± 0)	5 (± 6)	43 (± 18)	27 (± 20)	15 (± 18)	6 (± 8)	4(± 8)	0 (± 0)
Total	**101**	**56 (± 15)**	**0 (± 3)**	**0 (± 0)**	**5 (± 7)**	**35 (± 17)**	**28 (± 19)**	**18 (± 17)**	**7 (± 8)**	**7 (± 11)**	**0 (± 0)**

Appendix M.

Table M1. Mean values (± SD) of habitat parameters measured along transects on South Fork Little Deep Creek.

Reach	No. Sections	No. Transects	Wet Width (m)	Bankfull Width (m)	Mean Depth (cm)	Mean Max. Depth (cm)
1	1	17	1.0 (± 0.4)	1.5 (± 0.5)	5 (± 2)	10 (± 3)
2	1	17	1.9 (± 0.6)	2.9 (± 0.8)	10 (± 5)	20 (± 7)
3	1	17	2.0 (± 0.8)	3.3 (± 0.8)	8 (± 5)	17 (± 9)
4	1	16	2.7 (± 1.2)	4.9 (± 1.5)	9 (± 3)	18 (± 4)
5	1	17	1.8 (± 0.4)	3.3 (± 0.9)	9 (± 3)	18 (± 6)
6	1	17	1.8 (± 0.5)	3.7 (± 1.1)	8 (± 4)	15 (± 7)
7	3	51	2.0 (± 0.8)	3.2 (± 0.7)	9 (± 3)	18 (± 7)
8	1	17	2.1 (± 0.7)	2.9 (± 0.7)	12 (± 7)	24 (± 12)
9	1	17	2.0 (± 0.5)	3.6 (± 0.5)	12 (± 9)	24 (± 17)
Total	**11**	**186**	**1.9 (± 0.8)**	**3.2 (± 1.1)**	**9 (± 5)**	**18 (± 9)**

Table M2. Mean values (± SD) of habitat parameters measured and counted at each survey section on South Fork Little Deep Creek.

Reach	No. Sections	Gradient (%)	Water Temp. (°C)	Air Temp. (°C)	No. LWD/100 m	No. PP/km
1	1	13.0 (nc)	8.0 (nc)	16.0 (nc)	15 (nc)	0 (nc)
2	1	7.0 (nc)	8.0 (nc)	13.0 (nc)	24 (nc)	20 (nc)
3	1	6.0 (nc)	8.0 (nc)	15.0 (nc)	20 (nc)	30 (nc)
4	1	5.5 (nc)	9.0 (nc)	14.0 (nc)	29 (nc)	0 (nc)
5	1	3.0 (nc)	11.0 (nc)	17.0 (nc)	26 (nc)	20 (nc)
6	1	4.0 (nc)	13.0 (nc)	20.0 (nc)	13 (nc)	10 (nc)
7	3	4.7 (± 1.2)	13.0 (± 1.0)	20.3 (± 2.1)	28 (± 10)	10 (± 10)
8	1	1.0 (nc)	15.0 (nc)	25.0 (nc)	35 (nc)	40 (nc)
9	1	1.0 (nc)	15.0 (nc)	21.0 (nc)	27 (nc)	40 (nc)
Total	**11**	**5.0 (± 3.3)**	**11.5 (± 2.8)**	**18.4 (± 3.7)**	**25 (± 8)**	**17 (± 15)**

Table M3. Mean wetted widths, lengths, maximum depths, and residual depths (± SD) of primary pools on South Fork Little Deep Creek.

Reach	n	Mean Width (m)	Mean Length (m)	Mean Max. Depth (cm)	Mean Residual Depth (cm)
1	0	-	-	-	-
2	2	2.1 (± 0.8)	3.4 (± 1.0)	38 (± 6)	23 (± 3)
3	3	2.3 (± 0.3)	2.4 (± 0.8)	30 (± 8)	22 (± 3)
4	0	-	-	-	-
5	2	2.6 (± 0.4)	4.8 (± 4.6)	34 (± 11)	23 (± 6)
6	1	2.0 (nc)	3.1 (nc)	36 (nc)	24 (nc)
7	3	2.3 (± 0.4)	3.3 (± 0.2)	41 (± 9)	27 (± 3)
8	4	3.0 (± 0.8)	3.1 (± 0.9)	46 (± 14)	30 (± 9)
9	4	2.7 (± 0.6)	4.6 (± 1.9)	52 (± 14)	35 (± 9)
Total	**19**	**2.5 (± 0.6)**	**3.5 (± 1.6)**	**41 (± 12)**	**27 (± 7)**

Table M4. Mean width (± SD) and percent occurrence of each habitat type observed on South Fork Little Deep Creek.

Reach	Riffle			Run			Pool		
	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)	n	Width (m)	Occurrence (%)
1	17	1.0 (± 0.4)	100	0	-	0	0	-	0
2	15	1.6 (± 0.6)	75	0	-	0	5	1.7 (± 0.6)	25
3	13	1.8 (± 0.6)	72	1	3.7 (nc)	6	4	1.8 (± 0.8)	22
4	15	2.5 (± 1.4)	83	0	-	0	3	2.0 (± 0.4)	17
5	13	1.7 (± 0.5)	68	1	1.8 (nc)	5	5	1.6 (± 0.4)	26
6	15	1.9 (± 0.5)	88	0	-	0	2	1.4 (± 0.1)	12
7	43	1.9 (± 0.6)	75	0	-	0	14	1.7 (± 0.7)	25
8	8	1.8 (± 0.6)	45	4	1.7 (± 0.3)	22	6	2.5 (± 0.9)	33
9	10	1.6 (± 0.7)	56	4	2.2 (± 0.5)	22	4	2.4 (± 0.6)	22
Total	**149**	**1.8 (± 0.8)**	**74**	**10**	**2.1 (± 0.7)**	**5**	**43**	**1.9 (± 0.7)**	**21**

Table M5. Mean substrate embeddedness and percent composition of each substrate type (± SD) observed on South Fork Little Deep Creek.

			Mean Composition (%) of Each Substrate Type								
Reach	**n**	**Embeddedness (%)**	**Organic**	**Muck**	**Silt**	**Sand**	**Gravel**	**Cobble**	**Rubble**	**Boulder**	**Bedrock**
1	17	46 (± 17)	1 (± 5)	0 (± 0)	1 (± 3)	33 (± 24)	32 (± 27)	9 (± 11)	18 (± 23)	7 (± 18)	0 (± 0)
2	17	26 (± 19)	0 (± 0)	0 (± 0)	2 (± 5)	26 (± 27)	28 (± 24)	15 (± 15)	18 (± 23)	12 (± 18)	0 (± 0)
3	17	32 (± 26)	0 (± 0)	0 (± 0)	2 (± 4)	23 (± 27)	9 (± 10)	9 (± 10)	20 (± 19)	19 (± 27)	18 (± 39)
4	16	45 (± 17)	2 (± 5)	0 (± 0)	12 (± 20)	21 (± 17)	19 (± 16)	23 (± 19)	17 (± 20)	5 (± 8)	0 (± 0)
5	17	56 (± 24)	0 (± 0)	0 (± 0)	26 (± 33)	18 (± 18)	12 (± 14)	22 (± 21)	16 (± 13)	7 (± 14)	0 (± 0)
6	17	58 (± 12)	0(± 0)	0 (± 0)	10 (± 9)	15 (± 10)	31 (± 18)	30 (± 20)	9 (± 8)	5 (± 15)	0 (± 0)
7	51	54 (± 21)	0 (± 1)	0 (± 0)	9 (± 17)	32 (± 20)	21 (± 21)	12 (± 18)	14 (± 17)	12 (± 22)	0 (± 0)
8	17	53 (± 21)	0 (± 1)	0 (± 0)	24 (± 24)	22 (± 14)	46 (± 28)	7 (± 6)	1 (± 2)	0 (± 1)	0 (± 0)
9	17	-	1 (± 2)	1 (± 2)	44 (± 30)	23 (± 11)	32 (± 29)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)
Total	**186**	**48 (± 22)**	**0 (± 2)**	**0 (± 1)**	**13 (± 22)**	**25 (± 20)**	**25 (± 23)**	**14 (± 17)**	**13 (± 17)**	**8 (± 18)**	**2 (± 13)**

Appendix M.

Table M1. Locations of thermographs set in the Little Spokane River drainage in 2003. Lat.=latitude, Long.=longitude, and DD=decimal degrees.

Stream	Location	Lat (DD)	Lon (DD)
Little Deep Creek	lower	47.79720	117.37818
NF Little Deep Creek	lower	47.89283	117.23890
SF Little Deep Creek	lower	47.87081	117.23779
Dartford Creek	lower	47.78456	117.41733
Little Spokane River	Scotia	48.10586	117.15294
Little Spokane River	Elk	48.02140	117.27467
Little Spokane River	Chattaroy	47.89152	117.35400
Little Spokane River	Wandermere	47.78474	117.40478
Little Spokane River	Indian Painted Rocks	47.78087	117.49636
Little Spokane River	lower	47.78269	117.53013
Deadman Creek	upper	47.88382	117.13002
Deadman Creek	middle	47.80236	117.21914
Deadman Creek	lower	47.79339	117.37684
SF Deadman Creek	lower	47.84710	117.16836

Appendix N.

Population structure of rainbow trout in the Spokane River drainage

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January 24, 2005

Abstract: We examined population structure in rainbow trout (*Oncorhynchus mykiss)* collected from 12 sites in the Spokane River drainage using 14 microsatellite loci. Heterozygosity was high with 9 – 57 alleles per locus. Populations displayed some homozygosity and linkage disequilibrium, which more pronounced in upper tributary collections and likely the result of small effective population sizes. Population structure followed geographic structure with collections from nearby tributaries more closely related. Comparisons to cutthroat, steelhead, coastal and redband trout collections indicated little or no introgression by these groups.

Introduction: Effective fisheries management is based upon an understanding of population structure. Since salmonids home to their natal stream for breeding, population structure is generally organized upon geographic structure of drainages. As some amount of straying naturally occurs within drainages and to a lesser extent among drainages within the same region, population structure follows a hierarchy of regional structure with populations more closely related in nearby drainages. In addition to natural movement among drainages, fisheries managers have sometimes moved trout among drainages and among regions. Since salmonids are regionally adapted and hatchery fish often are of non-local origin and lack characteristics allowing them to succeed in regions different from their origins or to succeed under natural conditions, hatchery introductions have mixed impacts upon natural populations. Further, population structure is impacted by barriers to fish movement. Dams may prevent fish from moving throughout a drainage leading to a smaller effective population sizes and inbreeding. In this study, population genetic structure was investigated in rainbow trout occupying tributaries of the Spokane and Little Spokane rivers using microsatellite DNA. Hatchery and natural redband trout (or potentially redband trout) samples from Kettle River tributaries (drainage flowing into the dammed portion of the Columbia River, Roosevelt Lake, north of where Spokane River flows into Roosevelt Lake) were included to investigate success and introgression of hatchery redband trout samples planted into the drainage. Spokane hatchery samples, derived from a coastal strain, and Lyon's Ferry hatchery steelhead samples, derived from upper Snake River trout, were included to determine whether redband trout were more closely related to coastal rainbow trout or steelhead. Cutthroat samples were included to examine hybridization between rainbow and cutthroat trout.

Materials and methods: Genotypes were assessed at 14 microsatellite loci for 1682 rainbow trout collected 2001 through 2003 from 17 tributaries and the mainstem of the Spokane and Little Spokane rivers (Figure 1, Table 1), two hatchery stocks (Spokane and Phalon Lake hatcheries), and three tributaries of the Kettle River (Table 1, Kettle River not shown in Figure 1). All tributary collections were natural-origin, adult rainbow trout. A collection of summer steelhead from Lyon's Ferry hatchery on the Snake River was also analyzed. Cutthroat samples from another study (Pend Oreille cutthroat) were included only for a hybridization analysis. There were two collections in the dataset with the same name, Deadman Cr., one from Spokane River drainage and the other from Kettle River. These are distinguished in the report as 03Dead(Spok) and 02Dead(Kettle).

Statistical tests were applied to determine characteristics of individual collections, to estimate relatedness among collections from different locations, and to assess

relationships between natural-origin and hatchery-origin rainbow. To estimate inbreeding and population mixing, departures from Hardy-Weinberg equilibrium (HWE) values (departure from heterozygosity expected when collection is a set of randomly mating individuals) were tested in collections using FSTAT2.9.3 (Goudet 2001) with 322,000 randomizations for HWE tests at each locus, and GENEPOP3.3 (Raymond and Rousset 1995) for HWE tests globally across loci with 100 batches and 2000 iterations. In individual locus tests (Table 2), 75 F_{IS} tests were significant before Bonferroni corrections for multiple simultaneous tests and 22 were significant after corrections (Table 3). In global tests, over half of collections (Table 1) and 11/14 loci (Table 3) were out of HWE for homozygote excess. Most collections within the Spokane River drainage were out of equilibrium at *One*-108 (Table 2), suggesting a possible null allele at this locus in these collections. Since most collections were out of equilibrium at *One*-108, HWE values and F_{IS} values over all loci were calculated without *One*-108 in the data. Ten collections from the Spokane River drainage were out of HWE after removing *One*-108. Positive F_{IS} values and disequilibrium suggested that collections have experienced inbreeding from small effective population sizes sustained over several generations or that collections contained admixtures of trout strains. Since steelhead have been absent from this area following the construction of Long Lake dam in 1911 (Jason McLellan, pers. comm., Figure 1), it is unlikely that samples contained admixtures of resident and anadromous populations, a condition which could also cause disequilibrium in analyses.

In other examinations, loci were tested for linkage (are alleles at different loci associated?) in pairwise genotypic disequilibrium tests across all collections using GENEPOP3.3 with 300 batches and 3000 iterations. Before and after corrections for multiple tests, 100/120 and 52/120 loci pairs were in disequilibrium, respectively, when summed over all populations. This non-independence could arise from the following sources. If loci are in close proximity on the same chromosome then alleles at different loci are transmitted as a set rather than independently. If individuals mate non-randomly, then individuals with particular genotypes mate with each other. Mating may also appear non-random if the population has a small effective size or has experienced a recent bottleneck such that related individuals mate with each other. Finally, loci appear linked if there is an admixture of populations or sibling groups in the collections. Since different locus pairs were out of equilibrium in different collections, physical linkage is unlikely and all loci were retained for the analysis. Linkage in individual collections ranged from 0 pairs in 01Upper Spokane River to 12 pairs in Otter Cr. (Table 1), suggesting moderate to high levels of inbreeding in collections or admixtures. The 03 Dartford Cr. collection from below the barrier was in Hardy-Weinberg equilibrium yet had five locus pairs linked in the collection (Table 1). Most loci in 03Dartford Cr. tended toward negative (although not significant) F_{IS} values (Table 2), indicating a Wahlund effect or excess heterozygosity from recent outbreeding in the collection. Since the collection originated in the lower reaches of Dartford Cr., strays from Buck Cr. may have entered en route to their spawning area, as suggested by STRUCTURE results (below). The trend toward homozygote excess in most other collections could suggest population admixture where collections included individuals from two (or more) sibling or breeding groups. In sum, the HWE, F_{IS} and linkage results suggest small effective population sizes and tendencies towards inbreeding in most collections.

Allelic richness (number of alleles per collection corrected for sample size and for groups of samples) was estimated using FSTAT2.9.3. Among hatchery collections, Phalon Lake had the highest allelic richness (17.64) and Spokane hatchery had the lowest allelic richness (7.71). The high diversity in the Phalon Lake collection reflects that it was recently derived from several collections. The Spokane hatchery collection was founded with coastal rainbow trout and maintained as a hatchery stock. Within the Spokane River drainage, Deadman Cr. had the highest allelic richness (16.14) and the Upper Little Spokane collection had the lowest allelic richness (9.71). Collections from upper portions and smaller branches of tributaries (upper Little Spokane, upper Spokane, Little Deer etc.) generally had lower allelic diversity than lower portions and larger branches of tributaries. This suggests smaller effective population sizes in upper portions and smaller drainages. Populations in lower portions may receive allelic infusions from strays. Gene diversity (expected heterozygosity, corrected for sample size) was estimated using FSTAT and values were similar (Table 1).

Since loci appear to be non-independent (much linkage disequilibrium, Table 1) and most collections were out of HWE (Table 1), tests investigating relationships among collections should be interpreted cautiously. In pairwise genotypic tests using FSTAT (with 300,000 permutations), all but four comparisons indicated significant differences in genotypic distributions (Table 4, lower matrix). Undifferentiated comparisons were all within tributaries and included: Little Deep and South Fork Little Deep Cr., Deer and Little Deer Cr., Dartford Cr. above and below barrier, and 02Middle Spokane and 03Middle Spokane River (Table 4). Pairwise F_{ST} tests examine departures from heterozygosity expected if collections were part of the same mating group. Significant pairwise F_{ST} tests suggest that groups are not interbreeding or that small populations have differentiated due to enhanced genetic drift. Pairwise F_{ST} tests were completely concordant with genotypic tests (Table 4, upper matrix). Both genotypic and F_{ST} tests indicated that, with the exception of the four non-significant tests, populations within the Little Spokane drainage, the Spokane mainstem, coastal rainbow trout from Spokane hatchery and redband collections are all genetically distinct. Since data suggests small effective population sizes in some collections (high linkage, out of HWE, lower allelic richness), some of this differentiation may be due to enhanced drift as well as reproductive isolation.

Cavalli-Sforza and Edwards chord distances (1967) among collections were generated and employed in a dendrogram analysis using PHYLIP (Felsenstein 1993). Distances were based upon allele frequencies at 14 loci and plotted in a neighbor-joining (NJ) tree (Figure 2). The analysis was bootstrapped 10,000 times to give an indication of confidence for groupings in the dendrogram: to simulate variability in the data set encountered if populations were resampled 10,000 times, the allele frequency matrix was resampled 10,000 times, a distance matrix was calculated for each data set, and a NJ dendrogram was constructed from each distance matrix. The 10,000 dendrograms were combined in a consensus tree and values at the nodes of the tree indicate the percentage (above 65%) of 10,000 trees in which collections beyond the node occurred together.

The consensus tree (Figure 2) showed associations among collections within tributaries: Spokane River mainstem collections, Little Deep Cr. collections, Dartford Cr. collections, and Deer Cr. collections each formed a branch with 100% bootstrap support respectively (associations also indicated in pairwise tests); Dragoon Cr. collections and Dead(Spok) collections each formed a branch with 99% bootstrap support respectively. Collections from tributaries of the Kettle River (SF Boulder and 02Dead(Kettle) creeks) were genetically distant from each other (Figure 2). SF Boulder occupied a branch with the Spokane hatchery collection with 68% bootstrap support. 02Dead(Kettle) Cr. occupied a branch with the Phalon Lake hatchery collection. The collections from SF Boulder, 02Dead(Kettle) Cr. and Phalon Lake hatchery were all redband rainbow trout. The collection from WF Trout Cr., a potential redband trout collection from a Kettle River tributary, was distant from all collections (Figure 2). Some of the distance may be due to the small samples size (N = 37) in WF Trout Cr. such that the genetic distances involving this collection were distorted - in the STRUCTURE analysis (see below), WF Trout Cr. had a much stronger relationship with the other redband collections from SF Boulder and Phalon Lake hatchery. The NJ tree also indicated independence of some collections in the Spokane River drainage. Collections from the lower and upper regions of the Little Spokane drainage were on different branches and Buck Cr. was independent from other Little Spokane tributaries.

STRUCTURE 2.1 (Pritchard et al. 2000) was used to estimate the proportion of ancestry shared among collections, to examine hybridization between *O. clarki* and *O. mykiss*, and to estimate introgression by hatchery fish. In this program, collections are tested for membership in a series of user-defined hypothetical clusters. The program sorts individuals in order to achieve Hardy-Weinberg equilibria and linkage equilibrium in the hypothetical clusters or populations. For example, to test whether *O. clarki* and *O. mykiss* are reproductively isolated, two clusters (the two species) are hypothesized among the collection data and the percentage of membership in either cluster calculated for an individual gives an estimate of the individual's ancestry. If the individual were purely *O. clarki* or *O. mykiss*, they would be included in clusters with their conspecifics. A hybrid individual would show ancestry in both clusters, with percentage of ancestry varying by generation of hybridization event (1st generation 50:50). Migrants could be detected as individuals with high membership in another collection. Distinct populations would share little ancestry with other collections. Collections with a history of introgression or hatchery influence might display mixed ancestry or mixed membership in individuals. Membership is calculated per individual and over collections. However, analysis can be problematic and misleading with so many collections since the program will force individuals or collections into a group even if the group is genetically different since the program has to divide individuals among the number of groups hypothesized. Yet, when more groups are hypothesized, individuals may be partitioned into several groups. Further, the amount of Hardy-Weinberg and linkage disequilibrium in this data set makes the results from STRUCTURE difficult to interpret.

Several tests were conducted using STRUCTURE with the number of hypothetical populations (K) set from 2 to 24 and with cutthroat trout collections (Sullivan Cr., Sullivan Lk. and Gold Cr., all from the Pend Oreille system) included in the data set.

With K = 2, the cutthroat and the collections from Spokane River mainstem (Middle Spokane R., upper and middle Spokane rivers) formed one group and the rest of the rainbow trout collections formed the other group. Rather than inferring that collections from the Spokane River mainstem share more ancestry with the cutthroat, the Spokane River mainstem collections may be more distinct than other rainbow collections, but the program only had two choices for placement. With K set to 12, each cluster had a collection with at least 75% membership in the cluster (Table 5) and the Ln of the data (-103,308, a measure indicating the probability of the clusters given the data) suggested at least 12 genetically defined groups in the data set. The data indicated little cutthroat trout introgression into rainbow trout populations (see cluster 12 in Table 5). 03Upper Spokane had the highest membership in the cutthroat cluster (2%) and other collections shared less than 1% cutthroat ancestry. Hatchery introgression also appeared minimal. The Spokane hatchery occupied its own cluster (cluster 8) with other collections sharing 7.5% (Buck Cr.) or less ancestry with the cluster (Table 5). Phalon Lake hatchery appeared to be derived from multiple populations, including interior rainbow, since its membership was divided among several clusters, with the highest percentage of membership partitioned between a cluster shared with 02Dead(Kettle) Cr. (46%), and a cluster shared with SF Boulder and WF Trout (15%), all redband collections, and a cluster shared with several rainbow collections (12.6%). Lyon's Ferry hatchery collection occupied its own cluster (cluster 9) with less than 5% membership from Spokane River, redband or other hatchery collections (Table 5).

The data indicated regional genetic associations where collections from nearby tributaries shared membership in the same cluster. Mainstem Spokane River collections shared high membership in cluster 1, Little Deep Cr. collections shared high membership in cluster 5, and Dragoon Cr. collections shared high membership in cluster 7 (Table 5). Some upper tributary collections appeared more distinct since they had a higher percentage membership in their cluster (03Upper Spokane 92%, Upper Little Spokane 93%, Dartford above barrier 93%). Buck Cr. was divided among clusters 2, 4 and 7, each dominated by other Little Spokane tributaries, perhaps indicating some straying into Buck Cr. from other tributaries.

When STRUCTURE was run with higher numbers of clusters, most collections dominated a single cluster but some collections were subdivided among many clusters. Some collections were better defined and others more poorly defined with higher cluster numbers. With clusters set at 18, each cluster had at least one collection with 40% membership in the cluster and above 18 collections subdivided between clusters (data not shown).

The program WHICHRUN 4.1 (Banks and Eichert 2000) was used to perform maximum likelihood assignments of each fish to a collection (Table 6). The program implements a jackknife procedure, each fish in turn is removed from the dataset, allele frequencies of the baseline (all the collections in the study) are calculated and the fish is assigned to the most likely group based upon its genotype and the allele frequencies of the groups. Collections were combined that were not significantly different from each other and that had grouped together with 100% bootstrap support in the NJ tree (Dartford Cr. above and

below barrier, South Fork Little Deep Cr. and Little Deep Cr., Deer and Little Deer Cr., 02Middle Spokane and 03Middle Spokane, see Table 4 and Figure 2). Assignments were highest to collection of origin and second highest to another collection from the same drainage (Table 6). The lowest correct assignment was in 03Dead(Spok) Cr. (47%) with most misassigned fish going to 03SFDead Cr. (Table 6). Highest correct assignments were in 03Upper Little Spokane River and Spokane hatchery with 100% each. Results were similar to STRUCTURE results in that collections with high membership to a single cluster also had high numbers of correct assignments with WHICHRUN. Collections with a portion of their membership in other clusters also had assignments to other collections. Upper tributary collections, more defined in the STRUCTURE analysis, also had higher correct assignments.

Conclusion: In sum, the data suggest several independent populations within the greater Spokane River drainage: Spokane River mainstem (upper and middle Spokane River and Middle Spokane R.), Deadman Cr., Deer Cr., Little Deep Cr., Otter Cr., Dragoon Cr., Dartford Cr., Buck Cr., Upper Little Spokane and Lower Little Spokane. Tributaries within these drainages were genetically linked (eg. SFDeadman and Deadman Cr.), such that genetic structure followed geographic structure with collections from tributaries within the same drainage most closely related. Introgression by coastal rainbow trout, cutthroat trout and redband rainbow trout appeared minimal. Redband rainbow trout collections were genetically different from each other and redband rainbow trout from Phalon Lake hatchery appeared to be derived from multiple sources.

Acknowledgements
Samples were collected by Jason McLellan (WDFW). Funding was provided by the Bonneville Power Administration through a subcontract with the Kaispel Tribe and by Avista Corporation. Laboratory work for 2001 and 2002 collections was assisted by Alice Frye and Cherrill Bowman.

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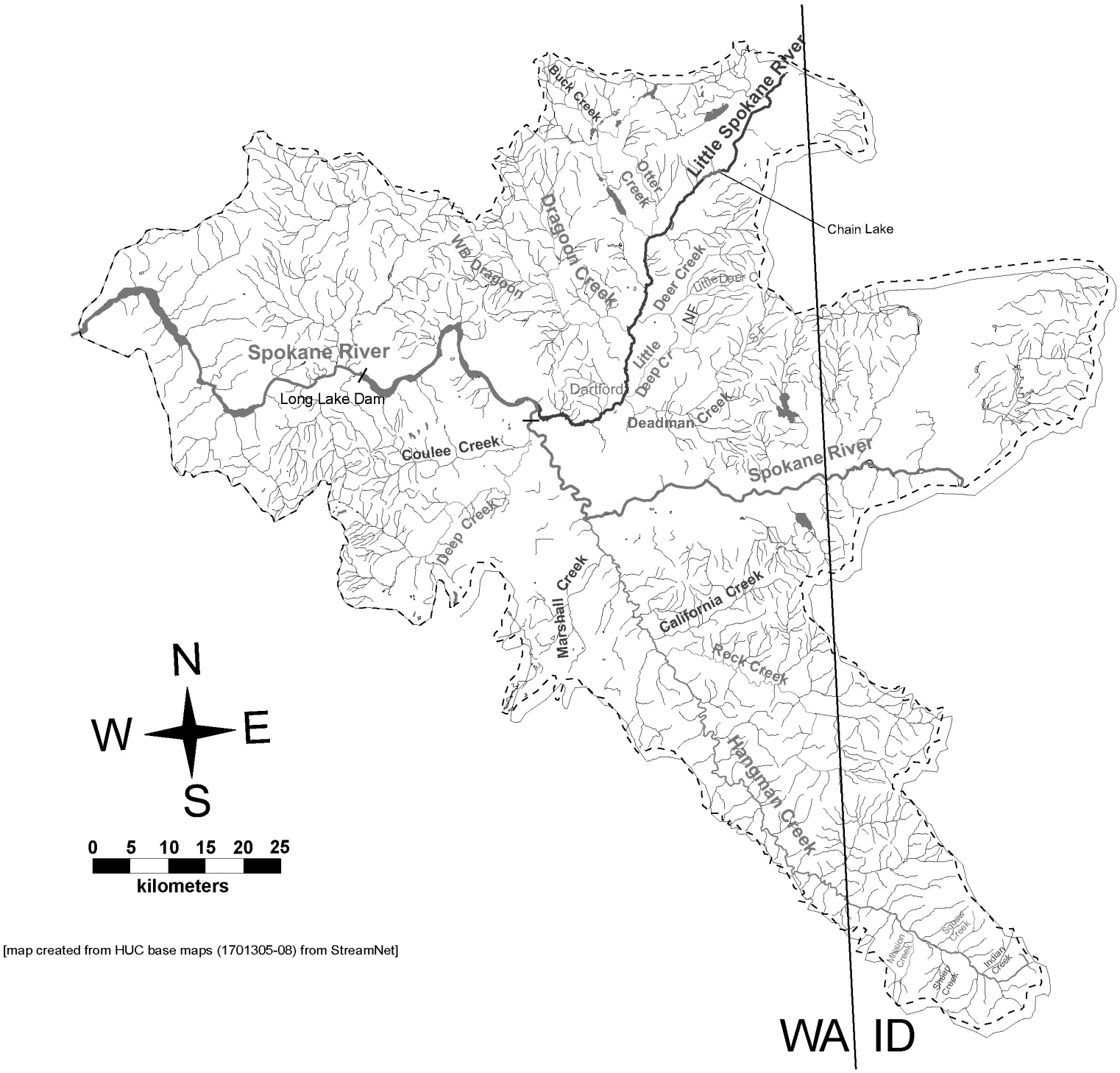
Figure 1. Map of Spokane River drainage showing tributaries where collections originated. Map was constructed by Jim Shaklee (WDFW). Kettle River is not shown.



[map created from HUC base maps (1701305-08) from StreamNet]

Figure 2. Consensus neighbor joining tree of Cavalli-Sforza and Edwards genetic chord distances (1967) among herring collections. Numbers at the nodes indicate the percentage of 1000 trees in which collections beyond the nodes grouped together. Abbreviations follow Table 1.

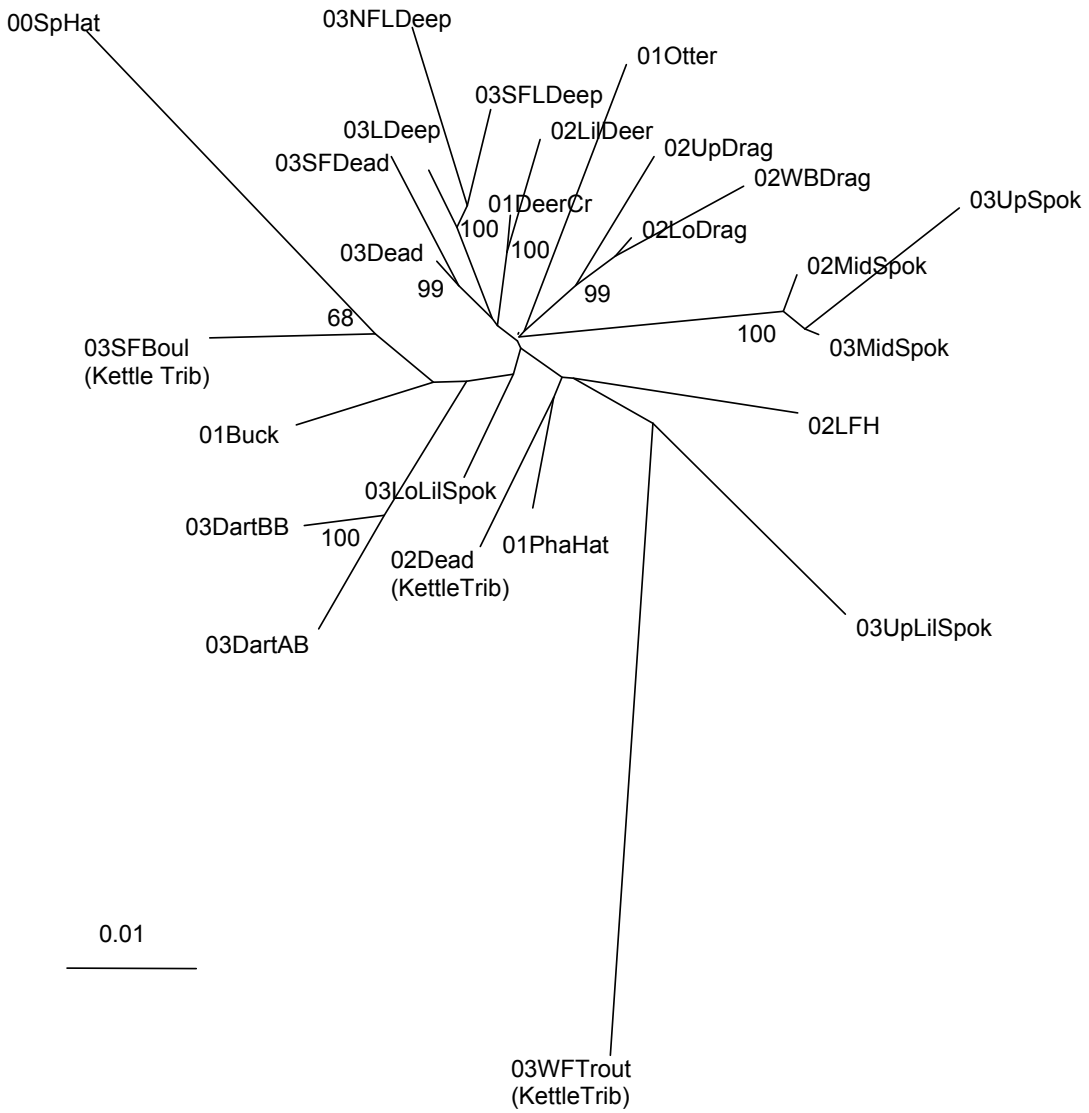


Table 1. Statistical information for collections and the WDFW collection code for sample. Number of individuals amplifying at 5 or more loci is under "N". The number of genotypic disequilibria (link) and the probability of conformance to Hardy-Weinberg expectations (HWE) were calculated using GENEPOP 3.3 (Raymond and Rousset, 1995). Gene diversity (expected heterozygosity corrected for sample size), was calculated using FSTAT2.9.3 (Goudet 2001). Allelic richness (Rich, number of alleles corrected for sample size), and F_{IS} over all loci (and *P* value) were calculated using FSTAT2.9.3.

River	Collection	Abbreviation	Code	N	link	Gene Div	HWE *P*	Rich	F_{IS}	P value
Spokane River (mainstem)	2002 Middle Spokane R.	02MidSpok	02HI	47	2	0.77	**0**	12.29	**0.056**	0.0018
	2003 Upper Spokane R.	03UpSpok	03AB	67		0.67	**0.0001**	10.07	**0.071**	0.0002
	2003 Middle Spokane R.	03MidSpok	03AC	92	4	0.74	**0**	12.79	**0.072**	0
Little Spokane River	2003 Upper Little Spokane R.	03UpLilSpok	03AD	39	1	0.75	0.0136	9.71	0.043	0.023
	2003 Lower Little Spokane R.	03LoLilSpok	03AE	62	6	0.80	**0**	14.86	**0.153**	0
	2003 Dartford Cr. (above barrier)	03DartAB	03AF	51		0.79	**0.0003**	10.64	0.042	0.0099
	2003 Dartford Cr. (below barrier)	03DartBB	03JF	29	5	0.78	0.7206	10.71	0.001	0.477
	2003 Deadman Cr	03Dead(Spok)	03AG	100	7	0.78	**0**	16.14	**0.111**	0
	2003 South Fork Deadman Cr.	03SFDead	03KI	49	1	0.74	**0.0002**	11.50	0.037	0.0269
	2003 Little Deep Cr.	03LDeep	03AH	50	2	0.75	0.0033	12.79	0.03	0.0404
	2003 North Fork Little Deep Cr.	03NFLDeep	03AI	50	1	0.69	0.1704	10.43	0.034	0.0438
	2003 South Fork Little Deep Cr.	03SFLDeep	03AJ	60	3	0.71	**0**	11.36	**0.062**	0.0003
	2001 Otter Cr.	01Otter	01BQ	50	12	0.76	0.0266	10.71	0.052	0.0034
	2001 Deer Cr.	01DeerCr	01BS	100		0.77	**0**	15.93	0.033	0.0034
	2002 Little Deer Cr.	02LilDeer	02AX	50		0.73	0.0207	12.14	0.037	0.0275
	2001 Buck Cr.	01Buck	01BU	50		0.80	0.2215	12.79	0.014	0.1988
	2002 Lower Dragoon Cr.	02LoDrag	02AN	100	6	0.79	**0**	15.43	**0.047**	0
	2002 West Branch Dragoon Cr.	02WBDrag	02AT	50	6	0.77	0.2065	10.71	-0.005	0.6028
	2002 Upper Dragoon Cr.	02UpDrag	02AU	50	1	0.77	0.0631	11.93	0.022	0.1123
Hatchery (Coastal)	2000 Spokane Hatchery	00SpHat	00DF	100	1	0.70	0.6719	7.71	-0.007	0.6625
Hatchery (Upper Snake)	2002 Lyon's Ferry Hatchery	02LFH	02GR	100	6	0.74	**0**	14.00	**0.065**	0
Hatchery (Redband)	2001 Phalon Lake Hatchery	01PhaHat	01BN	100	7	**0.83**	0.0011	17.64	0.021	0.0297
Kettle River (Redband?)	2002 Deadman Cr.	02Dead(Kettle)Cr	02MB	100	3	0.79	**0**	14.86	**0.081**	0
	2003 South Fork Boulder Cr.	03SFBoul	03KG	99	10	0.78	**0**	12.07	0.069	0
	2003 West Fork Trout Cr.	03WFTrout	03KH	37	1	**0.52**	0.6929	4.07	0.044	0.1125

Table 2. Loci information for each collection. Under each collection is the F_{IS} value at each locus, underlined values were significant before Bonferroni correction and bold type values were significant after correction. F_{IS} values were calculated using FSTAT2.9.3 (Goudet 2001) with 10,000 iterations.

	One-102	One-114	Ots-100	One-101	One-108	Ots-103	Omy-77	Ots-1	Ots-3M	Omm-1070	Omm-1130	Omy-1011	Oki-10	Omy-1001
02MidSpok	0.096	0.078	0.032	0.182	0.026	0.076	0.018	0.08	-0.042	0.039	0.072	0.125	-0.003	-0.039
03UpSpok	0.056	0.049	0.012	0.189	0.089	-0.013	-0.053	0.213	-0.008	0.057	0.091	**0.316**	0.027	-0.015
03MidSpok	0.072	0.113	0.045	-0.126	0.059	-0.013	0.093	0.012	0.044	**0.176**	0.046	0.149	0.011	0.061
03UpLilSpok	-0.085	0.062	0.03	0.131	0.177	-0.118	0.082	0.052	0.011	0.061	0.093	0.111	0.044	-0.022
03LoLilSpok	-0.027	0.109	0.047	0.068	0.064	0.148	0.012	0.1	-0.122	**0.726**	**0.544**	0.079	0.089	-0.01
03DartAB	0.014	0.095	-0.101	0.062	0.153	-0.13	0.017	-0.042	0.065	**0.231**	0.129	0.028	0.081	0.033
03DartBB	0.072	-0.022	-0.032	0.029	0.289	0.118	-0.106	-0.006	0.074	-0.042	0.103	-0.033	-0.092	-0.003
03Dead(Spok)	0.089	0.076	0.081	0.068	**0.195**	-0.058	0.062	**0.194**	0.108	**0.256**	**0.196**	0.072	0.065	0.023
03SFDead	-0.049	-0.02	0.093	0.105	**0.361**	-0.055	-0.139	0.029	0.085	0.154	0.023	0.088	0.078	0.108
03LDeep	-0.13	0.012	0.028	-0.026	0.193	0.31	-0.025	0.102	0.036	0.004	0.087	0.132	0.131	0.028
03NFLDeep	0.079	-0.044	0.218	-0.028	**0.434**	-0.014	-0.045	0.099	-0.005	0.04	-0.01	0.027	0.006	-0.015
03SFLDeep	0.101	0.082	0	-0.152	0.111	-0.009	0.094	0.08	0.039	0.069	0.061	0.052	-0.014	0.117
01Otter	0.081	-0.004	0.047	-0.102	**0.273**	0.073	0.094	-0.02	**0.395**	0.054	0.087	-0.094	0.003	0.064
01DeerCr	0.042	0.019	0.038	0.084	**0.28**	0.198	0.037	-0.059	0.198	0.025	**0.11**	-0.063	0.032	-0.041
02LilDeer	-0.006	0.023	0.028	0.043	**0.371**	-0.088	0.064	0.053	0.031	0.185	0.118	-0.084	-0.042	-0.03
01Buck	0.045	-0.049	-0.003	0.042	0.106	-0.065	0.017	-0.061	0.043	0.15	-0.057	0.037	-0.016	0.024
02LoDrag	0.105	0.011	-0.033	0.019	**0.172**	-0.048	0.06	0.12	-0.036	0.052	0.07	0.062	-0.036	0.082
02WBDrag	-0.15	0.016	-0.029	0.133	0.194	0.045	-0.083	0.029	0.056	0.139	0.04	-0.008	-0.034	-0.153
02UpDrag	-0.077	-0.023	-0.003	-0.017	0.165	0.021	0.191	-0.026	-0.117	0.04	0.123	0.128	-0.114	-0.027
00SpHat	-0.034	0.043	-0.014	0.021	0.006	0.124	0.004	-0.006	0.02	0.004	-0.062	-0.018	-0.162	-0.106
02LFH	0.061	0.058	0.053	0.032	0.113	-0.085	0.052	**0.195**	0.007	**0.14**	**0.15**	-0.031	NA	0.01
01PhaHat	0.019	0.013	0.055	0.05	0.084	-0.004	-0.006	0.005	0.04	0.045	0.054	-0.026	-0.036	0.005
02Dead(Kettle)Cr	0.078	0.048	0.02	-0.086	0.059	-0.126	0.037	**0.296**	0.012	**0.228**	0.098	0.03	-0.033	0.07
03SFBoul	0.118	0.048	0.017	0.304	0.101	-0.076	-0.059	0.082	0.211	0.052	0.086	0.107	-0.025	-0.008
03WFTrout	-0.092	-0.026	-0.018	-0.071	0.003	0.172	0.014	0.023	0.313	-0.128	0.432	0.053	-0.157	NA

Table 3. Information for multiplexes and loci: number of alleles in this study, size range (in basepairs), observed heterozygosity (Ho), repeat unit size (in basepairs), and *P*-value for deviation from Hardy-Weinberg equilibrium (HWE). Observed heterozygosity, G_{ST} (equivalent to F_{ST}) and G_{IS} (equivalent to F_{IS}) were calculated using FSTAT2.9.3.

Multiplex	Anneal T	cycles	Locus	conc [uM]	Dye	#alleles	range	Hobs	repeat	HWE *P*	Gst	Gis
Omy-B2	55	26	One-102	0.05	6fam	34	182-305	0.789	4	0	0.059	0.02
			One-114	0.05	vic	26	177-280	0.828	4	0	0.078	0.032
			Ots-100	0.04	ned	26	168-298	0.826	2	0	0.09	0.024
Omy-C2	55	28	One-101	0.02	ned	25	119-243	0.444	4	0.0007	0.115	0.051
			One-108	0.02	6fam	35	161-337	0.714	4	0	0.088	0.164
			Ots-103	0.015	vic	9	56-90	0.217	4	0.4006	0.099	0.017
Omy-D2	49	25	Omy-77	0.03	vic	22	97-147	0.835	2	0.0001	0.068	0.017
			Ots-1	0.03	6fam	22	158-266	0.727	2	0	0.098	0.06
			Ots-3M	0.02	ned	11	132-156	0.573	2	0	0.088	0.053
Omy-E2	62	26	Omm-1070	0.025	vic	42	164-374	0.797	4	0	0.064	0.113
			Omm-1130	0.05	6fam	57	185-399	0.8	4	0	0.073	0.103
			Omy-1011	0.045	ned	21	134-245	0.798	4	0	0.075	0.048
Omy-F2	52	25	Oki-10	0.02	vic	18	92-151	0.796	2	0.5487	0.095	-0.004
			Omy-1001	0.03	6fam	30	167-242	0.81	2	0.0665	0.12	0.007

Table 4. Results from pairwise genotypic and F_{ST} tests conducted using FSTAT2.9.3 (Goudet, 2001) with 30,000 permutations. Upper triangular matrix has *P* value for pairwise genotypic test and lower triangular matrix has pairwise FST value, values in bold type were not significantly different after Bonferroni corrections.

	03UpSpok	03MidSpok	03UpLilSpok	03LoLilSpok	03DartAB	03Dead(Spok)	03LDeep	03NFLDeep	03SFLDeep	03DartBB	03SFBoul	03WFTrout
03UpSpok	-	0	0	0	0	0	0	0	0	0	0	0
03MidSpok	0.0194	-	0	0	0	0	0	0	0	0	0	0
03UpLilSpok	0.1545	0.1072	-	0	0	0	0	0	0	0	0	0
03LoLilSpok	0.1088	0.0666	0.065	-	0	0	0	0	0	0	0	0
03DartAB	0.1668	0.113	0.0916	0.0485	-	0	0	0	0	**0.00195**	0	0
03Dead(Spok)	0.0845	0.0468	0.0561	0.0237	0.0633	-	0	0	0	0	0	0
03LDeep	0.1179	0.07	0.0804	0.0326	0.0661	0.0248	-	0	**0.00059**	0	0	0
03NFLDeep	0.1476	0.0979	0.1231	0.0799	0.1066	0.0648	0.0362	-	0	0	0	0
03SFLDeep	0.1319	0.0834	0.0966	0.0611	0.089	0.0413	**0.0108**	0.0317	-	0	0	0
03DartBB	0.1515	0.0948	0.0857	0.0418	**0.0073**	0.0539	0.0567	0.1075	0.0794	-	0	0
03SFBoul	0.1678	0.1119	0.0774	0.0479	0.067	0.0666	0.0624	0.1145	0.089	0.0617	-	0
03WFTrout	0.2818	0.2292	0.2108	0.2128	0.2429	0.1889	0.2024	0.2273	0.2095	0.2527	0.1853	-
03SFDead	0.1074	0.0643	0.0828	0.0559	0.0865	0.0154	0.0411	0.0774	0.0461	0.0809	0.095	0.2126
00SpHat	0.243	0.1886	0.1419	0.1071	0.1067	0.1337	0.1319	0.19	0.1575	0.1016	0.1002	0.2919
01PhaHat	0.1019	0.0652	0.0612	0.0263	0.0556	0.0292	0.0413	0.0837	0.063	0.0543	0.0447	0.1608
01Otter	0.1376	0.0861	0.0834	0.0418	0.0695	0.0435	0.0548	0.104	0.0757	0.0621	0.0698	0.241
01DeerCr	0.0915	0.0572	0.076	0.0246	0.0644	0.0155	0.0316	0.0619	0.0423	0.0598	0.0819	0.2031
01Buck	0.1375	0.0871	0.085	0.0319	0.0415	0.0507	0.0476	0.1078	0.077	0.0292	0.0409	0.2285
02LoDrag	0.1125	0.0721	0.0706	0.0239	0.0515	0.0283	0.0364	0.0803	0.0576	0.0441	0.0561	0.1983
02WBDrag	0.1311	0.0806	0.081	0.035	0.062	0.0393	0.0418	0.083	0.0602	0.054	0.0658	0.2099
02UpDrag	0.1187	0.0702	0.0773	0.0409	0.0635	0.033	0.0451	0.0789	0.0567	0.0504	0.0727	0.2188
02LilDeer	0.1054	0.0721	0.1028	0.0335	0.0842	0.0306	0.0493	0.0795	0.0561	0.081	0.1004	0.2376
02MidSpok	0.0213	**0.0031**	0.101	0.0586	0.1013	0.0447	0.066	0.1048	0.086	0.0828	0.0957	0.2273
02Dead(Kettle)Cr	0.0977	0.0615	0.0738	0.0417	0.0818	0.0338	0.0499	0.0767	0.0581	0.0804	0.0794	0.1784
02LFH	0.1195	0.0797	0.0693	0.0431	0.0768	0.0349	0.0504	0.0872	0.0647	0.074	0.0837	0.1783

Table 4.continued.

	03SFDead	00SpHat	01PhaHat	01Otter	01DeerCr	01Buck	02LoDrag	02WBDrag	02UpDrag	02LilDeer	02MidSpok	02Dead(Kettle)Cr	02LFH
03UpSpok	0	0	0	0	0	0	0	0	0	0	0	0	0
03MidSpok	0	0	0	0	0	0	0	0	0	0	**0.01818**	0	0
03UpLSpok	0	0	0	0	0	0	0	0	0	0	0	0	0
03LoLSpok	0	0	0	0	0	0	0	0	0	0	0	0	0
03DartAB	0	0	0	0	0	0	0	0	0	0	0	0	0
03Dead(Spok)	0.00001	0	0	0	0	0	0	0	0	0	0	0	0
03LDeep	0	0	0	0	0	0	0	0	0	0	0	0	0
03NFLDeep	0	0	0	0	0	0	0	0	0	0	0	0	0
03SFLDeep	0	0	0	0	0	0	0	0	0	0	0	0	0
03DartBB	0	0	0	0	0	0	0	0	0	0	0	0	0
03SFBoul	0	0	0	0	0	0	0	0	0	0	0	0	0
03WFTrout	0	0	0	0	0	0	0	0	0	0	0	0	0
03SFDead	-	0	0	0	0	0	0	0	0	0	0	0	0
00SpHat	0.16	-	0	0	0	0	0	0	0	0	0	0	0
01PhaHat	0.0469	0.1177	-	0	0	0	0	0	0	0	0	0	0
01Otter	0.0617	0.1333	0.0508	-	0	0	0	0	0	0	0	0	0
01DeerCr	0.0291	0.1454	0.0356	0.0459	-	0	0	0	0	**0.03141**	0	0	0
01Buck	0.0774	0.0943	0.042	0.0611	0.0618	-	0	0	0	0	0	0	0
02LoDrag	0.0452	0.1103	0.0304	0.0458	0.0281	0.0354	-	0	0	0	0	0	0
02WBDrag	0.0546	0.1153	0.0417	0.0567	0.0394	0.0465	0.0115	-	0	0	0	0	0
02UpDrag	0.0554	0.131	0.0478	0.0567	0.0429	0.0526	0.03	0.0261	-	0	0	0	0
02LilDeer	0.0431	0.1699	0.0508	0.0649	**0.0079**	0.0808	0.0427	0.057	0.0575	-	0	0	0
02MidSpok	0.0657	0.175	0.0537	0.0808	0.0546	0.0728	0.0619	0.0748	0.0682	0.0715	-	0	0
02Dead(Kettle)	0.0468	0.1548	0.0292	0.0614	0.0341	0.0716	0.0486	0.0583	0.0491	0.0478	0.0606	-	0
02LFH	0.0474	0.1465	0.0338	0.0578	0.0379	0.0673	0.0425	0.0574	0.0529	0.0508	0.0739	0.0354	-

Table 5. STRUCTURE results for Spokane River rainbow, hatchery and cutthroat trout. Collections were tested for percentage of membership in a cluster, with clusters set at 12, percentages over 0.1 are in bold type. Abbreviations follow Table 1.

	1	2	3	4	5	6	7	8	9	10	11	12
02MidSpok	**0.732**	**0.105**	0.013	0.009	0.006	0.008	0.025	0.019	0.011	0.016	0.053	0.003
03UpSpok	**0.925**	0.008	0.005	0.006	0.004	0.004	0.006	0.003	0.005	0.009	0.003	0.021
03MidSpok	**0.862**	0.013	0.009	0.012	0.011	0.012	0.011	0.021	0.014	0.014	0.018	0.003
03UpLilSpok	0.005	**0.927**	0.006	0.004	0.006	0.009	0.007	0.007	0.013	0.006	0.008	0.003
03LoLilSpok	0.025	**0.2**	**0.309**	0.065	0.068	**0.15**	0.051	0.029	0.036	0.042	0.022	0.003
03DartAB	0.003	0.011	0.008	**0.929**	0.008	0.011	0.006	0.007	0.005	0.006	0.005	0.002
03DartBB	0.009	**0.113**	0.007	**0.778**	0.012	0.009	0.019	0.019	0.007	0.007	0.018	0.002
03Dead(Spok)	0.02	**0.107**	0.022	0.034	0.09	**0.61**	0.027	0.017	0.03	0.017	0.023	0.002
03SFDead	0.024	0.044	0.018	0.009	0.038	**0.791**	0.024	0.006	0.018	0.017	0.008	0.002
03LDeep	0.031	**0.12**	0.037	0.019	**0.666**	0.031	0.034	0.019	0.016	0.011	0.015	0.002
03NFLDeep	0.011	0.008	0.008	0.009	**0.88**	0.026	0.008	0.006	0.008	0.024	0.01	0.002
03SFLDeep	0.019	0.018	0.014	0.017	**0.76**	0.087	0.028	0.008	0.013	0.021	0.011	0.002
01Otter	0.01	0.011	**0.844**	0.009	0.009	0.058	0.027	0.004	0.013	0.008	0.004	0.002
01DeerCr	0.01	0.081	0.058	0.038	0.031	**0.604**	0.08	0.009	0.033	0.045	0.007	0.006
02LilDeer	0.012	0.033	0.025	0.048	0.028	**0.731**	0.047	0.006	0.032	0.028	0.006	0.004
01Buck	0.023	**0.296**	0.063	**0.227**	0.019	0.017	**0.17**	0.075	0.025	0.038	0.044	0.003
02LoDrag	0.009	0.05	0.024	0.023	0.012	0.064	**0.754**	0.013	0.014	0.022	0.013	0.003
02WBDrag	0.006	0.013	0.015	0.009	0.009	0.012	**0.899**	0.006	0.012	0.007	0.01	0.002
02UpDrag	0.021	0.029	0.037	0.04	0.046	0.083	**0.644**	0.011	0.046	0.03	0.012	0.002
00SpHat	0.002	0.004	0.003	0.004	0.003	0.003	0.004	**0.968**	0.002	0.002	0.003	0.002
02LFH	0.008	0.013	0.008	0.008	0.012	0.012	0.014	0.006	**0.891**	0.015	0.011	0.002
01PhaHat	0.026	**0.126**	0.027	0.038	0.02	0.026	0.045	0.029	0.042	**0.464**	**0.153**	0.004
02Dead(Kettle)Cr	0.01	0.021	0.03	0.009	0.016	0.022	0.017	0.006	0.039	**0.812**	0.013	0.002
03SFBoul	0.004	0.071	0.014	0.026	0.012	0.006	0.022	0.042	0.007	0.017	**0.775**	0.003
03WFTrout	0.004	0.003	0.002	0.002	0.003	0.003	0.003	0.002	0.004	0.004	**0.969**	0.002
cutt(SullCr.)	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.002	0.004	0.002	**0.974**
cutt(SullLk.)	0.006	0.027	0.011	0.007	0.013	0.015	0.017	0.011	0.015	0.009	0.025	**0.843**
cutt(GoldCr.)	0.003	0.011	0.003	0.008	0.002	0.002	0.004	0.004	0.003	0.003	0.003	**0.955**

Table 6. Assignment test jackknife results from WHICHRUN (Banks and Eichart 2000) on greater Spokane River drainage. Individual fish were given the most likely assignment to a collection based upon the genotype of the fish and the allele frequencies in the collections. Each column presents the number of fish from a single collection assigned to various collections. The numbers of fish assigned to the collection of origin are in bold type along the diagonal. Abbreviations follow Table 1.

	03UpSpok	03MidSpok	03UpLilSpok	03LoLilSpok	03Dart	03Dead	03SFDead	03LDeep	03NFLDeep	01Otter	01DeerCr	01Buck	02LoDrag	02WBDrag	02UpDrag	00SpHat
03UpSpok	**63**	30														
03MidSpok	2	**92**														
03UpLilSpok	1		**39**	1		1		1			4					
03LoLilSpok		1		**33**		9	1	6		2	7		3	1		
03Dart				2	**76**							1	1			
03Dead				2		**47**	6	3	1	1	6		1			
03SFDead		1				22	**39**	3	1		4		1			
03LDeep				1		6	1	**80**	15							
03NFLDeep				2		4		13	**33**		1					
01Otter		1		1						**45**	3					
01DeerCr				8		1	1				**110**		8		1	
01Buck		3		4	2	5	1				4	**48**	1			
02LoDrag		1		1	1	1		2		2	4		**54**	6	7	
02WBDrag		1		2		1					2		27	**42**	3	
02UpDrag				1	1	2		1			2	1	4	1	**39**	
00SpHat		1		1												**100**
correct	**63**	**92**	**39**	**33**	**76**	**47**	**39**	**80**	**33**	**45**	**110**	**48**	**54**	**42**	**39**	**100**
Total	66	131	39	59	80	99	49	109	50	50	147	50	100	50	50	100
% correct	95.45	70.23	100.00	55.93	95.00	47.47	79.59	73.39	66.00	90.00	74.83	96.00	54.00	84.00	78.00	100.00

2003 WDFW Annual Report for the Project
RESIDENT FISH STOCK STATUS
ABOVE CHIEF JOSEPH AND GRAND COULEE DAMS

Part II. Assessment of the Harvey Creek Kokanee Spawning Run

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March 2005

Introduction

A naturally reproducing kokanee (*Oncorhynchus nerka*) population currently occupies Sullivan Lake in Pend Oreille County, WA. The population was likely established from hatchery stocking. The first reported stocking of kokanee in Washington State was in Sullivan Lake in 1904 when the U.S. Bureau of Fisheries planted 10,000 fry of unknown origin (Crawford 1979). However, after examination of U.S. Fish Commission stocking records, Nine (2005) concluded that the 1904 plant of "landlocked salmon" were Atlantic salmon, *Salmo salar Sebago*, and the first plant of kokanee in Sullivan Lake was in 1913. Sullivan Lake was planted with kokanee on numerous occasions between 1920 and 1945 (WDFW, unpublished data; Nine 2005); however, there were only three plants after 1945. The first occurred in 1976 when the Washington Department of Game planted 197,960 Lake Whatcom stock kokanee at 1,800 to the pound (WDFW, unpublished data). The Washington Department of Fish and Wildlife (WDFW) planted 43,320 and 25,769 Sullivan Lake origin fry in May 2003 and 2004, respectively (WDFW, unpublished data). The fry were offspring of spawning kokanee collected from Harvey Creek in 2002 and 2003 (McLellan 2003 and 2005). Based on genetic data, the current population (2003) is closely related to Lake Whatcom stock (Loxterman and Young 2003; Young 2004) suggesting that it was derived from stocking of Lake Whatcom origin fish.

At least a portion of the kokanee from Sullivan Lake spawn in Harvey Creek, a tributary that flows into the lake at its southern end. Kokanee migrate up Harvey Creek to spawn between the middle of October and late December. Spawning is limited to an approximately 600 m stretch just upstream from the lake-stream interface (McLellan 2003). Sullivan Lake is drawn down approximately 6.10 m each fall, beginning on October 1, from its full pool elevation of 788.82 m above mean sea level (msl) exposing approximately 700 m of stream (P. Buckley, Pend Oreille PUD, personal communication). All of the kokanee spawning in Harvey Creek occurred in the stretch of the stream that was exposed after the drawdown (McLellan 2003).

The WDFW, with the help of the Kalispel Tribe and Eastern Washington University, implemented a trapping project in 2002 to determine the status of the kokanee spawning population in Harvey Creek (McLellan 2003). The primary objectives were to

determine if a trapping project was feasible and to determine the total run size. The 2002 effort was a partial success due to delayed implementation and equipment problems. The delay was the result of trap components not being available in time for the start of the run. The upstream box portion of the trap was too small for the daily catch rates and it allowed fish to escape back downstream. Additional collection efforts (carcass counts, electrofishing, and seining) were used to quantify the number kokanee that were not captured in the trap. The estimated size of the spawning run in 2002 was 3,498 fish and the sex ratio was 1.7 females per 1.0 male. The estimate was likely low due to the trap problems, predation on live spawners, and scavenging of carcasses. However, the carcass counts may have been positively biased due to the loss of marks (caudal fin punches) as the carcasses decomposed.

In 2003, as part of the Joint Stock Assessment Project (JSAP), the trapping project was repeated with improvements. The 2003 project was identified as a priority by WDFW, to develop a population trend because the population was identified as a potential source of surplus eggs to supply a portion of the kokanee stocking program in Region 1 with the impending loss of the Lake Whatcom brood source (Parametrix 2003). The data would also complement a Colville National Forest funded fishery and limnology project to be conducted on Sullivan Lake in 2003 by Eastern Washington University.

The objective of the project was to evaluate the spawning run in Harvey Creek. Specific project tasks included: 1) determining the total run size of kokanee in Harvey Creek, 2) male-female ratios, 3) length and weight distributions, 4) estimating egg production, and 5) determining potential relationships between water temperature, discharge, photoperiod, and the kokanee migration.

Methods

A weir type kokanee trap was installed in Harvey Creek on October 15, 2003. The trap was placed directly downstream from the Sullivan Lake Road Bridge, upstream of Sullivan Lake (Figure 1). The trap location was selected due to the stream bank condition (steep sides with rocks) and the surface elevation of Sullivan Lake. The trap was placed directly upstream of the lake-stream interface in the portion of the stream that was inundated by Sullivan Lake when it was at full pool. It was assumed that all early

spawning would occur above the trap. On November 4, after the lake had receded several hundred meters, the trap was moved downstream near the lake-stream interface (Figure 1). The trap was moved in an attempt to collect late migrating kokanee that would spawn downstream of the initial trap location.

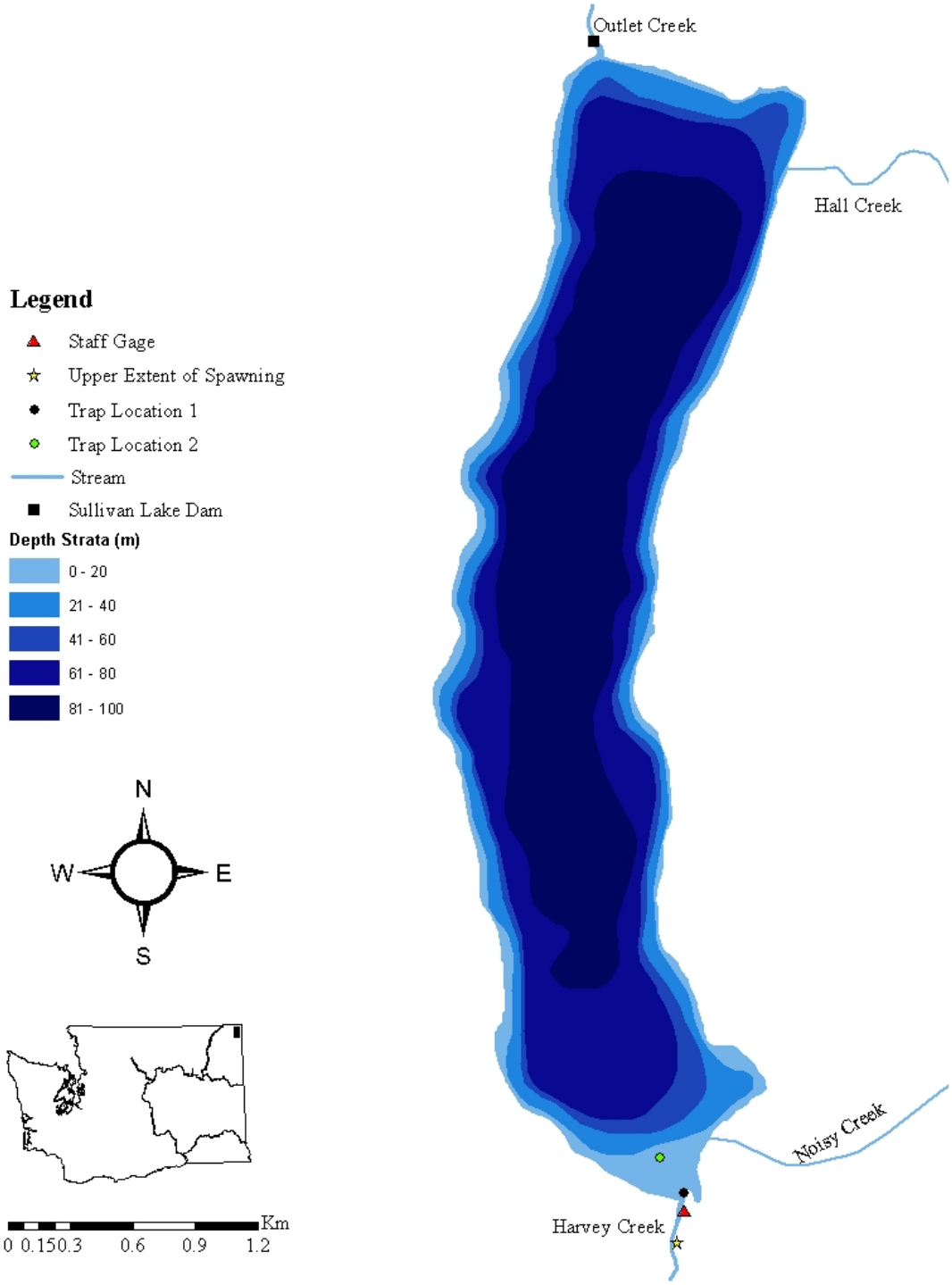

Figure 1. Map of Harvey Creek kokanee trap sites.

The trap consisted of an upstream box, a downstream box, and four panels that were secured in the stream with metal fence posts. The upstream box had a welded steel frame that was 2.44 m long and 1.22 wide and 0.84 m tall. The frame was constructed of 1.9 cm (0.75 in.) hollow square tubing. The top and bottom of the box were covered with plywood and the top was hinged so it could be opened to extract fish. The sides and front (entrance) of the trap were covered with aluminum sheeting that had 2.54 cm tall x 0.95 cm wide holes spaced approximately 2.54 cm apart. The back of the trap was comprised of 2.54 cm diameter aluminum bars spaced 1.27 cm apart. The front of the box had a 0.57 cm wide and 0.60 tall rectangular opening where the trap throat was bolted on. The throat was a triangle shape and the base was at the front of the trap. The front of the throat was 0.75 m wide and 0.61 m tall and the top and bottom (triangle) was 0.81 m long (32.0 in.). The sides of the throat consisted of 2.54 cm diameter aluminum bars spaced 2.54 cm apart, except for the final bar (at the top of the triangle), which was 6.99 cm from the second to last bars on either side.

The downstream box was constructed with a welded re-bar frame that was covered with 1.27 cm^2 mesh hardware cloth on the sides and bottom and a hinged plywood door on the top. The downstream box was located below the panels. A square aluminum funnel, that was 30.48 cm^2 at the mouth and necked down to 13.97 cm^2 at the tail end, was placed between two panels with the tail pointing downstream. The tail end of the aluminum funnel was inserted into a 15.24 cm diameter piece of PVC pipe, which extended 3.66 m downstream through a 15.24 cm^2 opening in the downstream box.

The panel frames were 1.22 m tall x 1.52 m wide and constructed with angle iron. The outer portion of the panel frame was fixed and the inner portion was mounted on bolt axles so that it could be spun for cleaning. The entire panel was covered in 1.27 cm cm^2 hardware cloth. A 30.48 cm long hardware cloth flap extended upstream from the bottom of the panels. Sand bags were placed on the flaps along the bottom of the panels to prevent undercutting. Sand bags were also placed on the shoreline next to the panels to prevent water from cutting around the sides.

The trap was operated between October 15 and December 30, 2003 and was checked daily through December 16, except for November 25-26, and three times a week through December 30. Between October 15 and November 3, all fish captured in the

upstream trap were measured to the nearest mm total length, marked with a left pectoral fin clip, examined to determine sex and reproductive condition, and released upstream. The same procedure was conducted for fish captured in the downstream trap, except that these fish were marked with a right ventral fin clip and released downstream of the trap. Weights were obtained from a subsample of the fish. Reproductive condition was defined as ripe (gametes flowing easily), mature (gametes not flowing, but not spawned out), and spawned out (all gametes had been expressed). After November 3, fish were counted, examined to determine sex and reproduction condition, marked with the appropriate mark, and released either up or downstream. We discontinued measuring and weighing fish after November 3, due to concerns about handling ripe females and accidentally expressing eggs.

On November 3, kokanee staging directly below the trap were herded into the trap and counted. On November 4, prior to moving the trap, an attempt was made to either herd the kokanee below the trap into the trap or seine them out. The fish that were seined were placed in the trap with fish that had been herded. The trap was being moved on November 4, so the attempted capture of all of the kokanee below the trap was to account for those fish in between the trap locations. The seining and herding had minimal success and due to concerns about disturbing redds, the seining and herding was abandoned. Those fish that were captured were examined to determine sex, counted, marked, and released.

There were unaccounted kokanee in Harvey Creek between the initial trap location at the bridge and the new location near the lake, due to the failed herding/seining attempt. In order to enumerate these fish, carcass counts were conducted daily beginning November 5. During each survey, both shorelines above the trap were walked along the entire length of the kokanee spawning area and carcasses were netted, placed in 5 gallon buckets, and carried to the lake. All of the carcasses collected were examined for marks, counted, and disposed of in the lake.

Some of the fish captured on November 4 were retained for spawning, disease testing, and fecundity counts. Ovarian fluid and kidney spleen samples were collected from 75 females. The samples were sent to the WDFW Fish Health Lab in Olympia for analysis. Fertilized eggs from spawning were taken to the WDFW Colville Hatchery for

incubation. The first 20 mature (green) females that were encountered from the seining/herding group were retained for determining fecundity. Each female was measured and weighed, and then its egg skeins were extracted. The skeins of each fish were placed in individual Ziploc bags filled with stream water. The eggs were allowed to water harden for approximately 24 hours, after which they were preserved in 70% ethanol. The eggs collected from each fish were later counted. The number of eggs per female was plotted against its weight to determine if there was a relationship.

The number of eggs produced during the 2003 spawning run was estimated by multiplying the average number of eggs per female from the fecundity counts by the estimated number of females in the run. The number of females in the run was calculated by applying the proportion of females in the catch in the upstream trap to the total run size.

A calibrated thermograph, programmed to record water temperatures every two hours, was attached to the throat of the upstream trap in the thalweg. A staff gage was installed at the bridge in order to determine daily stream discharge (Q; m^3/s) (Figure 1). Gage height was recorded daily. Discharge was measured weekly throughout the project to calibrate the staff gauge. The discharge was calculated according to the methods in Gallagher and Stevenson (1999). Velocity (m/s) was measured with a Swoffer 3000 Flow Meter. Three velocity measurements were taken in each cell (20 second measuring period) at 0.6 the depth and the average was used to calculate the discharge in each cell. A regression of measured discharge versus gage height was developed to estimate discharge on the days when it was not measured.

Results

The first day of the spawning run was on October 18, 2003 when 14 fish were captured in the upstream trap (Figure 2). The highest catch in the upstream trap (158 fish) was on November 18 (Figure 2). A total of 1,939 unmarked kokanee were collected in the upstream trap. All of the fish captured in the upstream box were released above the trap. There were 74 fish released above the trap without a mark, due to broken scissors or escapees. There were 312 live unmarked kokanee captured in the downstream trap. Unmarked carcasses removed from the downstream trap were included in the

carcass counts. A total of 6,608 unmarked carcasses were collected from above the trap. The 74 fish released above the trap without a mark were subtracted from the total carcass count. The adjusted carcass count was 6,534. There were 97 unmarked kokanee herded into the trap on November 3 and 349 unmarked fish were herded/seined on November 4. The sum total of all of the unmarked kokanee collected in the up and downstream traps, the adjusted carcass count, and the seining was 9,231 fish (Table 1).

Other species collected in the upstream and downstream traps included mountain whitefish (*Prosopium williamsoni*), brown trout (*Salmo trutta*), rainbow trout (*O. mykiss*), burbot (*Lota lota*), and sculpin (*Cottus* spp.) (Table 2).

Kokanee and redds were observed over a 600 m stretch of Harvey Creek during the spawning run. The downstream extent of the spawning was 550 m below the Sullivan Lake Road Bridge and the upper extent was 175 m above the bridge.

There were 913 females and 1,026 males captured in the upstream trap. The ratio of females to males was 0.9:1.0. The mean total length of the 373 females that were measured was 265 mm (SD=11). The mean weight of the 220 females that were identified as ripe or mature was 164 g (SD=19). The mean total length of the 491 males that were measured was 273 mm (SD=15). The mean weight of the 324 males that were identified as ripe or mature was 178 g (SD=25). The smallest kokanee captured was a 231 mm male and the largest was a 328 mm male (Figure 3). The length-weight relationship of the male kokanee that were measured and weighed was described by the equation $y(\text{Log}_{10}\text{ weight}) = -3.429 + 2.329x(\text{Log}_{10}\text{ total length})$ ($R^2 = 0.712$) (Figure 4). The length-weight relationship of the female kokanee that were measured and weighed was described by the equation $y(\text{Log}_{10}\text{ weight}) = -1.908 + 1.700x(\text{Log}_{10}\text{ total length})$ ($R^2 = 0.402$) (Figure 4).

Ninety-seven females and approximately 120 males captured on November 4 were spawned. There were approximately 30,000 eggs collected during spawning and they were taken to the WDFW Colville Hatchery for incubation and rearing (J. Ebel, WDFW, personal communication). The WDFW Fish Health Specialist collected ovarian fluid and kidney spleen samples were from 75 females for virology tests [IHN (infectious hematopoietic necrosis), IPN (infectious pancreatic necrosis), and VHS (Viral

Hemorrhagic Septicemia)]. All samples were negative (S. Roberts, WDFW, personal communication).

The mean length of the kokanee retained for fecundity counts (n=20) was 262 mm (SD=12), the mean weight (n=19) was 120 g (SD=20), and the mean number of eggs was 471 (SD=58). There was no apparent linear relationship between fish weight and the number of eggs (Figure 5).

There were an estimated 4,348 female kokanee in the spawning run. The estimated egg production (± 95% CI) was 2,047,814 eggs (± 110,999).

The mean temperature of Harvey Creek during the project (October 15 through December 30) was 5.73 °C (SD=0.67) and ranged from 2.92 to 8.67 °C. The mean daily temperature was plotted against the daily catch in the upstream trap (Figure 2).

The relationship of discharge to gage height was described by the equation, y(gage height) = 0.1154 + 0.9396x(discharge) and there was little variability in the relationship (R^2=0.973) (Figure 6). The gage height-discharge regression equation was used to estimate discharge on the days when it was not measured. The daily estimated discharge was plotted against the daily catch in the upstream trap (Figure 2).

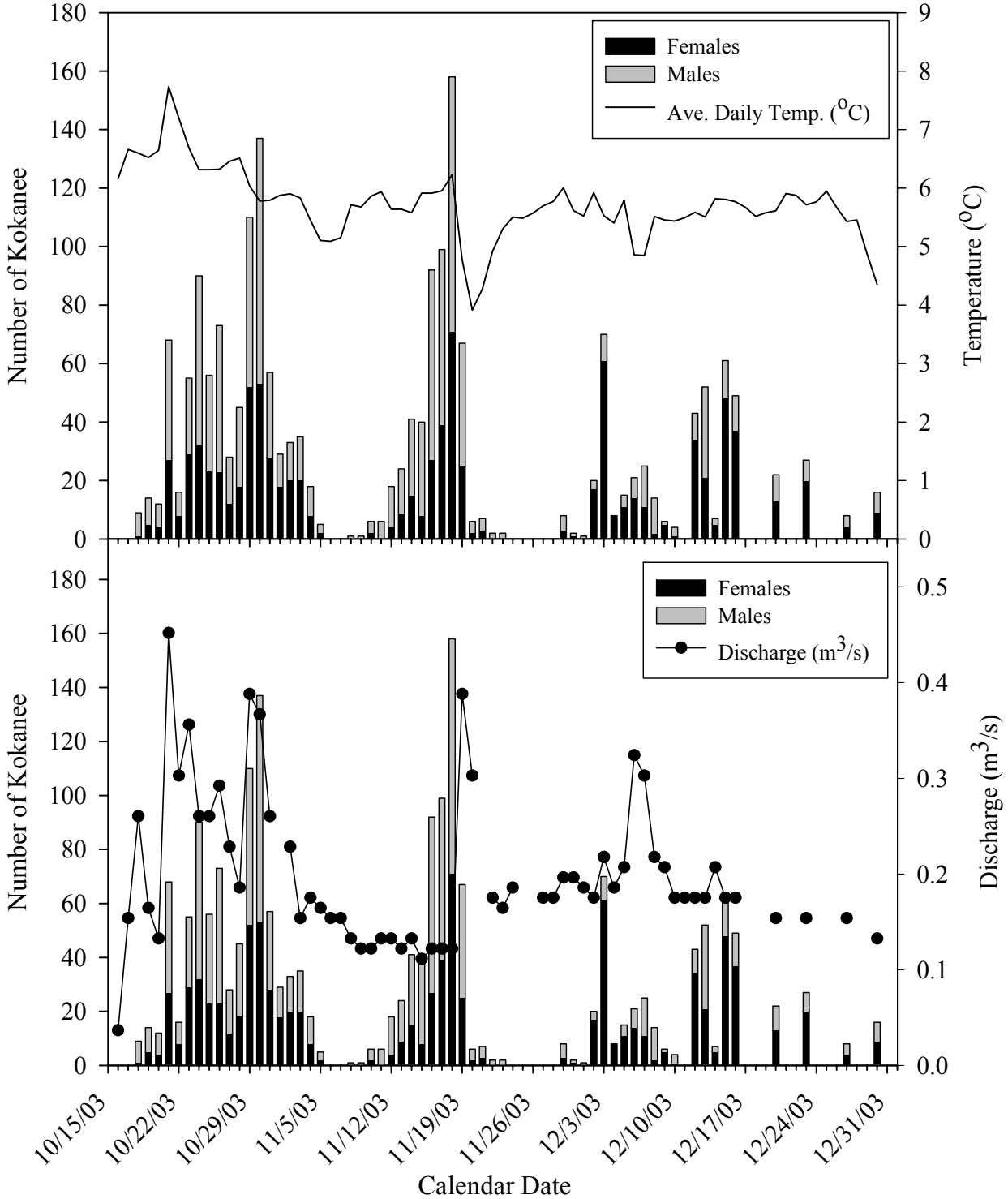

Figure 2. Daily catch of spawning kokanee captured in the upstream trap plotted against the average daily temperature (^{o}C) and estimated daily discharge (m^3/s).

Table 1. Total numbers of unmarked kokanee counted during the spawning run in Harvey Creek in 2003.

Capture Method	Females	Males	Total
Upstream trap (Oct. 15 – Nov. 3; measured)[1]	373	494	867
Upstream trap (Nov. 4 – Dec. 31; count)[1]	540	532	1,072
Downstream trap	133	179	312
Carcass Counts	-	-	6,534
Seining/herding (Nov. 3)	51	46	97
Seining/herding (Nov. 4)	209	140	349
Total			**9,231**

[1]Collections used to calculate sex ratio.

Table 2. Total numbers of other species captured in the Harvey Creek kokanee trap in 2003.

Species	Females	Males	Unknown Sex	Total	Size Range (mm)
Upstream Trap					
Mountain whitefish	7	5	11	23	120[1]-312
Brown trout		1	1	2	368[1]-510
Rainbow trout			1	1	152
Sculpin			1	1	-
Downstream Trap					
Mountain whitefish	2	1	3	6	-
Burbot			3	3	<175[1]
Sculpin			6	6	-

[1]Length was estimated.

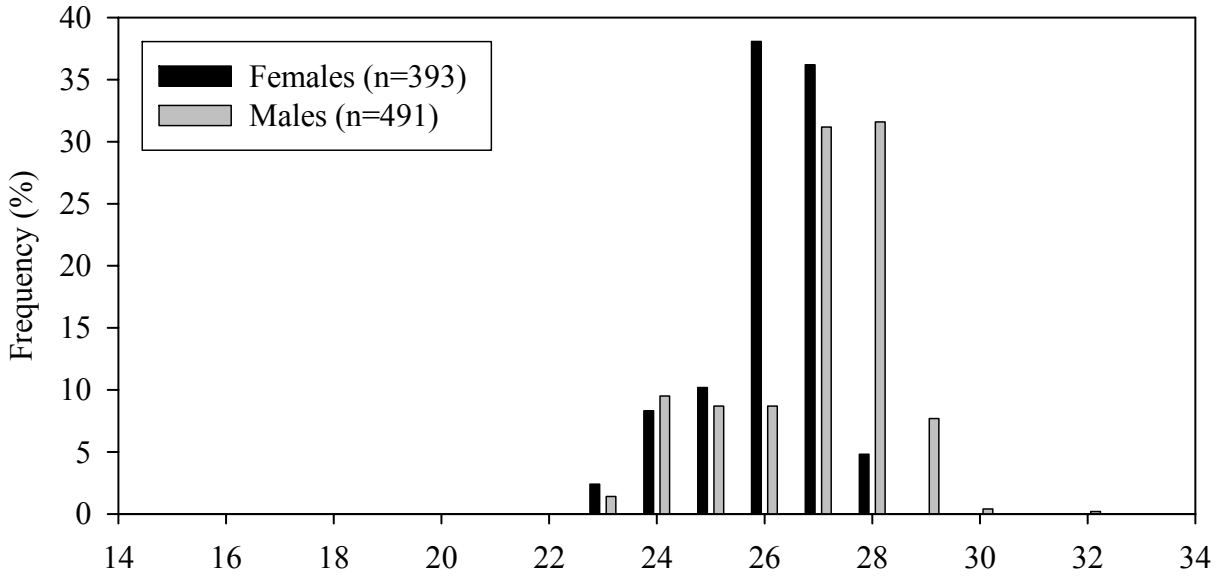

Figure 3. Length-frequency distribution of spawning kokanee captured in the upstream trap and measured.

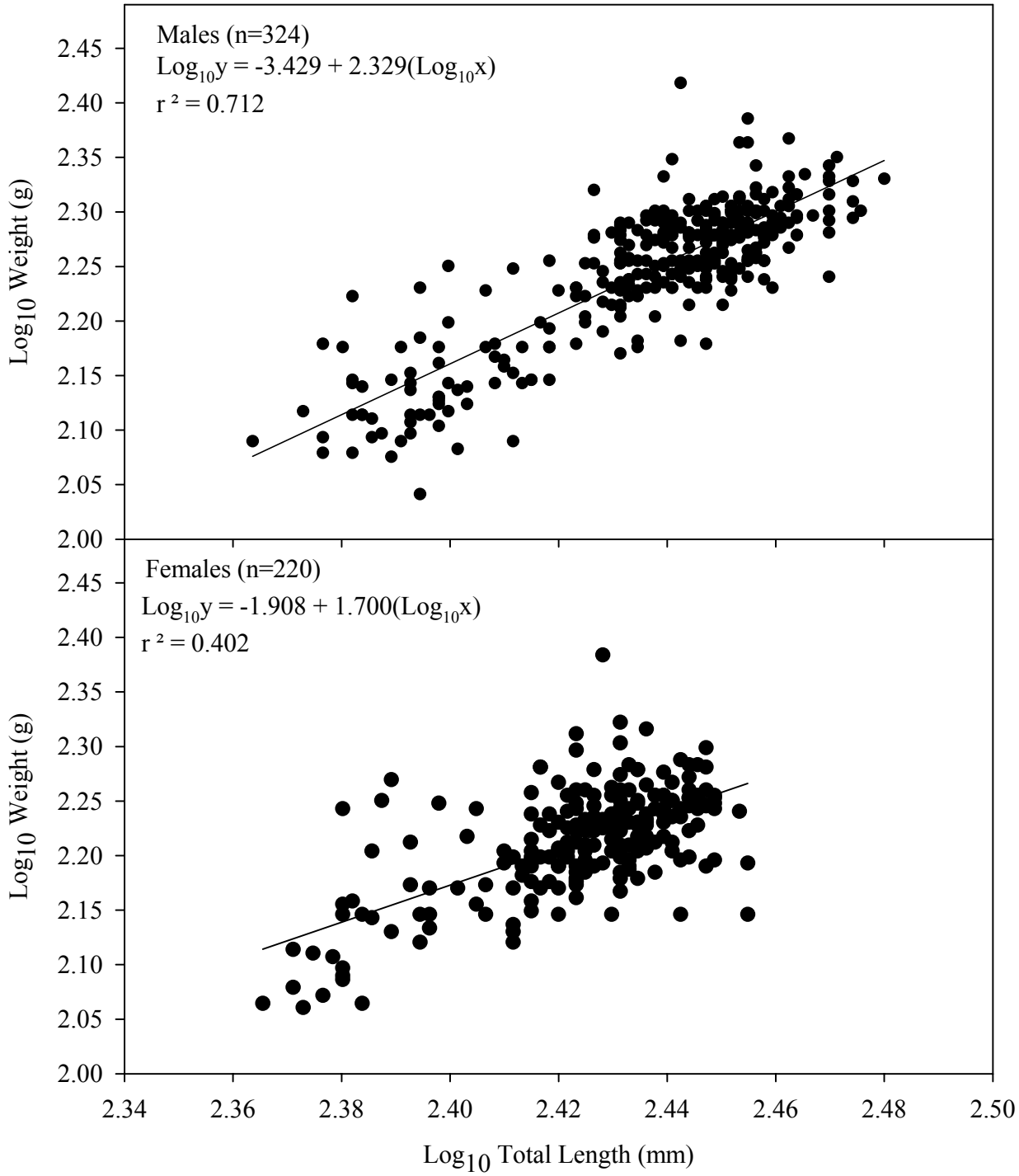

Figure 4. The length-weight relationships of mature and ripe male and female kokanee that were captured in the upstream trap.

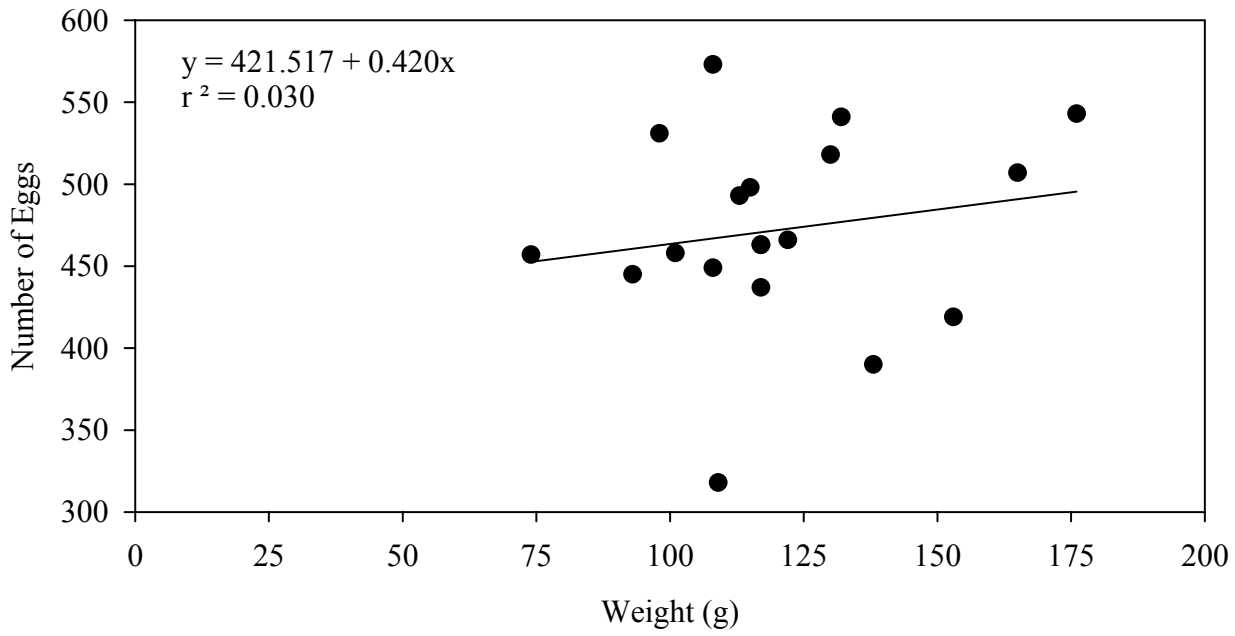

Figure 5. The weight-fecundity relationship of 19 mature female kokanee collected from Harvey Creek.

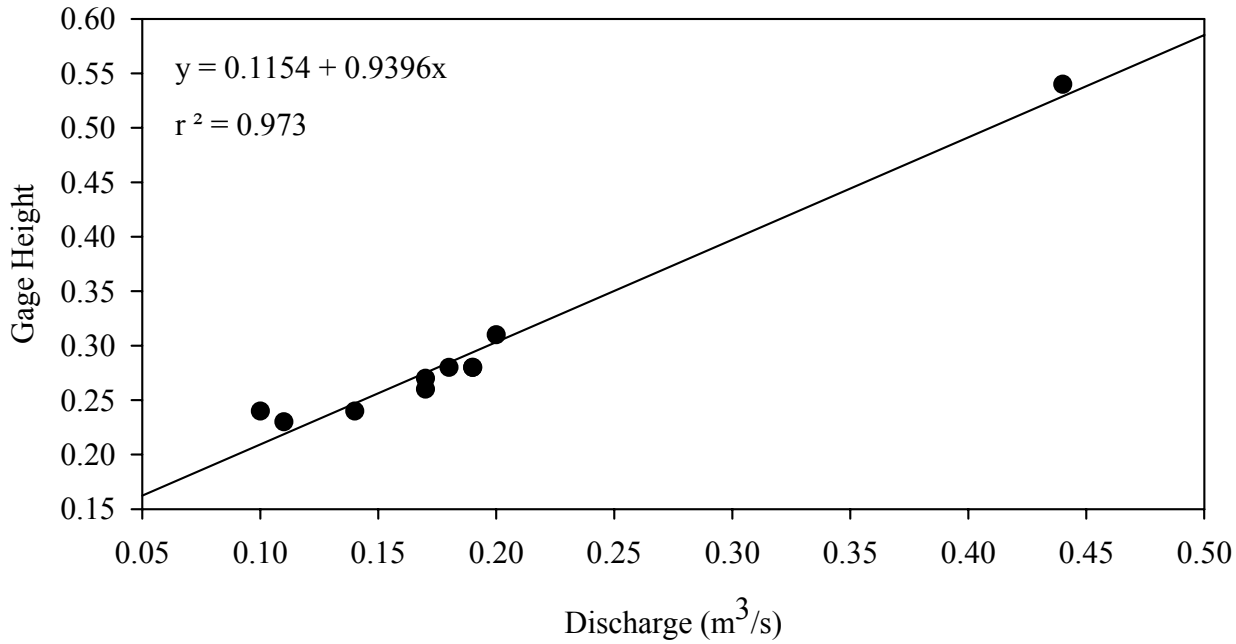

Figure 6. The relationship between gage height and discharge on Harvey Creek during the study period.

Discussion

Improvements to the Harvey Creek kokanee trapping project resulted in a more accurate estimate of the run size. However, there were other problems that added bias to the estimate. The upstream box trap allowed some kokanee to escape upstream and there were kokanee observed slipping between the bars, particularly when there were large numbers of kokanee in the trap. When the trap was moved (November 4), there were unaccounted for kokanee spawning between the initial and final trap locations. Attempts to collect these fish were unsuccessful and carcass counts were required to quantify the run size.

The total run size calculation was underestimated due to fish that were unaccounted for. The carcass counts were considered negatively biased due to unaccounted losses of fish and carcasses to predators and scavengers. Bald eagles were observed at the study area on a regular basis and partially consumed carcasses were observed along the shoreline. The lack of riparian habitat along the section of Harvey Creek where the spawning occurred likely exposed the kokanee to high rates of predation. However, the bias was considered low because 67.0% of the marked fish released above the trap were recovered as carcasses. In addition, there were an estimated 200 kokanee still remaining in the stream at the end of the project and a high proportion of them were likely unmarked and unaccounted for, based on the high percentage of unmarked fish (79.8%) observed during the carcass counts. The total run size was likely underestimated by a few hundred fish, which was considered minimal based on the total run size, which exceeded 9,200 fish. The 9,231 run size calculation should be considered a conservative estimate.

The 2003 spawning run was substantially larger than the 2002 run (n=3,498). The 2002 estimate was underestimated due to several factors, but based on our observations it was still not as large as the 2003 run. The mean length of the spawning kokanee was lower in 2003 than 2002. Kokanee growth is density dependent, so it would have been expected that spawner sizes would decrease as the number of spawners (population size) increased.

The timing of the 2002 and 2003 runs were slightly different (Figure 7). There was likely a peak in the run in late October 2002, similar to 2003, but it was missed

because the trap was installed after there were already large numbers of fish in Harvey Creek. There were multiple peaks in catch during both spawning periods but they occurred at different points in the run. The reasons were likely related to some environmental factor, such flow or temperature, but this could not be verified because the appropriate data were not collected in 2002. Escapees may have also biased the numbers caught in both years, but the catches were likely indicative of the numbers of fish entering the run on a given day.

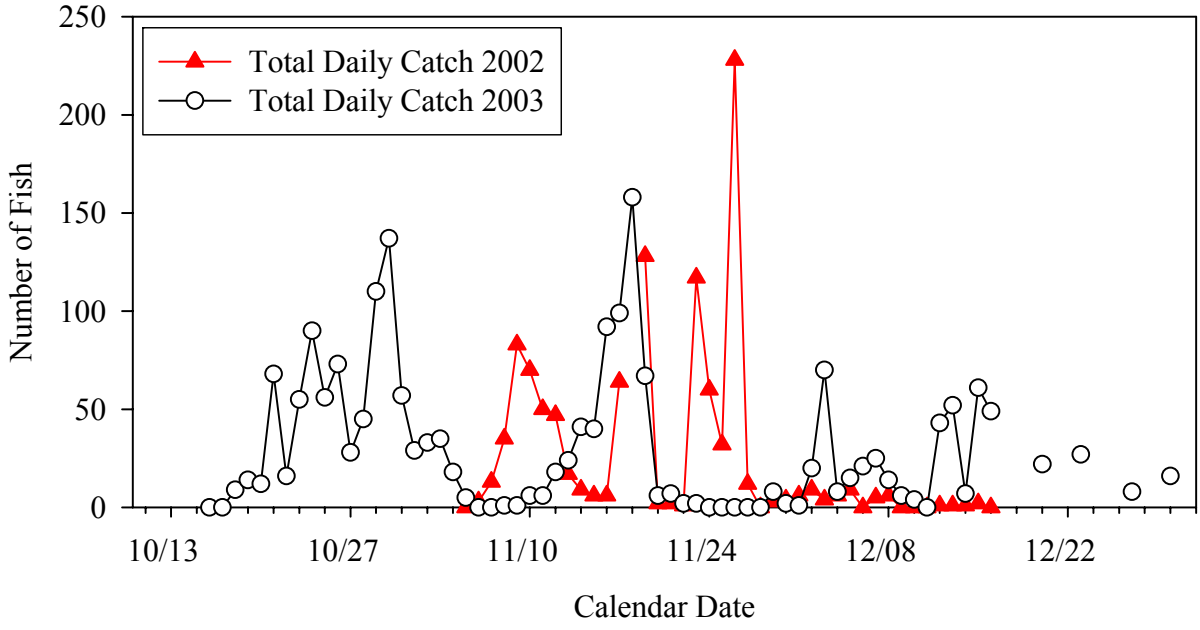

Figure 7. A comparison of daily catch rates of spawning kokanee in the upstream trap placed on Harvey Creek in 2002 and 2003. The trap was placed in Harvey Creek on November 5, 2002, after there were several hundred kokanee in the stream. In 2003, the trap was installed prior to the start of the run.

The ratio of females to males was lower in 2003 than the ratio observed in 2002. The difference was likely due to the timing of the arrivals of the two sexes. In 2003, more males were captured earlier than females, with the majority of females entering the run later (Figure 2). Since the trap was installed late in 2002, the early arrival of the males was likely missed. Thus, the sex ratio was likely biased towards females in 2002. The sex ratio observed in 2003 was likely more representative of the actual sex ratio.

There was a stronger relationship of length to weight for the male kokanee versus the females, based on the R^2 values of the length-weight regression ($R^2 = 0.712$ for males; $R^2 = 0.402$ for males). The lower r^2 value observed in the females may be the result of reproductive condition. Some ripe females may have expressed eggs prior to being collected, thus lowering their weight and adding variation to the relationship. The relatively low strength of the female's length-weight relationship may have also been natural. There was no linear relationship of fecundity and weight of mature (green) females, indicating that there was high variability in the weights of female kokanee that were the same length prior to any egg loss.

The trapping project should be continued in 2004 with improvements to obtain a more accurate estimate of the run size and monitor population trends. Improvements should include a smaller trap design that will allow for more frequent relocations to coincide with receding lake levels. The trap should also have narrower bar spacing to prevent escapees.

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2003 WDFW Annual Report for the Project
RESIDENT FISH STOCK STATUS
ABOVE CHIEF JOSEPH AND GRAND COULEE DAMS

Part III. Coordination, Data Standards Development, and Data Sharing Activities

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March 2005

Introduction

The Resident Fish Stock Status Project, also referred to as the Joint Stock Assessment Project (JSAP), was started in 1998 at the request of tribal and state fish management agencies in the Blocked Area (that part of the Columbia Basin above Chief Joseph and Grand Coulee Dams. The primary objective is to jointly perform stock assessment and generate a management plan for protection, mitigation, and enhancement of blocked area resident fish. To perform joint stock assessment, participants need a common database, and early reviews of available data identified both useful collections and major gaps in the biological data record for resident fish.

This project, then, has two main emphases. The "field research" part prioritizes identified data gaps, plans and conducts studies to gather needed baseline data, and provides the analysis required to fully address these gaps. The "data sharing" part of the project coordinates development of common data codes, formats, and standards for priority data categories, and facilitates sharing of these data among not only project participants but Columbia Basin interests at large via a direct connection with the Northwest Power and Conservation Council-funded StreamNet Project. Jason McLellan leads the field research, while Cynthia Burns and I provide coordination, data standards, and data sharing support.

The following summary covers activities from March 1, 2003 through February 29,2004.

Coordination and Data Standards Development

Emphasis this year was placed on performing data quality reviews of 1999-2001 contents of the Universal Database (UDB), exploring ways to build valid routines to update the UDB with 2002 data, and analyzing the data retrieval and analysis needs of Project participants in order to guide the consultants from Cevian, Inc. who submitted draft proposals to add data extraction to the existing UDB system. Coordination with the

StreamNet Project was related to guidance and data exchange related to the new StreamNet "Independent Datasets" focus area (formerly called "Warehouse Datasets").

In March 2003 I received and reviewed the final draft of the UDB Procedures manual, which describes various ways to interact with the UDB using SQL Server statements. Since the Project Database Manager (Jim Lemieux, Kalispel Tribe) is one of the few participants who is fluent in SQL Server (and has ready access to that software), this manual alone does not meet the data manipulation needs of most project participants. Subsequently, Cevian Inc. consultant Warren Wessels delivered an initial proposal for creation of a JSAP Data Engine (JDE) Data Extraction capability, which I reviewed and provided written comments on. The initial proposal addressed data selection and download, along with the creation of map images. No analytical capabilities were addressed in the initial proposal, but it was a good outline of the next steps we need to take to enable the UDB to be useful to all JSAP project participants (beyond the Database Manager).
Lemieux and I met in Spokane in June 2003 for some joint work on the existing UDB. We patched the copy of the JDE program I had installed on my laptop and verified that it could be used to navigate UDB records. We discussed building tools to load new data (from 2002 forward), and started on a pilot analysis of new data to work out table relationships and conversions needed to move a sample of WDFW 2002 field data into the UDB. The steps to defining and coding new sampling locations were worked out, and we left further development of these steps for later in the year. We agreed that WDFW would be responsible for generating new WDFW sampling data records for the UDB, starting with the 2002 data. WDFW will create data records in Microsoft Access tables built to mirror the UDB SQL Server tables, and transmit those tables to Lemieux, who will load them into the Master copy of the UDB.

In late December 2003, I traveled to Spokane to meet with Wessels and Lemieux to discuss details of the proposed JDE Data Extraction tool. Our focus was on graphic capabilities using ArcIMS (licensing cost tradeoffs versus quality of the images provided), and the level of "analysis" data users might want the system to perform

beyond the basic query, extraction, and reformatting into a common (Excel) standard. On the second day of the meeting, Lemieux and I re-visited UDB data verify and load topics we initially discussed in June. We confirmed a standard set of location and data coding steps to follow prior to submission of new (2002) WDFW data. I had not yet completed a careful review of the current UDB contents to verify all of the relationships between WDFW JSAP data sources/formats and the UDB system of master tables, lookup tables, and data tables.

Wessels distributed the second draft of Cevian's JDE Data Extraction tool proposal in January, and I provided written comments in response to his proposal as well as to a series of e-mail conversations on this topic among JSAP participants. The current proposal approaches this development in terms of **Get Results | Analyze Results | Show Results** phases. I advised project participants and Wessels to spend our resources on the first and last phases, leaving "Analyze Results" for last. In February, I reviewed 15 screen shots and an initial set of user instructions for the JDE DE tool and provided extensive written comments to Wessels and the JSAP Team.

Later in February, I continued in-depth reviews of the current WDFW data contents in the UDB. I found and documented data coding and entry errors, missing values in data records, misplaced data, redundant entries, and null WDFW personnel codes in the 1999-2001 data. For example, many WDFW Sample_Master records have survey type coded as "unknown", when there are clearly available survey type codes that match the surveys WDFW staff performed. I advised Lemieux to "thin" some of the larger look-up tables, such as the water body related tables (streams, lakes) to concentrate on water bodies in the Blocked Area. The statewide focus of the current tables makes them extremely large and slow to work with. My initial attempts to query out specific subsets of the UDB met with frustration, even with Wessels' advice. I began to suspect some of the WDFW 1999 data never got loaded into the UDB, but verification of that had to be postponed until the next project period.

Data Sharing Activities

WDFW headquarters staff participated in a series of activities supporting compilation, standardization, and sharing of data relevant to the JSAP effort:

- O'Connor migrated a complete set of UDB data tables from SQL Server into Microsoft Access, and then into MySQL, to facilitate WDFW data record extraction and review (data discovery, QA/QC) work. New records will be formatted according to UDB guidelines, and then submitted to Lemieux as Access tables for loading into the Master UDB copy.
- Burns used the new StreamNet Independent datasets tool to create independent dataset submissions for WDFW JSAP data from 1999 through 2002. Such submissions involve generating metadata describing each year's data (with Jason McLellan's extensive assistance), and packaging those metadata records with copies of the Excel data tables and a PDF version of the WDFW JSAP annual report for each year. Submissions were validated by Mike Banach of StreamNet and are now featured on the StreamNet Web site (http://www.streamnet.org).

Resident Fish Stock Status above Chief Joseph and Grand Coulee Dams

Spokane Tribe of Indians

2003 Annual Report

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Project Number

199700400

This report contains preliminary data and conclusions that may be subject to change. This report may be cited in publications, but the manuscript status (Annual Report) must be noted.

Previous annual reports maybe obtained by going to the BPA's website.

http://www.efw.bpa.gov/cgi-bin/ws.exe/websql.dir/FW/PROJECTS/ProjectSummary.pl?NewProjNum=199700400

Abstract

This report contains fish sampling, habitat, water quality, flows, and temperature data on Tshimikain Creek. Tshimikain Creek starts at the top of Hunters and Springdale summit and winds down onto the Spokane Indian Reservation to the Spokane River. Parts of Tshimikain Creek are perennial while much of its length is intermittent.

Habitat and electrofishing surveys in reaches one through 24 were completed on the reservation in 2003. Reach one began at the confluence of the Spokane River and Tshimikain Creek and ended with Reach 24 at the reservation boundary. The length of each reach averaged 1,260 meters. In 2002, Reaches one and two were completed, but were resurveyed in 2003. Another change from 2002 is that an additional reach was placed between the Martha Boardman Bridge and Tshimikain Falls. Electrofishing in Reaches one through 23 produced 3,880 fish representing 11 different species. Numerous sculpin spp. were collected in Reaches one through 13 but were not enumerated or identified to species. Tshimikain Creek subsurfaced 2,040 meters (Reach 14) above the Ford Bridge extending north of Reservation Road, leaving pools of water and short resurfacing stretches for fish to survive in until flow returns in September or October. When pools were present within the dry reaches, we modified our sampling techniques. Within these isolated pools a single electrofishing pass was used when salmonids were not sampled. The only pool that produced a salmonid in the dry stretches was located in Reach 15. The salmonids may migrate downstream with declining flows, water quality, and temperature increases, or were subject to predation.

Acknowledgments

I would like to take this opportunity to thank all those that have contributed to the success of the project. Those individuals and organizations that helped contribute in some way to the project are listed below in no particular order.

- Bonneville Power Administration (Funding)
- Brian Crossley (Program Manager)
- Chase Choate (Biologist)
- Andy Moss, Josh Flett, and TJ Lebrett (Technicians)
- Lake Roosevelt Fisheries Evaluation Program (Technical and Logistical Support)
- Spokane Tribal GIS Program (GIS & Mapping)
- Kalispel Tribe (Administration, Funding, & GIS)
- Spokane Tribal Wildlife Committee (Permitting)

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1. Introduction

Objectives

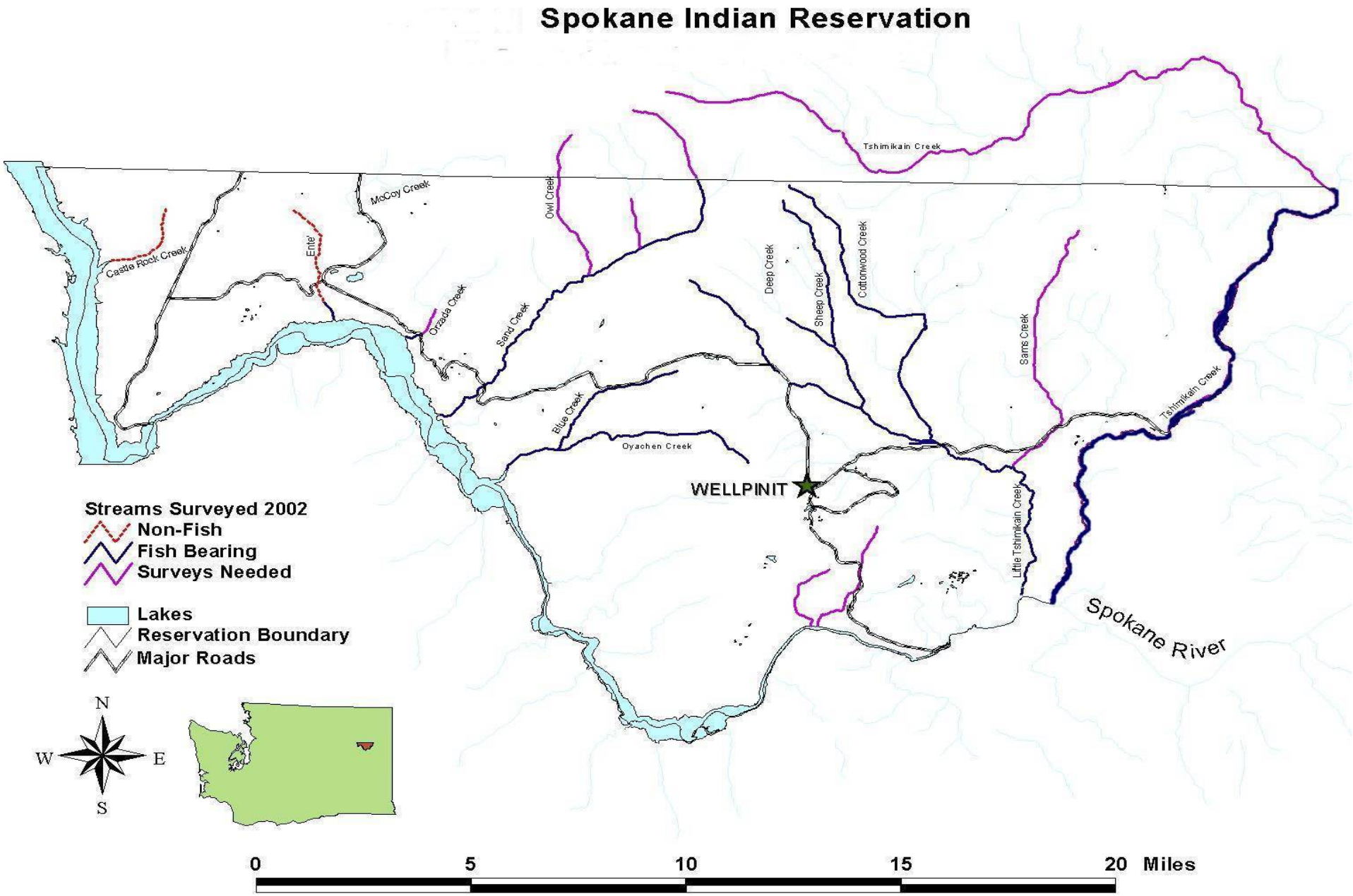
The Spokane Tribe is one of four organizations that are currently working under the "Resident Fish Stock Status above Chief Joseph and Grand Coulee Dams" project. Under this project, the Spokane Tribe will compile and analyze historical fish and fish habitat data on all water bodies within and near the Spokane Indian Reservation (SIR). Current baseline habitat and fisheries data will be collected on all fish bearing waters on or near the (SIR). A comprehensive coverage of fish distribution and habitats will be kept in a central database and linked with Geographic Information System (GIS) coverage's for all areas surveyed. Data collected by other projects, such as Lake Roosevelt Monitoring and hatchery-stocking records will be gradually incorporated into the central database.

The first data collected by the Spokane Tribe of Indians for this project is reported in the 1999 Annual Report, "Resident Fish Stock Status Above Chief Joseph and Grand Coulee Dams" project #199700400. Annual reports may contain only partial data on a stream or lake. Refer to prior and/or subsequent reports to obtain all data available that was collected under this project. This is the fifth annual report for this project.

Description of Study Area

Data collection activities in 2003 were concentrated on Tshimikain Creek within the (SIR) located in Stevens County, Washington. The borders of the SIR are Franklin D. Roosevelt Lake to the west, the Spokane River arm of Lake Roosevelt to the south, the 48° parallel to the north, and Tshimikain Creek to the east (Figure 1). Tshimikain Creek originates north of the reservation in the Huckleberry Mountain range and runs south to the Spokane River.

Figure 1. Spokane Indian Reservation Boundary and Streams Surveyed Under the JSA Program



2. Methods

Stream Habitat Survey

Streams were measured by walking in the stream channel using a hip-chain measuring 60 meter transects. The information collected at each transect included: habitat identification (i.e. riffle, run, pool), wetted width to the nearest tenth of a meter, water depths at 0.25, 0.5, and 0.75 width to the nearest centimeter, substrate size (Table 1), and a visual estimate of substrate embeddedness. Channel gradients were obtained using a percent scale clinometer. When the clinometer had a reading of zero, less than one was recorded. The number of primary pools and large woody debris (LWD) were recorded the entire length between transects. Primary pools were identified as those longer or wider than the average stream width and a maximum depth at least two times the tail-out depth. Large woody debris was tallied if it was at least one meter in length, and at least 10 cm in diameter. Bankfull widths and depths were measured at representative sites within each reach. Unstable banks were recognized by sloughing, steep slopes and lack of vegetation. Unstable banks were measured while walking up the stream channel with the hip-chain indicating the exact length while the east or west bank was noted. The results account for both sides of the stream and what percentage of the reach is stable. Water quality (Hydrolab: temperature, conductivity, pH, and D.O.) and flows are taken each month on Tshimikain Creek as part of the Water Quality Program. Where the streambed was dry, only transect, substrate, stable banks, gradient and bank-full widths were recorded.

Table 1. Substrate classifications according to Espinosa (1988)

Organic debris:	undecomposed sticks, leaves, logs, or other woody and herbaceous material
Muck:	decomposed organic material, usually black in color
Silt:	fine sediments with little grittiness
Sand:	< 0.25 inches in diameter
Small Gravel:	0.25 – 25 mm
Coarse Gravel:	25 – 76 mm
Cobble:	76 – 158 mm
Rubble:	158 – 305 mm
Boulders:	> 305 mm
Bedrock:	large masses of solid rock

Relative Fish Abundance

Within each reach delineated during the habitat survey, a minimum of one site was selected that represented the characteristics of the reach to collect relative fisheries abundance. Fish were sampled using backpack electroshockers according to Reynolds (1996). Fish sample sites were selected not to bisect habitat, and multiple habitats when present, and were a minimum of 30 meters in length. In reaches with stagnant pools, a single pass method was used unless salmonids were sampled.

Backpack electroshockers were used at all sites sampled in 2003. Smith Root models VII, XII or LR 24 were adjusted to the specific water depth and conductivity. Multiple-pass electrofishing was performed in reaches were the wetted width was < 4x the width of the channel. Fish were identified using Wydoski (1979-2003), as well as Simpson (1982).

Fish density (fish per 100/m²) was calculated based on the length of the sample site as well as the average width. Ninety-five percent confidence intervals were calculated for those sites where the multiple-pass depletion method was used.

The following size/age classes for salmonid species (Table 2) were determined according to Clearwater National Forest guidelines (Epinosa 1988). The size classifications are general guidelines found applicable in other northeastern Washington streams; however, not all streams will fall under these guidelines.

Table 2. Size/age class of specific species according to Espinosa (1988)

Species	Group	Size Range
Rainbow Trout	age 0+	< 65 mm FL
Cutthroat Trout	age 1+	65-110 mm FL
	age 2+	111-150 mm FL
	age 3+	151-200 mm FL
	age 4+	201-305 mm FL
	BIG	> 305 mm FL
Bull Trout	age 0+	< 65 mm FL
Brown Trout	age 1+	65-115 mm FL
Brook Trout	age 2+	116-165 mm FL
	age 3+	166-210 mm FL
	age 4+	211-305 mm FL
	BIG	> 305 mm FL
Mountain Whitefish: Record numbers of fish under 100mm, 100-305mm and over 305mm.		
Sculpin: Record total number of sculpin; by species if possible.		
Sucker: Record total number of suckers; by species if possible.		
Other: Record total number; by species if possible.		

Temperature Data Loggers

Temperature loggers were placed in the streams main flow and anchored with weights. The temperature data loggers that are used to obtain current stream

temperatures are made by Onset Corp., and will record to the nearest ± 0.2˚C. The start dates for the temperature loggers was June 1st 2003, and were retrieved by November 2003. The data loggers are programmed to record temperature every hour, from which maximum, minimum, and daily temperatures for each month were calculated. The Spokane Tribal Water Quality Standards set a maximum seven-day average temperature of 18.50˚C in Tshimikain Creek to protect designated uses from June 1st through September 1st. From September 2nd through October 1st, and April 2nd through May 31st the seven-day maximum average criteria is 13.50 ˚C. From October 2nd to April 1st, the seven day maximum average criteria is 11˚C.

3. Results

Tshimikain Creek

The following species of fish were sampled throughout Reaches one through 23 in Tshimikain Creek: rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonesis*), redside shiner (*Richardsonius balteatus*), pumpkinseed (*Lepomis gibbosus*), chiselmouth (*Acrocheilus alutaceus*), bridgelip suckers (*Catostomus columbianus*), and speckled dace (*Rhinichthys osculus*). The family Cottidae (Sculpin) was also observed in Tshimikain Creek, but was not identified to species.

Reach 1

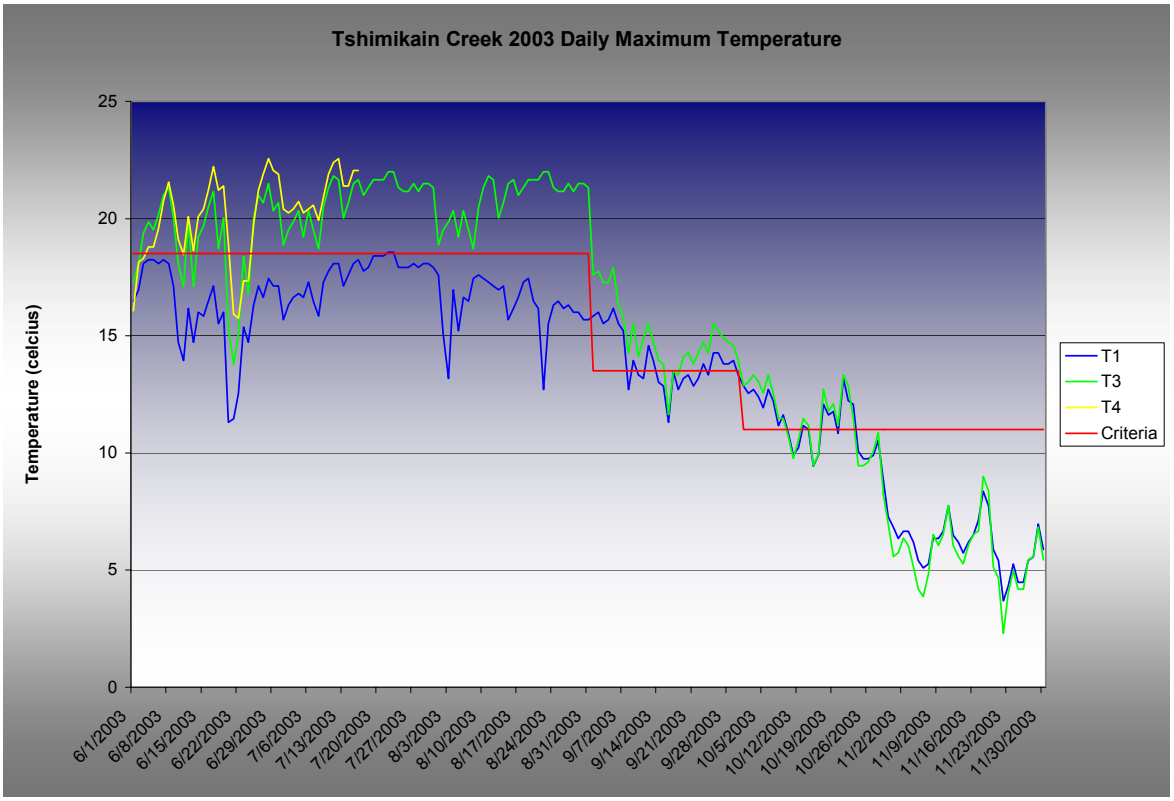
Reach 1 had to be shocked twice due to a malfunction with the backpack electroshocker. The data reported is referred to as R-1 the first time, and R-1A the second time (Table 14). Rainbow trout, brown trout, brook trout, mountain whitefish, largescale sucker, northern pikeminnow, redside shiner, pumpkinseed, and chiselmouth were sampled. A total of 56 fish were sampled, giving R-1 a total density of 9.60 fish/100m². Out of the 56 fish sampled, 37 were salmonids, which had a total density of 6.34 fish/100m². The age of the rainbow trout was one at 4+. The five brown trout were estimated at 4+, and two were considered "big." The ages of the mountain whitefish consisted of 29 that were 0+, and one brook trout age 1+ (Table 17). A total of 164 fish

were sampled in R-1A, which had a total density of 28.11 fish/100m². Twelve of the 164 fish were salmonids species with a total density of 0.17 fish/100m². The ages of the rainbow trout were one at 0+, and one that was considered 4+. One brown trout was aged "big," nine were considered 4+, and two were considered 2+ (Table 17).

Habitat surveying started at the confluence of the Spokane River and Tshimikain Creek heading north to the Martha Boardman Bridge (Figure 2). Reach 1 consisted of 12 transects totaling 720 meters. Reach 1 (Table 3) had an average gradient of 1.6%, an average depth of 54.8 cm, an average wetted width of 13.7 m, and 93.6% of the banks were considered stable. The majority of the substrate consisted of gravel (27.3%) and silt (29.3%) with an average embeddedness of 50.3%. The stream habitat types for Reach 1 were: pools (34.4%), riffles (33.0%), and runs (32.5%). There were 13 primary pools with an average maximum depth of 129.5 cm and an average tail out depth of 52.8 cm.

A temperature logger was placed in Tshimikain Creek below the Martha Boardman Bridge (Table 4) that is recognized as T1 (Figure 2). Tshimikain Creeks daily maximum average for the month of June was 16.11˚C, 17.61˚C in July, 16.28˚C in August, 13.93˚C in September, and 10.95˚C in October. The highest temperature that was recorded for the month of June was 18.24˚C, 18.57˚C in July, 17.6˚C in August, 16.16˚C in September, and 13.17˚C in October. The lowest temperature that was recorded for the month of June was 8.67˚C, 8.97˚C in July, 10.22˚C in August, 8.97˚C in September, and 4.97˚C in October. Tshimikain Creek periodically exceeded the Tribal Water Quality standards from June 1st to October 31st (Figure 2).

Figure 2. Tshimikain Creek Daily Maximum Temperatures, Summer 2003 in (˚C)



Reach 2

Brown trout, bridgelip suckers, largescale sucker, northern pikeminnow, and chiselmouth were sampled. A total of 19 fish were sampled, giving Reach 2 a total density of 2.02 fish/100m² (Table 14). Four of the fish sampled were brown trout with a total density of 0.42 fish/100m². The ages of the brown trout were all 4+ (Table 17).

Habitat surveying started at Martha Boardman Bridge and continued to the end of the road paralleling Tshimikain Creek on the reservation (Figure 2). Reach 2 consisted of 16 transects totaling 960 meters. Reach 2 (Table 3) had an average gradient of 1.4%, an average depth of 39.6 cm, an average wetted width of 9.5 m, and 93.0% of the banks were considered stable. The majority of the substrate consisted of cobble (61.2%) and gravel (26.3%) with an average embeddedness of 44.7%. The stream habitat types for Reach 2 were: pools (2.1%), riffles (47.4%), and runs (50.6%). There were 13 primary pools with an average maximum depth of 120.5 cm and an average tail out depth of 46.4 cm.

Reach 3

Brown trout and bridgelip suckers were the only fish sampled. A total of seven fish were sampled, giving Reach 3 a total density 0.98 fish/100m² (Table 14). Six of the fish were brown trout which calculates to a total density of 0.84 fish/100m. The ages of the brown trout were; two estimated at 1+, one at 3+, and three were considered "big" (Table 17).

Habitat surveying started at the end of the road and ended at Tshimikain Falls (Figure 2). Reach 3 consisted of 21 transects totaling 1260 meters. Reach 3 (Table 3) had an average gradient of 1.5%, an average depth of 51.4 cm, an average wetted width of 10.0 m, and 89.1% of the banks were considered stable. The majority of the substrate consisted of: cobble (42.7%) and gravel (24.4%) with an average embeddedness of 40.8%. The stream habitat types for Reach 3 were: pools (13.3%), riffles (41.3%), and runs (42.4%). There were 15 primary pools with an average maximum depth of 124.1 cm and an average tail out depth of 49.3 cm.

Figure 3. Reaches 1-3 of Tshimikain Creek

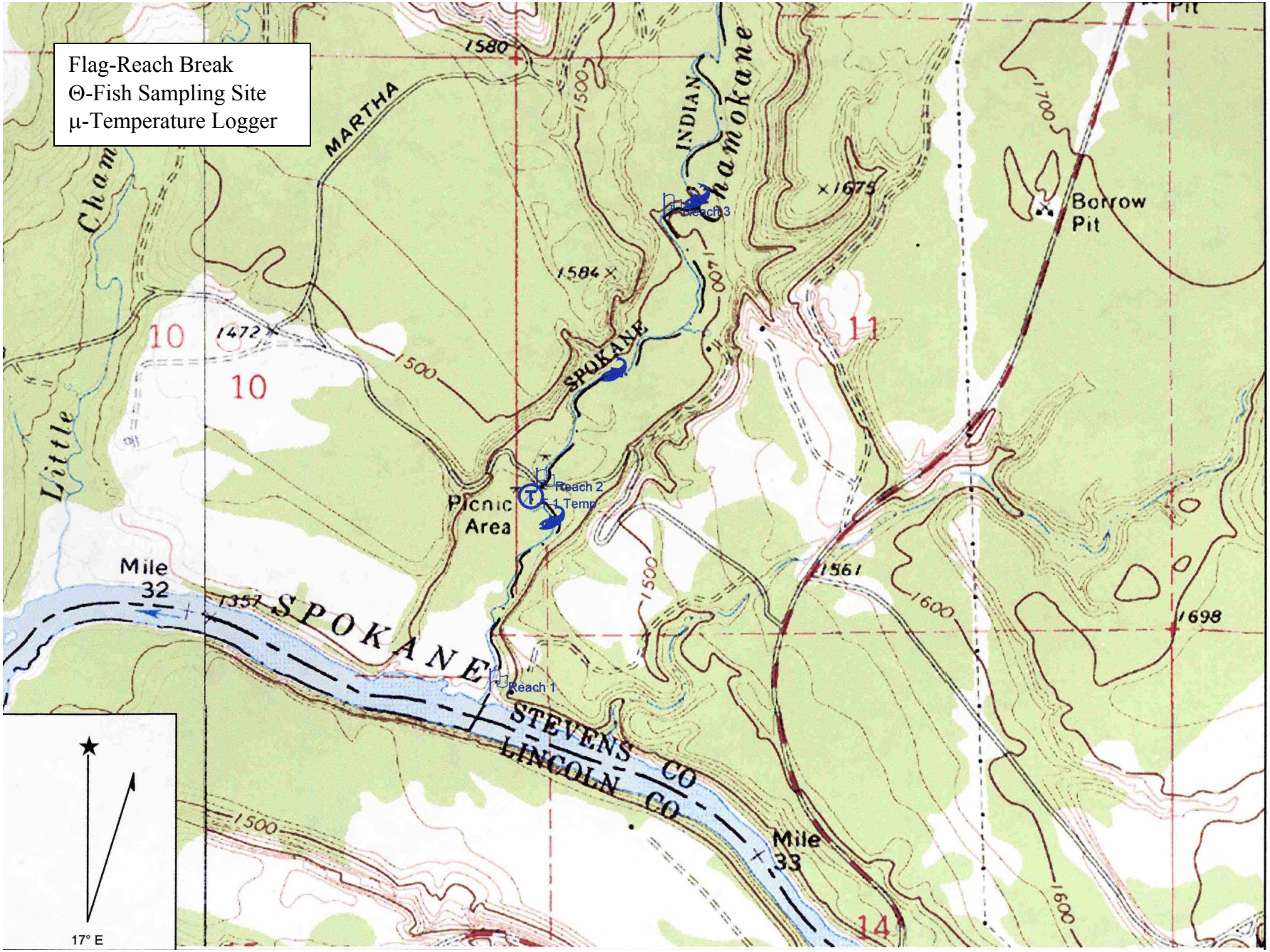


Table 3. Habitat Data for Reaches 1-3 of Tshimikain Creek, Summer 2003

Reach	**1**	**2**	**3**
Length (m)	720	960	1260
Mean Embeddedness %	45.3	44.7	40.8
Min	20	25	0
Max	100	100	90
Pool-Riffle Ratio	.6:1	.1:1	.4:1
LWD (#/100m)	14.58	6.67	7.54
Primary Pools (#/Km)	18.1	13.5	11.9
Mean Stream Width (m)	13.7	9.5	10
Mean Stream Depth (cm)	54.8	39.6	51.4
Mean Gradient (%)	1.6	1.4	1.5
Min	0.5	1	1
Max	2.5	2	2
Substrate (% Occurrence)			
Bedrock	0	0	19.7
Boulders	7.1	0	0
Rubble	4	10.3	4.7
Cobble	20.3	61.2	42.7
Gravel	27.3	26.3	24.4
Small Gravel	12.1	0	8.5
Sand	0	2.1	0
Silt	29.3	0	0
Muck	0	0	0
Habitat Types			
Pool (% Occurrence)	34.4	2.1	13.3
Mean Width (m)	18.9	3.1	7
Min Width (m)	8.4	3.13	4.5
Max Width (m)	33	3.13	9
Riffle (% Occurrence)	33	47.4	41.3
Mean Width (m)	10.9	9	8.7
Min Width (m)	6.5	6	1.8
Max Width (m)	12.9	12.65	30.3
Run (% Occurrence)	32.5	50.6	42.4
Mean Width (m)	7.6	8.6	8.1
Min Width (m)	4.4	1.5	2.8
Max Width (m)	10.9	13.25	16.4
Pocketwater (% Occurrence)	0	0	0
Mean Width (m)	0	0	0
Min Width (m)	0	0	0
Max Width (m)	0	0	0

Table 4 . **Temperature Data for Reach 1 of Tshimikain Creek, Summer 2003**

Stream	**T1 (˚C)**
June High	18.24
June Low	8.67
June avg.	12.82
June Daily Max avg.	16.11
July High	18.57
July Low	8.97
July avg.	13.68
July Daily Max avg.	17.61
August High	17.60
August Low	10.22
August avg.	13.38
August Daily Max avg.	16.28
September High	16.16
September Low	8.97
September avg.	11.88
September Daily Max avg.	13.93
October High	13.17
October Low	-4.97
October avg.	9.71
October Daily Max avg.	10.95
Total avg. Temp	11.14
Highest Temp	18.57
Lowest Temp	2.43
Lowest Date	10/30/2003
Logger Start Date	6/1/2003
Logger Finish Date	11/30/2003

Reach 4

Rainbow trout, brown trout, bridgelip suckers, and pumpkinseed were sampled. A total of 19 fish were sampled, giving Reach 4 a total density of 2.95 fish/100m² (Table 14). Seventeen of the fish sampled were salmonids with a total density of 2.64 fish/100m². The age of the rainbow trout were: five estimated at 0+, one at 1+, and two estimated at 4+. The age of the brown trout were: two estimated at 1+, one at 3+, four at 4+, and two were considered "big" (Table 17).

Habitat surveying for Reach 4 started at the Tshimikain Falls and consisted of 17 transects totaling 1,020 meters ending by a white house (Figure 3). Reach 4 (Table 5) had an average gradient of 2.1%, an average depth of 48 cm, an average wetted width of 8.6 m, and 80.8% of the banks were considered stable. The majority of the substrate consisted of rubble (40.3%), cobble (30.2%), and gravel (26.8%) with an average embeddedness of 49.3%. The stream habitat types for Reach 4 were: runs (51.0%), riffles (43.4%), pools (4.9%), and pocketwater 0.7%. There were 10 primary pools with an average maximum depth of 107.5 cm and an average tail out depth of 44.1 cm.

Reach 5

Rainbow trout, and brown trout were sampled. A total of 14 fish were sampled, giving Reach 5 a total density of 2.41 fish/100m² (Table 14). The age of the rainbow trout was one estimated at 0+. The brown trout were: seven estimated at 0+, one at 1+, one at 3+, two at 4+, and two considered "big" (Table 17).

Habitat surveying started at the white house (east of Tshimikain Creek) which consisted of 27 transects totaling 1620 meters (Figure 3). Reach 5 (Table 5) had an average gradient of 1.9%, an average depth of 39.5 cm, an average wetted width of 8.0 m, and 82.1% of the banks were considered stable. The majority of the substrate consisted of cobble (53.7%) and rubble (25.7%) with an average embeddedness of 44.3%. The stream habitat types for Reach 5 were: pools (1.0%), riffles (25.7%), and runs (73.3%). There were 15 primary pools with an average maximum depth of 110.8 cm and an average tail out depth of 43.3 cm.

Reach 6

Brown trout, and chiselmouth were sampled. A total of 22 fish were sampled, giving Reach 6 a total density of 3.16 fish/100m² (Table 14). Fifteen of the fish sampled were brown trout which had a total density of 2.15 fish/100m². The age of the brown trout were; three estimated at 1+, two at 3+, five at 4+, and five considered "big" (Table 17).

Reach 6 consisted of 20 transects totaling 1200 meters (Figure 3). Reach 6 (Table 5) had an average gradient of 2.7%, an average depth of 44.3 cm, an average wetted width of 8.6 m, and 58.8% of the banks were considered stable. The majority of the substrate consisted of cobble (27.5%), rubble (24.7%), and boulders (18.3%) with an average embeddedness of 53.4%. The stream habitat types for Reach 6 were: runs (64.3%), pools (18.0%), and riffles (17.7%). There were 10 primary pools with an average maximum depth of 99.7 cm and an average tail out depth of 33.9 cm.

Figure 4. Reaches 4-6 of Tshimikain Creek

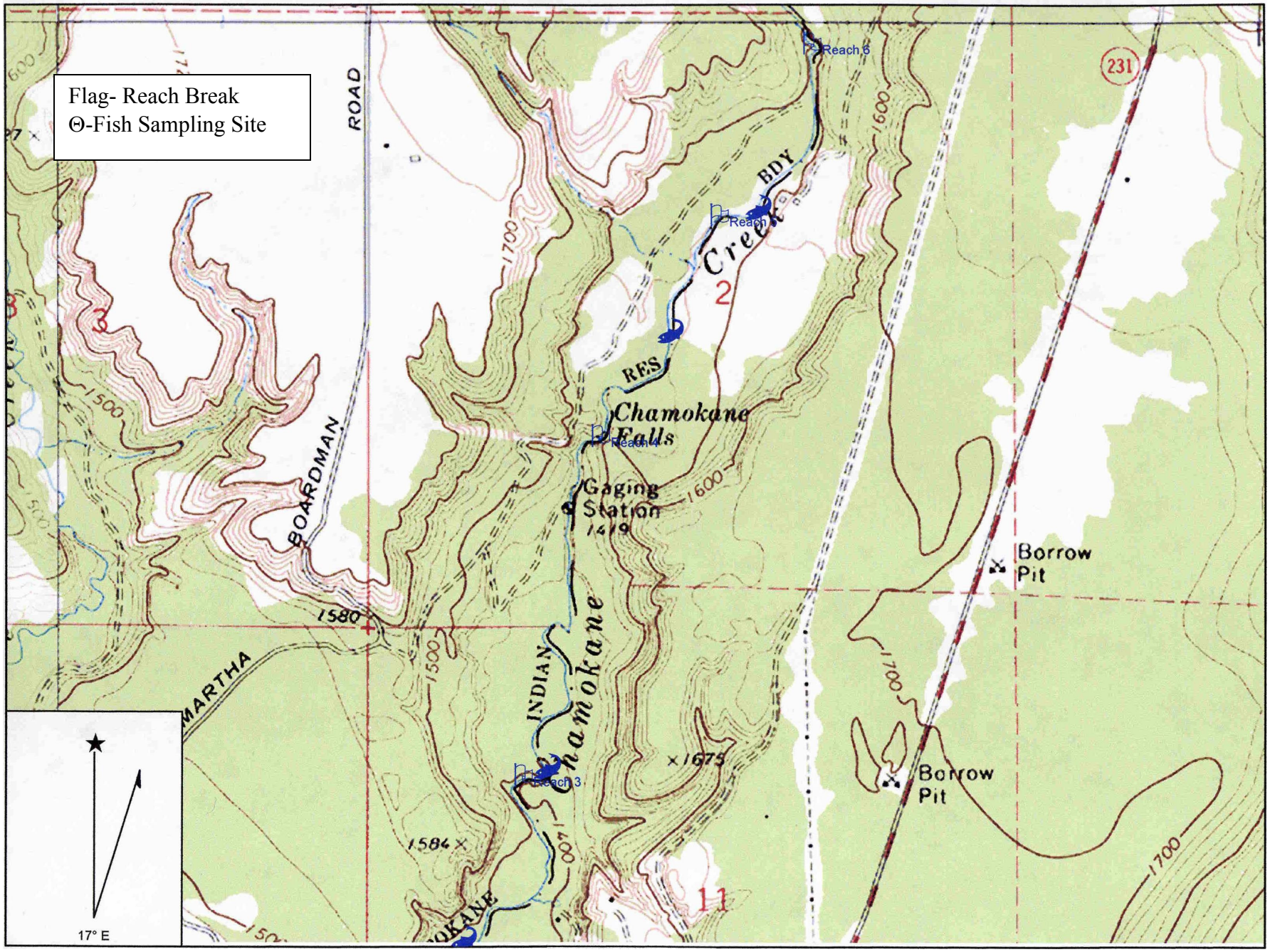


Table 5. Habitat Data for Reaches 4-6 of Tshimikain Creek, Summer 2003

Reach	**4**	**5**	**6**
Length (m)	1020	1620	1200
Mean Embeddedness	49.3	44.3	53.4
Min	25	25	25
Max	100	70	100
Pool-Riffle Ratio	.2:1	.1:1	1:01
LWD (#/100m)	2.84	0.6	1.3
Primary Pools (#/Km)	9.8	9.26	8.3
Mean Stream Width (m)	8.6	8	8.6
Mean Stream Depth (cm)	48	39.5	44.3
Mean Gradient (%)	2.1	1.9	2.7
Min	1.5	1.5	1.5
Max	3.5	2.5	4
Substrate (% Occurrence)			
Bedrock	2.1	0	0
Boulders	0	4.6	18.3
Rubble	40.3	25.7	24.7
Cobble	30.2	53.7	27.5
Gravel	26.8	12.8	15.9
Small Gravel	0	0	10
Sand	0.7	3.2	3.5
Silt	0	0	0
Muck	0	0	0
Habitat Types			
Pool (% Occurrence)	4.9	1	18
Mean Width (m)	7.2	2.2	7.7
Min Width (m)	7.2	2.2	6
Max Width (m)	7.2	2.2	10.5
Riffle (% Occurrence)	43.4	25.7	17.7
Mean Width (m)	7	8	7.6
Min Width (m)	2.5	4.4	6.3
Max Width (m)	10.9	12.4	9.1
Run (% Occurrence)	51	73.3	64.3
Mean Width (m)	7.4	7.9	9.2
Min Width (m)	3	3.3	6.7
Max Width (m)	10.95	15.8	16
Pocketwater (%Occurrence)	0.7	0	0
Mean Width (m)	1	0	0
Min Width (m)	1	0	0
Max Width (m)	1	0	0

Reach 7

Rainbow trout, brown trout, and pumpkinseed were sampled. A total of 22 fish were sampled, giving Reach 7 a total density of 2.75 fishh/100m² (Table 14). Twenty of the fish sampled were salmonids with a total density of 2.50 fish/100m². The age of the rainbow trout was one considered "big". The age of the brown trout were: five estimated at 0+, one at 1+, one at 3+, 10 at 4+, and two considered "big" (Table 17).

Habitat surveying for Reach 7 started at the end of the dirt road that parallels Tshimikain Creek from the falls, and ends at the power lines that cross Tshimikain Creek. Reach 7 consisted of 20 transects totaling 1200 meters (Figure 4). Reach 7 (Table 6) had an average gradient of 1.9%, an average depth of 59.3 cm, an average wetted width of 8.1 m, and 78.4% of the banks were considered stable. The majority of the substrate consisted of cobble (37.8%) and gravel (32.9%) with an average embeddedness of 52.5%. The stream habitat types for Reach 7 were: pools (21.2%), riffles (17.3%) and runs (61.4%). There were 19 primary pools with an average maximum depth of 113.3 cm and an average tail out depth of 39.8 cm.

Reach 8

Rainbow trout, brown trout, redside shiner, speckled dace, bridgelip suckers, and pumpkinseed were sampled. A total of 73 fish were sampled, giving Reach 8 a total density of 13.16 fish/100m² (Table 14). Thirty-seven of the fish sampled were salmonids with a total density of 6.67 fish/100m². The age of the rainbow trout were: three estimated at 1+, four at 3+, and one considered 4+. The age of the brown trout were: 14 estimated at 1+, eight at 3+, four at 4+, and three considered "big" (Table 17).

Reach 8 consisted of 21 transects totaling 1260 meters (Figure 4). Reach 8 (Table 6) had an average gradient of 1.8%, an average depth of 46 cm, an average wetted width of 7.4 m, and 68.3% of the banks were considered stable. The majority of the substrate consisted of cobble (41.5%) and gravel (30.7%) with an average embeddedness of 43.5%. The stream habitat types for Reach 8 were: pools (32.6%), riffles (21.1%) and runs (46.3%). There were 22 primary pools with an average maximum depth of 103.1 cm with an average tail out depth of 36.3 cm.

Reach 9

Brown trout, brook trout, and pumpkinseed were sampled. A total of 86 fish were sampled, giving Reach 9 a total density of 13.17 fish/100m² (Table 14). Thirty-three of the fish were salmonids with a total density of 5.05 fish/100m². The ages of the brown trout were: one estimated at 0+, eight at 1+, three at 2+, seven at 3+, seven at 4+, six considered "big", and one brook trout estimated at 2+ (Table 17).

Reach 9 consisted of 25 transects totaling 1500 meters (Figure 4). Reach 9 (Table 6) had an average gradient of 2.2%, an average depth of 35.3 cm, an average wetted width of 6.3 m, and 69.7% of the banks were considered stable. The majority of the substrate consisted of gravel (56.9%) and cobble (37.4%) with an average embeddedness of 35.8%. The stream habitat types for Reach 9 were: runs (72.0%), riffles (14.5%), and pools (8.6%). There were 19 primary pools with an average maximum depth of 91.3 cm and an average tail out depth of 34.6 cm.

A temperature logger was placed in Galbraith Springs. Galbraith Springs is the Spokane Tribal Hatchery outfall (Table 8), which connects to Tshimikain Creek on Reach 9. Galbraith Springs had a daily maximum average in July of 14.67˚C, 14.02˚C in August, 13.02˚C in September, and 11.29˚C in October. The highest temperature that was recorded for the month of July was 15.18˚C, 14.68˚C in August, 14.08˚C in September, and 12.68˚C in October. The lowest temperature that was recorded for the month of July was 10.52˚C, 10.36˚C in August, 9.58˚C in September, and 7.11˚C in October. Galbraith Spring was within the Tribal Water Quality Standards from July 1st to October 31st.

Figure 5. Reaches 7-9 of Tshimikain Creek

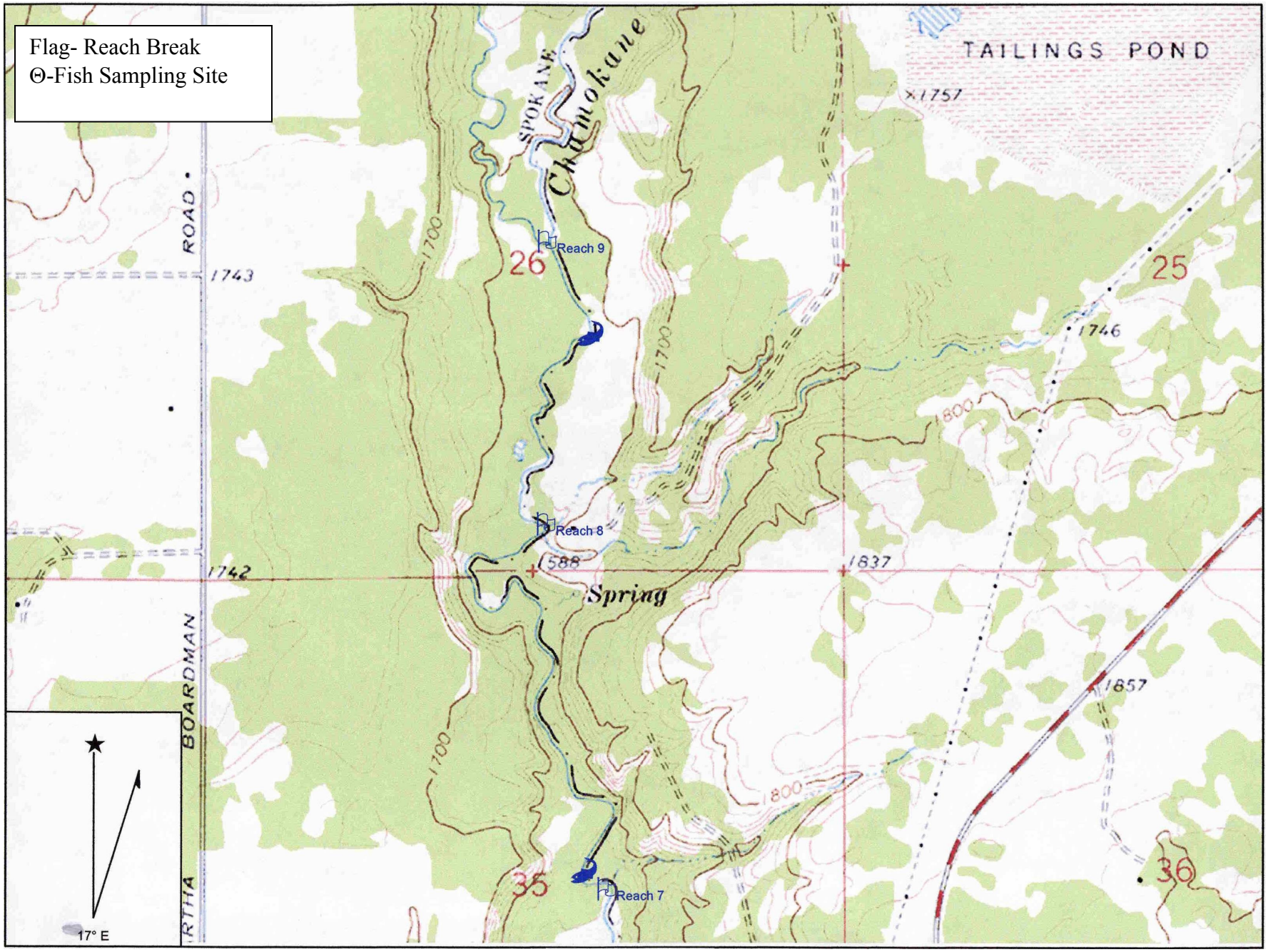


Table 6. Habitat Data for Reaches 7-9 for Tshimikain Creek, Summer 2003

Reach	**7**	**8**	**9**
Length (m)	1200	1260	1500
Mean Embeddedness	52.5	43.5	35.8
Min	20	15	20
Max	100	100	50
Pool-Riffle Ratio	1.2:1	.8:1	.4:1
LWD (#/100m)	6.83	5	12.67
Primary Pools (#/Km)	15.83	17.46	6.3
Mean Stream Width (m)	8.1	7.4	35.3
Mean Stream Depth (cm)	59.3	46	2.2
Mean Gradient (%)	1.9	1.8	1.5
Min	1.5	1.5	2.5
Max	2.5	2	2
Substrate (% Occurrence)			
Bedrock	0	0	0
Boulders	0	0	0
Rubble	13.7	9	5.7
Cobble	37.8	41.5	37.4
Gravel	32.9	30.7	56.9
Small Gravel	2.5	3.9	0
Sand	4.6	14.9	0
Silt	8.6	0	0
Muck	0	0	0
Habitat Types			
Pool (% Occurrence)	21.2	32.6	8.6
Mean Width (m)	6.9	8.4	6.8
Min Width (m)	3.8	6	6.5
Max Width (m)	14	16.3	7
Riffle (% Occurrence)	17.3	21.1	14.5
Mean Width (m)	7.1	4.7	4.6
Min Width (m)	5.5	2	3.2
Max Width (m)	8.5	7.4	6
Run (% Occurrence)	61.4	46.3	72
Mean Width (m)	6.7	7.2	6.7
Min Width (m)	2.6	4.3	4
Max Width (m)	11	11	10
Pocketwater (% Occurrence)	0	0	0
Mean Width (m)	0	0	0
Min Width (m)	0	0	0
Max Width (m)	0	0	0

Reach 10

Rainbow trout, brown trout, speckled dace, pumpkinseed, and bridgelip suckers were sampled. A total of 199 fish were sampled, giving Reach 10 a total density of 26.96 fish/100m² (Table 14). Fifty-two of the fish were salmonids with a total density of 7.04 fish/100m². The ages of the rainbow trout were: one estimated at 3+ and two estimated at 4+. The ages of the brown trout were: 30 estimated at 1+, nine at 3+, and 11 considered 4+ (Table 17).

Reach 10 consisted of 20 transects totaling 1200 meters (Figure 5). Reach 10 (Table 7) had an average gradient of 1.7%, an average depth of 40.9 cm, an average wetted width of 6.5 m, and 70.9% of the banks were considered stable. The majority of the substrate consisted of gravel (56.5%) and cobble (25.1%) with an average embeddedness of 46.3%. The stream habitat types for Reach 10 were: runs (52.7%), pools (35.5%), and riffles (11.8%). There were 17 primary pools with an average maximum depth of 112.8 cm and an average tail out depth of 26.2 cm.

Reach 11

Rainbow trout, brown trout, speckled dace, pumpkinseed, and bridgelip suckers were sampled. A total of 325 fish were sampled, giving Reach 11 a total density of 70.60 fish/100m² (Table 14). Forty-three of the fish were salmonids with a total density of 9.34 fish/100m². The ages of the rainbow trout were: two estimated at 1+, one at 2+, and one considered "big". The ages of the brown trout were: 14 estimated at 1+, five at 2+, 10 at 3+, three at 4+, and seven considered "big" (Table 17).

Habitat surveying for Reach 11 started at the power lines that crossed Tshimikain Creek and consisted of 21 transects totaling 1260 meters (Figure 5). Reach 11 (Table 7) had an average gradient of 2.0%, an average depth of 26.1 cm, an average wetted width of 4.5 m, and 80.4% of the banks were considered stable. The majority of the substrate consisted of gravel (56.1%) and cobble (34.8%) with an average embeddedness of 38.0%. The stream habitat types for Reach 11 were: runs (77.2%), riffles (16.7%), and pools (6.2%). There were 14 primary pools with an average maximum depth of 113.9 cm and an average tail out depth of 26.0 cm.

Temperature loggers were placed above and below the Ford Fish Hatchery (Table 8). The springs had a daily maximum average for the month of July 11.52˚C,

10.98˚C in August, 10.98˚C in September, and 10.70˚C in October. The highest temperature that was recorded for the month of July was 11.52˚C, 11.36˚C in August, 11.36˚C in September, and 11.36˚C in October. The lowest temperature that was recorded for the month of July was 8.12˚C, 8.88˚C in August, 9.04˚C in September, and 8.12˚C in October. The discharge waters had a daily maximum average for the month of July of 13.14˚C, 12.69˚C in August, 11.94˚C in September, and 10.83˚C in October. The highest temperature that was recorded for the month of July was 13.97˚C, 12.69˚C in August, 11.94˚C in September, and 11.97˚C in October. The lowest temperature that was recorded for the month of July was 8.13˚C, 9.04˚C in August, 8.59˚C in September, and 6.9˚C in October. The average water temperature increase through the hatchery in July and August was 1.24˚C and 1.05˚C. The hatchery waters are significantly cooler than the mainstem of Tshimikain Creek (Table 8).

Figure 6. Reaches 10-11 of Tshimikain Creek

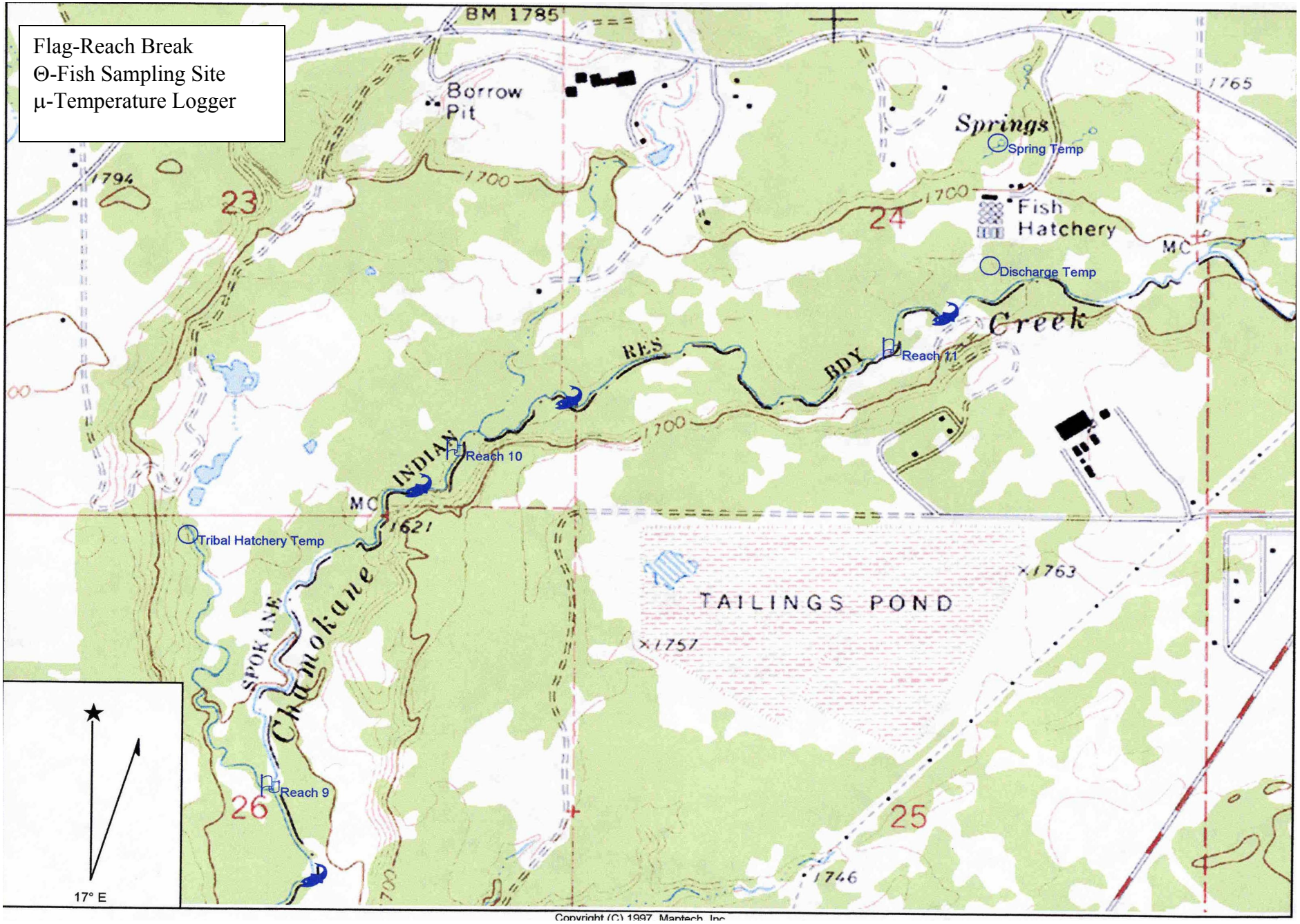


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Table 7. Habitat Data for Reaches 10-11 of Tshimikain Creek, Summer 2003

Reach	**10**	**11**
Length (m)	1020	1260
Mean Embeddedness	49.3	38
Min	25	20
Max	100	70
Pool-Riffle Ratio	.2:1	.5:1
LWD (#/100m)	2.84	2.2
Primary Pools (#/Km)	9.8	11.1
Mean Stream Width (m)	8.6	4.5
Mean Stream Depth (cm)	48	26.1
Mean Gradient (%)	2.1	2
Min	1.5	2
Max	3.5	2
Substrate (% Occurrence)		
Bedrock	2.1	0
Boulders	0	0
Rubble	40.3	9.1
Cobble	30.2	34.8
Gravel	26.8	56.1
Small Gravel	0	0
Sand	0.7	0
Silt	0	0
Muck	0	0
Habitat Types		
Pool (% Occurrence)	4.9	6.2
Mean Width (m)	7.2	2.9
Min Width (m)	7.2	2.4
Max Width (m)	7.2	3.4
Riffle (% Occurrence)	43.4	16.7
Mean Width (m)	7	3.9
Min Width (m)	2.5	2.1
Max Width (m)	10.9	7.5
Run (% Occurrence)	51	45.5
Mean Width (m)	7.4	4.8
Min Width (m)	3	2.5
Max Width (m)	10.95	6.4
Pocketwater (%Occurrence)	0.7	0
Mean Width (m)	1	0
Min Width (m)	1	0
Max Width (m)	1	0

Table 8. Temperature Data for the Tribal and Ford Hatcheries, Summer 2003

Data Logger	Tribal Hatchery Outfall	Spring Ford Hatchery	Discharge Ford Hatchery	Ford Hatchery Comparison Spring/Discharge
June High	No Data	no data	no data	no data
June Low	No Data	no data	no data	no data
June avg.	No Data	no data	no data	no data
June Daily Max avg.	No Data	no data	no data	no data
July High	11.52	11.52	13.97	2.45
July Low	8.12	8.12	8.13	0.01
July avg.	9.47	9.47	10.71	1.24
July Daily Max avg.	11.28	11.28	13.14	1.87
August High	11.36	11.36	14.28	2.92
August Low	8.88	8.88	9.04	0.16
August avg.	9.71	9.71	10.76	1.05
August Daily Max avg.	10.98	10.98	12.69	1.71
September High	11.36	11.36	12.9	1.54
September Low	9.04	9.04	8.59	-0.45
September avg.	9.96	9.96	10.40	0.44
September Daily Max avg.	10.98	10.98	11.94	0.95
October High	11.36	11.36	11.97	0.61
October Low	8.12	8.12	6.9	-1.22
October avg.	9.91	9.91	9.75	-0.16
October Daily Max avg.	10.70	10.70	10.83	0.14
Total avg. Temp	9.57	9.57	9.94	0.36
Highest Temp	11.52	11.52	14.28	
Highest Date	7/23/2003	7/23/2003	8/10/2003	
Lowest Temp	7.11	6.9	8.12	
Lowest Date	10/31/2003	10/31/2003	10/31/2003	
Logger Start Date	7/1/2003	7/1/2003	7/1/2003	
Logger Finish Date	11/1/2003	11/30/2003	11/30/2003	

Reach 12

Rainbow trout, brown trout, brook trout, speckled dace, pumpkinseed, and bridgelip suckers were sampled. A total of 266 fish were sampled, giving Reach 12 a total density of 82.92 fish/100m² (Table 14). Ninety-nine were salmonids with a total density of 30.86 fish/100m². The ages of the rainbow trout were: four estimated at 0+, 20 at 1+, one at 2+, 37 at 3+, 17 at 4+, and three considered "big." The ages of the brown trout were: one estimated at 2+, three at 3+, eight at 4+, five considered "big," and one brook trout estimated at 4+ (Table 17).

Reach 12 consisted of 24 transects totaling 1440 meters (Figure 6). Reach 12 (Table 9) had an average gradient of 1.0%, an average depth of 29.2 cm, an average wetted width of 5.7m, and 56.8% of the banks were considered stable. The majority of the substrate consisted of cobble (60.1%), gravel (17.6%), and rubble (14.6%) with an average embeddedness of 50.4%. The stream habitat types for Reach 12 were: runs (82.4%), riffles (9.8%), and pools (7.7%). There were three primary pools with an average maximum depth of 128.3 cm and an average tail out depth of 23 cm.

A temperature logger was placed in Tshimikain Creek below the Ford Bridge (Table 10), which is recognized as T3. Tshimikain Creek had a daily maximum average for the month of June was 19.05˚C, 20.88˚C in July, 18.56˚C in August, 14.98˚C in September, and 11.04˚C in October. The highest temperature that was recorded for the month of June was 21.49˚C, 21.99˚C in July, 20.67˚C in August, 17.91˚C in September, and 13.33˚C in October. The lowest temperature that was recorded for the month of June was 10.39˚C, 11.01˚C in July, 10.86˚C in August, 8.68˚C in September, and 3.08˚C in October. Tshimikain Creek was within the seven day tribal water quality standards from June 1st to 30th, but had exceedances from July 1st to August 31st.

Reach 13

Rainbow trout, brown trout, brook trout, redside shiner, speckled dace, pumpkinseed, and bridgelip suckers were sampled. A total of 525 fish were sampled, giving Reach 13 a total density of 127.50 fish/100m² (Table 14). Twenty-eight were salmonids with a total density of 6.80 fish/100m². The ages of the rainbow trout were: three estimated at 1+, four at 3+, three at 4+, and two considered "big." The ages of the

brown trout were: two estimated at 3+, four at 4+, eight considered "big," and two brook trout at 3+ (Table 17).

Habitat surveying for Reach 13 started at the Peone Bridge and consisted of 21 transects totaling 1260 meters (Figure 6). Reach 13 (Table 9) had an average gradient of 1.3%, an average depth of 9.4 cm, an average wetted width of 1.4m, and 17.7% of the banks were considered stable. The majority of the substrate consisted of cobble (42.8%), rubble (29.5%), and gravel (27.7%) with an average embeddedness of 54.0%. The stream habitat types for Reach 13 were: runs (74.8%) and pools (25.2%). There were three primary pools with an average maximum depth of 101.3 cm and an average tail out depth of 41.7 cm.

Reach 14

Due to the streambed being completely dry there was no fish sampling in this reach. Reach 14 consisted of 22 transects totaling 1320 meters (Figure 6). Reach 14 (Table 9) had an average gradient of 1.8%, and 4.0% of the banks were considered stable. The majority of the substrate consisted of sand 40.9 %, cobble at 27.3 % with embeddedness being irrelevant.

Figure 7. Reaches 12-14 of Tshimikain Creek

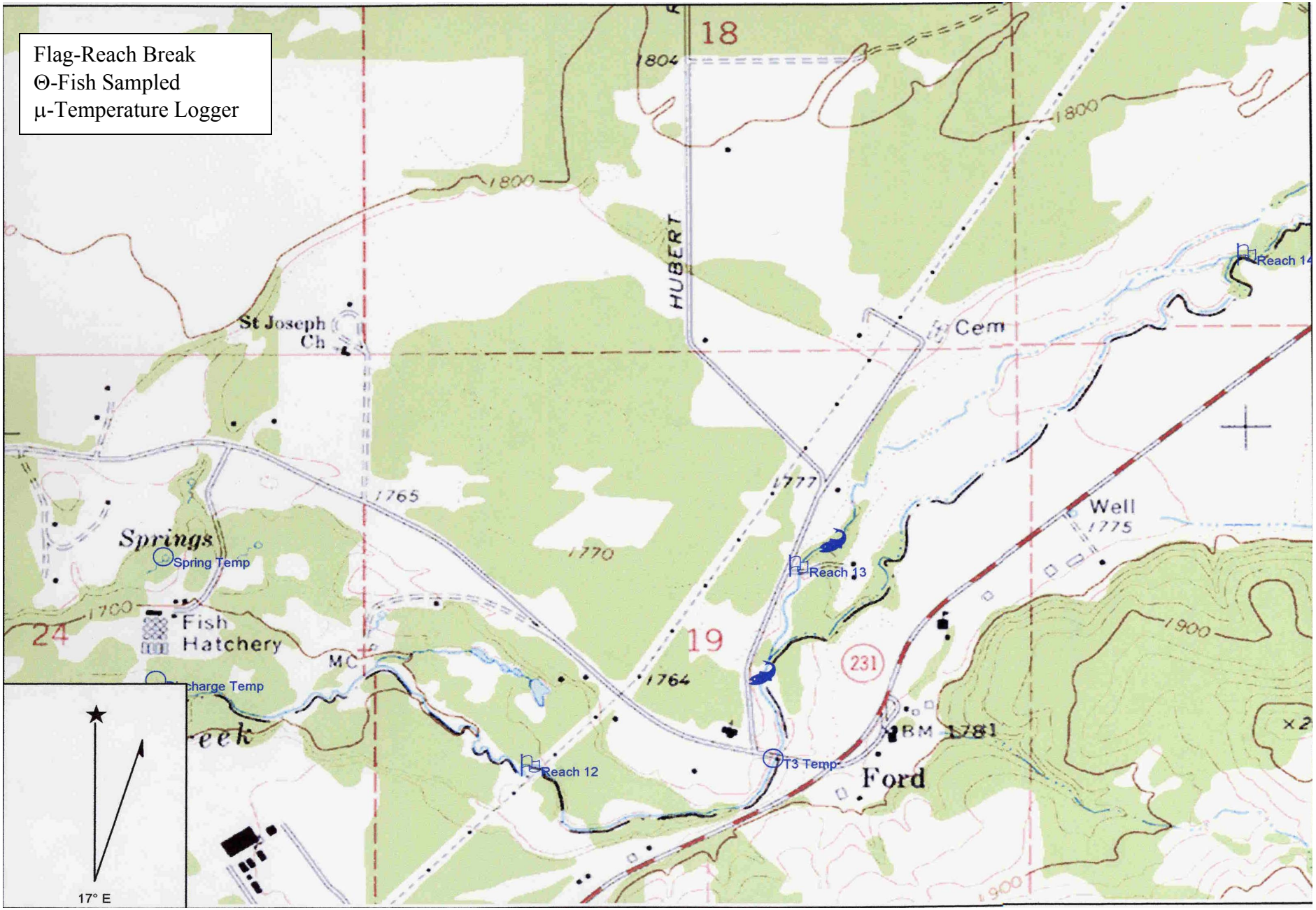

Table 9. Habitat Data for Reaches 12-14 of Tshimikain Creek, Summer 2003

Habitat			
Reach	**12**	**13**	**14**
Length (m)	1440	1260	1320
Mean Embeddedness	50.4	54	0
Min	25	20	0
Max	100	100	0
Pool-Riffle Ratio	.2:1	0:00	Dry
LWD (#/100m)	1.4	0.2	0
Primary Pools (#/Km)	2.1	2.38	0
Mean Stream Width (m)	5.7	1.4	0
Mean Stream Depth (cm)	29.2	9.4	0
Mean Gradient (%)	1	1.3	1.8
Min	1	1	1
Max	1	1.5	2.5
Substrate (% Occurrence)			
Bedrock	0	0	0
Boulders	0	0	0
Rubble	14.6	29.5	0
Cobble	60.1	42.8	27.3
Gravel	17.6	27.7	18.2
Small Gravel	0	0	13.6
Sand	7.7	0	40.9
Silt	0	0	0
Muck	0	0	0
Habitat Types			
Pool (% Occurrence)	7.7	25.2	0
Mean Width (m)	10.5	7.4	0
Min Width (m)	10.5	7.4	0
Max Width (m)	10.5	7.4	0
Riffle (% Occurrence)	9.8	0	0
Mean Width (m)	3.3	0	0
Min Width (m)	2.99	0	0
Max Width (m)	3.6	0	0
Run (% Occurrence)	44.6	35.3	0
Mean Width (m)	5	3.5	0
Min Width (m)	1.8	3.08	0
Max Width (m)	8.5	3.8	0
Alcove (% Occurrence)	0	0	0
Mean Width (m)	0	0	0
Min Width (m)	0	0	0
Max Width (m)	0	0	0

Table 10. **Temperature Data for Tshimikain Creek 2003**

Stream	T3
June High	21.49
June Low	10.39
June avg.	15.30
June Daily Max avg.	19.05
July High	21.99
July Low	11.01
July avg.	16.65
July Daily Max avg.	20.88
August High	20.67
August Low	10.86
August avg.	15.39
August Daily Max avg.	18.56
September High	17.91
September Low	8.68
September avg.	12.62
September Daily Max avg.	14.98
October High	13.33
October Low	3.08
October avg.	9.57
October Daily Max avg.	11.04
Total avg. Temp	12.39
Highest Temp	21.99
Highest Date	7/22/2003
Lowest Temp	3.08
Lowest Date	10/30/2003
Logger Start Date	6/1/2003
Logger Finish Date	11/3/2003

Reach 15

Most of the streambed was dry with only limited stagnant pools. The largest pool in this reach was selected for fish sampling. Brown trout, Redside shiner, Speckled dace, Pumpkinseed, and Bridgelip suckers were sampled. A total of 632 fish were sampled, giving Reach 15 a total density of 1,472.5 fish/100m² (Table 14). Only one was a salmonid with a total density of 2.33 fish/100m². The age of the brown trout was estimated at 4+ (Table 17).

Reach 15 consisted of 20 transects totaling 1200 meters (Figure 7). Reach 15 (Table 11) had an average gradient of 1.0%, an average depth of 40.4 cm, an average wetted width of 6.2m, and 43.1% of the banks were considered stable. The majority of the substrate consisted of gravel (31.4%) and cobble (29.9%) with an average embeddedness of 43.3%. The stream habitat types for Reach 15 were: runs (58.4%), pools (28.9%), riffles (8.2%), and alcoves (4.5%). There were four primary pools with an average maximum depth of 88.8 cm and an average tail out depth of 42.5 cm.

Reach 16

Bridgelip suckers, speckled dace, pumpkinseed were sampled. A total of 120 fish were sampled, giving Reach 16 a total density of 27.62 fish/100m² (Table 14).

Habitat surveying for Reach 16 started at the Newhouse Lane Bridge and consisted of 20 transects totaling 1200 meters (Figure 7). Reach 16 (Table 11) had an average gradient of 1.3%, an average depth of 35.9 cm, an average wetted width of 6.5m, and 38.9% of the banks were considered stable. The majority of the substrate consisted of gravel (41.8%) and cobble (37.4%) with an average embeddedness of 40.5%. The stream habitat types for Reach 16 were: pools (12.1%) and runs (87.9%). There were four primary pools with an average maximum depth of 100.5 cm and an average tail out depth of 31.5 cm.

Reach 17

The majority of Reach 17 was dry with only occasional stagnant pools. The largest pool in the reach was selected for fish sampling. Bridgelip suckers, redside shiner, speckled dace, and pumpkinseed were sampled. A total of 265 fish were sampled, giving Reach 17 a total density of 222.13 fish/100m² (Table 14).

Reach 17 consisted of 20 transects totaling 1200 meters (Figure 7). Reach 17 (Table 11) had an average gradient of 1.0%, an average depth of 17.2 cm, an average wetted width of 2.8m, and 9.2% of the banks were considered stable. The majority of the substrate consisted of gravel (46.9%) and cobble (26.0%), with an average embeddedness of 54.8%. The stream habitat types for Reach 17 were: pools (92.9%) and runs (7.1%). There were five primary pools with an average maximum depth of 74.4 cm and an average tail out depth of 15.2 cm.

Reach 18

Due to the streambed being completely dry there was no fish sampling in this reach. Reach 18 consisted of 24 transects totaling 1440 meters (Figure 7). Habitat surveying (Table 11) had an average gradient of 1.1%. The majority of the substrate consisted of cobble (66.7%) and small gravel (16.7%).

Reach 19

Do to the streambed being completely dry there was no fish sampling in this reach. Habitat surveying for Reach 19 started behind Dennis Lovingtons House and consisted of 20 transects totaling 1200 meters (Figure 7). Reach 19 (Table 11) had an average gradient of .90%. The majority of the substrate consisted of sand (35.0%) and silt (30.0%).

Figure 8. **Reaches 15-19 of Tshimikain Creek**

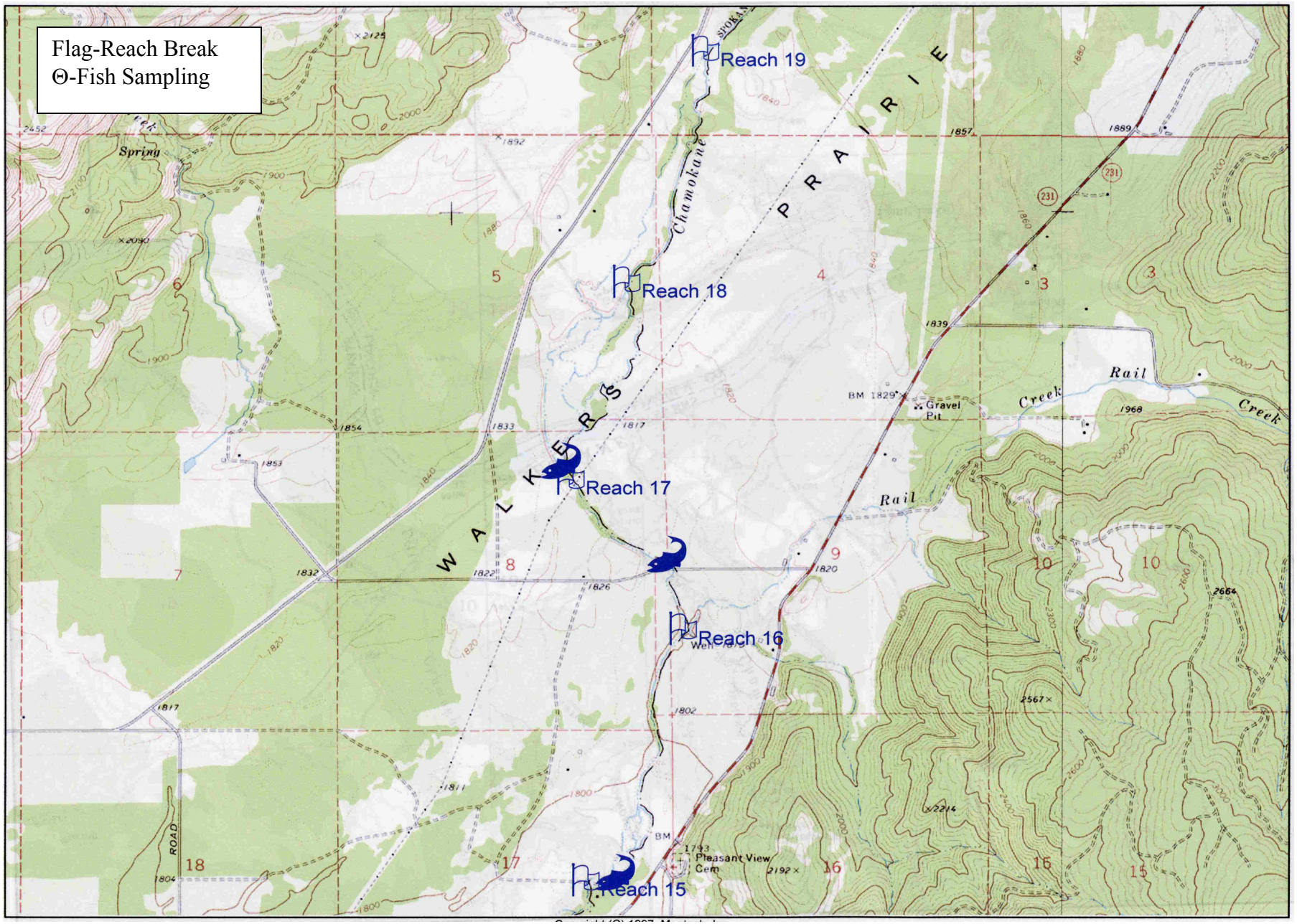

Table 11. Habitat Data for Reaches 15-19 of Tshimikain Creek, Summer 2003

Reach	**15**	**16**	**17**	**18**	**19**
Length (m)	1200	1200	1200	1440	1200
Mean Embeddedness	43.3	40.5	54.8	0	0
Min	10	10	20	0	0
Max	100	100	100	0	0
Pool-Riffle Ratio	2:01	0:00	0:00	0:00	0:00
LWD (#/100m)	0	0	0.3	0	0
Primary Pools (#/Km)	3.3	3.3	4.2	0	0
Mean Stream Width (m)	6.2	6.5	2.8	0	0
Mean Stream Depth (cm)	40.4	35.9	17.2	0	0
Mean Gradient (%)	1	1.3	1	1.1	0.9
Min	0.5	0.5	0.3	0.5	0.5
Max	1.5	2	2	1.5	1.5
Substrate (% Occurrence)					
Bedrock	0	0	0	0	0
Boulders	0	0	0	0	0
Rubble	0	0	0	0	0
Cobble	29.9	0	0	8.3	10.0
Gravel	31.4	37.4	26	66.7	25.0
Small Gravel	15.3	41.8	46.9	0	0
Sand	23.4	7	14.3	16.7	35.0
Silt	0	13.8	12.8	8.3	30.0
Muck	0	0	0	0	0
Habitat Types					
Pool (% Occurrence)	28.9	12.1	92.9	0	0
Mean Width (m)	8.9	7.8	7.4	0	0
Min Width (m)	6.4	7.8	5.6	0	0
Max Width (m)	10.6	8	9	0	0
Riffle (% Occurrence)	8.2	0	0	0	0
Mean Width (m)	10.2	0	0	0	0
Min Width (m)	10.2	0	0	0	0
Max Width (m)	10.2	0	0	0	0
Run (% Occurrence)	58.4	87.9	7.1	0	0
Mean Width (m)	5.6	6.7	4	0	0
Min Width (m)	2.2	2.2	4	0	0
Max Width (m)	9.7	11.8	4	0	0
Alcove (% Occurrence)	4.5	0	0	0	0
Mean Width (m)	5.6	0	0	0	0
Min Width (m)	5.6	0	0	0	0
Max Width (m)	5.6	0	0	0	0

Reach 20

Due to the streambed being completely dry there was no fish sampling in this reach. Reach 20 consisted of 20 transects totaling 1200 meters (Figure 8). Reach 20 (Table 12) had an average gradient of 1.8%. The majority of the substrate consisted of cobble (30.0%) and small gravel (45.0%).

Reach 21

Most of the streambed was dry with few pools of water left behind for fish to survive in. The largest pool in the reach was selected for fish sampling. Redside shiner, speckled dace, pumpkinseed, and largescale sucker were sampled. A total 314 fish were sampled, giving Reach 21 a total density of 281.24 fish/100m² (Table 14).

Reach 21 consisted of 26 transects totaling 1560 meters (Figure 8). Reach 21 (Table 12) had an average gradient of 1.3%, an average depth of 2.5 cm, an average wetted width of 0.3m, and 34.0% of the banks were considered stable. The majority of the substrate consisted of gravel (55.0%) and sand (45.0%), with an average embeddedness of 72.1%. The stream habitat types for Reach 21 were: pools (100.0%). There were two primary pools with an average maximum depth of 87.0 cm and an average tail out depth of 0.0 cm.

Reach 22

Most of the streambed was dry with few pools of water left behind for fish to survive in. The largest pool in the reach was selected for fish sampling. Bridgelip suckers, redside shiner, speckled dace, and pumpkinseed were sampled. A total of 332 fish were sampled, giving Reach 22 a total density of 34.96 fish/100m² (Table 14).

Reach 22 consisted of 22 transects totaling 1320 meters (Figure 8). Reach 22 (Table 12) had an average gradient of 1.3%, an average depth of 6.3 cm, an average wetted width of 0.9m, and 0.0% of the banks were considered stable. The majority of the substrate consisted of small gravel (51.9%) and sand (31.6%), with an average embeddedness of 56.14%. The stream habitat type for Reach 22 was pools (100.0%). There were no primary pools within this reach.

Figure 9. **Reaches 20-22 of Tshimikain Creek**

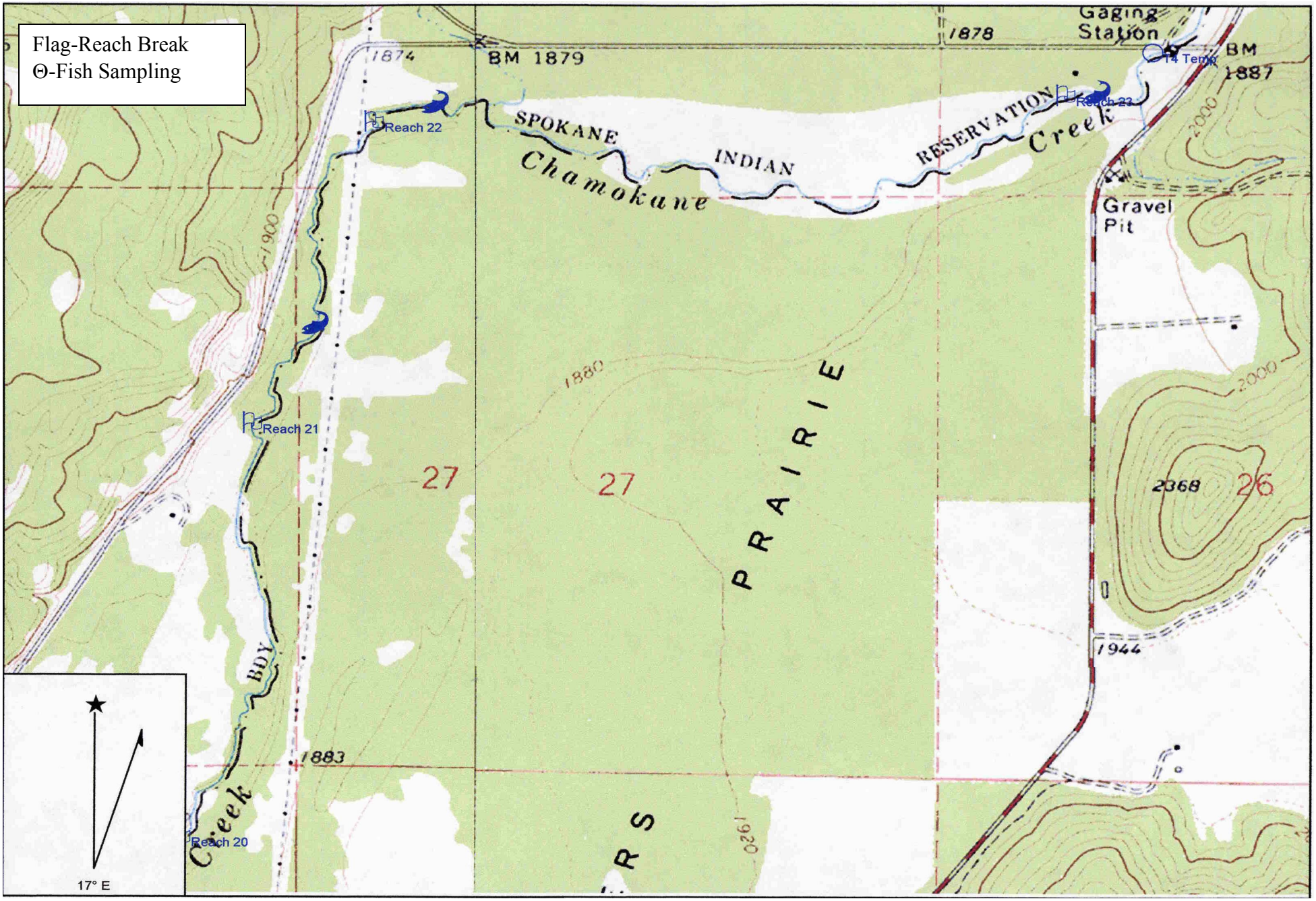

Table 12. Habitat Data for Reaches 20-22 of Tshimikain Creek, Summer 2003

Habitat			
Reach	**20**	**21**	**22**
Length (m)	1200	1560	1320
Mean Embeddedness	0	72.1	0
Min	0	20	0
Max	0	100	0
Pool-Riffle Ratio	0	0:00	0:00
LWD (#/100m)	0	0	0
Primary Pools (#/Km)	0	1.3	0
Mean Stream Width (m)		0.3	0.9
Mean Stream Depth (cm)	0	2.5	6.3
Mean Gradient (%)	1.8	1.3	1.3
Min	1	0.5	0.5
Max	2.5	3	2.5
Substrate (% Occurrence)			
Bedrock	0	0	0
Boulders	0	0	0
Rubble	15.0	0	0
Cobble	30.0	0	26
Gravel	0	55	16.6
Small Gravel	45.0	0	51.9
Sand	10.0	45	31.6
Silt	0	0	0
Muck	0	0	0
Habitat Types			
Pool (% Occurrence)	0	100	100
Mean Width (m)	0	4	4.7
Min Width (m)	0	3.6	3.1
Max Width (m)	0	4.4	5.9
Riffle (% Occurrence)	0	0	0
Mean Width (m)	0	0	0
Min Width (m)	0	0	0
Max Width (m)	0	0	0
Run (% Occurrence)	0	0	0
Mean Width (m)	0	0	0
Min Width (m)	0	0	0
Max Width (m)	0	0	0

Reach 23

Most of the streambed was dry with few pools of water left behind for fish to survive in. The largest pool in the reach was selected for fish sampling. Bridgelip suckers, redside shiner, speckled dace, and pumpkinseed were sampled. A total of 420 fish were sampled, giving Reach 23 a total density of 319.15 fish/100m² (Table 14).

Reach 23 consisted of 21 transects totaling 1260 meters (Figure 9). Reach 23 (Table 13) had an average gradient was less than 1%, an average depth of 17.5 cm, an average wetted width of 2.1m, and 0.0% of the banks were considered stable. The majority of the substrate consisted of sand (58.7%) and silt (30.2%), with an average embeddedness of 80.24%. The stream habitat type for Reach 23 was pools (100.0%). There were no primary pools within this reach.

A temperature logger was placed in Tshimikain Creek below the Rez Road Bridge (Table 14), which is recognized as T4. Due to the streambed going dry in August, we only have data from June 1st to July 18th. Tshimikain Creek (T4) had a daily maximum average for the month of June 19.67˚C and 20.65˚C in July. The highest temperature that was recorded for the month of June was 22.56˚C and 22.56˚C in July. The lowest temperature that was recorded for the month of June was 12.32˚C and 14.02˚C in July. Tshimikain Creek (T4) was within the seven day daily maximum Tribal Water Quality Standards from June 1st to 30th, but had exceedances from July 1st to the 18th (see figure 2).

Reach 24

Fish sampling will begin with Reach 24 in the summer of 2004. Habitat surveying for Reach 24 started at the bend before Rez Rd. Bridge and ended at the reservation boundary. Reach 24 consisted of 30 transects totaling 1800 meters (Figure 9). Reach 24 (Table 13) had an average gradient of 1.3%, an average depth of 25.0 cm, an average wetted width of 3.0m, and 75.6% of the banks were considered stable. The majority of the substrate consisted of sand (40.0%) and cobble (36.0%), with an average embeddedness of 77.7%. The stream habitat types for Reach 24 were: runs (59.3%) and pools (40.7%). There were three primary pools with an average maximum depth of 96.0 cm and an average tail out depth of 41.7 cm.

Figure 10. Reaches 23-24 of Tshimikain Creek

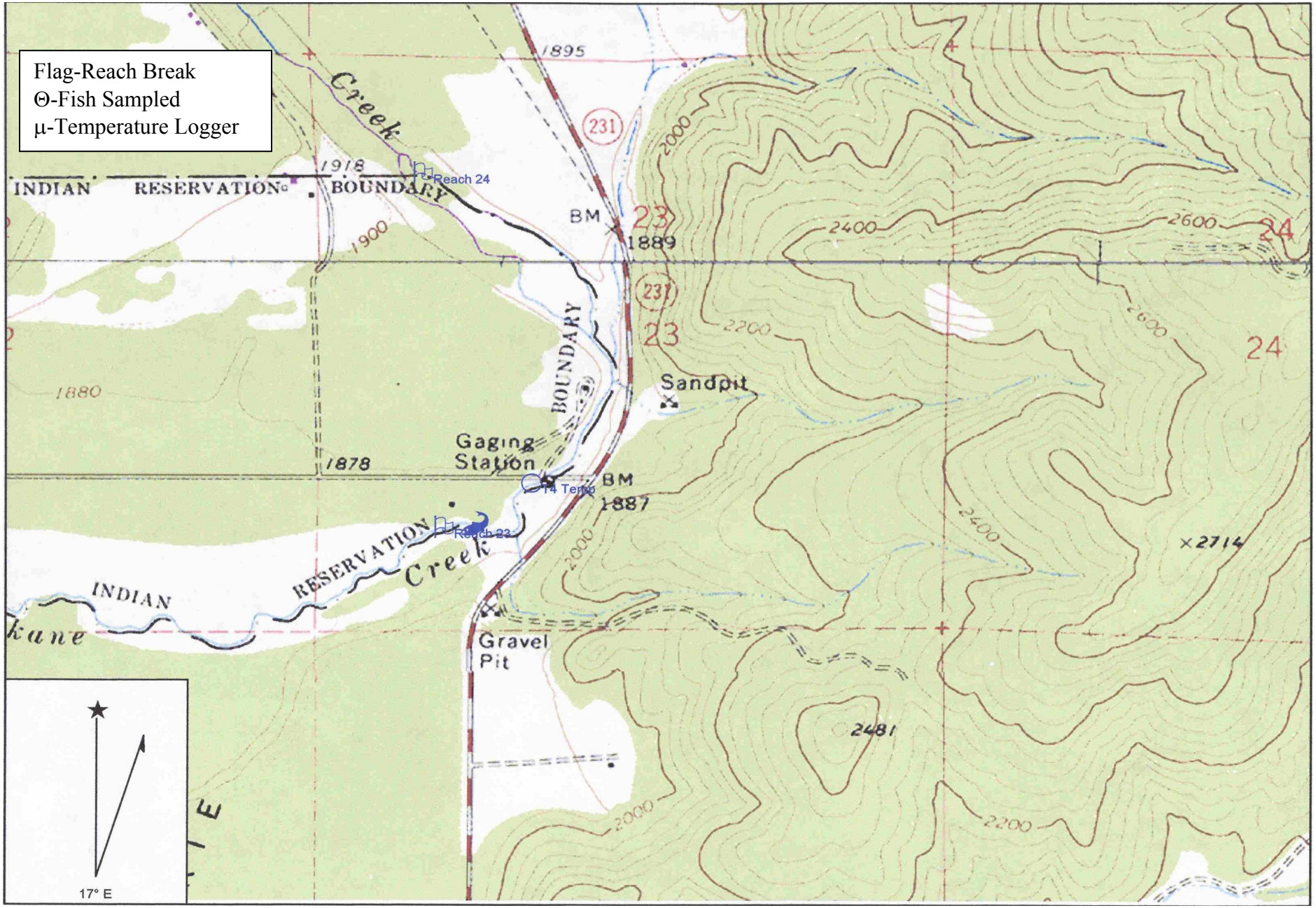

Table 13. Habitat Data for Reaches 23-24 of Tshimikain Creek, Summer 2003

Habitat		
Reach	**23**	**24**
Length (m)	1260	1800
Mean Embeddedness	0	77.7
Min	0	50
Max	0	100
Pool-Riffle Ratio	0:00	0:00
LWD (#/100m)	0	0
Primary Pools (#/Km)	0	1.7
Mean Stream Width (m)	2.1	3
Mean Stream Depth (cm)	17.5	25
Mean Gradient (%)	1	1.3
Min	1	1
Max	1	1.5
Substrate (% Occurrence)		
Bedrock	0	0
Boulders	0	0
Rubble	0	17
Cobble	0	36
Gravel	0	4.5
Small Gravel	11.1	2.5
Sand	58.7	40
Silt	30.2	0
Muck	0	0
Habitat Types		
Pool (% Occurrence)	100	40.7
Mean Width (m)	5.4	7.3
Min Width (m)	3.15	3
Max Width (m)	8.6	11.8
Riffle (% Occurrence)	0	0
Mean Width (m)	0	0
Min Width (m)	0	0
Max Width (m)	0	0
Run (% Occurrence)	0	59.3
Mean Width (m)	0	4.8
Min Width (m)	0	2
Max Width (m)	0	9.2

Table 14. Temperature Data for Tshimikain Creek, Summer 2003

Stream	**T4**
June High	22.56
June Low	12.32
June avg.	17.52
June Daily Max avg.	19.67
July High	22.56
July Low	14.02
July avg.	18.22
July Daily Max avg.	20.65
August High	0
August Low	0
August avg.	0
August Daily Max avg.	0
Total avg. Temp	17.41
Highest Temp	22.56
Highest Date	6/28/03
Lowest Temp	12.32
Lowest Date	6/7/03
Logger Start Date	6/1/03
Logger Finish Date	8/31/03

Discussion for Reaches 1-23 Combined

The following section is a combined effort for reaches one through 23. Non-salmonid species were put into a length-frequency distribution chart to visualize the different age structures for each species.

Pumpkinseeds

The pumpkinseed (nonnative to Washington State) in general lives in cooler waters than other members of the genus. Pumpkinseeds prefer quiet, clear water where the bottom has some organic debris, aquatic vegetation, and tend to inhabit large dense vegetation (Carlander, Kenneth D. 1977). Tshimikain Creek appears to provide adequate habitat for pumpkinseed year-round. In drought years, Tshimikain Creek will subsurface above the Ford Bridge, leaving pockets of water for fish to survive in while waiting for the flows to return to Tshimikain Creek. Pumpkinseed may be entering into Tshimikain Creek from Swamp Creek. At the bottom of Swamp Creek there is a large slough that was created from a historical river bend and appears to provide good pumpkinseed habitat.

The pumpkinseed that were shocked in Reach 1 led us to believe that they were coming out of the Spokane Arm until pumpkinseeds were sampled above Tshimikain Falls.

A total of 1,787 pumpkinseed (Table 12), were sampled from Reaches one through 23. This is nearly seventy-four times more than what Al Scholz saw in 1985 (Personal communication, 2004). The length-frequency distribution for pumpkinseed (Figure 7) shows evidence of multiple age classes (Wydoski and Whitney, 2003). Figure 7 shows a steady increase in sizes, except for size class 31-40 mm, up to 60 mm and a steady decrease to 100 mm. These size classes represented 95.97% of the population. An increase for the 110 mm size fish representing another age class, with the rest of the fish sampled having a steady decrease down to 140 mm. These size classes represented 4.03% of the population that had been sampled. This strongly indicates multiple age classes, although it is still unknown if spawning occurs in Tshimikain Creek.

Bridgelip Suckers

Bridgelip suckers (native to Washington State) can be found anywhere from inshore of the main river current (fry) to deep pools (subadults and adults) depending on the age of the fish (Wydoski and Whitney, 1979). A total of 470 bridgelip suckers (Table 12) were sampled in Reaches one through 23. The length-frequency distribution (Figure 8) identifies multiple age classes similar to those in Wydoski and Whitney 2003. The first spike size class was 41-60 mm, which represented 27.66% of the fish sampled, while the next spike 81-90 mm represented 10.00% of the fish sampled. The next spike is at 141-150 mm which represented 5.74% of the fish sampled. The next two spikes were 161-170 mm and 191-200 mm representing 4.26% and 1.28% of the fish sampled respectively. The data suggest there is a natural reproducing population of bridgelip suckers in Tshimikain Creek.

Redside Shiner

Redside shiners (native to Washington State) are found in a variety of habitats where the current is slow to moderate. They are found in rivers, streams, sloughs, irrigation ditches, ponds, and lakes where usual summer water temperatures are between 6.0˚C and 24.0˚C. The fish move about in schools and tend to occupy habitats with aquatic vegetation when in shallow areas (Wydoski and Whitney, 2003). A total of 235 redside shiners (Table 12), were sampled in Reaches one through 23. The length-frequency distribution chart revealed many spikes throughout the size classes. The size class 21-30 mm represented 32.34% of the total fish sampled. The majority of the fish sampled were between 11-40 mm in length representing 65.53% of the fish. While the next spike in the graph was 51-60 mm representing 4.68% of the fish sampled. The next spike in the graph was 71-80 mm representing 8.94% of the fish sampled, with a steady decrease in the size classes all the way to 110 mm. The data suggests there is a natural reproducing population of redside shiners in Tshimikain Creek.

Speckled Dace

Speckled Dace (native to Washington State) inhabit the cooler waters of streams, with currents ranging from slow to swift, and sometimes they are found in lakes. Generally speckled dace are found in shallow water less than 3 feet deep (Wydoski and Whitney, 1979). A total of 570 speckled dace (Table 12), were sampled in Reaches one through 23. The length-frequency distribution (Figure 10) identifies multiple age classes (Wydoski and Whitney, 2003). The majority of the fish sampled were anywhere from 31 mm to 60 mm, representing 74.38% of the population, which could represent two different age groups (Wydoski and Whitney, 2003). While the size classes 61 mm to 100 mm had a steady drop in the total fish sampled. A speckled dace that is 91-100 mm could be 4 to 5 years in age according to (Wydoski and Whitney 2003) and suggests they are naturally reproducing in Tshimikain Creek.

Largescale Suckers

Largescale suckers (native to Washington State) are often abundant at the mouths of streams entering lakes. They can also be found in backwaters of streams and shallow areas of lakes in spring (Wydoski and Whitney, 2003). A total of 227 largescale suckers (Table 12) were sampled in Reaches one through 23. The length-frequency distribution for the largescale suckers suggest multiple age groups (Figure 11). The size class 31-40 mm made up 27.75% of the fish sampled. While the next spike in the figure was 81-90 mm represented 15.86% of the total fish sampled. The size class 141-150 mm made up 5.29% and the largest fish sampled was 441-450 mm in length. The data strongly suggest there is a natural reproducing population of largescale suckers in Tshimikain Creek.

Table 15. Total Non-Salmonid Fish sampled by Size Categories in Millimeters

Pumpkin Seed	Fish Sampled
0-10	
11-20	
21-30	193
31-40	143
41-50	306
51-60	397
61-70	354
71-80	200
81-90	85
91-100	37
101-110	39
111-120	26
121-130	5
131-140	2
141-150	0
151-160	
161-170	
Total	1787

Bridgelip Suckers	Fish Sampled
0-10	
11-20	
21-30	9
31-40	19
41-50	68
51-60	62
61-70	35
71-80	26
81-90	47
91-100	44
101-110	24
111-120	22
121-130	21
131-140	7
141-150	27
151-160	15
161-170	20
171-180	15
181-190	1
191-200	6
201-210	2
Total	470

Largescale Suckers	Fish Sampled
0-10	
11-20	
21-30	
31-40	63
41-50	8
51-60	11
61-70	4
71-80	14
81-90	36
91-100	22
101-110	11
111-120	2
121-130	3
131-140	10
141-150	12
151-160	8
161-170	7
171-180	7
181-190	2
191-200	
221-230	1
371-380	2
381-390	1
391-400	1
401-410	
411-420	1
421-430	
431-440	
441-450	1
Total	227

Speckled Dace	Fish Sampled
0-10	
11-20	
21-30	
31-40	145
41-50	124
51-60	155
61-70	77
71-80	47
81-90	17
91-100	5
Total	570

Red-side Shiners	Fish Sampled
0-10	
11-20	29
21-30	76
31-40	49
41-50	2
51-60	11
61-70	8
71-80	21
81-90	17
91-100	13
101-110	9
Total	235

Figure 11. Length-Frequency Distribution Chart for Pumpkinseed

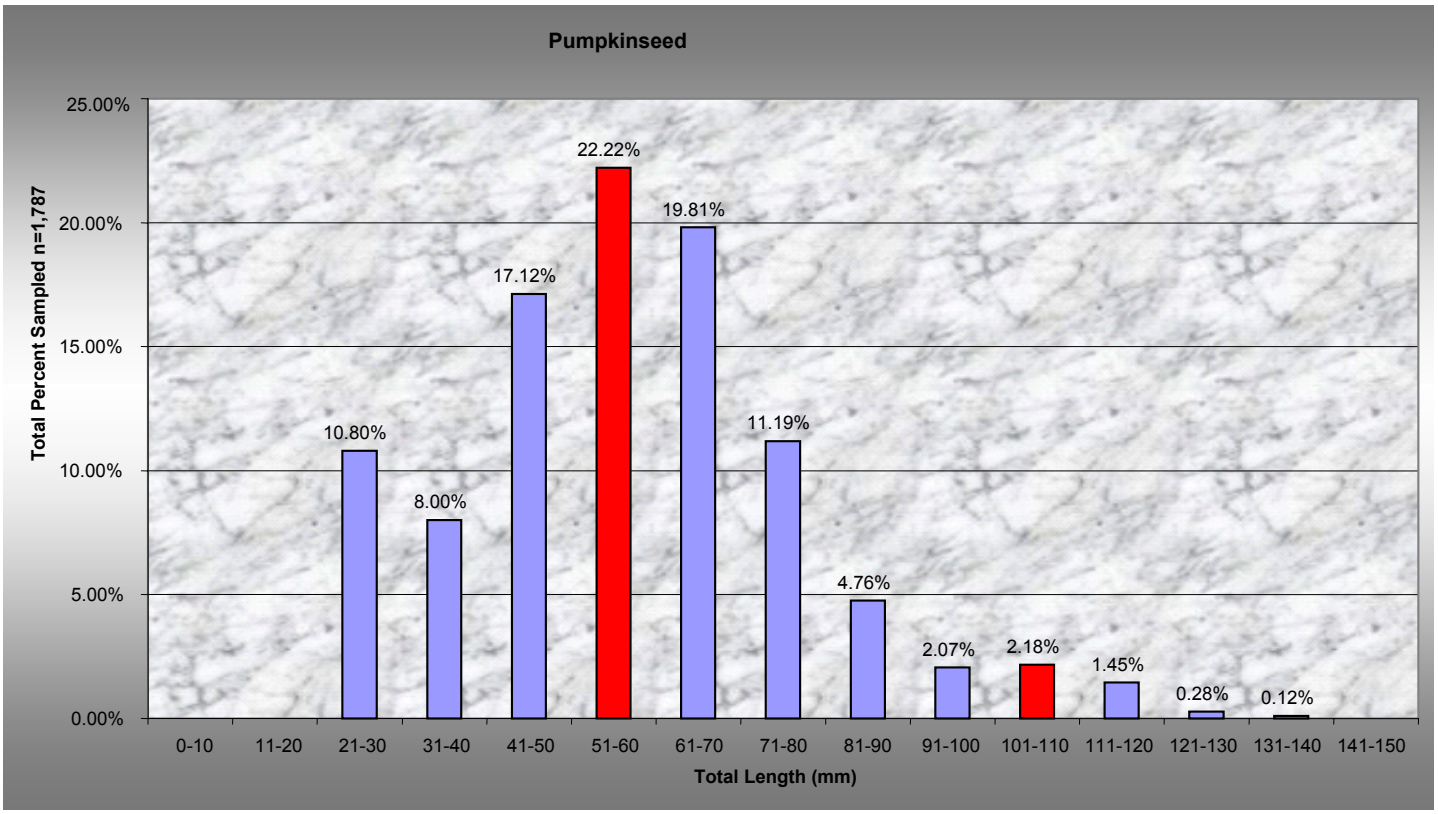

Figure 12. Length-Frequency Distribution Chart for Bridgelip Suckers

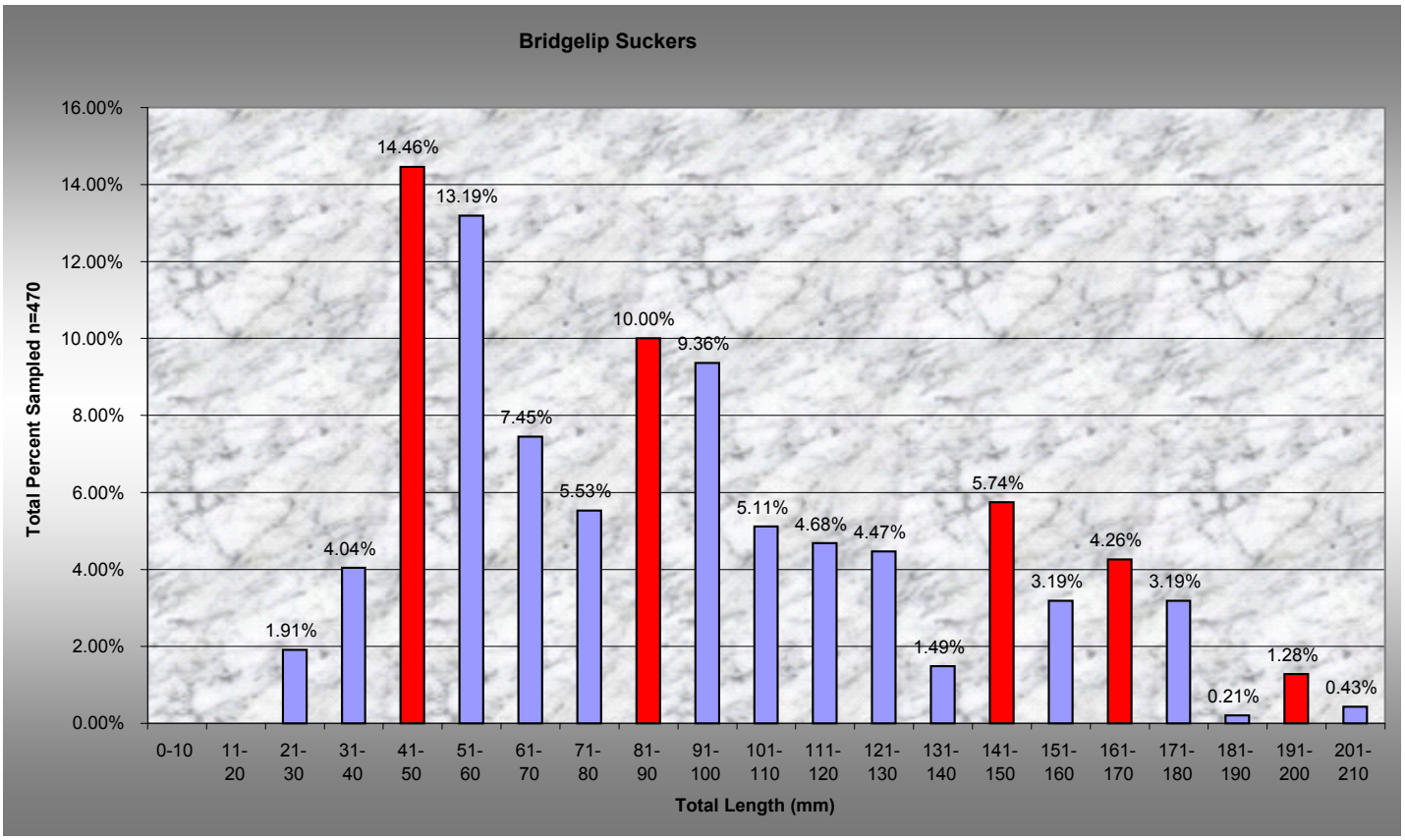

Figure 13. Length-Frequency Distribution Chart for Redside Shiners

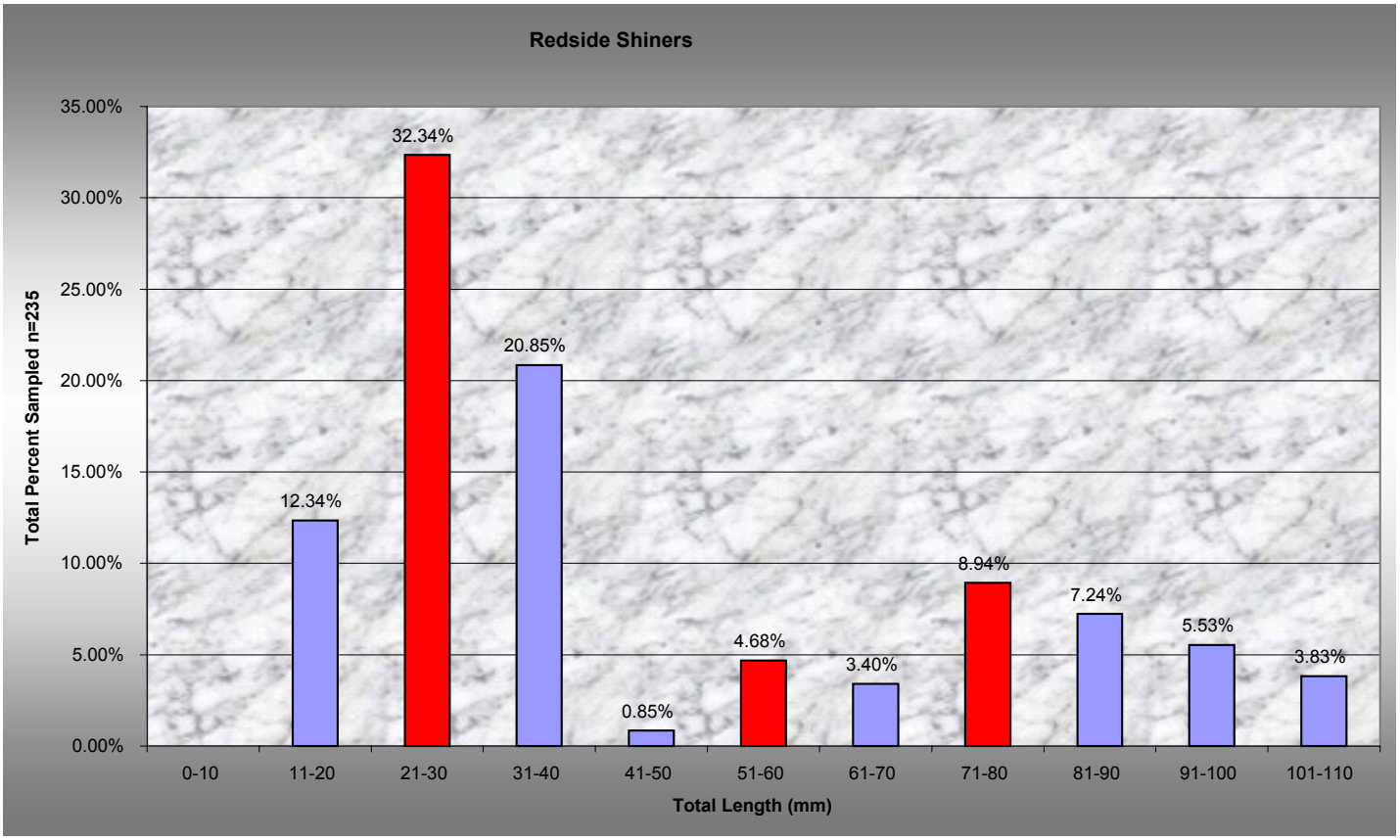

Figure 14. Length-Frequency Distribution Chart for Speckled Dace

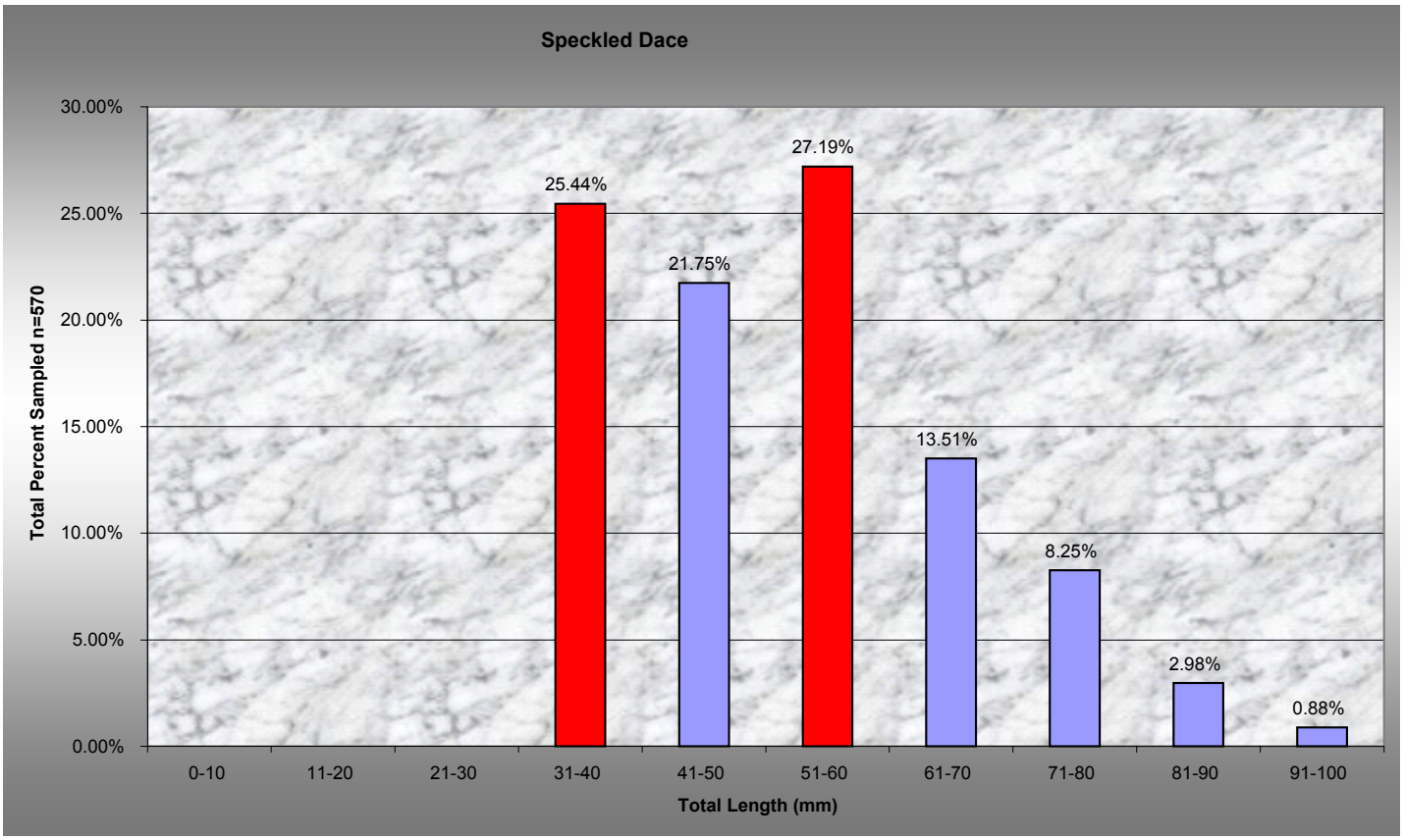

Figure 15. Length-Frequency Distribution Chart for Largescale Sucker

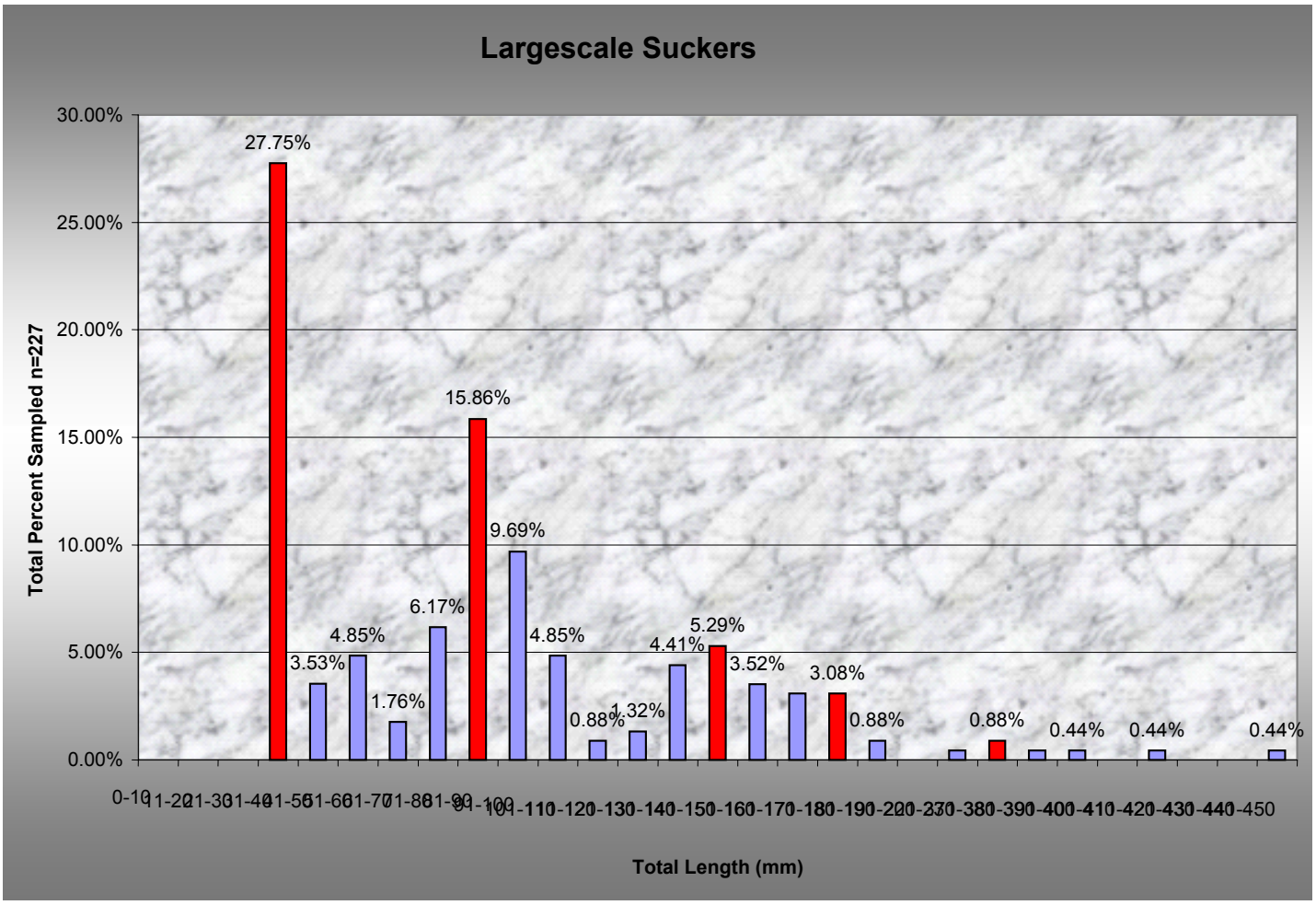

Table 16. Shocking Data for Fish Sampling, in Reaches 1-23 of Tshimikain Creek, Summer 2003

							Depletion	Calculation
Reaches	Method	Area(m²)	Total Fish Sampled	Total Density (#/100m²)	Total Salmonids	Salmonid Density (#/100m²)	Pop. Est. #/100m²	Lower/Upper Pop. Conf. inter.
1	Shock	583.42	56	9.6	37	6.34	30.95	36.00/49.04
1-A	Shock	583.42	164	28.11	12	2.05	10.80	13.00/15.19
2	Shock	942.1	19	2.02	4	0.42	0.91	4.00/7.08
3	Shock	712.57	7	0.98	6	0.84	4.78	6.00/7.21
4	Shock	644.77	19	2.95	17	2.64	9.73	17.00/30.26
5	Shock	580.3	14	2.41	14	2.41	12.69	14.00/15.30
6	Shock	696.91	22	3.16	15	2.15	13.03	15.00/16.96
7	Shock	799.2	22	2.75	20	2.5	17.78	20.00/22.21
8	Shock	554.63	73	13.16	37	6.67	35.17	37.00/38.82
9	Shock	652.85	86	13.17	33	5.05	25.45	31.00/44.54
10	Shock	738.26	199	26.96	52	7.04	50.06	52.00/55.93
11	Shock	460.37	325	70.6	43	9.34	35.00	43.00/68.99
12	Shock	320.78	266	82.92	98	30.86	96.37	99.00/107.62
13	Shock	411.76	525	127.5	28	6.8	25.74	28.00/30.25
15	Shock	42.92	632	1472.5	1	2.33	0	0
16	Shock	434.39	120	27.62	0	0	0	0
17	Shock	119.3	265	222.13	0	0	0	0
21	Shock	111.65	314	281.24	0	0	0	0
22	Shock	949.65	332	34.96	0	0	0	0
23	Shock	131.6	420	319.15	0	0	0	0

Table 17. Salmonid Size Categories for Reaches 1-15 in Millimeters for Tshimikain Creek

Species	Rainbow Trout						Brown Trout						Brook Trout						Mountain Whitefish
Size	0-65 mm	65-110 mm	111-150 mm	151-200 mm	201-305 mm	>305 mm	0-65 mm	65-115 mm	116-165 mm	166-210 mm	211-305 mm	>305 mm	0-65 mm	65-115 mm	116-165 mm	166-210 mm	211-305 mm	>305 mm	0-100mm
Reaches																			
1	1	0	0	0	2	0	0	0	2	0	14	3	0	1	0	0	0	0	29
2	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	2	0	1	0	3	0	0	0	0	0	0	0
4	5	1	0	0	2	0	0	2	0	1	4	2	0	0	0	0	0	0	0
5	1	0	0	0	0	0	7	1	0	1	2	2	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	3	0	2	5	5	0	0	0	0	0	0	0
7	0	0	0	0	0	1	5	1	0	1	10	2	0	0	0	0	0	0	0
8	0	3	0	4	1	0	0	14	0	8	4	3	0	0	0	0	0	0	0
9	0	0	0	0	0	0	1	8	3	7	7	6	0	0	1	0	0	0	0
10	0	0	0	1	2	0	0	30	0	9	11		0	0	0	0	0	0	0
11	0	2	1	0	0	1	0	14	5	10	3	7	0	0	0	0	0	0	0
12	4	20	1	37	17	3	0	0	1	3	8	5	0	0	0	0	1	0	0
13	0	3	0	4	3	2	0	0	0	2	4	8	0	0	0	2	0	0	0
14	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Water Quality and Flows

The flow and water quality data (Table 15) is an average from January 1 through August 31. Tshimikain is a loosing reach from T4 at Rez Rd. to T3 at Ford. The stream flow at T3 is only 63.55% of what are average was for T4. Station T2 lies below both the Ford Hatchery and the Spokane Tribal Hatchery and it shows a large increase in flow from their discharges back into Tshimikain Creek. Station T2 shows an increase of 59.33% from the flow at T4 and an increase of 265.23% from T3. Using the flow data from the USGS station, (located below Tshimikain Falls), we have an increased flow of 282.63% at T1 then at T4. T1 showed an increase of 444.74% flow over T3 and an increase of 59.64% over T2. The water quality data shows that all the sampling stations stayed within these percentages throughout the year. Tshimikain Creek will exceed the seven day maximum average of 18.5˚C periodically during the summer months.

Table 18. Water Quality and Flow Averages from June to August 2003

Streams	Temp ˚C	D.O. mg/l	Cond. µs/cm	pH	Flow ft^3/s
T1	9.52	11.08	305.94	8.42	82.5
T2	9.83	11.58	275.81	8.17	49.2
T3	8.27	11.34	160	7.85	18.55
T4	8.69	10.63	148.94	7.69	29.19

4. Discussion

Tshimikain Creek has excellent species diversity, while flow (reaches 1-8), and basic water quality is sufficient to support fish. In the springtime, Tshimikain Creek has a high runoff (766 ft^3/sec, in 2002) that usually does not last more than a couple of weeks. Most of Tshimikain drainage from the town of Ford heading north to Rez Rd. has extensive unstable banks. A large amount of sediment is swept downstream each spring while the runoff also creates more unstable banks. In March 1999, a peak bed load was calculated at 218 tons of sediment per day (Kessler and Schumaker 2000). Extensive channel migration occurs above the bedrock formation at Tshimikain Falls that inhibits the channel from becoming deeper. Beaver dams are more prevalent north of the Ford Bridge. Beavers create good habitat for young and adult species of fish, while temporarily slowing the transport of sediment although stream temperatures and evaporation tend to increase in slow moving pools. During the spring runoff, the previous year's beaver dams are usually broken up under the high flows.

Tshimikain Creek supports two fish hatcheries: the Spokane Tribal Hatchery and the Ford Hatchery (WDFW). Both hatcheries draw from spring water and well water below Ford. The hatcheries provide additional flow and nutrients for which resident fish and macro-invertebrates appear to benefit from. Caddis fly larvae are noticeable, larger directly below the hatchery inflows. As observed in the data, Tshimikain Creek maintains an adequate flow (Reaches one through 11) and produces reasonable habitat for fish below the Ford Bridge year round. Tshimikain is home to four species of salmonids: rainbow trout, brown trout, brook trout, and mountain whitefish. Rainbow trout and mountain whitefish are the only native salmonids. Various spring, summer, and fall spawners utilize Tshimikain Creek up to the falls from the Little Falls pool. The data strongly suggest that mountain whitefish spawn below the falls. No mountain whitefish were sampled above the falls while rainbow trout, brown trout, and brook trout were sampled up to Reach 15. In previous years, land locked salmon that washed down from Coeur d'Alene Lake have been observed building redds up to Tshimikain Falls (Crossley, personal communication). The Tribe is uncertain if these completed redds are producing viable offspring at this time. The brown trout population is the strongest in Tshimikain

Creek. The largest salmonid density (30.86/100m²) came from Reach 12 which is located above the hatcheries. Tshimikain Creek is large enough that it should be sustaining a larger density of salmonids. The popular fishery in Tshimikain Creek and no catch limit may explain the low densities of adult fish. The majority of the young fish of the year, or even older fish, could be swept down stream to the Spokane River during the spring run off or are migrating downstream due to the lack of flow. A large number of fish were sampled (Reaches one through 23) that were estimated to be between 1 and 2 years old. The data strongly suggest that there is a natural reproducing population, but was lacking the larger age groups.

Sampling the large numbers of pumpkinseed could mean that a private landowner's pond above the reservation had been affected by the spring run off in the past. This could account for the difference Al Scholz saw in 1985 from what we have seen this year (Al Scholz, personal communication).

Above the Ford Bridge Tshimikain Creek will sub-surface throughout Reaches 14 through 24. The data shows high concentrations of fish in these reaches due to their being concentrated into isolated pools. The only pool that produced a salmonid was located in Reach 15. The lack of salmonids could be due to migration downstream with declining flows, water quality, temperature increases, or predation. If Tshimikain Creek remains dewatered for a long period of time, it is expected that thousands of fish will die.

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