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Methow and Columbia Rivers Studies, Washington—Summary of Data Collection, Comparison of Database Structure and Habitat Protocols, and Impact of Additional PIT Tag Interrogation Systems to Survival Estimates, 2008–2012

Open-File Report 2014–1016

U.S. Department of the Interior
U.S. Geological Survey

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2014

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per minute (ft/min)	0.3048	meter per minute (m/min)
foot per hour (ft/hr)	0.3048	meter per hour (m/hr)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per year (ft/yr)	0.3048	meter per year (m/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
cubic foot per day (ft^3/d)	0.02832	cubic meter per day (m^3/d)

Multiply	By	To obtain
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
gallon per day per square mile [(gal/d)/mi^2]	0.001461	cubic meter per day per square kilometer [(m^3/d)/km^2]
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
million gallons per day per square mile [(Mgal/d)/mi^2]	1,461	cubic meter per day per square kilometer [(m^3/d)/km^2]
inch per hour (in/h)	0 .0254	meter per hour (m/h)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
mile per hour (mi/h)	1.609	kilometer per hour (km/h)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8.$$

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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By Kyle D. Martens, Wesley T. Tibbits, Grace A. Watson, Michael A. Newsom, and Patrick J. Connolly

Executive Summary

The U.S. Geological Survey (USGS) received funding from the Bureau of Reclamation (Reclamation) to provide monitoring and evaluation on the effectiveness of stream restoration efforts by Reclamation in the Methow River watershed. This monitoring and evaluation program is designed to partially fulfill Reclamation's part of the 2008 Biological Opinion for the Federal Columbia River Power System that includes a Reasonable and Prudent Alternative (RPA) to protect listed salmon and steelhead across their life cycle. The target species in the Methow River for the restoration effort include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*), which are listed as threatened or endangered under the Endangered Species Act.

Since 2004, the USGS has completed two projects of monitoring and evaluation in the Methow River watershed. The first project focused on the evaluation of barrier removal and steelhead recolonization in Beaver Creek with Libby and Gold Creeks acting as controls. The majority of this work was completed by 2008, although some monitoring continued through 2012.

The second project (2008–2012) evaluated the use and productivity of the middle Methow River reach (rkm 65–80) before the onset of multiple off-channel restoration projects planned by the Reclamation and Yakama Nation. The upper Methow River (upstream of rkm 80) and Chewuch River serve as reference reaches and the Methow River downstream of the Twisp River (downstream of rkm 65) serves as a control reach. Restoration of the M2 reach was initiated in 2012 and will be followed by a multi-year, intensive post-evaluation period.

This report is comprised of three chapters covering different aspects of the work completed by the USGS. The first chapter is a review of data collection that documents the methods used and summarizes the work done by the USGS from 2008 through 2012. This data summary was designed to show some initial analysis and to disseminate summary information that could potentially be used in ongoing modeling efforts by USGS, Reclamation, and University of Idaho. The second chapter documents the database of fish and habitat data collected by USGS from 2004 through 2012 and compares USGS habitat protocols to the Columbia Habitat Monitoring Program (CHaMP) protocol. The third chapter is a survival analysis of fish moving through Passive Integrated Transponder (PIT) tag interrogation systems in the Methow and Columbia Rivers. It examines the effects of adding PIT tags and/or PIT tag interrogation systems on survival estimates of juvenile steelhead and Chinook salmon.

Chapter 1. Pre-Treatment Monitoring for Stream Restoration in the Methow River Watershed, Washington (2008–2012)—Summary of Data Collection

By Kyle D. Martens, Wesley T. Tibbits, Grace A. Watson, Patrick J. Connolly, and Michael A. Newsom

Introduction

The U.S. Geological Survey (USGS) has been funded by the Bureau of Reclamation (Reclamation) to provide pre-treatment assessment of the “M2” Reach and pre/post assessment of the Beaver Creek project areas that are in the Methow River watershed, a watershed of the Columbia River in the Upper Columbia River Basin. This monitoring and evaluation program was funded to document Reclamation’s effort to partially fulfill the 2008 Federal Columbia River Power System Biological Opinion (BiOp) (National Oceanographic and Atmospheric Administration, Fisheries Division, 2003). This Biological Opinion includes Reasonable and Prudent Alternatives (RPA), to protect listed salmon and steelhead across their life cycle. Species of concern in the Methow River include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR summer steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*) that are listed under the Endangered Species Act (ESA).

Most of the work done by the USGS since 2004 has focused around three phases of work. The first phase of work started in 2004 and has continued through 2012. The first phase involved the evaluation of stream colonization and fish production in Beaver Creek following the modification of several water diversions (2000–2006) that were acting as barriers to upstream fish movement (Bureau of Reclamation, 2004a, 2004b, 2004c, 2005; Martens and Connolly, 2010). The second phase initiated in 2008 focuses on the evaluation of the M2 reach (rkm 66–80) of the mainstem Methow River prior to restoration actions planned by Reclamation and Yakama Nation. The third phase of work has been to help with the development and to provide data for modeling efforts. Restoration actions were initiated in 2012 (Whitefish Island side channel, also referred to as SC3) and are planned to continue over the next several years. The M2 study was designed to help understand the inter-relationships between stream habitat and life history of various fish species, to explain potential success, or limitations in response to restoration actions. To help document changes derived by restoration, two reference reaches (Upper Methow between rkm 85–90, and Chewuch River between rkm 4–11) were identified based on relative lack of disturbance, proximity to the restoration reach, and relative unconfined geomorphology. A control reach (Lower Methow between rkm 57–64, also referred to as “silver reach”) was identified based on its similar disturbance as the reference reach, proximity to the restoration reach, and relative unconfined geomorphology.

This report compiles and summarizes the entire range of data collected by the USGS from 2008 through 2012 under the first two phases of work. The data contained in this report will guide the development and testing of the Aquatic Trophic Production (ATP) modeling group, which is a collaboration between the USGS, University of Idaho, and Reclamation (funded by Reclamation). The ATP model is being designed to predict responses in periphyton, invertebrate, and juvenile fish production to potential changes in stream conditions, such as the addition of wood structures in streams, side channel and flood plain connection, barrier removal, climate change, and other changes that could affect stream productivity. The modeling group plans to update and test the model with data derived by these projects. The modeling effort is expected to inform the group of data gaps, sensitivity of key variables, potential fish response, and the ability to detect the fish response based on variability of the data.

Study Area

The Methow River is a fifth-order stream in north-central Washington that drains into the Columbia River at river kilometer (rkm) 843 in the Upper Columbia River Basin. The Methow River has two major tributaries, the Twisp River entering the Methow River at rkm 66 near the town of Twisp, Washington, and the Chewuch River that enters the Methow River at rkm 80 near the town of Winthrop, Washington. Anadromous fish travel through nine Columbia River dams between the Methow River and Pacific Ocean. Migrating juvenile passive integrated transponder (PIT)-tagged salmonids have the potential to be detected on PIT-tag interrogation systems (PTIS) located at Rocky Reach, McNary, John Day, and Bonneville Dams and in a PIT-tag trawl in the Columbia River Estuary. Adult salmonids have the potential to be detected on PTIS located at Bonneville, John Day, McNary, Priest Rapids, Rocky Reach, and Wells Dams. In addition to ESA-listed bull trout, Upper Columbia summer steelhead, and Upper Columbia spring Chinook, the Methow has anadromous populations of summer Chinook, coho, and Pacific lamprey (*Entosphenus tridentatus*). The watershed also contains several resident salmonids species that include, but are not limited to mountain whitefish (*Prosopium williamsoni*), westslope cutthroat (*O. clarki*), and brook trout (*Salvelinus fontinalis*).

Methods

Habitat Surveys.—Two types of habitat surveys were deployed to characterize fish habitat in the Methow River watershed: (1) lateral margins and bank survey, and (2) habitat type and unit. The lateral margins and bank survey, designed by the USGS and completed by the U.S. Forest Service personnel, was designed to categorize the bank units (BU) of the M2 and Lower Methow reaches. The left and right banks of the Methow River were categorized into seven types of bank units—undercut bank, high slope bank (>45°), medium slope bank (>20°–45°), low slope bank (≤20°), side channel, alcove, rip rap, or other. Each bank unit's length (m) was measured and water depth was measured 1 m from the water's edge. Vertical height (m) also was measured from water's edge to bankfull and bankfull to the first terrace. Substrate (bedrock, boulder, cobble gravel, and sand/silt), bank vegetation (grass, shrubs, hardwood trees, conifer trees, and other), and fish habitat metrics (large woody debris, small woody debris, and substrate) also were recorded. Substrate included five size classes—bedrock (>4,000 mm), boulder (>250–400 mm), cobble (>64–250 mm), gravel (>2–64 mm), and sand/silt (0.01–2 mm). The number of wood jams (five or more pieces of wood debris) and pieces of woody debris were categorized by three diameters (10–15, >15–30, and >30 cm) and length classes (1–3, >3–6, and >6 m). Global Positioning System (GPS) coordinates were recorded at the start and end point for each bank unit.

Habitat unit surveys were completed prior to fish population surveys. These surveys were designed to help delineate habitat unit strata for assessing fish populations. Field personnel identified habitat unit types (for example, pools, glides, riffles, and side channels). Each habitat unit was measured for length (m), average width (m), average depth (cm), and maximum depth (cm). For pools, a visual estimate of total cover was made, and subdivided into types of instream cover (large woody debris, small woody debris, substrate, undercut bank, or other) and overhead cover (large woody debris, small woody debris, or other).

Fish Sampling and Workup.—The USGS used four methods (electrofishing, netting, snorkeling, and a screw trap) to assess fish populations in the Methow River watershed from 2008 through 2012. Electrofishing was used in three types of sampling—population assessments, point abundance surveys, and simple fish capture by backpack or raft electrofishing. In areas too deep to effectively sample with electrofishing, we used a combination of gill nets or seine nets with snorkeling. A screw trap was installed at the mouth of Chewuch River to collect and tag moving juvenile fish. The trap typically operated from March through November and was checked daily. We installed and maintained a network of PTIS throughout the watershed to assess movement of PIT tagged fish and to estimate survival (fig. 1-1). This network combined with PTIS installed and maintained by the Washington Department of Fish and Wildlife (WDFW), provided extensive coverage of tributaries and mainstem areas.

All fish were measured for fork length to the nearest millimeter, weighed to the nearest 0.1 g and inspected for external signs of disease. We tagged most target fish 65 mm or longer with a 12-mm PIT tag and fish 55–65 mm with an 8-mm PIT tag. Our PIT tagging procedures followed the guidelines outlined by Columbia Basin Fish and Wildlife Authority (1999). Large fish (>200 mm) were tagged in the pelvic girdle or dorsal sinus to prevent tag loss during spawning events. All PIT tag and recapture data were submitted to the Columbia Basin PIT Tag Information System (PTAGIS) database that is administered by USGS personnel for the Pacific States Marine Fisheries Commission.

The two runs of Chinook salmon both rear in the M2 and Lower Methow reaches as juveniles, causing difficulties in separating summer and spring run fish. Spring Chinook mostly spawn in the upper watersheds (upstream of rkm 71) and tributaries of the Methow River watershed, but can rear throughout the watershed. Summer Chinook mostly spawn and rear downstream of rkm 80 (Northwest Power and Conservation Council, 2004) creating the potential for overlapping populations downstream of rkm 80. Typically, spring Chinook juveniles will migrate as yearling fish although most summer Chinook migrate as subyearlings (Miller and others, 2011), however Myers and others (1998) estimated that 12–42 percent of summer Chinook migrate as yearlings in the Upper Columbia. It is currently unknown what percentage of Chinook found in seasonally disconnected side channels of the Methow River are from spring or summer Chinook, because it is not known if summer subyearlings move prior to seasonally disconnection side channels losing their connection to the mainstem.

For all population assessments conducted by backpack electrofishing, we stratified the sampling effort based on habitat unit types (for example, pools, glides, riffles, and side channels) and shocked a systematic sample of units within each habitat type. In cases where a habitat unit was unable to be sampled, the next unit of the same strata was sampled. Habitat units selected for electrofishing were blocked off with nets to insure no immigration or emigration of fish. A backpack electrofisher was used to conduct two or more passes (a maximum of six) using the removal-depletion methodology (White and others, 1982), as described in Martens and Connolly (in press). The field guides of Connolly (1996) were used to determine the number of passes necessary to achieve the desired level of precision in the population abundance estimate (coefficient of variation [CV] < 25 percent for young-of-year salmonids and CV < 12.5 percent for age-1 or older salmonids) of each sampling unit for each salmonid species (bull trout, brook trout, Chinook salmon, cutthroat trout, and steelhead/rainbow trout) and age group (young-of-year and age-1 or older). If passes two and three did not meet the desired level of precision, fish counts from passes one and two were combined and compared with passes three and four, using the two-pass field guide of Connolly (1996) with the next lower CV (for example, in place of the 25 percent column, the 12.5 percent column would be used) to determine the need for a fifth pass. On the rare occasion when fish counts continued to increase after the fifth pass, we would complete a sixth and final pass. These methods were chosen to minimize the number of units sampled and the number of passes per unit. This approach lessened the chance that individual fish would be exposed to the effects of electrofishing while it insured a high degree of precision in our estimates. When fork length was not obvious in the field, we used a fork length of 80 mm as a separation point between age-0 and age-1 or older fish. In units that were unsuitable for multiple-pass removal, typically due to stream depth, we would attempt a two-pass, mark-recapture estimate with a seine or through electrofishing and complete a snorkel survey. The snorkel survey count was only used if there were not enough recaptures to get an estimate through mark-recapture, or snorkeling found more fish than the mark recapture estimates. In most cases, the side channels did not have enough habitat units to subsample, and in these cases, we sampled every habitat unit.

Population surveys were conducted in six sections of five tributaries from 2008 through 2012. In 2008, we sampled in Eightmile (rkm 0), Wolf (rkm 0), South Fork Gold (rkm 4), and Beaver (Reach 1; rkm 5) Creeks. In 2009, we sampled in Eightmile, Wolf, and Beaver (Reach 2; rkm 13) Creeks, and in 2010, we sampled in Wolf Creek, Libby Creek, and two sites in Beaver Creek (Reach 1, rkm 4; Reach 2, rkm 13). In 2011 and 2012, we sampled in Wolf Creek and both Beaver Creek reaches. All population surveys in tributaries were conducted using multiple-pass removal electrofishing. In 2008, we sampled two side channels (SC2 at rkm 70; SC3 at rkm 76) once a year (August) in the M2 reach. In 2009, the number of sites was increased to five side channels, two in the Upper Methow (SC4 at rkm 87; SC5 at rkm 95) and three in the M2 reach (SC1 at rkm 66; SC2 at rkm 70; SC3 at rkm 76). The number of samples also increased to three times a year (July, August, September/October, and October/November). From 2010 to 2012, we further increased the number of sites to10 side channels—4 in the M2 reach (SC1; SC2; 3R at rkm 75; SC3), 3 in the Upper Methow (SC4; CC at rkm 89; SC5), 2 in the Chewuch (WH at rkm 6; UC at rkm 22), and 1 in the Lower Methow (LM at rkm 56). Sampling occurred in March (before high flows), August (after high flows), and October. The additional side channel sites were added to increase sample size of all three types of side channels to help determine differences between side channel types. If time and staff were available, additional non-population electrofishing was done throughout the Methow River watershed to deploy PIT tags at key locations and at each of the tributary sites in the spring and in the fall to aid in determination of age classes and growth.

The presence and abundance of age-0 fish in the mainstem restoration reach and neighboring reference reaches were measured using a point-abundance survey. These surveys were conducted by electrofishing the stream margins (4.5 m from the edge) of one bank within a contiguous section of three pools and three non-pools. These surveys typically were conducted three times a year during 2008–2010—once in March before high flows, once in July after high flows, and once in late September or October. This approach was largely derived from Connolly and Brenkman (2008). If a pool or non-pool section was too large to sample in a reasonable amount of time, we would break the units into 25-m sections and would sample the first, middle, and final sections. Three sections of the treatment reach (upper, middle, lower) and one section in each of the reference and control reaches were sampled with this point-abundance methodology. Due to lack of fish in one of our reference sites (Chewuch), a new site was established in 2010. All sites were located in similar unconfined reaches and selected based on accessibility.

To increase the number of PIT-tagged fish potentially traveling through the M2 reach, we used a 5-ft rotary screw trap in the Chewuch River near its mouth. This screw trap was deployed in 2009 and fished year-round or until ice conditions in the fall or high waters in spring required us to remove the trap for fish health and trap safety reasons. Fish collections occurred Monday through Friday. To estimate capture efficiency, marked fish (largely with PIT tags) were periodically released 100 m upstream of the trap.

Snorkel surveys were conducted to provide an index of fish assemblage and abundance in the unconfined mainstem reaches of the Methow and Chewuch Rivers. Following Brenkman and Connolly (2008), surveys were conducted a minimum of three times within a year in order to examine effect of season on fish presence and abundance. These surveys were completed using four snorkelers that moved in a straight line, perpendicular to the shore line, floating in a downstream direction. Fish were counted by species and size range, 0–150 mm (parr-smolt), 150–300 mm (smolt-resident), and 300–500 mm (anadromous adult or large resident). Each snorkeler used a search window defined by their position in-line with the other snorkeler surveyors. Starting on river left, the first snorkeler counted fish directly beneath their head and to the left bank. Snorkeler number two (adjacent to snorkeler one) counted fish directly beneath their head and to snorkeler number ones position. Moving right, snorkeler positions followed the same method up to the far right snorkeler, who counted both fish on his or her left and right up to the river right bank edge. In circumstances where there were fully connected side channels, the snorkeler closest to the side channel sampled those units. From 2008 through 2010, we snorkeled three reaches (Upper Methow, Chewuch, and M2) with four snorkelers in a downstream direction. In 2009 and 2010, we snorkeled an additional site in the Lower Methow. Sites ranged between 3 and 5 km in length and were guided by potential put-in and take-out locations in our desired reaches. Each site was sampled at least three times a year (spring, summer, and fall) and up to eight times per year at some sites.

We used “snetting” (a combination of snorkeling and gill netting) to collect and PIT tag a sample of large sized (>150 mm) fish species present in the M2 reach. Hook and line use was initially used in 2008, but was inefficient when compared to snetting. Snetting surveys were conducted using a crew of four to six snorkelers. When first entering a location, which was restricted to large pool units, one to three snorkelers would snorkel through the unit to look for large debris or substrate that could snag the net and to note if there were enough fish present to make sampling worthwhile. Two snorkelers would then stretch a 36.5-m long by 3.0-m tall variable mesh (8.9, 7.6, 6.3, 5.1, 3.8, and 2.5 cm) gill net with a weighted bottom line and floating top line across the upstream end of a pool or glide. Two to three additional snorkelers positioned themselves 1–5 m downstream of the net. The two snorkelers at the ends of the net coordinated the release of the net with all other snorkelers. The snorkelers would place themselves into the water holding the ends of the gill net and start to drift downstream with the current. When possible, an additional snorkeler was positioned behind the net, to pull the net free if it caught on debris or substrate during the drift. All snorkelers moved downstream with the net and observed fish behavior as the net drifted downstream. Once fish were seen moving parallel to or downstream away from the net, the downstream snorkelers would move their arms and legs in sporadic motions to herd fish back towards the net. The snorkelers on the ends of the net kept the net stretched tight as they drifted through the unit and tried to prevent fish from moving around the ends of the nets. Although great care was taken to avoid endangered or threatened species, if one was caught in the net, we would immediately haul the net to shallow water to remove fish from the net. The primary goal of snetting was to determine the life history and movement of resident fish populations through the use of PIT tags and PTIS in the Methow River.

PIT Tag Interrogation Systems.—PTIS were used to detect fish movement and survival (fig. 1-1). Between 2008 and 2012, a total of four side channel sites (SC2, SC3, SC4, and SC5), six tributary sites (Wolf Creek, Eightmile Creek, Libby Creek, Gold Creek, and two in Beaver Creek) and three mainstem Methow River sites (MRT, CRW, MRW) were maintained by the USGS. In addition, WDFW maintained two mainstem PTIS, one located near the mouth of the Methow (LMR) and the other one was at rkm 2 on the Twisp River. A complete list of PTIS site configurations and years of operation are shown in table 1-1. The Gold and BVC sites have three rows of antennas (that is, three arrays), and the three USGS and two WDFW mainstem sites contain two rows of antennas (that is, two arrays). These additional rows of antennas helped to increase site efficiency and determine direction of movement. To help determine the detection efficiency of PTIS in the Methow River, the USGS, with assistance from U.S. Fish and Wildlife Service and WDFW, released hatchery steelhead upstream of four PTIS (CRW, MRW, MRT, and LMR) from 2010 through 2012.

Data Analysis.—Length-frequency data were examined using the frequency function in Microsoft® Excel. Length-weight regressions were calculated using the slope, intercept, and RSQ functions in Excel®. Length-frequency and length-weight regressions were only done if enough fish were present of each species and size class per sampling event. To determine population estimates from multiple-pass removal population estimates, Seber and Le Cren (1967) estimator was used when we stopped at a two-pass depletion effort, Junge and Libosvarsky (1965) explicit solution of Zippin's (1956) maximum likelihood estimator was used when we stopped at a three-pass depletion effort, and the removal estimator in the program Capture (Otis and others, 1978; White and others, 1982) as described in Bateman and others (2005) was used when we conducted four or more passes. In habitat units that were too deep to effectively sample with removal techniques, we used mark-recapture to determine population abundance. On the rare occasion that the mark-recapture estimator failed, or if a snorkel count was higher than the mark-recapture estimate, a direct snorkel count was substituted. Mark-recapture estimates of population abundance were calculated using the Petersen and Cederholm (1984) estimator. Population estimates were then divided by stream area to determine fish density estimates. Survival estimates were calculated for side channels based on PIT tag mark-recapture data over time using Cormack-Jolly-Serber estimates (Cooch and White, 2012) from the program MARK (Colorado State University, Fort Collins, Colorado). Due to the presence of known hybridization (8 of 8 know hybrids; U.S. Geological Survey, unpub. data, 2012) between Chinook and coho salmon in the M2 reach, any analysis that involves the recapture of PIT-tagged fish of Chinook and coho were combined into one analysis. Smolts were determined by PIT-tagged fish detected at PITS sites at Columbia River dams. Smolt densities were calculated by the number of smolts divided by the length of the side channel and then multiplied by 100. Smolt densities were then divided by the number of tagged fish per 100 m to determine the smolt production rate. Survival and detection efficiency estimates of hatchery and smolt releases from screw traps over distance followed the methods described in Chapter 3 (Martens and others, in press).

Results

Side Channels

Habitat Survey.—Mean lengths of side channels that were annually sampled in 2008–2012 ranged from 139 to 782 m (table 1-2). Pool habitat units were the dominant habitat unit in all but two (LM and 3R) of the side channels. Pool units represented the highest percent length in all but three (SC1, 3R, and CC) of the side channels (fig. 1-2).

Fish Sampling.—Twelve species of fish were found in the 10 Methow River side channels. Rainbow trout/steelhead and Chinook salmon were found in all 10 side channels from 2008 through 2012 (table 1-3). The majority (95 percent) of PIT tags deployed in the M2 side channels were deployed in rainbow trout/steelhead, Chinook, and coho. Bull trout were present in five of the side channels, but there was never more than one per year tagged at any of the sites (table 1-4). To determine fish age and growth, length-frequency graphs were constructed for the dominant fish species present for each sampling event from 2008 through 2012 (appendix 1-1). Length-frequency distributions from July through October display the growth of the population of age-0 Chinook through the shift in frequencies over time (fig. 1-3). Length-weight regressions were developed for most fish species at each side channel and sampling event from 2008 through 2012 (appendix 1-2). In many cases for age-0 fish, such as in SC3 (fig. 1-4), we observed good relationships (r^2 >0.80) between fish of the same species and age group.

Growth data were compiled for PIT-tagged fish that were recaptured over all side channels sites and sampling events (appendix 1-3). Growth varied from site to site with higher growth ranges in the Chewuch (WH and UC) and Upper Methow (SC4, CC, and SC5) side channels and a smaller range of growth in most of the M2 side channels (SC1, SC2, 3R, and SC3; fig. 1-5). Population abundance was estimated for each species and sampling event from 2008 through 2012 (appendix 1-4). Side channels that were not connected to the mainstem experienced a decline in abundance from July to March (fig. 1-6). The SC3 abundance estimates varied considerably over the course of the study (fig. 1-7). Fish abundance in seasonally disconnected side channels decreased an average of 65 percent from just after reconnection to just prior to reconnection. Apparent survival estimates were produced from mark-recapture data of PIT tags for all sites and between sampling events (appendix 1-5). Apparent survival estimates from partially connected and fully connected side channels were a combination of fish that moved out of a sampling area and those that died. Survival estimates from seasonally disconnected side channels during periods of disconnection account for loss by mortality only and are estimates of true survival. Survival from the connected side channels were lower than survival from seasonally disconnected side channels, possibly due to fish moving out of connected side channels (fig. 1-8), as further described in Martens and Connolly (in press).

Fish Movement.—A portion of the fish tagged in all side channels, except in the seasonally disconnected WH, were detected in the Columbia River as smolts (table 1-5). Seasonally disconnected side channels produced more than two times the rate of smolts per meter of coho compared to steelhead or Chinook (fig. 1-9). A more in-depth analysis of these side channels is described in Martens and Connolly (in press).

Mainstem

Habitat Surveys.—The two sections of the mainstem Methow River surveyed for bank unit habitat varied considerably in their composition (fig. 1-10). The number of bank units of undercut bank was larger in the M2 reach than the Lower Methow reach (fig. 1-10). The M2 reach had more diverse bank habitats in the M2 reach than the Lower Methow reach, but the Lower Methow reach had more large woody debris (table 1-6). The M2 Reach, including both the right and left banks, covered 33,135 m of bank units and the Lower Methow reach covered 42,803 m. Data from the bank unit habitat surveys are shown in appendix 1-6.

Fish Sampling,**—**Fish sampling in the mainstem reaches of the Methow River varied by different methods and objectives. Fish in these reaches ranged from large adult fish to small age-0 fish. Twelve species of fish were collected or sighted in the M2 reach. More species were observed in the Lower Methow and M2 reaches than in the upper reaches (Upper Methow and Chewuch River; table 1-7). Juvenile Chinook received the highest number of PIT tags at the screw trap followed by juvenile rainbow trout/steelhead (table 1-8). Length-frequency graphs were produced to assess the length distribution of fish in the mainstem reaches of the Methow River (appendix 1-7). The length of mountain whitefish collected in the M2 reach ranged from greater than 167 to less than 488 mm in 2010 (fig. 1-11). Length-weight regressions were calculated for most sites and occasions of sampling (appendix 1-2). Length-weight regressions for mountain whitefish in the M2 reach from 2010 produced r^2 values >0.90 (fig. 1-12). Most of these estimates were gained from fish collected by snetting or raft electrofishing. Point-abundance sampling rarely produced enough fish by species to build length-frequency and length-weight relationships.

Fish per square meter estimates were lowest in the mainstem sites than in both side channel and tributaries sites (fig. 1-13). Fish per square meter estimates were lowest during summer sampling, but varied at the M2 site from 2008 through 2010 (fig. 1-14). Point-abundance electrofishing estimates of fish per meter and square meter were calculated for each site and occurrence are given in appendix 1-8. Mountain whitefish were the most numerous species found during snorkel surveys in the M2 reach from 2008 through 2010. Mountain whitefish numbers in the M2 reach peaked in the early fall and were at their lowest in early spring (fig. 1-15). Adult whitefish numbers decreased from August through November in the Lower Methow and M2 reaches; the number of whitefish slightly increased during the same period in the Upper Methow and Chewuch reaches (fig. 1-16). Snorkel data for each site and occurrence are shown in appendix 1-9.

Fish Movement.—Although the number of fish PIT tagged were limited in the mainstem reaches, some of these fish were detected in the Columbia River as smolts (table 1-9). The Chewuch River screw trap was our primary means of securing juvenile fish for PIT tagging in mainstem habitat. The screw trap collected most of juvenile Chinook during spring and fall. Juvenile Chinook that moved in the spring typically moved through the M2 reach in 1–2 days, with all of them through the M2 reach within 14 days. The majority (72 percent) of fall-moving Chinook that were detected at the MRT PTIS site moved through the M2 reach within 1 day of release. More than one-half (54 percent) of fish that were released from the Chewuch screw trap and detected at the LMR PTIS site left the Methow River within 60 days (fig. 1-17).

Some mountain whitefish that were PIT tagged in the Methow River were detected making seasonal movements into the Columbia River. In addition to moving into the Columbia River, two fish were detected in the Entiat River. A more thorough analysis of mountain whitefish movement in the Methow River is described in Benjamin and others (2013).

Survival Estimates.—Survival estimate comparisons of juvenile Chinook collected at the screw trap in the fall versus the spring showed that fall-moving fish had a lower survival than spring-moving fish (fig. 1-18). Survival estimates from release site to McNary Dam should be taken with caution because fall-moving fish would have taken more than 4 months to get to McNary Dam, while spring-moving fish would reach McNary Dam within weeks of release at the screw trap, leaving the fall fish more susceptible to mortality over a longer period. Survival and detection efficiency estimates have been completed for hatchery releases in 2011 and 2012 (appendix 1-10). The LMR had low detection efficiency that negatively impacted the precision of the survival estimates in the Methow River (table 1-10). The Methow River PTIS sites had higher detections of juvenile salmonids at low flows (as high as 70.6 percent) than at high flows (as low as 0.0 percent; table 1-11).

Tributaries

Fish Sampling.—Rainbow trout/steelhead were present in all tributaries that were sampled from 2008 through 2012. The tributaries had fewer species (mean = 4) present for each site than side channel (mean = 8) and mainstem sites (mean = 8; table 1-12). Chinook and coho were not present in 5 of 18 tributary sites that were sampled, and were largely restricted to the downstream reaches. The majority of PIT tags (93 percent) that we deployed in 2008 through 2012 were in rainbow trout/steelhead (table 1-13). Tributary sites (54 percent) received more PIT tags for rainbow trout/steelhead than mainstem (21 percent) and side channel (25 percent) sites. Length-frequency graphs were constructed for most sites and sampling occasions (appendix 1-11). Length-frequency graphs from August collections in Beaver Creek show that age-0 and age-1 rainbow trout/steelhead generally were smaller in Reach 2 than in Reach 1 (fig. 1-19). Length-weight regressions were constructed for most sites and occasions (appendix 1-2). Length-weight regressions in tributaries generally had high (>0.91) r^2 values for age-1 and older rainbow trout/steelhead, but varied more (range 0.70–0.95) for age-0 rainbow trout. For example, in Reach 1 of Beaver Creek in 2010, the length weight regression was $r^2 = 0.7008$ for age-0 in rainbow trout/steelhead and $r^2 = 0.9817$ for age-1 or older in rainbow trout/steelhead (fig. 1-20).

Growth between capture and recapture periods have been compiled for all tributary sites (appendix 1-3). Specific growth of PIT-tagged rainbow trout/steelhead varied among all tributary sites, with Beaver Creek's Reach 2 showing the highest mean and greatest variation (fig. 1-21). Tributary site population estimates were calculated for all sites and occasions (appendix 1-12). Tributary sites had the highest mean density of juvenile rainbow trout/steelhead relative to side channels and mainstem lateral margins (fig. 1-13). The Reach 1 population estimates varied from year to year with low numbers of age-0 rainbow trout/steelhead in 2006 and 2011 and the largest number of age-0 rainbow trout/steelhead found to date in 2012 (fig. 1-22). Juvenile Chinook numbers in Beaver Creek have been small or absent since barrier removal was mostly completed in 2005. In 2012, we encountered our first juvenile Chinook in Reach 2 and also found the largest population to date in Reach 1 (fig. 1-23).

Fish Movement.—Movement was detected from all sites sampled in Beaver Creek from 2004 through 2008, although the percentage of tagged fish that moved varied from year to year. The lower two sites (<5 rkm) ranged from 3.8 to 14.5 percent of fish tagged that were detected as smolts in the Columbia River (table 1-14). Only one fish tagged in the Reach 4 sampling site was detected as a smolt in the Columbia River. The number of rainbow trout/steelhead moving downstream in Beaver Creek past the BVC (rkm 4) increased from 0 fish in 2004 and 2005 to more than 30 fish in 2012 (fig. 1-24). Juvenile steelhead tagged in Beaver Creek, which have returned as adults, have been mostly made up of fish that left Beaver Creek in the fall (64 percent) for additional rearing downstream before smolting. Spring moving fish that spent all of their pre-smolt rearing in Beaver Creek consisted of 21 percent of adult tag returns (fig. 1-25).

Summary

Side Channels

- Seasonally disconnected side channels appeared to have high mortality (mean = 65 percent) for juvenile rainbow trout/steelhead, Chinook, and coho during the months that they are disconnected with the mainstem (typically August through March).
- Seasonally disconnected side channels produced more than two times the rate of smolts per meter of coho compared to steelhead or Chinook.

Mainstem Methow

- Large fish (>150 mm) assemblage in the M2 reach was dominated by mountain whitefish (snorkelers observed over five times more mountain whitefish than any other species).
- The majority (72 percent) of fall-moving juvenile Chinook spent less than 2 days rearing before passing through the M2 reach.
- More than one-half (54 percent) of the fall-moving Chinook left the Methow River within 60 days of release from the Chewuch screw trap (80 rkm traveled).
- Juvenile Chinook that were exposed to longer periods of time downstream of the screw trap (fall moving) appear to have lower survival than fish that did not hold downstream of the screw trap (spring moving).
- Low detection of PIT tags at the LMR (0.03–0.88 percent) limited the precision of our survival estimates of fish moving out the Methow River, but the addition of a new PTIS near Carlton, Washington, and the reestablishment of the MRT site with a new and improved PIT tag reader should help these estimates.

Tributary

- Juvenile Chinook abundance has slowly increased at Beaver Creek Reach 1 since barrier removal (0–0.0730 fish per meter), with a decided spike in 2012.
- Juvenile steelhead migrants from upper Beaver Creek have steadily increased since barrier removal (0–35 migrants).
- Adult steelhead from Beaver Creek were more likely to return if they moved as juvenile fish in the fall (64 percent) and spent some time outside of Beaver Creek before smolting in the spring (21 percent).

Comparisons Among Habitat Types

- Tributary sites had fewer species (mean = 4) present than in side channel sites (mean = 8).
- Side channel fish abundance (STH = 0.3453–0.5993, CHN = 0.0438–0.1139; fish per square meter) was slightly less than tributary fish abundance (STH = 0.6688, CHN = 0.1357), but higher than lateral margins of the mainstem abundance (STH = 0.0271, CHN = 0.0006).

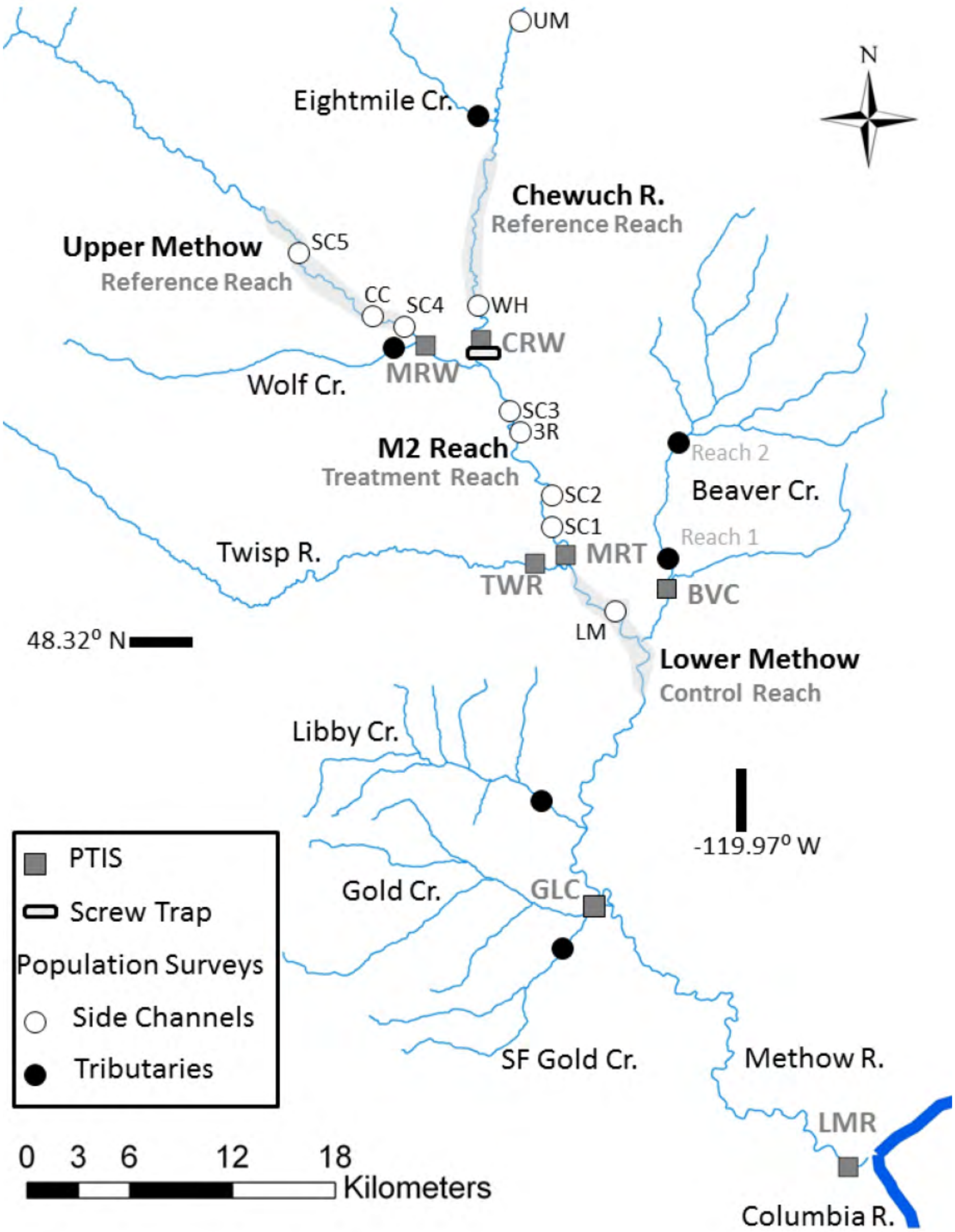

Figure 1-1. Map of Methow River watershed, Washington, with key sampling locations. BVC, Beaver Creek; CRW, Chewuch River above Winthrop; LMR, Lower Methow River; MRT, Methow River above Twisp; TWR, Twisp River; PTIS, PIT tag interrogation system.

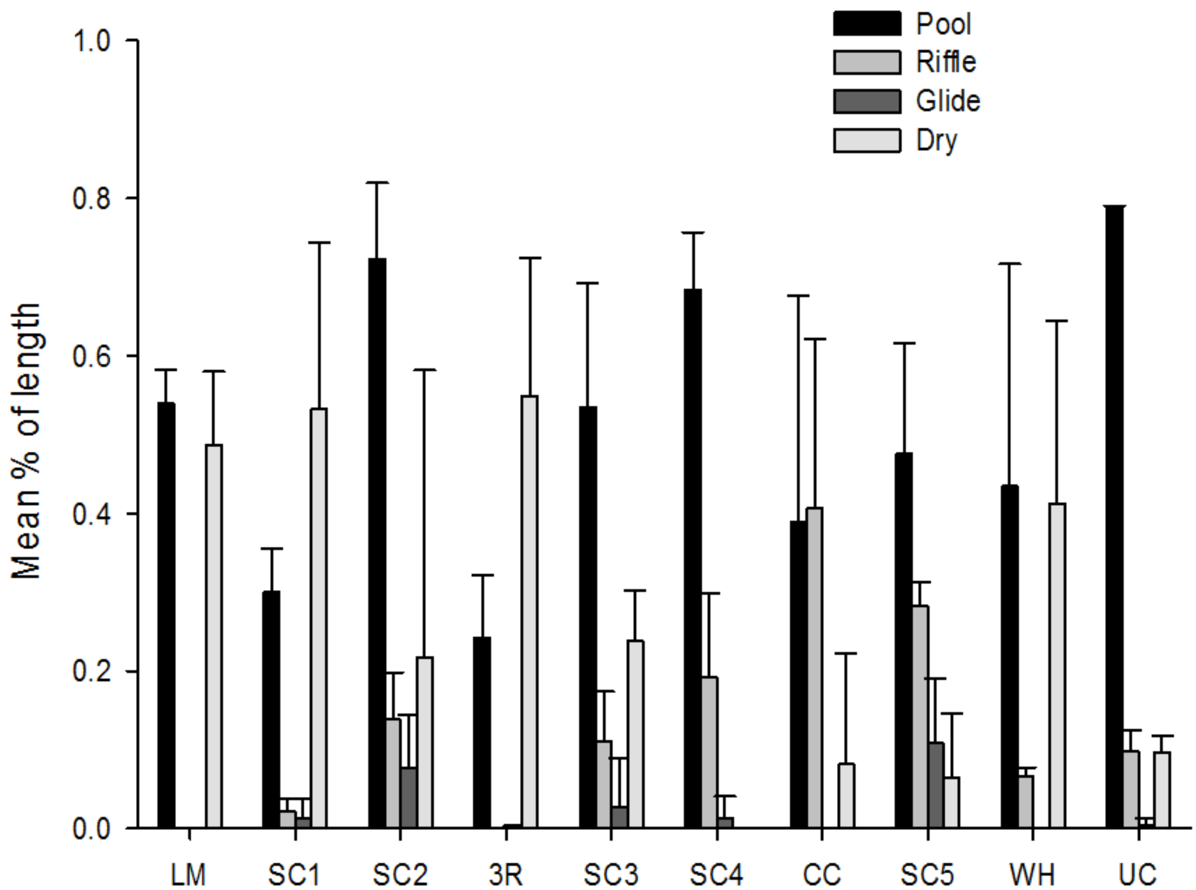

Figure 1-2. Mean percentage of length of habitat units in side channels, Methow River watershed, Washington, late July to early September 2008–2012.

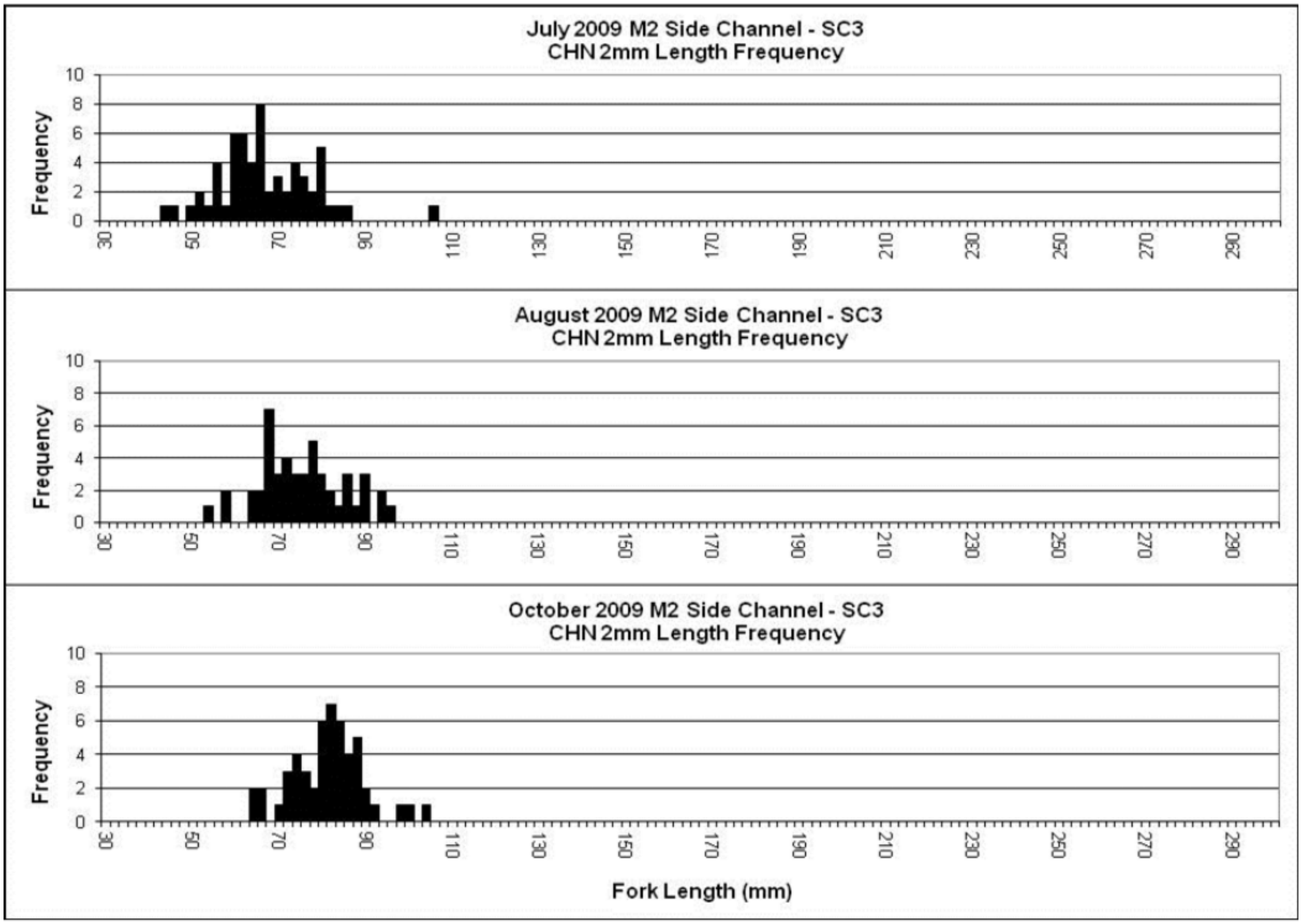

Figure 1-3. Length frequency graphs of juvenile Chinook salmon for three population surveys (July, August, and October) at the Whitefish Island side channel (SC3), Methow River watershed, Washington, 2009.

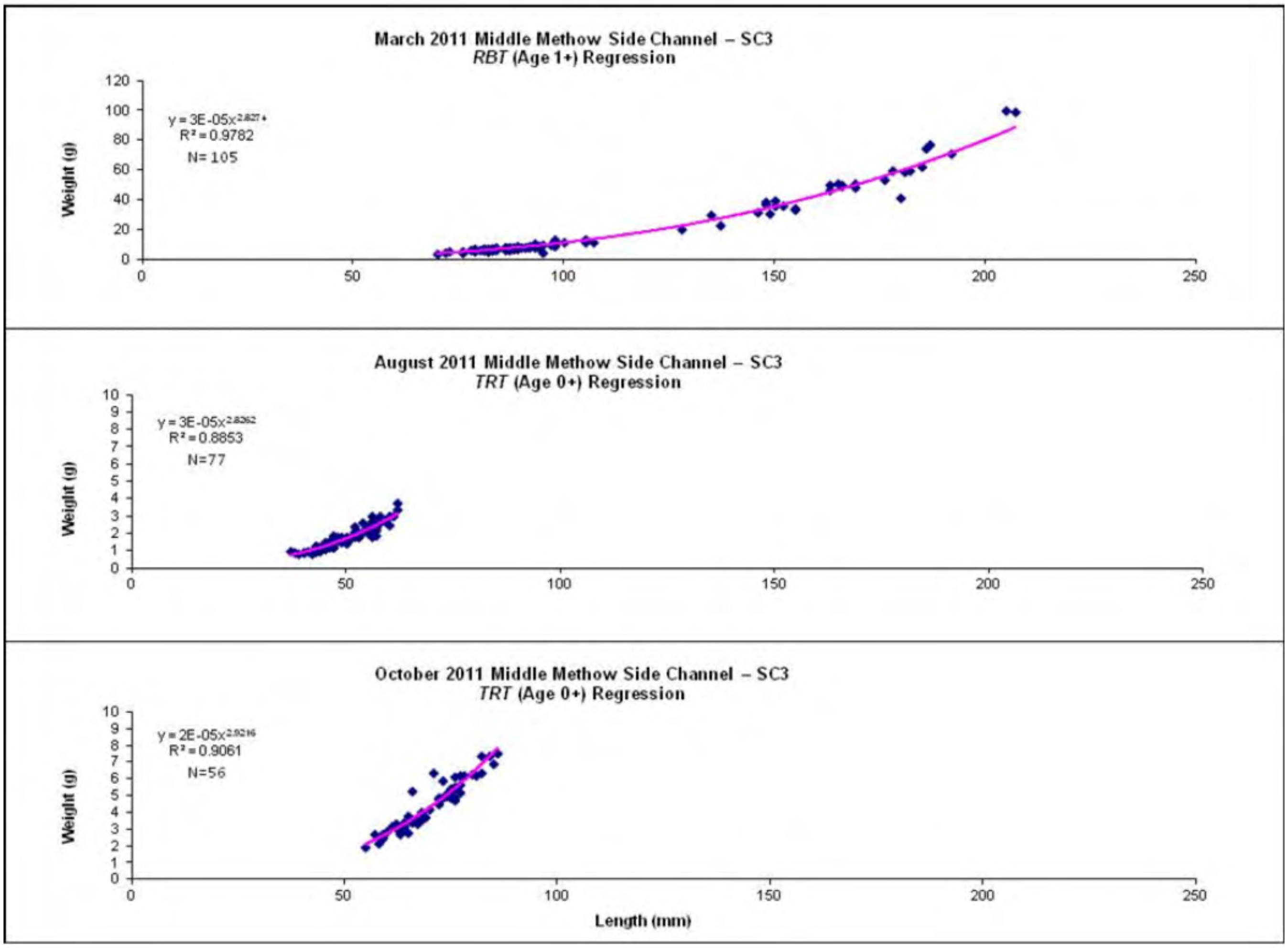

Figure 1-4. Length weight regressions of juvenile rainbow trout/steelhead for three population surveys (March, August, and October) at the Whitefish Island side channel (SC3), Methow River watershed, Washington, 2011.

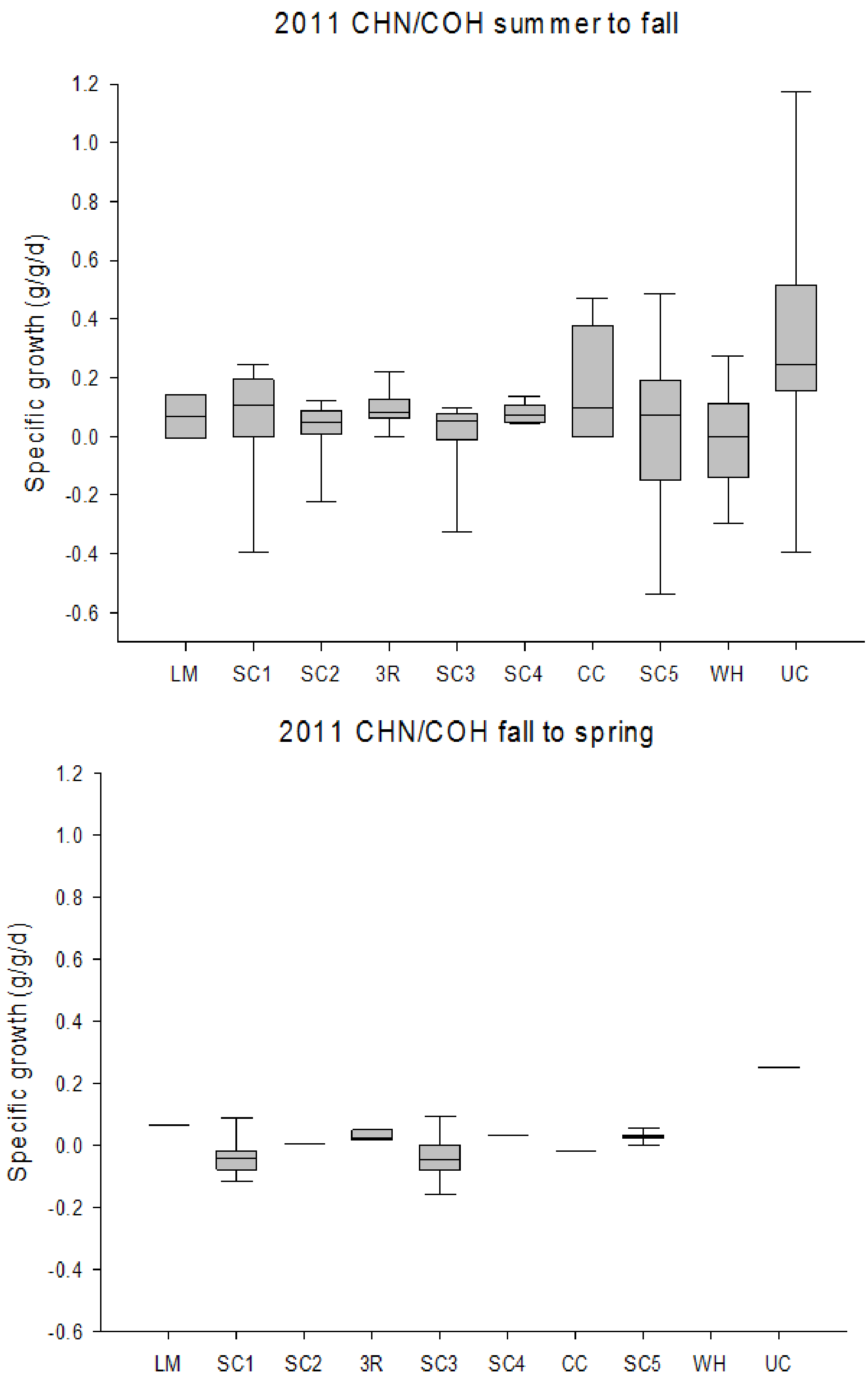

Figure 1-5. Specific growth of PIT-tagged Chinook/coho recaptured in 2011 for 10 side channels in the Methow River watershed, Washington.

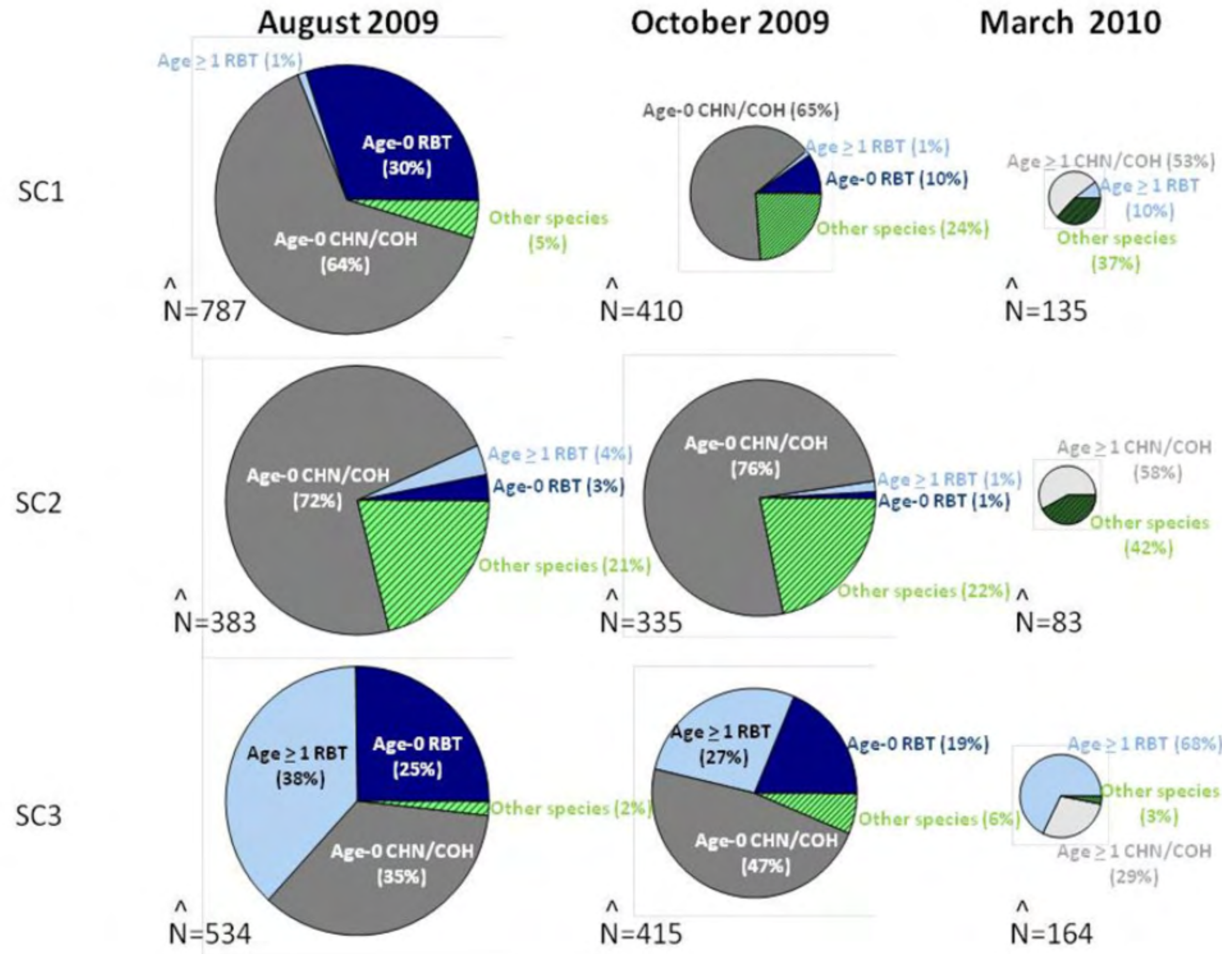

Figure 1-6. Three population estimates (August, October, and March) from 2009 through 2010 at three seasonally disconnected side channels (SC1, SC2, and SC3) in the M2 reach, Methow River watershed, Washington. RBT, rainbow trout/steelhead, CHN, Chinook, and COH, coho.

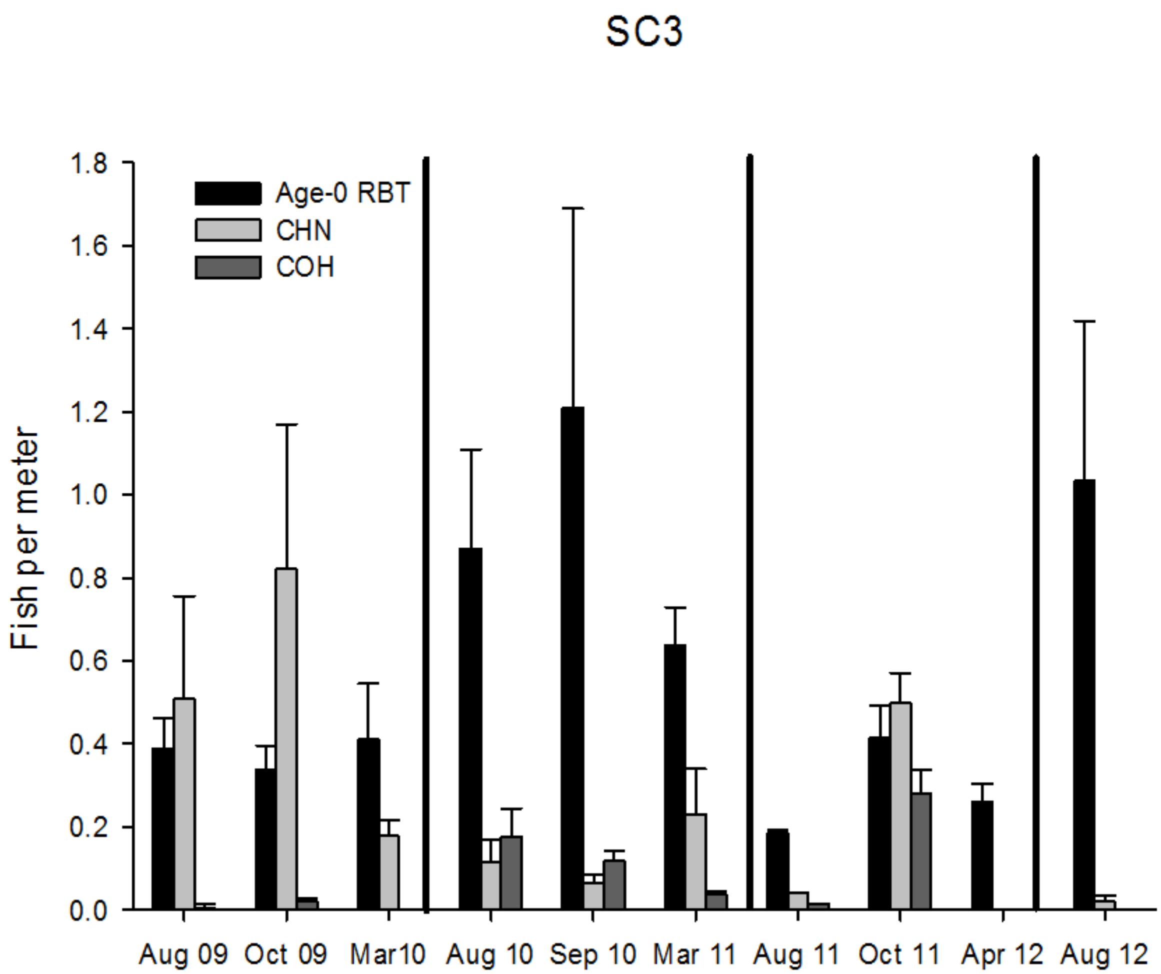

Figure 1-7. Population estimates (n=10) for the Whitefish Island side channel (SC3; rkm 76), Methow River watershed, Washington, August 2009 through August 2012. RBT, rainbow trout/steelhead; CHN, juvenile Chinook salmon’ COH, juvenile coho salmon.

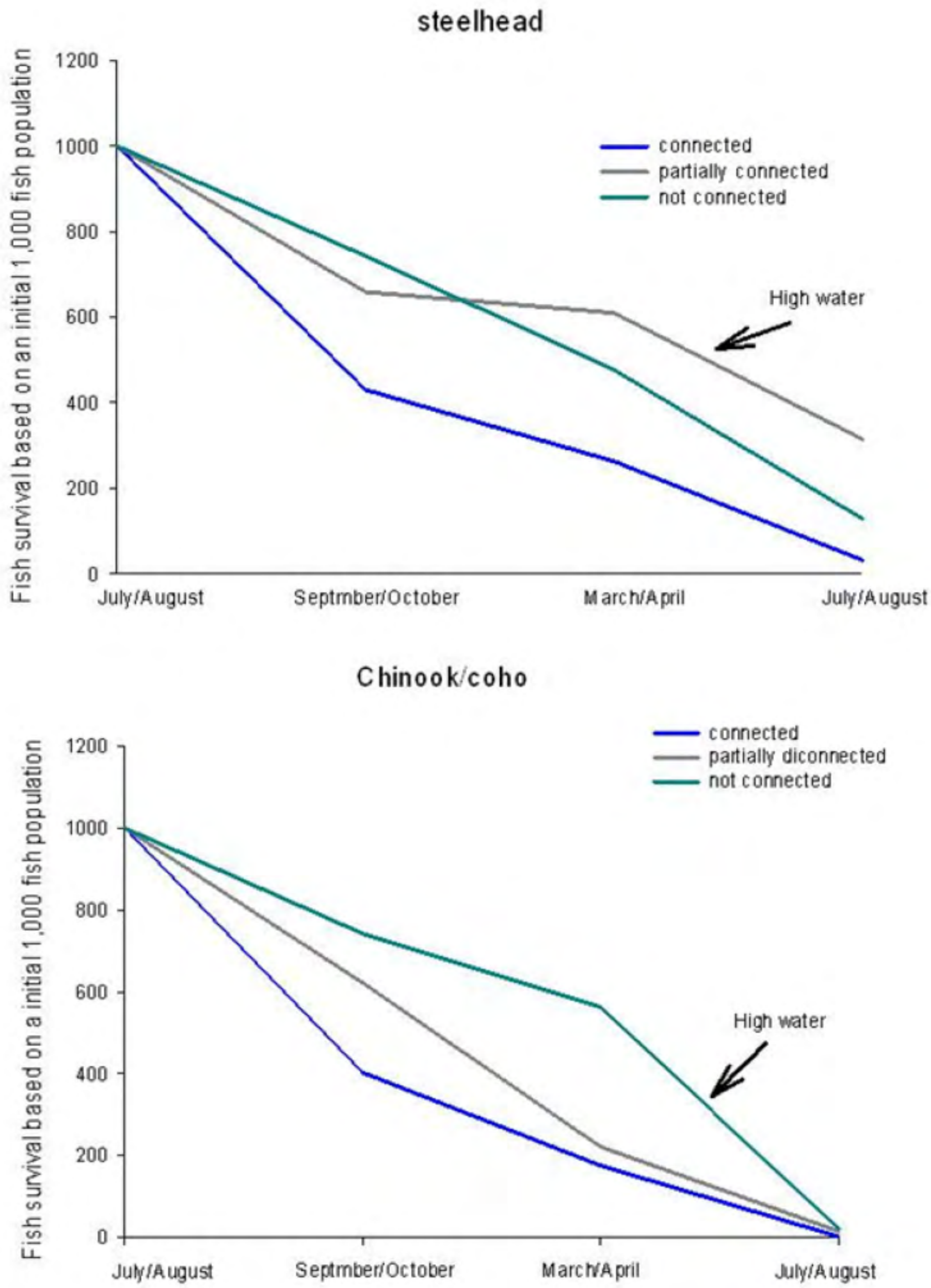

Figure 1-8. Survival estimates of juvenile steelhead and juvenile Chinook/coho from three types of side channels based on an initial population of 1,000 fish, Methow River watershed, Washington, 2009–2012.

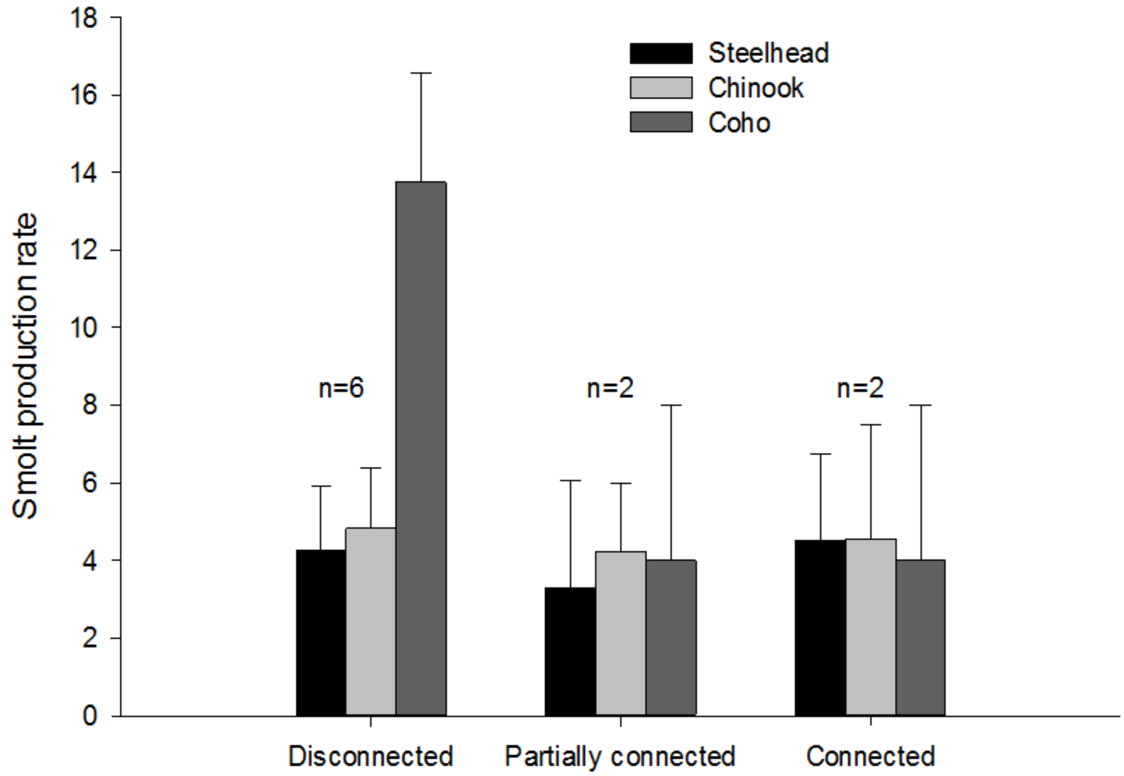

Figure 1-9. Smolt production rate (smolts per 100 m/tags per 100 m) of steelhead, Chinook salmon, and coho salmon from the three types of side channels in the Methow River watershed, Washington. Smolts were detected at Columbia River juvenile PIT tag interrogation systems during spring migration.

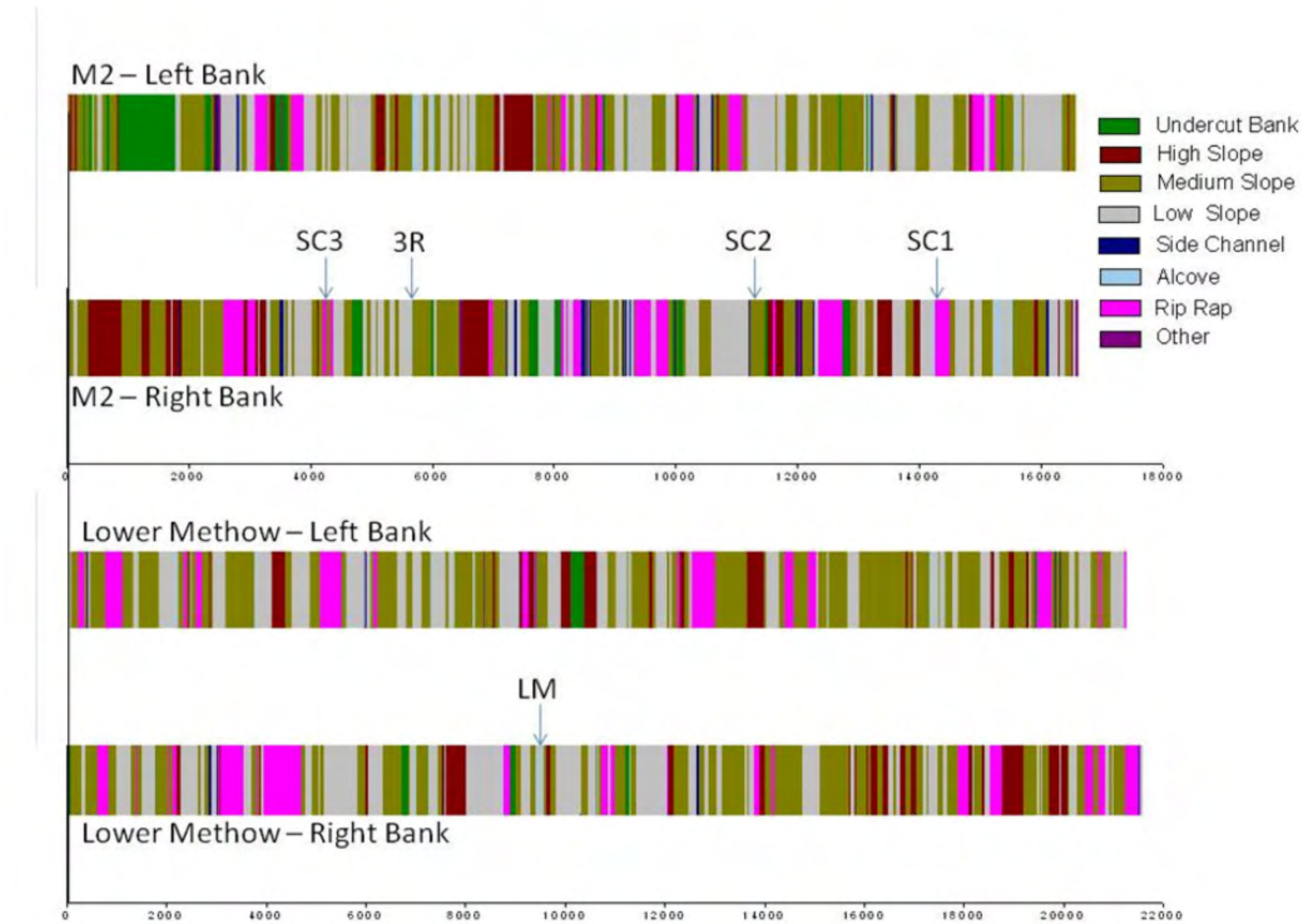

Figure 1-10. Length of habitat units found in the M2 reach (treatment) and Lower Methow (control) reach, Methow River Watershed, Washington.

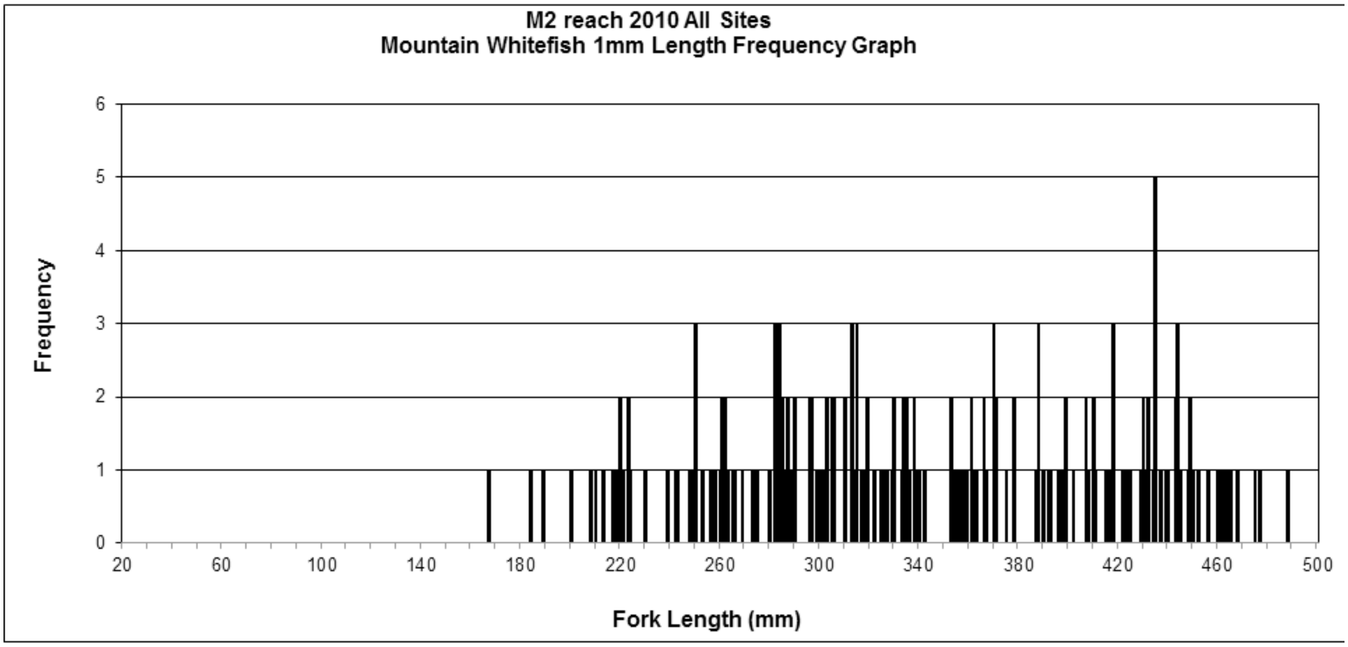

Figure 1-11. Length frequency for all mountain whitefish collected in the M2 reach of the Methow by snetting in 2010, Methow River Watershed, Washington.

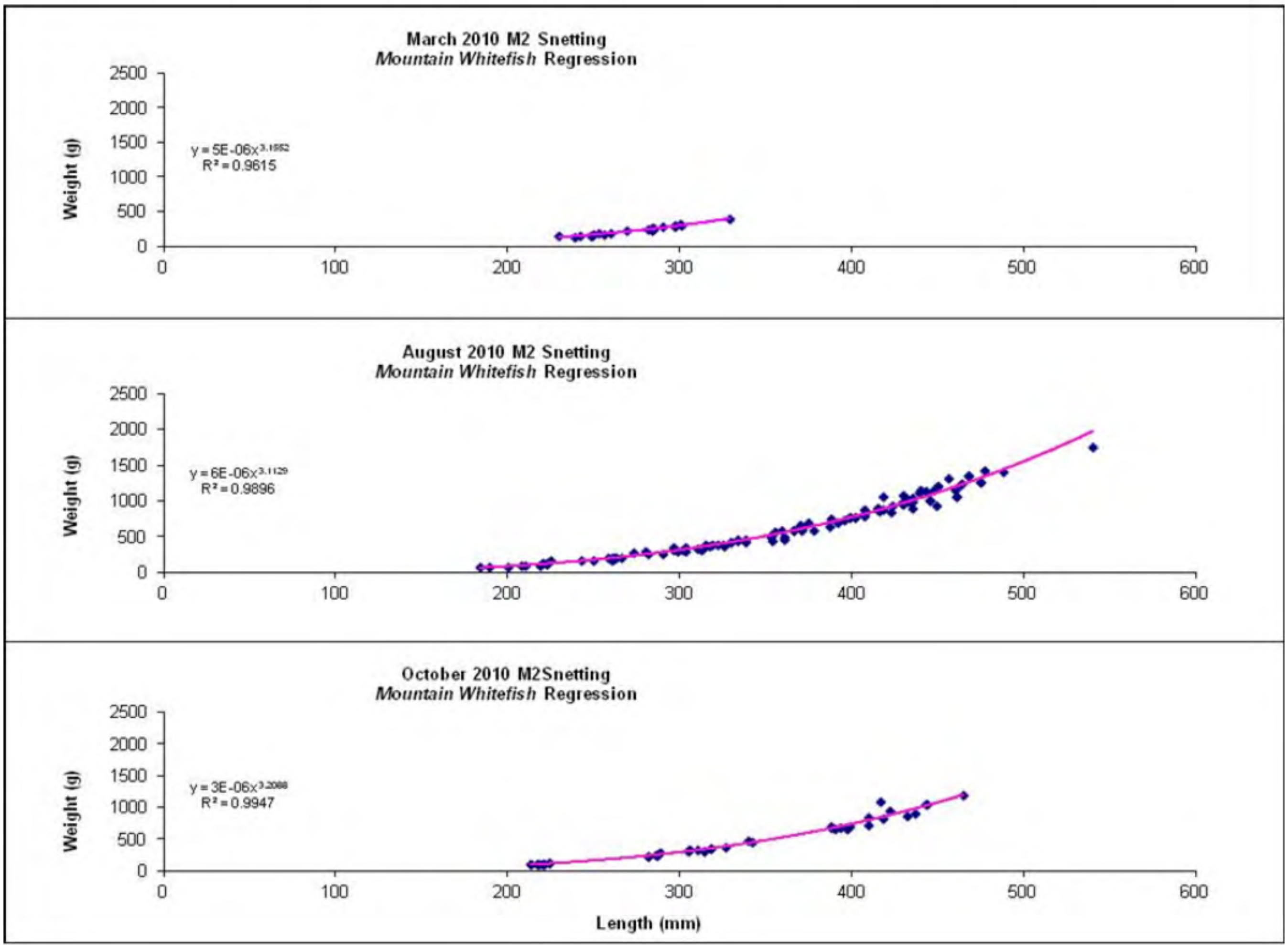

Figure 1-12. Length-weight regressions of mountain whitefish for three sampling occasions (March, August, and October) in the M2 reach, Methow River watershed, Washington, 2010.

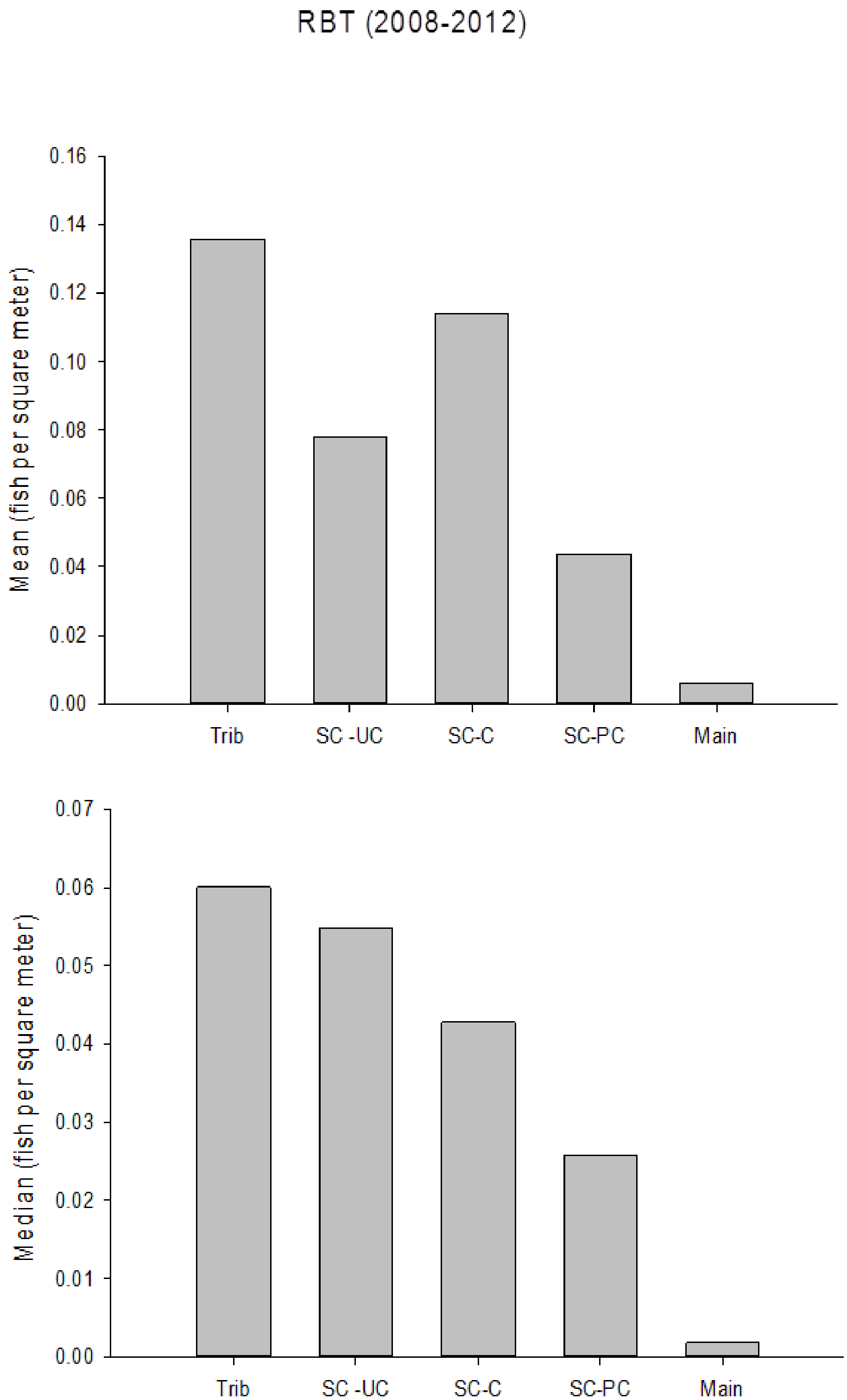

Figure 1-13. Fish per square meter of age-0 rainbow trout/steelhead during summer surveys from 2008 through 2012 by habitat type, Methow River watershed, Washington. Trib, tributary; SC-UC, seasonally disconnected side channel; SC-C, connected side channel; SC-PC, partially connected side channel; and Main, mainstem.

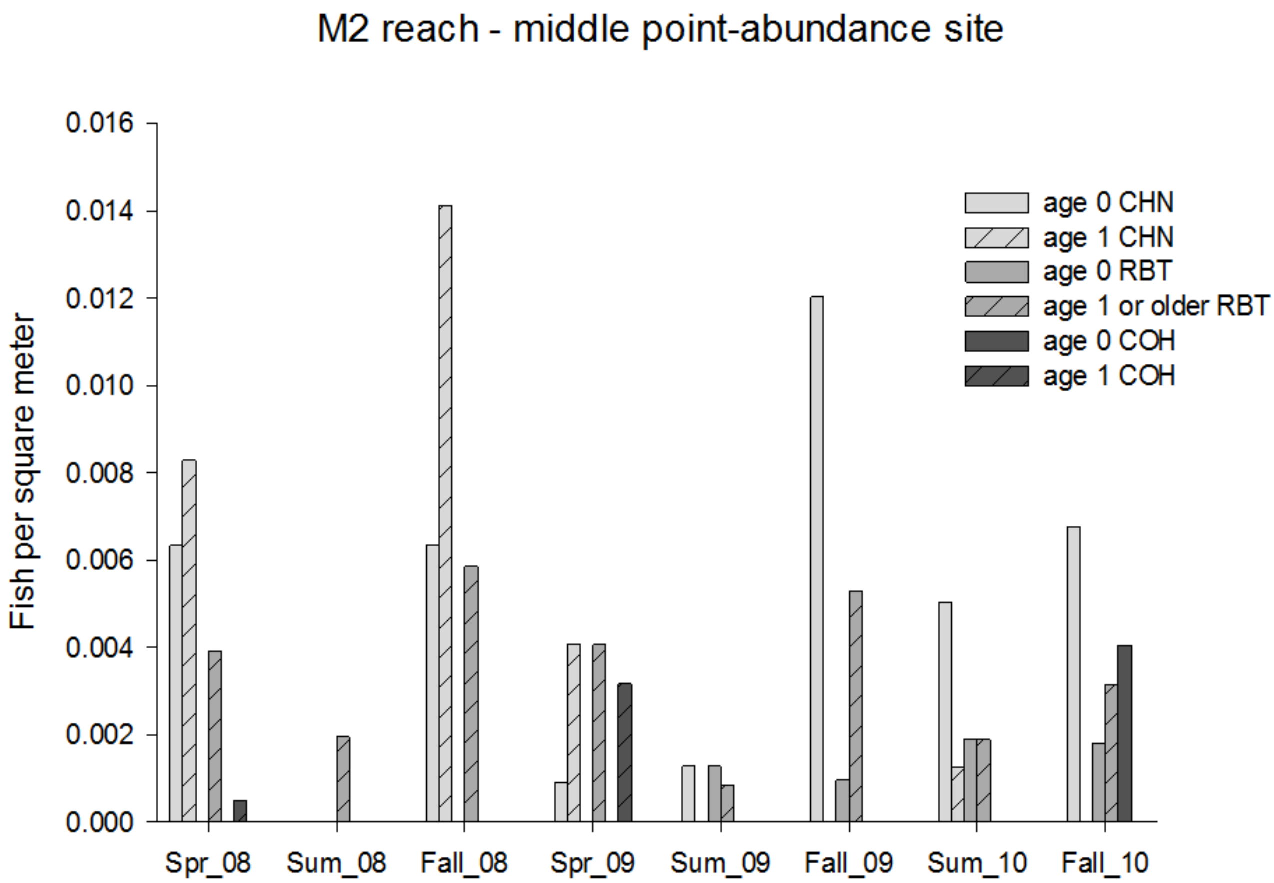

Figure 1-14. Fish per square meter of fish collected at the Middle M2 point-abundance site, Methow River watershed, Washington, 2008–2010 (n=8). COH, coho salmon; CHN, Chinook salmon; RBT, rainbow trout/steelhead.

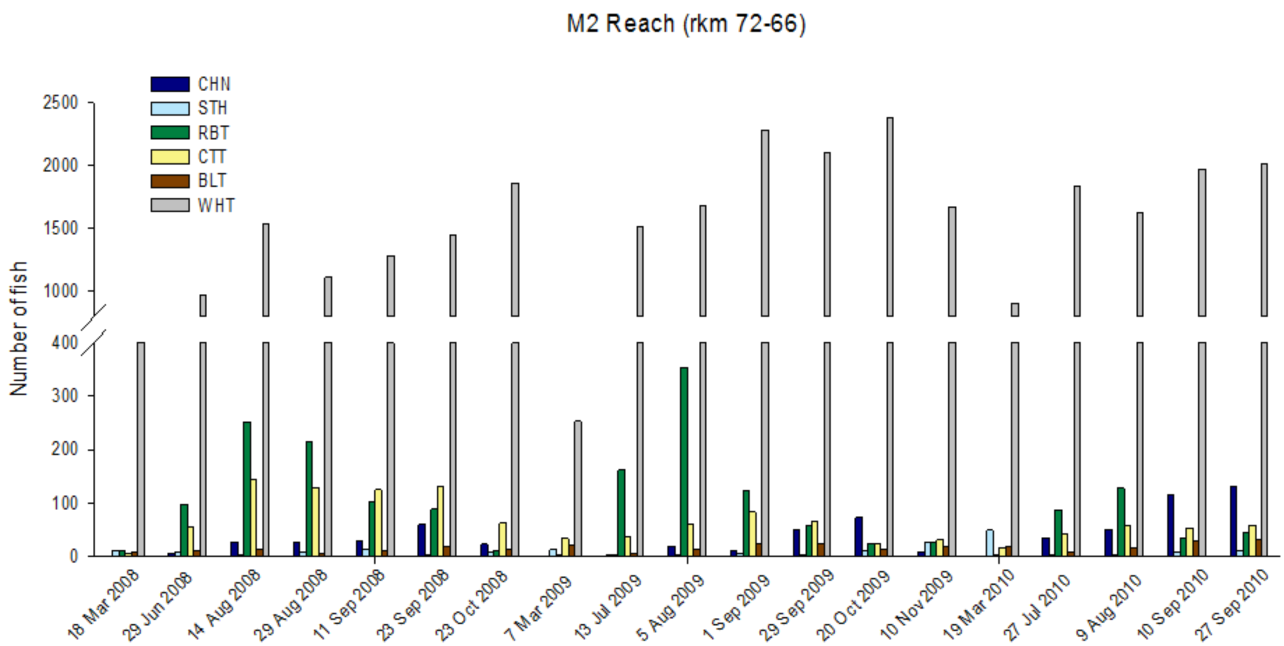

Figure 1-15. Snorkel counts from the M2 reach of the Methow River, Methow River watershed, Washington, 2008–2010 (n=19). BLT, bull trout; CHN, adult Chinook salmon; CTT, westslope cutthroat trout; RB, mature rainbow trout; STH, adult steelhead; WHT, mountain whitefish.

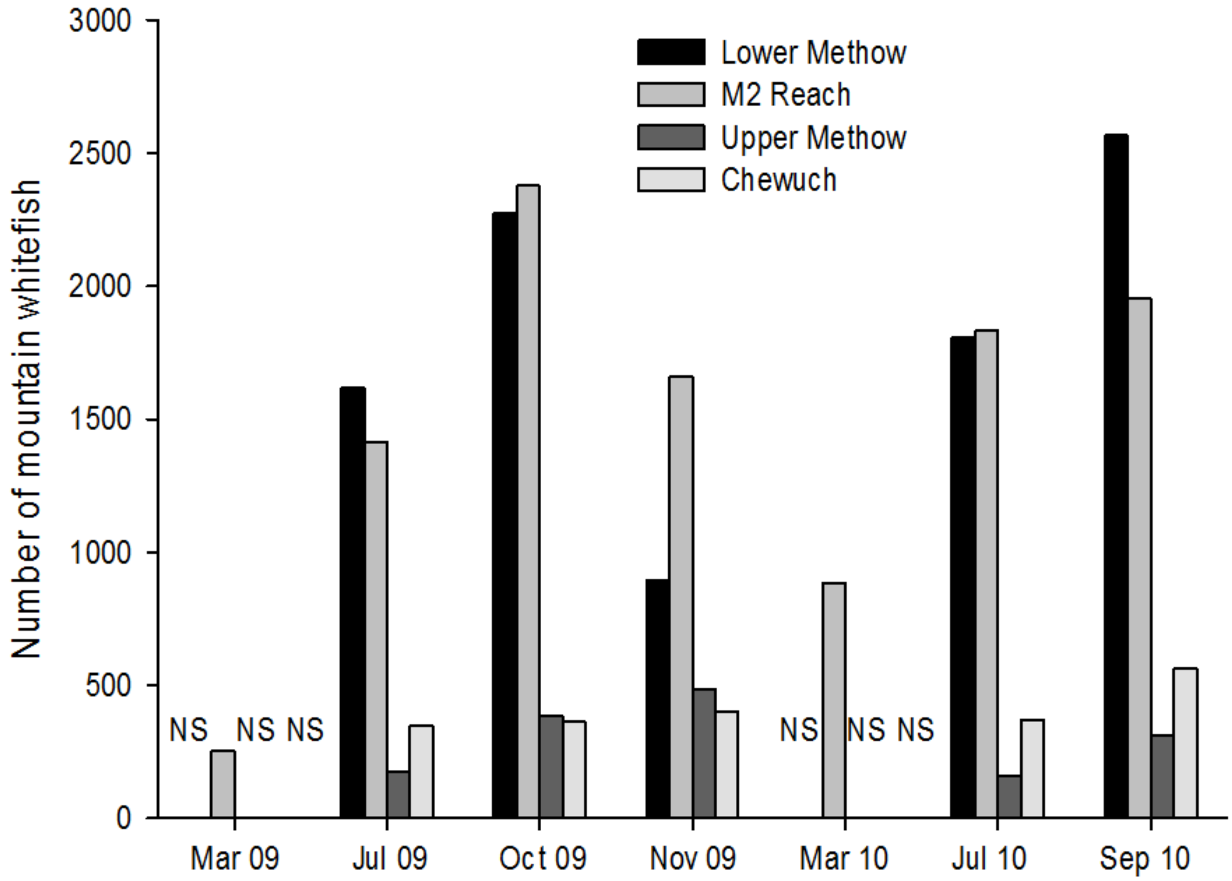

Figure 1-16. Number of mountain whitefish counted during snorkel surveys in four reaches of the Methow River watershed, Washington, 2009. NS= not sampled.

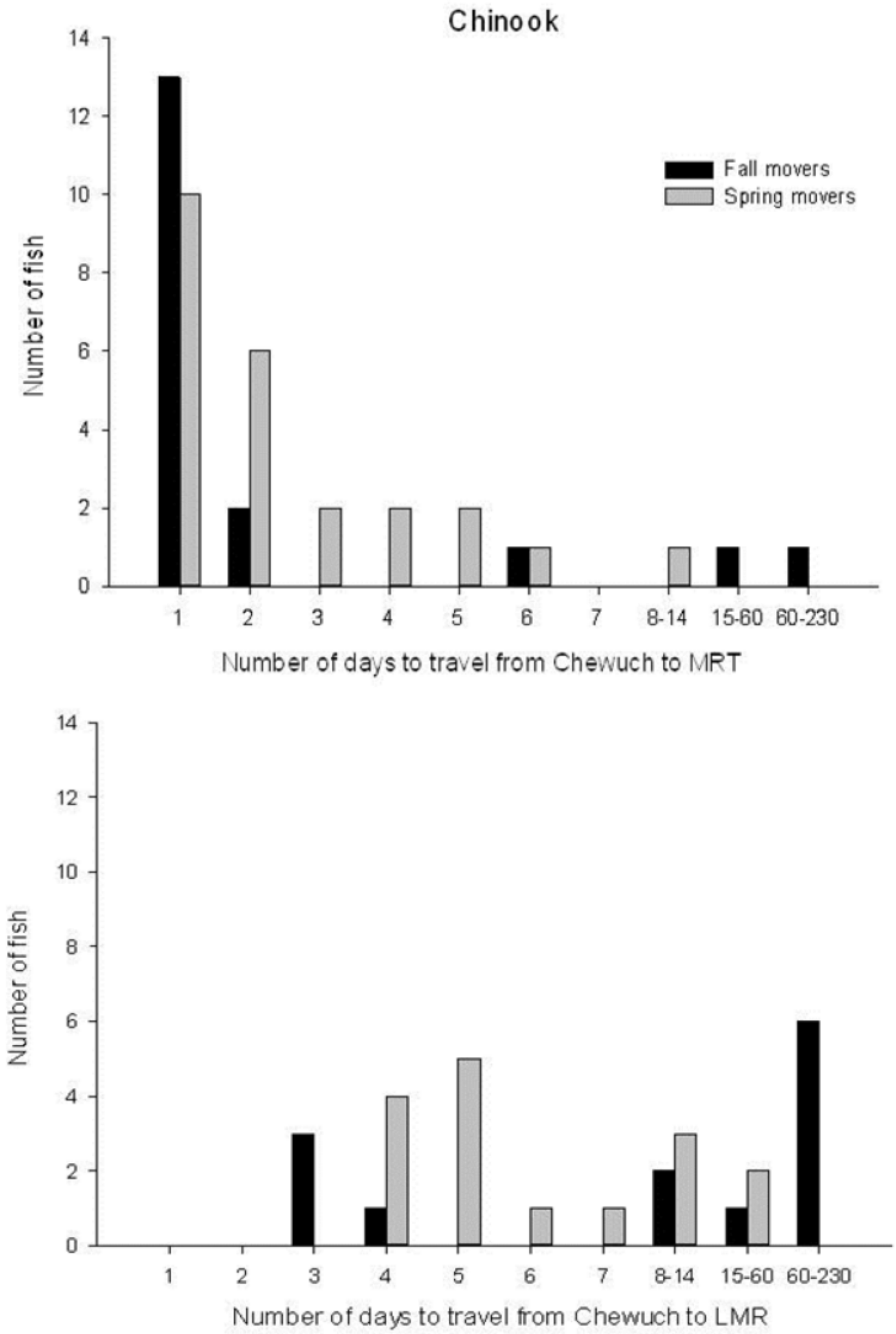

Figure 1-17. Number of days from release at the Chewuch River screw trap to detection at the Methow River above Twisp (MRT, rkm 66) and Lower Methow River (LMR, rkm 1) PIT-tag interrogation systems for juvenile Chinook that were collected in the spring and fall, Methow River watershed, Washington.

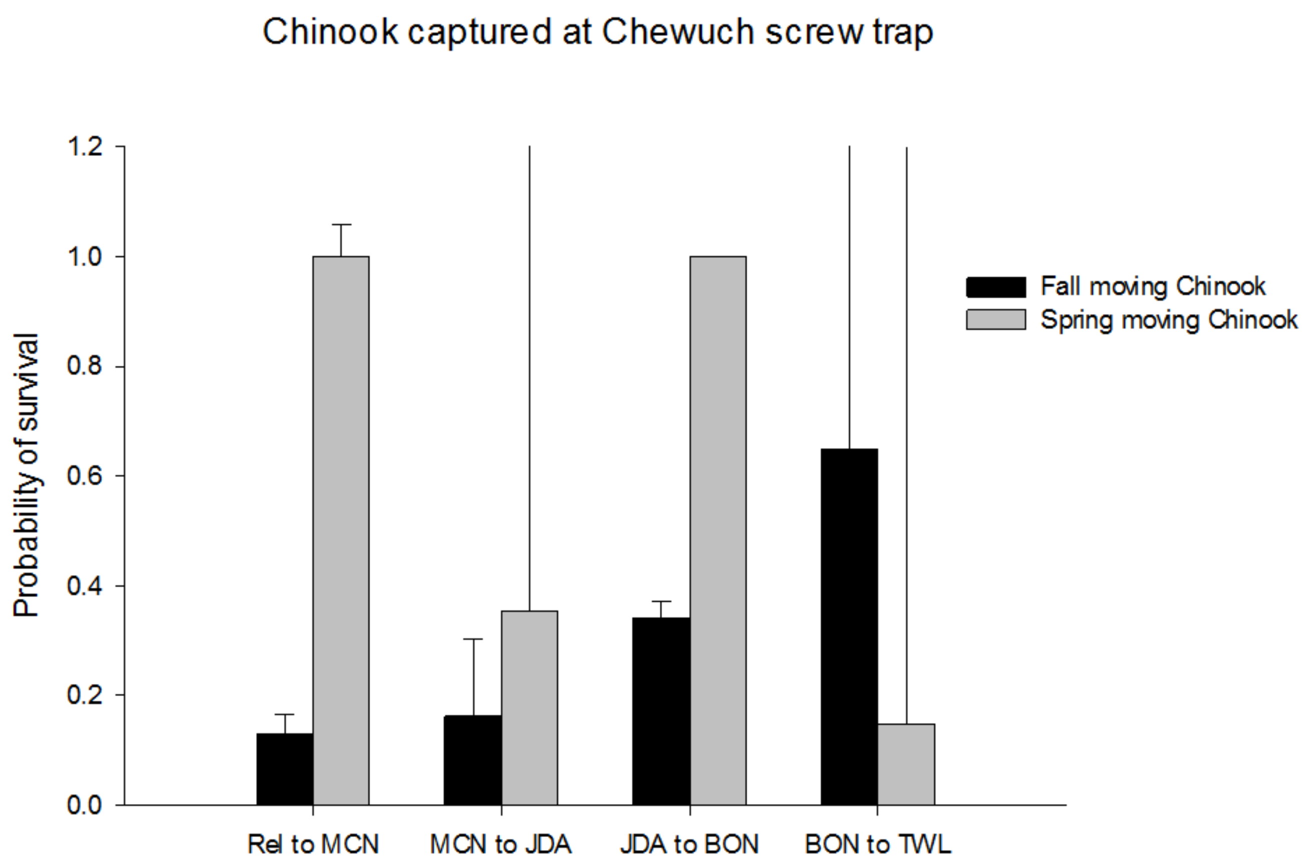

Figure 1-18. Probability of survival of juvenile Chinook salmon caught in the Chewuch River screw trap in the spring and fall, Methow River watershed, Washington. BON, Bonneville Dam; JDA, John Day Dam; MCN, McNary Dam; TWL, lower Columbia River trawl.

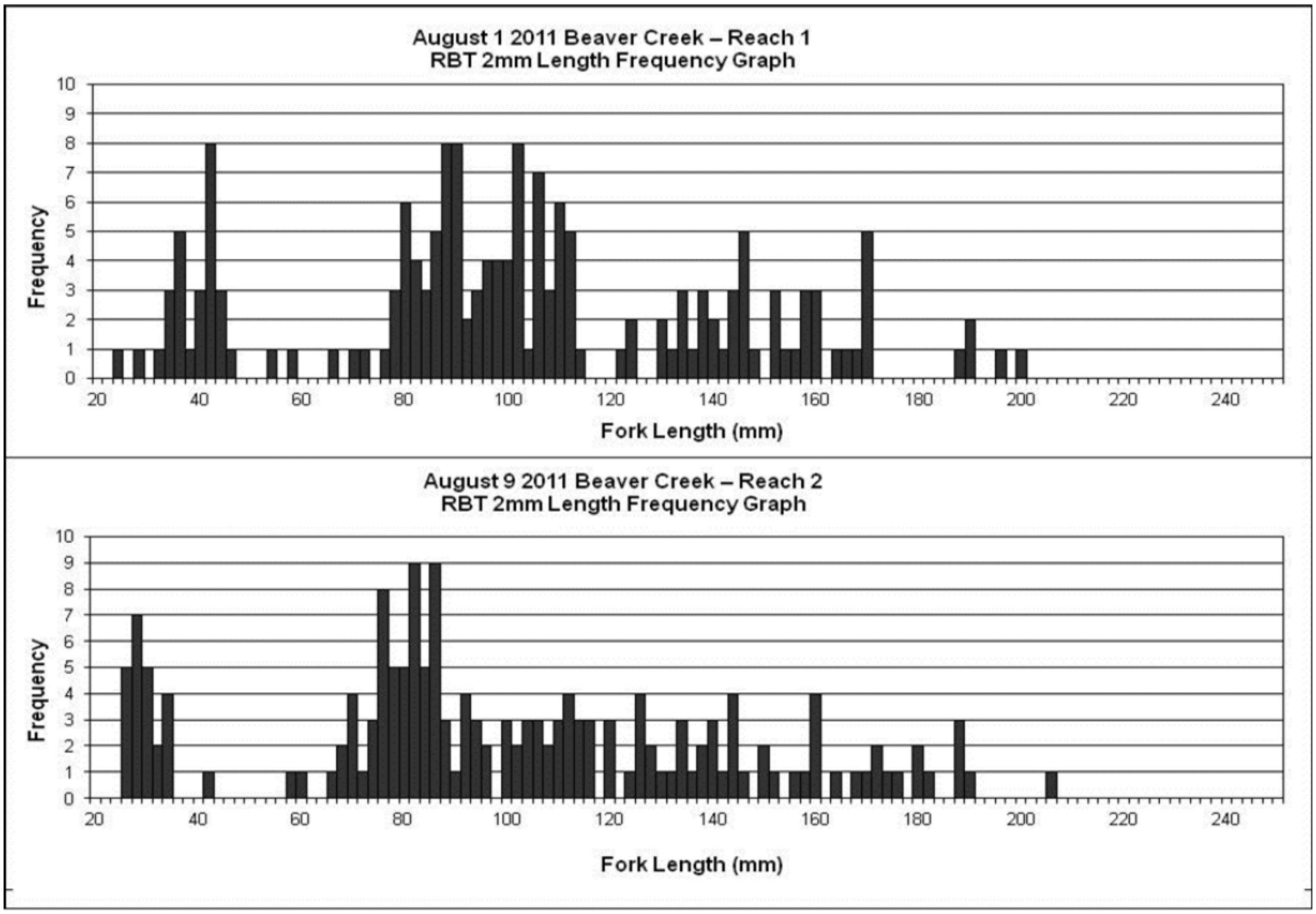

Figure 1-19. Length frequency graphs of juvenile rainbow trout/steelhead for two population Reach 1 (rkm 4) and Reach 2 (rkm 13) of Beaver Creek, Methow River watershed, Washington, 2011.

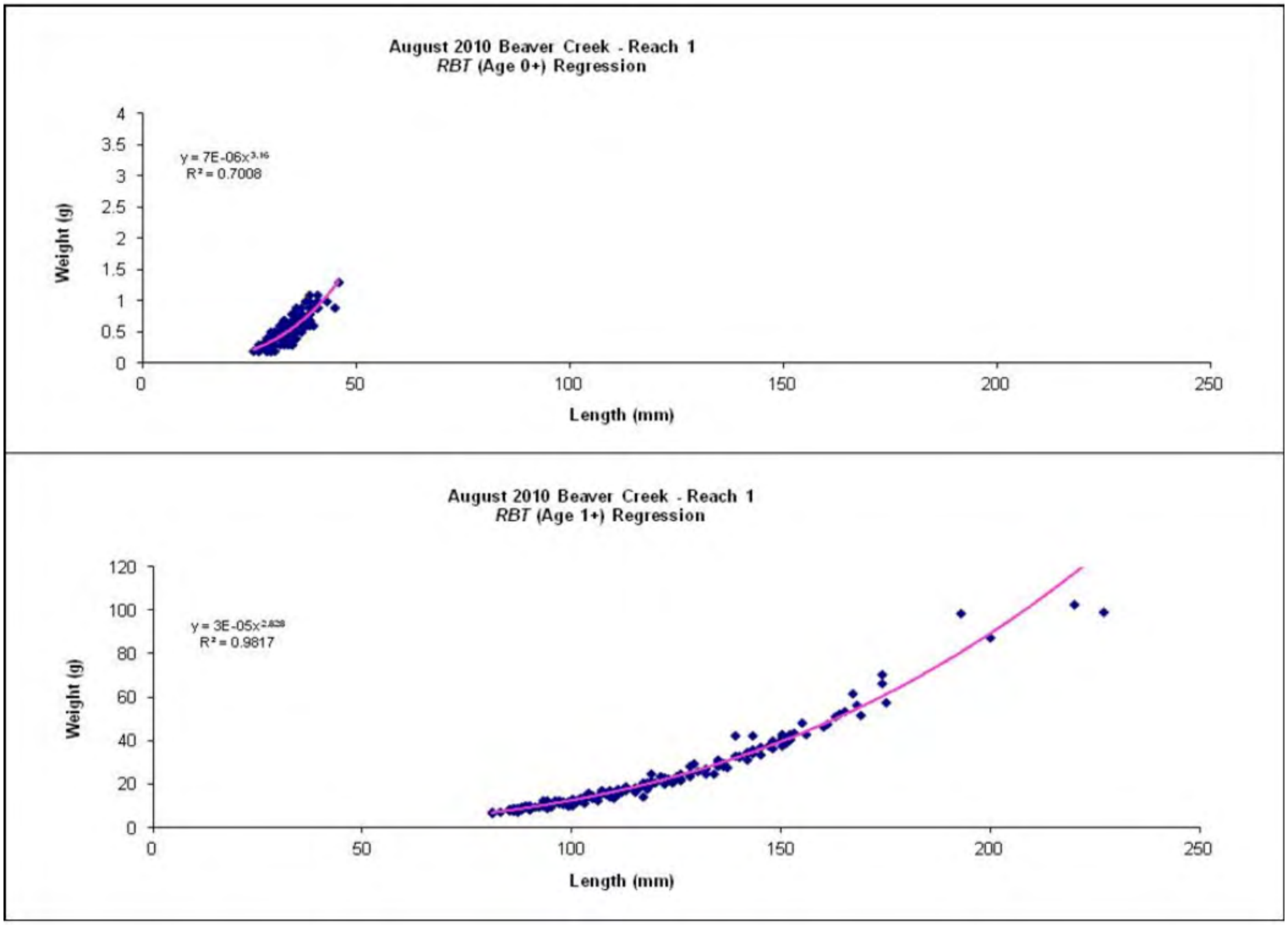

Figure 1-20. Length-weight regressions of age-0 and age 1 and older juvenile rainbow trout/steelhead in Reach 1 (rkm 5) of Beaver Creek, Methow River watershed, Washington, August 2010.

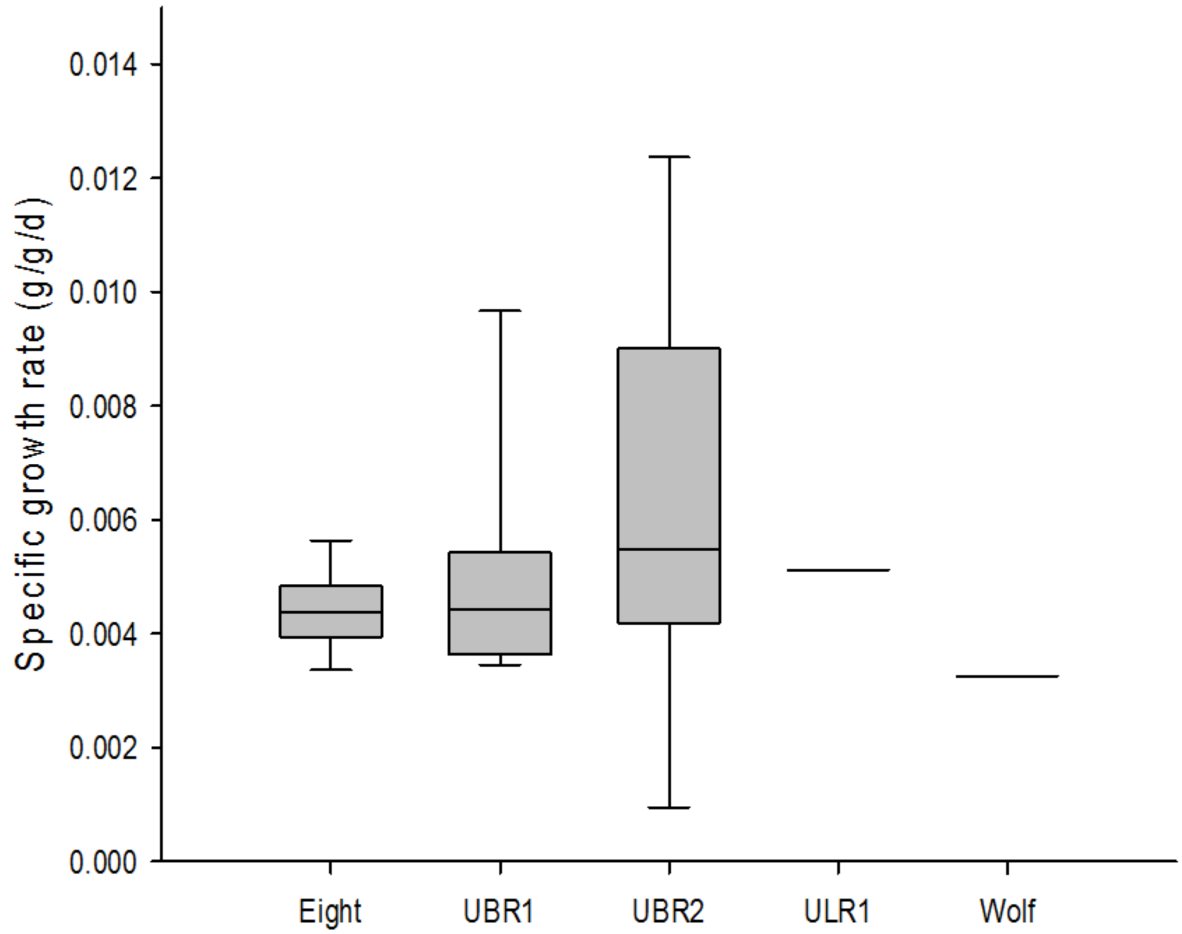

Figure 1-21. Specific growth of PIT tagged juvenile steelhead/rainbow trout recaptured for five tributaries in the Methow River watershed, Washington. Eight, Eightmile Creek (near mouth); UBR1, Beaver Creek - Reach 1 (rkm 5); UBR2, Beaver Creek - Reach 2 (rkm 13); and Wolf, Wolf Creek (near mouth).

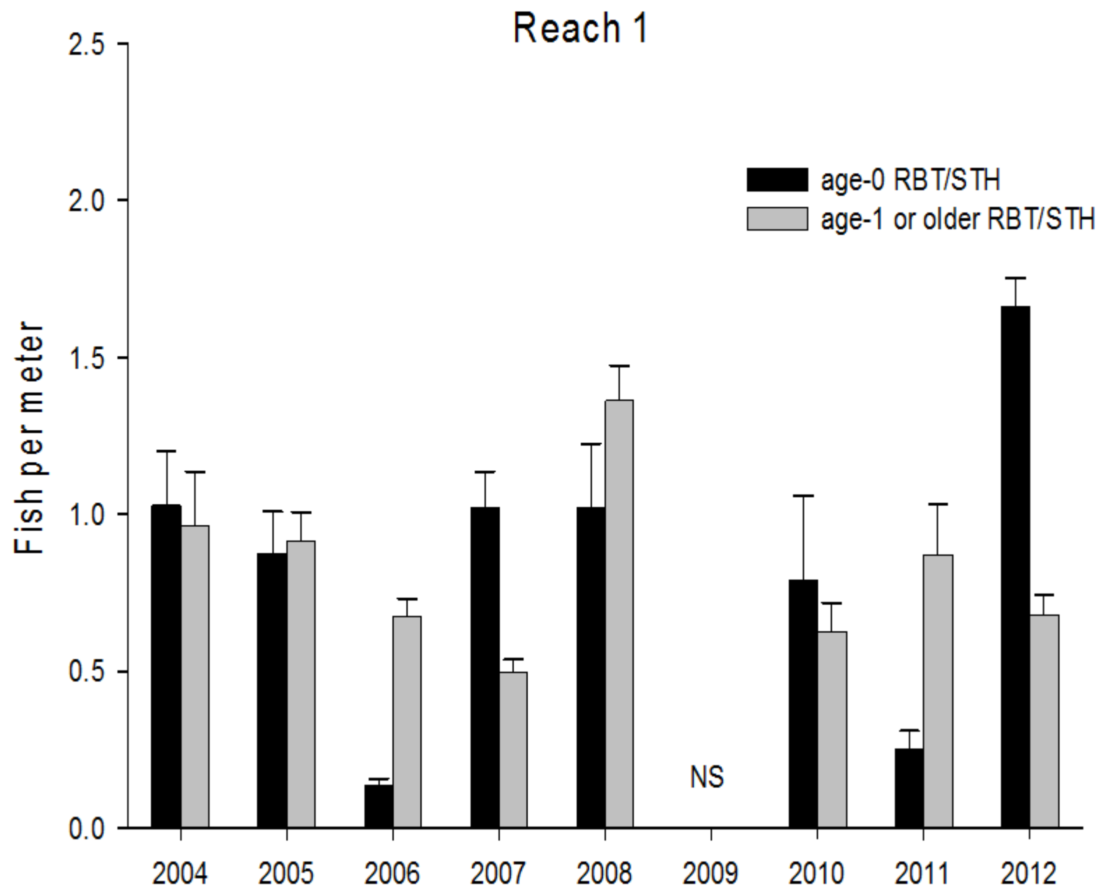

Figure 1-22. Fish per meter of rainbow trout/steelhead from population surveys in Reach 1 (rkm 5) of Beaver Creek, Methow River watershed, Washington, 2004–2012. NS, not sampled; RBT, rainbow trout; STH, steelhead.

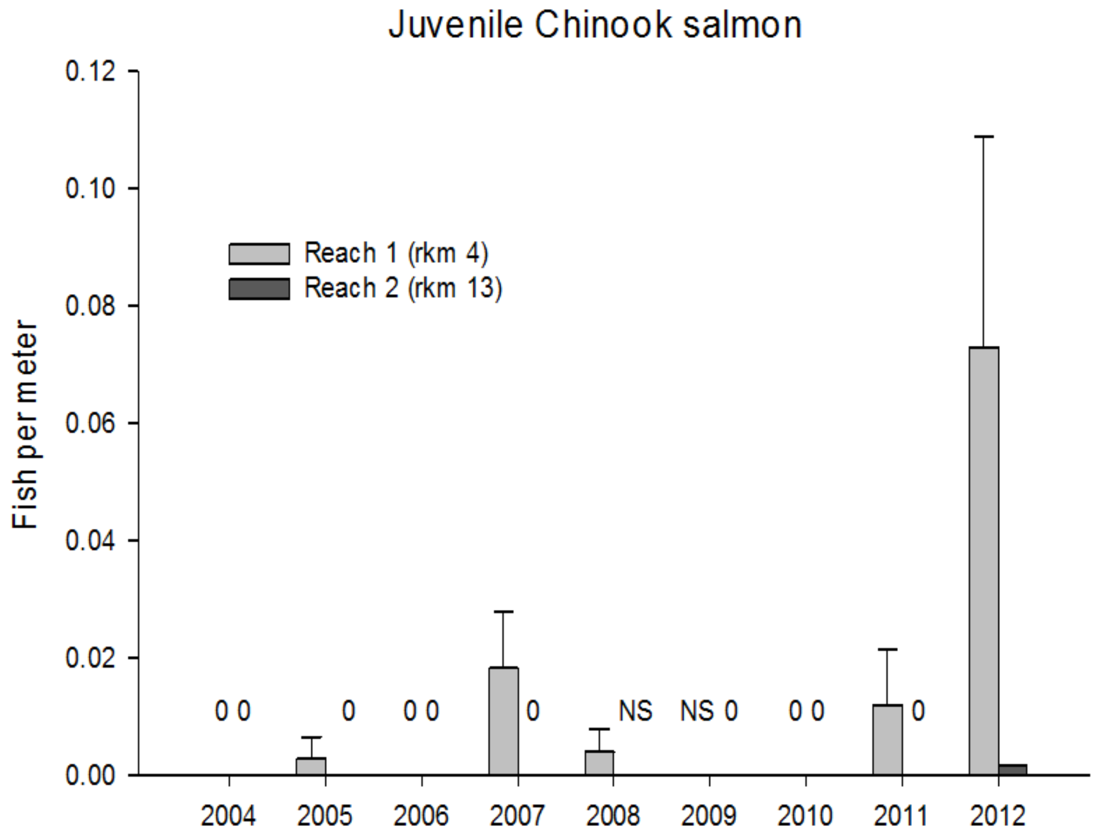

Figure 1-23. Fish per meter of juvenile Chinook salmon from population surveys in Reach 1 and 2 of Beaver Creek, Methow River watershed, Washington, 2004–2012. NS, not sampled.

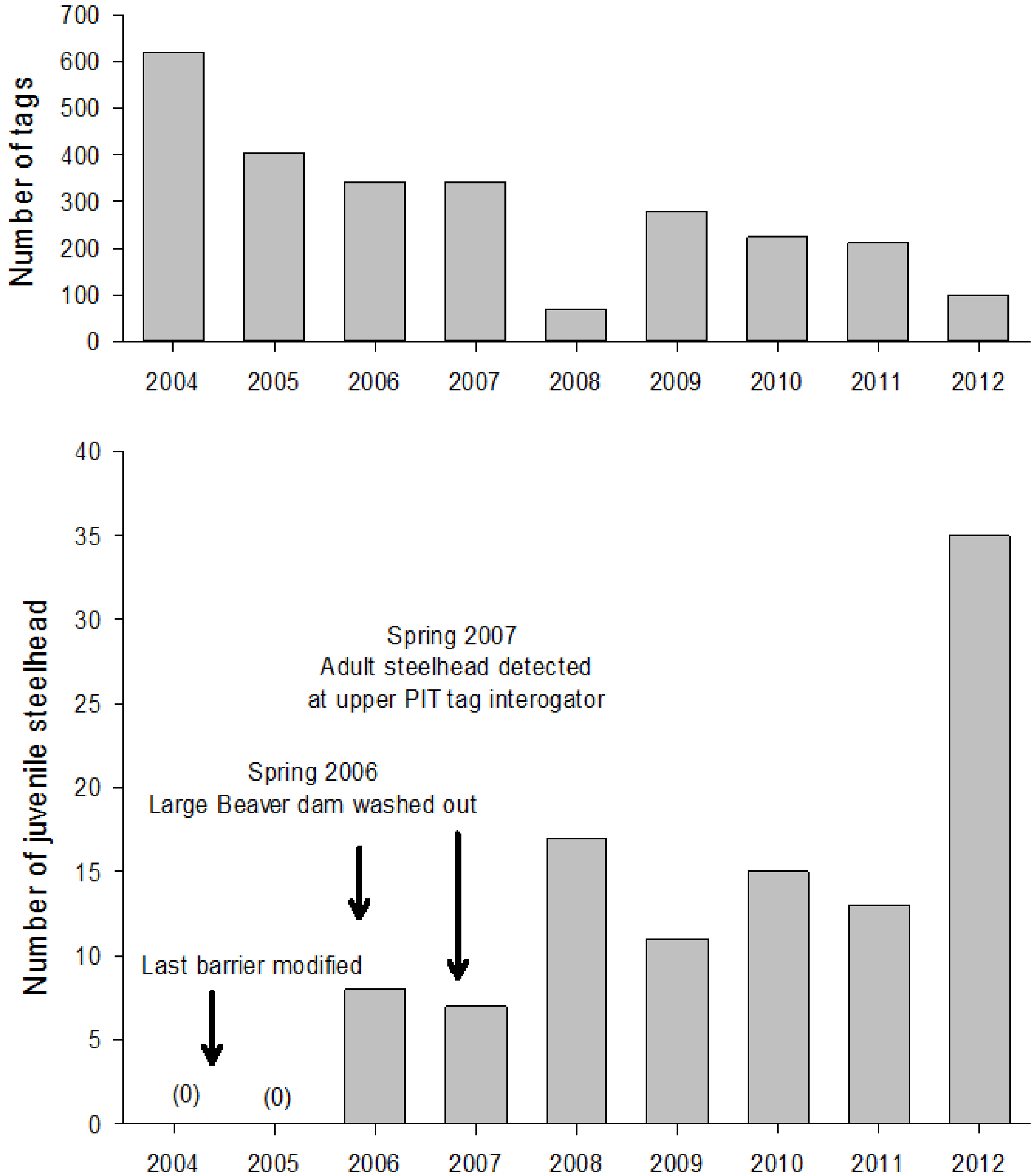

Figure 1-24. Number of PIT-tagged juvenile steelhead/rainbow trout tagged upstream of rkm 12 by year and the number of these fish that were detected at middle Beaver interrogation system (BVC; rkm 4) by year, Methow River watershed, Washington.

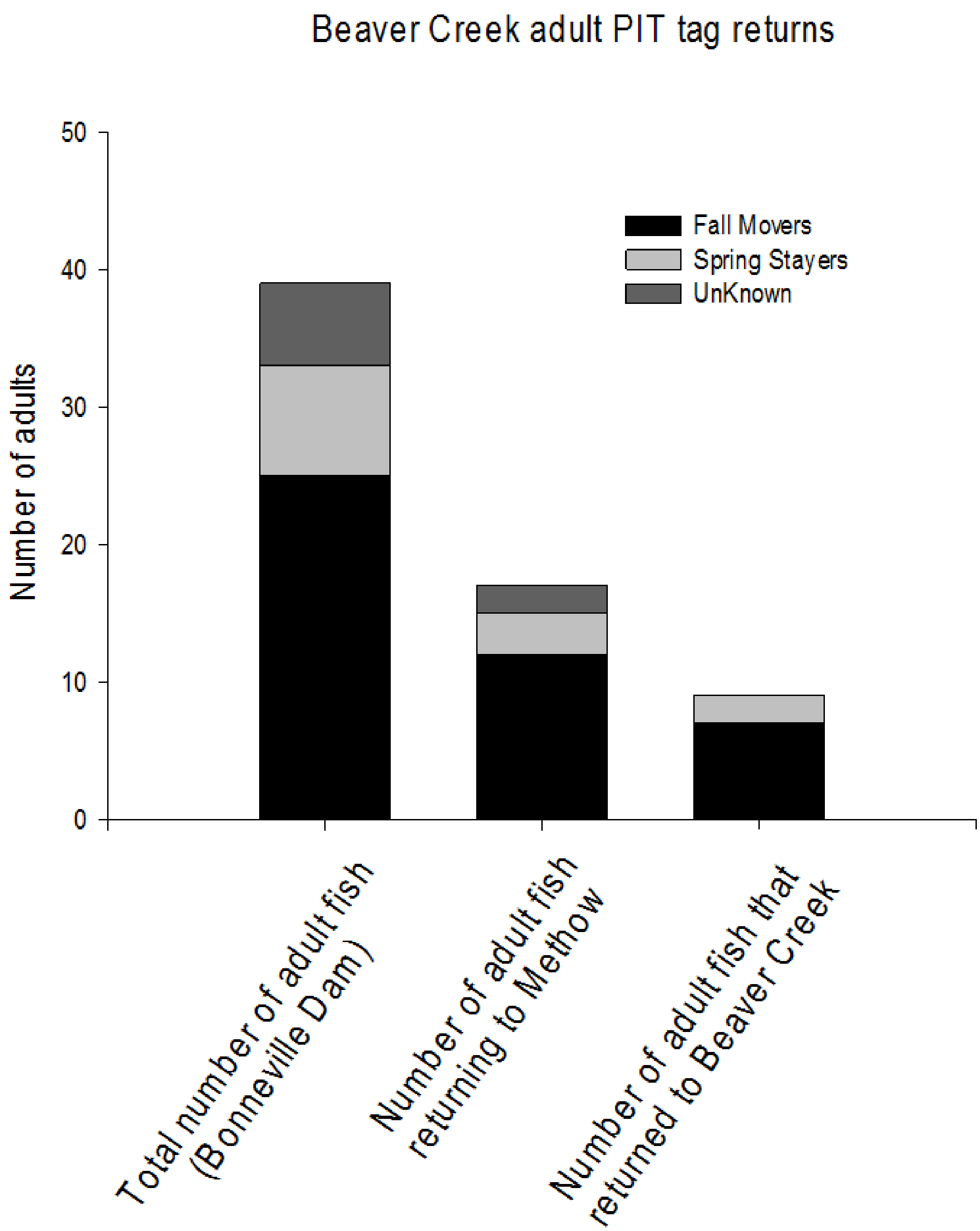

Figure 1-25. Adult steelhead detected at Bonneville Dam, at Wells Dam, and in Beaver Creek that were tagged in Beaver Creek as juveniles by juvenile migration timing, Methow River watershed, Washington.

Table 1-1. PIT-tag interrogation systems and years of operation, Methow River watershed, Washington.

[X, present; --, not present]

Watershed Stream/site	rkm	arrays	antennas	Years of operation 2008	2009	2010	2011	2012
Methow River								
LMR (WDFW)	3	2	6	--	X	X	X	X
Gold Creek	1	3	6	X	X	X	X	X
Libby Creek	1	1	1	X	X	X	X	X
Beaver Creek (BVC)	4	3	6	X	X	X	X	X
Beaver Creek (upper)	12	1	1	--	--	X	X	X
Twisp River (TWR; WDFW)	2	2	6	X	X	X	X	X
Methow River								
MRT	66	2	6	X	X	--	--	--
SC2	70	1	1	X	X	X	X	X
SC3	76	1	1	X	X	X	X	X
Chewuch River (CRW)	1	2	6	--	--	--	X	X
Eightmile Cr.	1	1	1	X	X	X	--	--
Methow River								
MRW	85	2	6	--	X	X	X	X
Wolf Creek	1	1	1	X	X	X	X	X
Methow River								
SC4	86	1	1	X	X	X	X	X
SC5	93	1	1	X	X	X	X	X

Table 1-2. Mean length and mean number of habitat units per side channel in late July to early September 2008–2012.

[All side channels were completely sampled unless otherwise indicated. Dry, Dry unit; GL, Glide; PL, Pool; RI, Riffle]

Watershed site	rkm	Years sampled	Mean sampled Length – m (SD)	Mean number (SD) of habitat units			
				PL	GL	RI	Dry
Methow River							
LM	56	3	281.3(7.2)	4.0(0)	0.0(0)	0.0(0)	4.3(1.2)
SC1	66	4	544.6(64.2)	7.0(2.2)	0.8(0.5)	0.3(0.5)	7.0(0.82)
SC2[1]	70	4	559.8(63.0)	7.8(1.9)	5.4(2.3)	1.4(1.1)	3.0(3.9)
3R	75	3	341.5(153.5)	3.7(0.6)	0.0(0)	0.3(0.6)	4.7(0.6)
SC3	76	5	587.5(151.3)	9.0(1.9)	2.6(1.1)	0.2(0.4)	7.4(0.9)
SC4	87	4	305.0(17.9)	4.3(1.0)	4.0(0.8)	0.3(0.5)	0.0(0)
CC	89	3	269.5(1.3)	5.7(2.5)	3.0(1.0)	0.0(0)	2.0(3.5)
SC5	94	4	782.3(52.3)	8.5(2.9)	9.3(1.0)	2.3(1.7)	1.3(1.3)
Chewuch River							
WH	6	3	138.6(10.2)	4.7(3.1)	1.7(0.6)	0.0(0)	4.0(1.7)
UC	22	3	293.4(16.8)	13.3(1.5)	4.7(1.5)	0.3(0.6)	6.3(1.5)

[1]Side channel was partially sampled.

Table 1-3. Presence and absence of fish species sampled and/or observed in side channels in the Methow River watershed by the U.S. Geological Survey during the 2008–2012 field seasons.

[Watersheds and streams are listed in a downstream to upstream pattern within a watershed. A, absent; P, present]

Watershed Side channel	Distance upstream of mouth (km)	Year sampled	Rainbow trout/steelhead *Oncorhynchus mykiss*	Brook trout *Salvelinus fontinalis*	Cutthroat trout *Oncorhynchus clarkii*	Chinook salmon *Oncorhynchus tschawytshca*	Coho salmon *Oncorhynchus kisutch*	Bull trout *Salvelinus confluentus*	Mountain whitefish *Prosopium williamsoni*	Other species
Methow River										
LM	56.0	2010-2012	P	A	A	P	P	A	A	**P[3,4,5,6,7]**
SC1	66.0	2009-2012	P	A	A	P	P	A	P	**P[3,4,5,6,7]**
SC2	70.0	2008-2012	P	P	A	P	P	P[1]	P	**P[3,4,5,6,7]**
3R	75.0	2010-2012	P	P	A	P	P	A	P	**P[3,4,5,6,7]**
SC3	76.0	2008-2012	P	P[1]	A	P	P	A	A	**P[3,4,5,7]**
SC4	87.0	2009-2012	P	P	A	P[2]	P	P[1]	P	**P[3,4,5]**
CC	89.0	2010-2012	P	P	A	P[2]	P	P[1]	A	**P[3,5]**
SC5	94.0	2009-2012	P	P	P	P[2]	A	P	P	**P[3,4,5]**
Chewuch River										
WH	6.0	2010-2012	P	P	A	P	A	A	A	**P[3,5]**
UC	22.0	2010-2012	P	A	A	P	A	A	A	**P[3,4,5,7]**

[1]Only one individual was observed during surveys at this site.

[2]Adult and juvenile of the same species were observed in this reach.

[3]sculpin.

[4]bridgelip sucker.

[5]longnose dace.

[6]brown bullhead.

[7]Pacific lamprey.

Table 1-4. PIT tags deployed in side channels to the Methow and Chewuch Rivers during the 2008–2012 field seasons.

[Side channels are listed in a downstream to upstream pattern within a watershed. Methods surveyed: FSNP, fish sampled by electrofishing, not a population survey; H/L, hook and line survey; PS, 500 m reach population survey. Fish codes are BBH, brown bullhead; BLS, bridgelip sucker; BLT, bull trout; BRK, brook trout; CHN, Chinook; COH, coho; CTT, cutthroat trout; LND, longnose dace; RBT, juvenile steelhead and rainbow trout; SCP, sculpin; STH, adult steelhead; WHT, mountain whitefish. km, kilometer]

Watershed Side channel	Distance upstream of mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
Methow River															
LM	56.0	2010	PS	59	0	2	0	15	86	0	0	7	0	0	0
		2011	PS	32	0	1	0	22	28	0	0	3	0	0	0
		2012	PS	10	0	0	0	17	9	0	0	1	0	0	0
SC1	66.0	2009	PS	79	0	0	0	192	19	0	0	0	0	0	0
		2010	PS	152	0	0	0	13	48	0	0	6	1	0	1
		2011	PS	53	0	0	0	71	117	0	7	3	1	0	0
		2012	PS	7	0	0	0	23	46	0	0	0	0	0	0
SC2	70.0	2008	PS;FSNP	13	0	0	0	36	183	0	0	1	0	0	0
		2009	PS	35	0	0	0	168	95	0	0	22	4	1	6
		2010	PS	24	0	0	0	86	427	0	0	36	16	0	0
		2011	PS	109	0	4	0	157	272	1	1	41	5	0	0
		2012	PS	6	0	0	0	61	158	0	0	14	11	0	0
3R	75.0	2010	PS	4	0	0	0	28	249	0	0	13	0	0	0
		2011	PS	9	0	2	0	23	357	0	1	19	0	0	0
		2012	PS	1	0	0	0	12	174	0	0	0	0	0	0
SC3	76.0	2008	PS	25	0	1	0	1	21	0	0	0	0	0	0
		2009	PS;FSNP	171	0	1	0	119	11	1	0	9	0	0	0
		2010	PS	276	0	0	0	48	53	0	0	6	0	0	0
		2011	PS	204	0	0	0	127	62	0	0	0	0	0	0
		2012	PS	73	0	0	0	29	38	0	0	0	0	0	0
	87.0	2009	PS;FSNP	35	0	9	2	35	0	0	0	0	2	5	1

Watershed Side channel	Distance upstream of mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
SC4															
		2010	PS	37	0	3	0	5	1	0	0	2	0	5	2
		2011	PS	71	0	6	0	111	7	0	0	0	5	0	0
		2012	PS	38	0	0	0	62	3	1	0	0	5	10	0
CC	89.0	2010	PS,FSNP	103	0	3	0	33	3	0	0	0	0	0	0
		2011	PS;FSNP	57	0	0	0	71	3	0	0	0	0	10	0
		2012	PS	43	0	0	0	91	2	1	0	0	0	3	0
SC5	94.0	2009	PS, FSNP	143	0	3	0	82	0	1	0	1	0	0	10
		2010	PS, FSNP	213	0	10	0	76	0	0	0	8	2	0	0
		2011	PS, FSNP	151	0	0	0	242	0	1	0	24	0	0	0
		2012	PS	83	0	0	0	66	0	1	0	0	1	0	0
			Totals	**2,278**	**0**	**44**	**2**	**2,085**	**2,268**	**7**	**9**	**215**	**53**	**34**	**20**
Chewuch															
WH	6.0	2010	PS	21	0	1	0	2	0	0	0	0	0	0	0
		2011	PS	13	0	4	0	45	0	0	0	0	0	0	0
		2012	PS	0	0	0	11	0	0	0	0	0	0	0	0
UC	22.0	2010	PS, FSNP	162	0	0	0	59	1	1	0	4	0	0	0
		2011	PS	142	0	0	0	82	0	0	0	0	0	0	0
		2012	PS	38	0	0	0	24	0	0	0	0	0	0	0
			Totals	**378**	**0**	**5**	**0**	**223**	**1**	**1**	**0**	**4**	**0**	**0**	**0**

Table 1-5. Year that PIT tags were released that were subsequently detected downstream of the Methow River at one or more Columbia River dams for the control and treatment and reference sites during the pre-treatment phase (2009–2012).

[Connectivity: NC, not connected; CN, connected; PC, partially connected. Species: CHN, Chinook; COH, coho; RBT, rainbow trout]

Watershed Stream reach or section	Distance upstream of mouth (km)	Connectivity	Species	Total number detected in Columbia River as smolts				
				2009	2010	2011	2012	Total
Lower Methow (Reference)								
LM	56.0	NC	RBT	0	3	1	0	**4**
			CHN	0	0	1	1	**2**
			COH	0	29	5	1	**35**
Middle Methow (Treatment)								
SC1	66.0	NC	RBT	0	2	0	4	**6**
			CHN	7	0	6	0	**13**
			COH	4	8	20	1	**33**
SC2	70.0	NC	RBT	1	0	0	0	**1**
			CHN	0	0	0	1	**1**
			COH	0	3	17	14	**34**
3R	75.0	NC	RBT	0	0	0	2	**2**
			CHN	0	0	1	0	**1**
			COH	0	26	17	1	**44**
SC3	76.0	NC	RBT	8	16	9	2	**35**
			CHN	10	9	20	2	**41**
			COH	2	13	6	8	**29**
Upper Methow (Control)								
SC4	86.8	CN	RBT	0	2	4	3	**9**
			CHN	0	0	12	1	**13**
			COH	0	1	0	0	**1**
CC	89.0	PC	RBT	0	0	0	0	**0**
			CHN	0	0	4	2	**6**
			COH	0	0	0	1	**1**
SC5	94.5	PC	RBT	0	12	7	1	**20**
			CHN	0	3	17	0	**20**
			COH	0	0	0	0	**0**
Chewuch River (Control)								
WH	6.0	NC	RBT	0	0	0	0	**0**
			CHN	0	0	0	0	**0**
			COH	0	0	0	0	**0**
UC	22.0	CN	RBT	0	0	3	1	**4**
			CHN	0	0	8	4	**12**
			COH	0	0	0	0	**0**

Table 1-6. Number of units, mean length, total length, and number of large woody debris (LWD) pieces by bank unit type in the M2 and Lower Methow reaches, Washington.

[Units by type: AL, alcove; HS, high slope; LS, low slope; MS, medium slope; OT, other; RR, rip rap; SC, side channel; UC, undercut bank]

Reach bank	Number of units by type								
	UC	HS	MS	LS	SC	AL	RR	OT	Total
M2 reach									
Left	12	16	55	38	6	10	10	4	151
Right	8	19	48	40	17	8	13	4	157
Lower Methow									
Left	3	16	65	39	4	11	15	1	154
Right	5	22	64	47	8	11	19	0	176
Reach bank	**Mean length of units by type**								
	UC	HS	MS	LS	SC	AL	RR	OT	
M2 reach									
Left	129.1	79.0	108.1	151.2	37.2	34.8	141.2	15.5	
Right	98.5	121.1	128.4	113.9	22.5	28.8	154.4	40.3	
Lower Methow									
Left	113.3	114.8	155.8	155.2	25.3	28.5	170.1	15.0	
Right	80.4	111.7	124.5	150.8	19.5	26.6	168.3	0.0	
Reach bank	**Total length of units by type**								
	UC	HS	MS	LS	SC	AL	RR	OT	Total
M2 reach									
Left	1,549	1,264	5,947	5,747	223	348	1,412	62	16,552
Right	788	2,300	6,164	4,555	382	230	2,003	161	16,583
Lower Methow									
Left	340	1,837	10,129	6,053	101	314	2,552	15	21,341
Right	402	2,458	7,967	7,088	156	293	3,198	0	21,562
Reach bank	**Total LWD pieces units by type**								
	UC	HS	MS	LS	SC	AL	RR	OT	Total
M2 reach									
Left	84	67	241	191	1	37	31	2	654
Right	32	73	117	62	128	29	32	7	480
Lower Methow									
Left	16	79	124	35	2	20	30	0	306
Right	13	90	229	87	36	9	64	0	528

Table 1-7. Presence and absence of fish species sampled and/or observed in the mainstem Methow, Chewuch, and Twisp Rivers by the U.S. Geological Survey during the 2009–2012 field seasons.

[Watersheds and streams are listed in a downstream to upstream pattern within a watershed. A, absent; P, present]

Watershed **Reach or section**	**Distance upstream from mouth (km)**	**Year sampled**	**Rainbow trout/steelhead *Oncorhynchus mykiss***	**Brook trout *Salvelinus fontinalis***	**Cutthroat trout *Oncorhynchus clarkia***	**Chinook salmon *Oncorhynchus tschawytshca***	**Coho salmon *Oncorhynchus kisutch***	**Bull trout *Salvelinus confluentus***	**Mountain whitefish *Prosopium williamsoni***	Other species
Methow River										
Lower Methow	54.0-64.0	2009-11	P[1]	A	P	P[1]	P[1]	P[1]	P[1]	P[34567]
Middle Methow	64.0-81.0	2009-12	P[1]	P	P	P[1]	P	P	P	P[34567]
Upper Methow	81.0-94.0	2009-12	P[1]	P[1]	P	P[1]	P[1]	P[1]	P[1]	P[345]
Twisp River										
Buttermilk Br.	21.0	2010	A	A	A	A	A	A	P	P[3]
Chewuch River										
Screw Trap	1.0	2009-12	P	A	P	P	A	P	P	P[23457]
Reach 1	2.0-8.0	2010-11	P	P	A	P	A	A	A	P[3457]
Reach 2	9.0-18.0	2009-12	P[1]	P	P	P[1]	P[1]	P	P[1]	P[4]
Reach 3	19.0-29.0	2009-11	P	A	P	P[1]	P	P	P	P[347]
Reach 4	30.0	2009	P	A	P	A	A	P	A	P[3]

[1] Adult and juvenile of the same species were observed in this reach.

[2] One redside shiner collected in Chewuch rotary screw trap.

[3] sculpin.

[4] bridgelip sucker.

[5] longnose dace.

[6] brown bullhead.

[7] pacific lamprey.

Table 1-8. PIT tags deployed in the mainstem Methow and Chewuch Rivers during the 2008–2012 field seasons.

[Methods surveyed: BS, Boat electrofisher; FSNP, fish sampled by electrofishing, not a population survey; H/L, hook and line survey; RST, Rotary screw trap; SN, snetting. Fish codes are BBH, brown bullhead; BLS, bridgelip sucker; BLT, bull trout; BRK, brook trout; CHN, Chinook; COH, coho; CTT, cutthroat trout; LND, longnose dace; RBT, juvenile steelhead and rainbow trout; SCP, sculpin; STH, adult steelhead; WHT, mountain whitefish]

Watershed Reach or section	Distance upstream of mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
Methow River															
Lower Methow	54.0-64.0	2009	FSNP,H/L,SN	19	0	0	2	25	1	1	0	0	87	0	0
		2010	FSNP,SN	1	0	0	5	0	0	5	0	1	105	0	0
		2011	SN	0	0	0	4	0	0	1	0	0	13	0	0
Middle Methow	64.0-81.0	2008	FSNP	71	0	0	2	56	18	0	0	0	3	0	0
		2009	FSNP,H/L,SN	143	2	0	89	155	6	16	0	0	317	0	5
		2010	FSNP,H/L,SN	55	1	0	17	44	11	11	0	0	166	0	0
		2011	FSNP,H/L,SN	72	0	0	8	114	18	6	0	2	83	4	0
		2012	FSNP,BS	144	0	0	3	134	30	2	0	1	42	2	0
Upper Methow	81.0-94.0	2008	FSNP	37	0	18	0	62	28	0	0	0	0	0	0
		2009	FSNP	97	0	13	0	73	2	1	0	4	0	0	0
		2010	FSNP	112	0	4	0	41	5	0	0	0	0	0	0
		2011	FSNP	6	0	3	0	32	4	0	0	0	0	0	0
		2012	FSNP	4	0	0	0	5	0	0	0	0	0	0	0
Chewuch River															
Rotary Screw Trap	1.0	2009	RST	13	0	0	7	75	0	0	0	4	0	84	0
		2010	RST	542	0	0	13	1,106	8	3	0	16	14	289	0
		2011	RST	325	0	0	14	1,304	1	0	0	7	29	231	0
		2012	RST	185	0	0	16	957	1	1	0	8	4	319	0
Reach 1	2.0-8.0	2008	FSNP	45	0	12	0	0	0	0	0	0	0	0	0
		2010	FSNP	41	0	0	0	3	0	0	0	0	0	0	0
		2011	FSNP	24	0	1	0	20	0	0	0	0	0	0	0
Reach 2	9.0-18.0	2008	FSNP	46	0	3	1	4	1	0	0	0	0	0	0
		2009	FSNP	24	0	1	0	20	0	0	0	0	0	0	0
		2011	FSNP	13	0	1	0	5	0	0	0	0	0	0	0
		2012	FSNP	2	0	0	0	0	0	0	0	0	0	0	0

Watershed Reach or section	Distance upstream of mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
Reach 3	19.0-29.0	2009	FSNP	16	0	0	0	21	0	0	0	0	0	0	0
		2010	FSNP	43	0	0	0	13	0	0	0	2	0	0	0
		2011	FSNP, H/L	28	0	0	5	4	0	0	0	1	1	0	0
Reach 4	30.0	2009	FSNP	48	0	0	0	1	0	1	0	0	0	0	0

Table 1-9. Number of fish (by tag year) that were detected downstream of the Methow River at one or more Columbia River dams for the control and treatment and reference sites during the pre-treatment phase (2009–2012).

[Species: CHN, Chinook; COH, coho; RBT, rainbow trout. km, kilometer]

Watershed Stream reach or section	Distance upstream of mouth (km)	Species	Total detected in Columbia River				
			2009	2010	2011	2012	Total
Lower Methow (Reference)							
M3	54.0-63.0	RBT	5	0	0	0	**5**
		CHN	2	0	0	0	**2**
		COH	0	0	0	0	**0**
Middle Methow (Treatment)							
M2	64.0-74.0	RBT	0	0	11	0	**11**
		CHN	2	0	7	0	**9**
		COH	0	0	0	0	**0**
Upper Methow (Control)							
M1	87.0-94.0	RBT	14	0	0	0	**14**
		CHN	6	0	0	0	**6**
		COH	0	0	0	0	**0**
Chewuch River (Control)							
Screw Trap	1.0	RBT	0	0	81	15	**96**
		CHN	0	0	215	153	**328**
		COH	0	0	0	0	**0**
Chewuch – Reach 1	2.0-6.0	RBT	1	2	0	1	**4**
		CHN	4	1	0	0	**5**
		COH	0	0	0	0	**0**
Chewuch – Reach 3	19.0-22.0	RBT	1	2	0	1	**4**
		CHN	0	1	0	0	**1**
		COH	0	0	0	0	**0**

Table 1-10. Survival and detection estimates from hatchery releases 2011–2012.

[Hatchery codes: WINT, Winthrop hatchery; METH, Methow hatchery. Species codes: CHN, Chinook; STH, steelhead. Dam codes: BON, Bonneville Dam; JDA, John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; REL, Release site; RRE, Rocky Reach Dam]

Year	Site	Species	Number of tags	Detection probability					
				LMR	RRE	MCN	JDA	BON	TWL
2011	WINT	STH	29,580	0.0025	0.3208	0.1615	0.1611	0.0667	0.0490
2011	METH	CHN	15,988	0.0026	0.2964	0.1341	0.1641	0.0311	0.1521
2012	WINT	STH	39,088	0.0067	0.3024	0.0979	0.2007	0.0908	0.1076
2012	WINT	CHN	14,901	0.0013	0.1775	0.1837	0.1394	0.1394	0.1317

Year	Site	Species	Number of tags	Detection probability					
				Rel-LMR	LMR-RRE	RRE-MCN	MCN-JDA	JDA-BON	BON-TWL
2011	WINT	STH	29,580	1.000	0.7675	0.7072	1.000	0.6412	0.2126
2011	METH	CHN	15,988	1.000	0.7391	0.6151	1.000	1.000	0.0869
2012	WINT	STH	39,088	0.9991	0.6332	0.5623	0.8177	0.9999	0.3021
2012	WINT	CHN	14,901	0.9982	0.7744	0.6982	0.8527	0.9999	0.1315

Table 1-11. PIT tags detected from hatchery fish releases in the Methow River watershed.

[Site codes: CRW, Chewuch River above Winthrop; LMR, lower Methow River; MRT, Methow River above Twisp; MRW = Methow River above Winthrop]

Date	Site	PIT tags released	Number of tag detected	Percentage of tags detected	Flow (ft^3/s)
04/08/2010	LMR	100	10	10.0	672
04/08/2010	MRT	100	7	7.0	672
04/08/2010	MRW	100	37	37.0	672
04/21/2010	LMR	100	1	1.0	3,630
04/21/2010	MRT	100	0	0	3,630
04/21/2010	MRW	100	6	6.0	3,630
04/22/2010[1]	CRW	810	6	0.7	4,490
05/24/2010	LMR	100	0	0	5,550
04/05/2011	LMR	201	3	1.5	1,360
04/06/2011	LMR	202	7	3.5	1,330
04/05/2011	MRT	204	21	10.3	1,360
04/06/2011	MRT	203	28	13.9	1,330
04/05/2011	MRW	204	21	10.3	1,360
04/06/2011	MRW	202	28	13.9	1,330
04/26/2011[a]	CRW	515	180	35.0	1,530
05/12/2011	LMR	200	0	0	5,680
05/13/2011	LMR	195	0	0	5,880
05/12/2011	MRT	193	0	0	5,680
05/13/2011	MRT	191	0	0	5,880
05/12/2011	MRW	199	4	2.0	5,680
05/13/2011	MRW	193	2	1.0	5,880
05/11/2011[a]	CRW	588	7	1.2	4,390
03/30/2012	LMR	398	44	11.1	518
03/30/2012	MRW	399	88	22.1	518
03/30/2012	CRW	394	278	70.6	518
04/24/2012	LMR	400	2	0.5	5,100
04/23/2012	MRW	394	21	5.3	2,790
04/23/2013	CRE	402	85	21.1	2,790

[1] Data from a sample of WDFW fish releases to test efficiency of CRW interrogator.

Table 1-12. Presence and absence of fish species sampled and/or observed in tributaries to the Methow watershed by the U. S. Geological Survey during the 2009–2012 field seasons.

[Watersheds and streams are listed in a downstream to upstream pattern within a watershed. A, absent; P, present]

Watershed Tributary Reach	**Distance upstream from mouth (km)**	**Year sampled**	**Rainbow trout/steelhead** ***Oncorhynchus mykiss***	**Brook trout** ***Salvelinus fontinalis***	**Cutthroat trout** ***Oncorhynchus clarkii***	**Chinook salmon** ***Oncorhynchus tschawytshca***	**Coho salmon** ***Oncorhynchus kisutch***	**Bull trout** ***Salvelinus confluentus***	**Mountain whitefish** ***Prosopium williamsoni***	Other species
Methow River										
Gold Cr.										
Reach 2	**4.0**	**2009**	**P**	**A**	**A**	**P**	**A**	**P**[1]	**A**	**P**[3]
S. Fork Gold Cr.	**2.0**	**2009-12**	**P**	**A**	**A**	**A**	**A**	**A**	**A**	**P**[3]
Libby Cr.										
Reach 1	**2.6**	**2009-11**	**P**	**P**	**P**	**P**[2]	**A**	**P**[1]	**A**	**P**[3]
Beaver Cr.										
Lower	**1.3**	**2009**	**P**[2]	**P**	**A**	**A**	**A**	**A**	**A**	**P**[34]
Reach 1	**4.6**	**2009-12**	**P**	**P**	**A**	**P**	**P**	**A**	**A**	**P**[3]
Campbells	**8.0**	**2010,12**	**P**	**P**	**A**	**A**	**A**	**A**	**A**	**A**
Marracci	**10.0**	**2011**	**P**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Reach 2	**13.0**	**2009-12**	**P**	**P**	**P**[1]	**P**[1]	**A**	**P**	**A**	**P**[3]
R2 Campground	**14.0**	**2011-12**	**P**	**P**[1]	**A**	**A**	**A**	**A**	**A**	**A**
Reach 4	**16.0**	**2009,11**	**P**	**P**	**P**[1]	**A**	**A**	**A**	**A**	**A**
Wolf Creek										
Reach 1	**1.0**	**2009-12**	**P**	**A**	**A**	**P**	**A**	**P**[2]	**A**	**P**[3]
Fish Screen	**2.0**	**2010**	**P**	**A**	**P**[1]	**A**	**A**	**P**[1]	**A**	**P**[3]
Twisp River										
Poorman Cr.	**7.0**	**2009**	**P**	**P**	**A**	**A**	**A**	**A**	**A**	**P**[3]
Little Bridge Cr.	**4.0**	**2012**	**P**	**A**	**A**	**A**	**A**	**P**	**A**	**P**[3]
Chewuch River										
Eightmile Cr.										
Reach 1	**1.0**	**2009-12**	**P**	**P**	**P**	**P**	**A**	**P**[2]	**A**	**P**[3]
Below 2nd Bridge	**2.0**	**2010-11**	**P**	**P**[1]	**A**	**A**	**A**	**A**	**A**	**A**
Flats Campground	**4.0**	**2009**	**P**	**P**	**A**	**A**	**A**	**A**	**A**	**P**[3]
Ab. Flats Cmp	**5.0**	**2009-11**	**P**	**P**	**A**	**A**	**A**	**A**	**A**	**P**[3]

[1] Only one individual was observed during surveys at this site.
[2] Adult and juvenile of the same species were observed in this reach.
[3] sculpin.
[4] bridgelip sucker.

Table 1-13. PIT tags deployed in tributaries to the Methow, Chewuch, and Twisp Rivers during the 2008–2012 field seasons.

[Methods surveyed: FSNP, fish sampled by electrofishing, not a population survey; PS, population survey; Weir, fish collection weir. . Fish codes are BBH, brown bullhead; BLS, bridgelip sucker; BLT, bull trout; BRK, brook trout; CHN, Chinook; COH, coho; CTT, cutthroat trout; LND, longnose dace; RBT, juvenile steelhead and rainbow trout; SCP, sculpin; STH, adult steelhead; WHT, mountain whitefish]

Watershed Side Channel	Distance upstream From mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
Methow River															
Gold Cr.															
S. Fork Gold Cr.	2.0	2008	PS	138	0	0	1	0	0	0	0	0	0	0	0
		2009	PS, FSNP	82	0	0	0	0	0	0	0	0	0	0	1
		2010	FSNP	30	0	0	0	0	0	0	0	0	0	0	0
		2011	FSNP	21	0	0	0	0	0	0	0	0	0	0	0
		2012	FSNP	14	0	0	0	0	0	0	0	0	0	0	0
			Total	**285**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Libby Cr.															
Reach 1	2.6	2008	FSNP	201	0	0	1	0	0	0	0	0	0	0	0
		2009	FSNP	26	0	0	0	0	0	0	0	0	0	0	0
		2010	PS, FSNP	329	0	1	1	0	0	0	0	0	0	0	0
		2011	FSNP	59	0	1	0	0	0	1	0	0	0	0	0
			Total	**615**	**0**	**2**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Beaver Creek															
Ott	1.3	2008	Weir	563	0	48	1	18	1	0	0	0	0	0	0
		2009	FSNP	78	0	3	0	0	0	0	0	0	0	0	2
Stokes	4.6	2008	PS, FSNP	465	0	31	0	2	0	0	0	0	0	0	0
		2009	FSNP	110	1	8	0	0	0	0	0	0	0	0	0
		2010	PS, FSNP	250	0	17	0	0	1	0	0	0	0	0	0
		2011	PS, FSNP	232	0	12	0	3	0	0	0	0	0	0	0
		2012	PS, FSNP	246	0	0	0	27	1	0	0	0	0	0	0
Cambells	8.0	2010	FSNP	22	0	1	0	0	0	0	0	0	0	0	0
		2012	FSNP	8	0	0	0	0	0	0	0	0	0	0	0
Marracci	10.0	2011	FSNP	32	0	0	0	0	0	0	0	0	0	0	0
Reach 2	13.0	2008	FSNP	69	0	1	0	0	0	0	0	0	0	0	0
		2009	PS;FSNP	229	0	11	0	0	0	0	0	0	0	0	0
		2010	PS, FSNP	207	0	7	0	0	0	0	0	0	0	0	0
		2011	PS, FSNP	177	0	6	1	0	0	0	0	0	0	0	0
		2012	PS, FSNP	97	0	0	0	1	0	2	0	0	0	0	0
R2 Camp	14.0	2011	FSNP	12	0	1	0	0	0	0	0	0	0	0	0
		2012	FSNP	3	0	0	0	0	0	0	0	0	0	0	0
S.Fork Beaver	14.0	2009	FSNP	26	0	0	0	0	0	0	0	0	0	0	0
Reach 4	16.0	2009	FSNP	24	0	1	0	0	0	0	0	0	0	0	0
		2011	FSNP	21	0	1	0	0	0	0	0	0	0	0	0

Watershed Side Channel	Distance upstream From mouth (km)	Year surveyed	Method surveyed	Total number of 134.2 khz PIT tags deployed											
				RBT	STH	BRK	CTT	CHN	COH	BLT	BBH	BLS	WHT	LND	SCP
			Totals	**2871**	**1**	**145**	**2**	**51**	**10**	**3**	**0**	**0**	**0**	**0**	**2**
Wolf Creek															
Reach 1	1.0	2008	PS, FSNP	60	0	0	0	28	1	0	0	0	0	3	3
		2009	PS, FSNP	73	0	0	0	12	0	2	0	0	0	0	3
		2010	PS, FSNP	21	0	0	0	11	0	2	0	0	0	3	0
		2011	PS, FSNP	57	0	0	0	40	0	3	0	0	0	0	0
		2012	FSNP	2	0	0	0	3	0	0	0	0	0	0	0
Fish Screen	2.0	2008	FSNP	58	0	0	0	2	0	0	0	0	0	0	0
		2010	FSNP	29	0	0	0	0	0	0	0	0	0	0	0
	7.0	2008	FSNP	72	0	0	0	0	0	0	0	0	0	0	0
			Totals	**372**	**0**	**0**	**0**	**96**	**1**	**7**	**0**	**0**	**0**	**3**	**6**
Twisp River															
Poorman Cr.	7.0	2009	FSNP	47	0	12	0	0	0	0	0	0	0	0	0
			Totals	**47**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Little Bridge Cr		2008	FSNP	19	0	0	0	2	0	0	0	0	0	0	0
		2012	FSNP	1050	0	0	0	0	0	6	0	0	0	0	0
			Totals	**1069**	**0**	**0**	**0**	**2**	**0**	**6**	**0**	**0**	**0**	**0**	**0**
Chewuch River															
Eightmile Cr.															
Reach 1	1.0	2008	PS, FSNP	112	0	1	5	0	0	8	0	0	0	0	0
		2009	PS, FSNP	148	0	2	2	8	0	6	0	0	0	0	0
		2010	FSNP	50	0	1	1	0	0	2	0	0	0	0	0
		2011	FSNP	42	0	1	0	0	0	0	0	0	0	0	0
		2012	FSNP	2	0	0	0	0	0	0	0	0	0	0	0
Below 2nd Bridge	2.0	2010	FSNP	16	0	1	0	0	0	0	0	0	0	0	0
		2011	FSNP	19	0	0	0	0	0	0	0	0	0	0	0
Flats Camp	4.0	2009	FSNP	18	0	11	0	0	0	0	0	0	0	0	0
Ab. Flats Camp	5.0	2009	FSNP	2	0	0	0	0	0	0	0	0	0	0	0
		2010	FSNP	3	0	15	0	0	0	0	0	0	0	0	0
		2011	FSNP	23	0	9	0	0	0	0	0	0	0	0	0
			Totals	**434**	**0**	**41**	**8**	**8**	**0**	**16**	**0**	**0**	**0**	**0**	**0**

Table 1-14. Number of tagged fish and the percent of fish tagged in Beaver Creek that were detected in the Columbia River.

Site	Distance upstream from mouth (km)	Number and percent of fish detected in the Columbia River			
		Year	Number tagged	Number detected	% detected
Lower	1	2004	182	7	3.8
		2005	1335	90	6.7
		2006	596	60	10.0
		2007	1320	151	11.4
		2008	549	62	11.2
Reach 1	4	2004	321	39	12.1
		2005	285	22	7.7
		2006	422	21	5.0
		2007	395	23	5.8
		2008	465	39	8.4
		2009	141	8	5.7
		2010	249	36	14.5
		2011	232	12	5.2
		2012	253	--	--
Reach 2	13	2004	198	2	2.5
		2005	161	2	1.2
		2006	176	0	0
		2007	340	8	2.4
		2008	69	0	0
		2009	190	5	2.6
		2010	229	6	2.6
		2011	209	4	1.9
		2012	97	--	--
Reach 4	16	2004	103	0	0
		2005	111	0	0
		2006	131	0	0
		2007	133	1	0
		2011	22	0	0

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Appendices

Appendix 1-1. Length frequency from all side channel sites (2008–2012). This appendix contains 189 graphs for key species (rainbow/steelhead, coho, and Chinook) found at each site and occasion. Graphs were plotted for every 2 mm.

Appendix 1-2. Length-weight relationships for every site sampled from 2008 to 2012. Key fish species length and weights were compared to establish a relationship through linear regression.

Appendix 1-3. Growth data for all side channel and lateral mainstem habitat (2008–2012). Growth data were determined from 2,409 recaptured PIT-tagged fish events.

Appendix 1-4. Population estimates for all side channel sites (2008–2012). Surveys typically were done with multiple-pass regression. In some cases, habitat units were too deep to effectively sample with multiple-pass removal, in these cases mark-recapture or snorkel estimates were used.

Appendix 1-5. Survival estimates for all side channel sites (2008–2012). Corrmack Jolly-Seber survival estimates were run over three seasons (summer, winter, and spring) in the program MARK.

Appendix 1-6. USGS/USFS bank unit habitat survey. Data from a bank habitat survey conducted in the M2 and silver reach of the Methow River during the summer of 2011.

Appendix 1-7. Length frequency from all mainstem sites (2008-2012). This appendix contains 26 graphs for key species (rainbow/steelhead, coho, and Chinook) found at each site and occasion. Graphs were plotted for every 2 mm.

Appendix 1-8. Point-abundance counts (2008-2011). Fish and biomass per meter estimates from mainstem lateral margin electrofishing sampling at three site in the M2 reach, and one site in the upper Methow, Chewuch, and Lower Methow reaches.

Appendix 1-9. Snorkel data counts (2008-2011). Data from snorkel surveys of fish over 150 mm completed over four reaches of mainstem river (Upper Methow, Chewuch, Middle Methow and Lower Methow).

Appendix 1-10. Survival estimates for hatchery release (2011-2012). Corrmack Jolly-Seber survival estimates were run using PIT-tagged hatchery smolt releases and Methow and Columbia River PIT tag interrogation systems in the program MARK.

Appendix 1-11. Length frequency for tributaries (2008-2012). This appendix contains 27 graphs for key species (rainbow/steelhead, coho, and Chinook) found at each site and occasion. Graphs were plotted for every 2 mm.

Appendix 1-12. Population estimates for tributaries (2004-2012). Surveys were done with multiple-pass regression on a subset of habitat units and then extrapolated over the length of survey (Typically 500 meters).

Chapter 2. Description of the U.S. Geological Survey's Database from Field Work Completed in the Method River Watershed from 2004 to 2012 and Comparison of USGS Habitat and CHaMP Protocols

By Kyle D. Martens, Patrick J. Connolly, and Michael A. Newsom

Introduction

From 2004 through 2012, the U.S. Geological Survey (USGS) collected fish and habitat data in the Methow River watershed. Initial work focused on three tributaries (Beaver, Libby, and Gold Creeks) of the lower Methow River. This effort was designed to assess the effectiveness of the Bureau of Reclamation's (Reclamation) work to improve fish passage within Beaver Creek, with Libby and Gold Creeks serving as controls. The work is described in more detail in Ruttenburg (2007), Connolly and others (2008, 2010), Connolly (2010), Martens and Connolly (2008, 2010), Benjamin and others (2012), Romine and others (2013a), and Weigel and others (2013a, 2013b, 2013c). In 2008, the focus of USGS efforts in the Methow shifted from the lower tributaries to a basin-wide design that specifically focused on the M2 reach (rkm 66–80), but still included some continued sampling in Beaver Creek. This new work was targeted towards assessing the effectiveness of planned stream reconstruction in the M2 reach at ESA-listed species in the Methow River watershed (Barber and others, 2011; Bellmore, 2011; Tibbits and others, 2012; Bellmore and others, 2013; Benjamin and others, 2013*;* Martens and Connolly, in press; and Romine and others, 2013b). The first section of this report documents the USGS database for all data collected in the Methow River watershed to partially fulfill our contract requirements with Reclamation. The second part of this report assesses the compatibility of habitat protocols by USGS and U.S. Forest Service (USFS) to protocols used by National Oceanic and Atmospheric Administration's (NOAA) Columbia River Habitat Monitoring Program (CHaMP; 2013). This was done at the request of Reclamation to help determine the need for CHaMP surveys at current or future USGS fish sampling sites, or if modifications could be done to USGS surveys to collect comparable data.

Structure of U.S. Geological Survey Database

The USGS database contains raw data (data that has not been analyzed) collected in the Methow River watershed from 2004 through 2012; with plans to integrate to a regional database currently being developed by the University of Idaho. This database is currently (2013) in Microsoft® Access and located at USGS's Columbia River Research laboratory (appendix 2-1) in Cook, Washington. The database contains two raw data tables, two primary metadata tables, and five secondary metadata tables. The first raw data table contains all data collected on individual fish from 2004 through 2012. The second table contains all habitat data collected from 2004 through 2012. Detailed information for each column of data are provided in the primary metadata tables. If a column had multiple types of entries that could not be described in the primary metadata table, a new secondary metadata table was created to describe all metrics in the database. In these cases, the secondary metadata tables were named after the corresponding column in the raw data tables (figs. 2-1 and 2-2).

The 2004–2012 version of the USGS fish database contains 70,323 fish collection events from 130 sites under 25 columns of data. These columns contain the range of data collected over the duration of the study. At a minimum, the location, species, and length were collected for each fish record.

Population abundance fish surveys (Martens and Connolly, in press) contained the most detailed information, because they typically were associated with habitat data. Cosmic sampling, electrofishing to collect or tag fish, typically contained the least amount of information. Some types of data, such as scale number, eye, isotope, stomach, and genetic number, were taken in key locations to address specific projects and not taken on every sampling occasion. These metrics typically were additions to the sampling plan and done to support other projects (that is, Dana Weigel of University of Idaho and Ryan Bellmore of Idaho State University's graduate work).

The 2004–2012 version of the USGS habitat database contains information on 7,082 habitat units from 21 sites under 35 columns of data. These habitat data were collected by the USGS under two types of surveys. The first type of survey was associated with fish population estimates, and the second type determined periods of connectivity in side channels. Details for population habitat surveys are described in Chapter 1. The side channel survey was designed to document changes in side channels at different mainstem flow levels. These surveys typically were conducted every 2 weeks during high flows and then periodically throughout the remainder of the year. At the start of each survey event, we collected stream discharge and river stage height at the nearest USGS streamgage. During the survey, we documented pool and non-pool lengths, wetted and bankfull widths, pool temperature, pool-residual depth, and pool-tail crest.

The two primary metadata tables contain details that describe the types of data in each column of the raw data tables. The primary metadata tables contain the column names, a description of the data in each column and the options for data entry, unit of measure, or the secondary metadata table to find additional information about the data. The five secondary metadata tables are site code, survey type, WSU code, species code, and habitat type. The site code, survey type, and WSU code contains information for the raw data tables for fish and habitat. The species code table only corresponds to the fish data table, and the habitat type table only corresponds to the habitat data table. The site code table lists the site code, stream name, river kilometer (rkm), USGS name, other names associated with the site, and comments. The survey type table contains the name of the survey, a description of the survey, and any comments. The WSU code or watershed unit code table contains the WSU number, WSU name, boundaries and comments. The species code table contains information on a species common name, species code, and comments, and the habitat type table has the habitat unit code, the definition, and comments.

Comparison of Habitat Monitoring Protocols between the U.S. Geological Survey and Columbia Habitat Monitoring Program

We compared protocols from the USGS's fish population and side channel surveys and a bank unit survey performed by USFS personnel and designed by the USGS to the Columbia Habitat Monitoring Program (CHaMP) protocol. The CHaMP protocol was developed by National Oceanic and Atmospheric Administration to create a standard set of habitat monitoring techniques to monitor the status and trends of salmonid habitat in the Columbia River Basin. The protocol allows for comparisons of salmonid habitat data at the basin and site scale. When fully implemented, the CHaMP protocol collects data from at least 25 sites a year per monitored basin on a 3-year rotating panel sampling a total of 45 sites in the Methow River watershed (Columbia Habitat Monitoring Program, 2013).

Although CHaMP and USGS survey methods and sampling intensity are different, some of the resulting data were similar and could potentially be used for comparisons. Comparisons between USGS and CHaMP surveys were based on professional judgment and not by statistical analysis. Protocols used by the USGS and CHaMP surveys used different tools and/or techniques to assess habitat conditions. Most stream measurements under the CHaMP protocol were taken using a total station and computer processing to produce a digital elevation model, and the USGS protocol relied on manual measurements of lengths and depths. Although both methods are repeatable, the CHaMP surveys through the use of permanent monuments associated with the topographical surveys allows for detecting more precise changes in stream sections than the USGS surveys. The USGS surveys allowed for larger segments of stream to be surveyed in a single day, while the CHaMP protocol was limited to 20 times the bankfull width or 600 m.

Habitat associated with fish population assessments were completed on tributaries and mainstem side channels from 2004 through 2012. The USGS surveys were up to 1,000 m, but typically 500 m or less. The survey's length was determined by the length of a side channel or the length of stream that could be sampled within 1 week of effort using a stratified systematic design. The habitat surveys had strong compatibility when comparing length, width, maximum depth, tier 1 and 2 channel unit types, and water temperatures (table 2-1). Pool layout, site layout, and estimated fish cover had some potential to compare across methods, but none of the other CHaMP metrics could be used without additional sampling. This protocol was somewhat compatible with the CHaMP protocols and has great potential to be modified to closer align with CHaMP protocols.

A mainstem bank unit survey was completed over the M2 reach (rkm 66–80) and Lower Methow reaches (also known as silver reach; rkm 53–66) of the mainstem Methow River during the summer of 2011 by USFS personnel. This survey measured over 30 km of stream. The survey was associated with minimal fish data and there would not be enough data to make any fish comparisons without additional sampling. These habitat surveys had strong compatibility when comparing length, bankfull width, wetted width, Tier 1 and 2 channel unit types, woody debris, log jams, substrate composition, and water temperatures (table 2-2). They had medium compatibility with slope, pool spacing, undercut banks, particle distribution, and riparian structure. This protocol was the most compatible habitat survey with CHaMP protocols.

Side channel habitat surveys were done several times throughout the year from 2009 through 2012. They were designed to collect pool length and side channel connectivity at different mainstem flow levels. Although these habitat data were not connected with any fish sampling period, they were done in the same location as our side channel fish population surveys. These surveys had high compatibility with CHaMP surveys for length, wetted width, bankfull width, pool spacing, Tier 1 habitat units, photo points and water temperatures (table 2-3). This was the least compatible with the CHaMP protocol of all types of our habitat surveys.

Although the CHaMP protocol would likely produce a higher level of precision than all USGS habitat protocols, the importance of that precision in relating habitat to fish abundance is currently unknown, especially if the fish abundance estimates are not made with similar precision or not at all. An experiment using USGS habitat protocols, the CHaMP protocols, and fish abundance estimates at several sites would be needed to determine how well the different types of habitat surveys could identify changes that are meaningful to fish populations. The CHaMP protocol was designed to use sites from several different watersheds to detect changes within the Columbia River Basin while also detecting changes at the individual site level. It is unclear whether the CHaMP protocol will have enough sites within a single watershed to adequately detect changes within a single watershed. Although the addition of more CHaMP sites to a watershed would be preferable, the use of modified USGS habitat surveys could provide a more cost effective means to collect habitat data, especially if continuous reach-wide habitat data were desired.

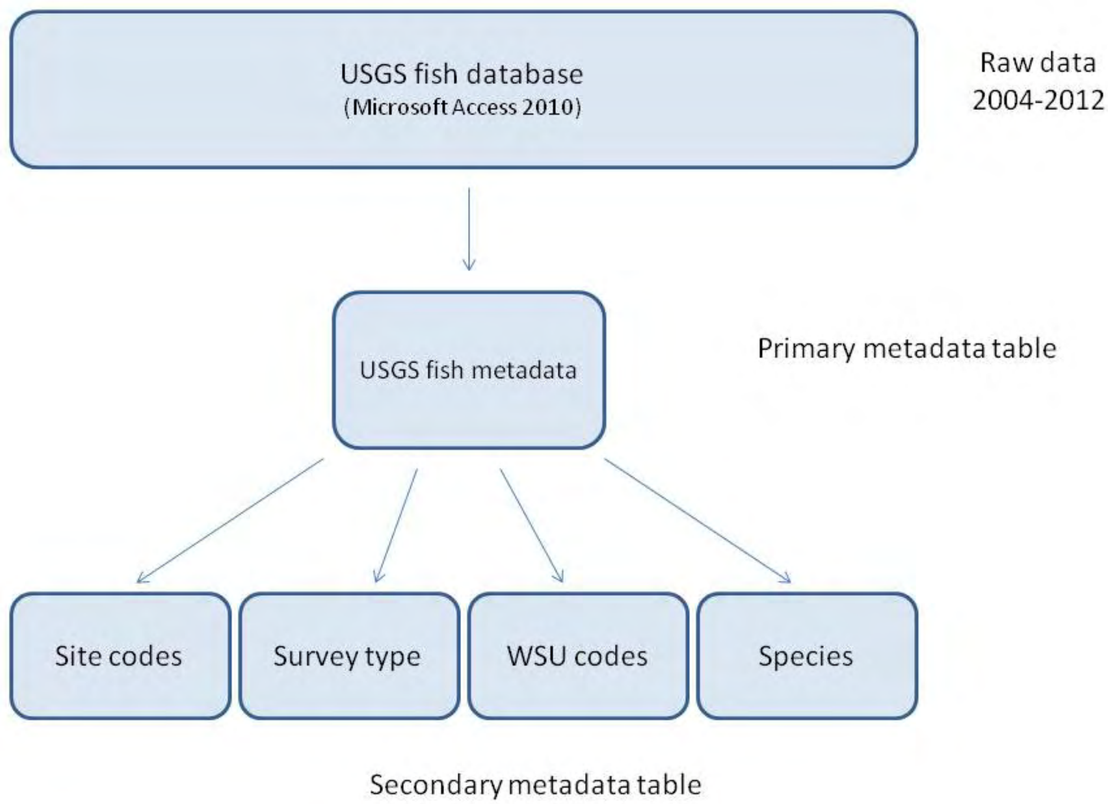

Figure 2-1. Diagram of the USGS's Methow River fish database for fish collected from 2004 through 2012.

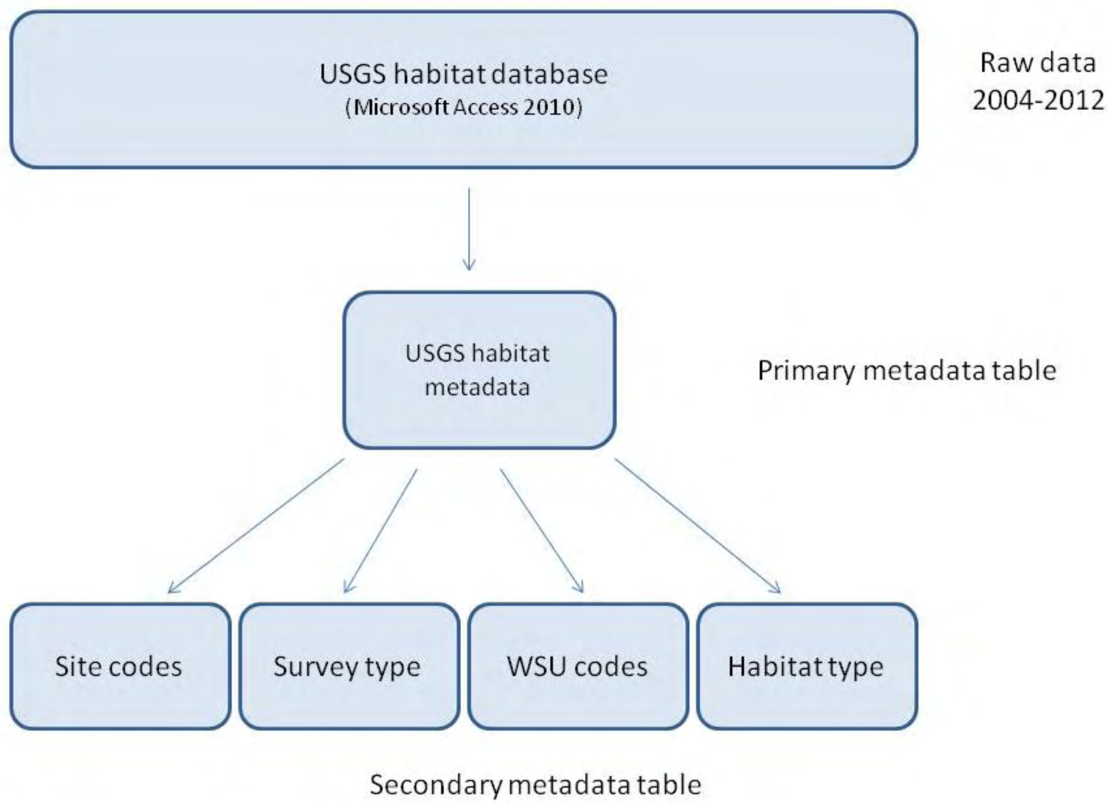

Figure 2-2. Diagram of the USGS's Methow River habitat database for fish collected from 2004 through 2012.

Table 2-1. Comparison of the Columbia Habitat Monitoring Program (CHaMP) and the U.S. Geological Survey (USGS) habitat protocols for fish population surveys.

[TS,Total station; VE, Visual estimate; N/A, Not applicable; ID, Identification]

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Site layout	TS	Measured	Low
Channel segment number	Measured	Measured	Med
Stream length	TS	Measured	High
Stream width	TS	Measured	High
Maximum depth	TS	Measured	High
Mean depth	TS	Measured	High
Site gradient	TS	N/A	None
Site sinuosity	TS	N/A	None
Site wetted area and volume	TS	Calculated	High
Site bankfull area	TS	N/A	None
Bankfull width	TS	N/A	None
Typical confinement	TS	N/A	None
Pool count and spacing	TS	Calculated	Med
Channel units			
Tier 1			
Fast water turbulent	VE and TS	VE	High
Fast water non-turbulent	VE and TS	VE	High
Slow water/pool	VE and TS	VE	High
Tier 2			
Riffle	VE and TS	VE	High
Cascade	VE and TS	VE	High
Rapid	VE and TS	N/A	None
Falls and steps	VE and TS	VE	High
Scour pool	VE and TS	VE	High
Plunge pool	VE and TS	VE	High
Dam pool	VE and TS	VE	High
Beaver pond	VE and TS	N/A	None
Fish cover elements			
Woody debris	VE	VE (pools only)	Med
Overhanging vegetation	VE	VE (pools only)	Med
Aquatic vegetation	VE	VE (pools only)	Med
Artificial structure	VE	VE (pools only)	Med
Total no fish cover	VE	VE (pools only)	Med
Substrate composition	VE	VE (pools only)	Low
Undercut bank	Measured	N/A	None
Woody debris	Count	N/A	Low
Log jams	Count	N/A	None
Particle distribution	Count	N/A	None
Particle embeddedness	Count	N/A	None
Site map	Drawn	N/A	None
Photos	Yes	N/A	None
Solar input	Measured	N/A	None

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Riparian structure			
Dominate vegetation/soil/rock	VE	N/A	None
Canopy	VE	N/A	None
Understory	VE	N/A	None
Ground	VE	N/A	None
Water temperature	Measured	Measured	High
Stream discharge	Measured	N/A	None
Water chemistry			
Conductivity	Measured	N/A	None
Alkalinity	Measured	N/A	None
Aquatic insects	Count and ID	N/A	None

Table 2-2. Comparison of the Columbia Habitat Monitoring Program (CHaMP) and U.S. Forest Service (USFS) habitat protocol for assessing mainstem bank unit habitat.

[TS,Total station; VE, Visual estimate; N/A, Not applicable; ID, Identification]

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Site layout	TS	Measured	Low
Channel segment number	Measured	Measured	High
Stream length	TS	Measured	High
Stream width	TS	Measured	High
Maximum depth	TS	N/A	None
Mean depth	TS	N/A	None
Site gradient	TS	N/A	None
Site sinuosity	TS	N/A	None
Site wetted area and volume	TS	Calculated	High
Site bankfull area	TS	Calculated	High
Bankfull width	TS	Measured	High
Typical confinement	TS	Measured	High
Pool count and spacing	TS	Measured	High
Channel units			
Tier 1			
Fast water turbulent	VE and TS	VE	High
Fast water non-turbulent	VE and TS	VE	High
Slow water/pool	VE and TS	VE	High
Tier 2			
Riffle	VE and TS	VE	High
Cascade	VE and TS	VE	High
Rapid	VE and TS	N/A	None
Falls and steps	VE and TS	VE	High
Scour pool	VE and TS	VE	High
Plunge pool	VE and TS	VE	High
Dam pool	VE and TS	VE	High
Beaver pond	VE and TS	N/A	None
Fish cover elements			
Woody debris	VE	N/A	None
Overhanging vegetation	VE	N/A	None
Aquatic vegetation	VE	N/A	None
Artificial structure	VE	N/A	None
Total no fish cover	VE	N/A	None
Substrate composition	VE	VE	Med
Undercut bank	Measured	VE	Med
Woody debris	Count	Count	High
Log jams	Count	Count	High
Particle distribution	Count	VE	Med
Particle embeddedness	Count	N/A	None
Site map	Drawn	N/A	None
Photos	Yes	N/A	None
Solar input	Measured	N/A	None

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Riparian structure			
Dominate vegetation/soil/rock	VE	VE	High
Canopy	VE	VE	High
Understory	VE	VE	High
Ground	VE	VE	High
Water temperature	Measured	N/A	None
Stream discharge	Measured	N/A	None
Water chemistry			
Conductivity	Measured	N/A	None
Alkalinity	Measured	N/A	None
Aquatic insects	Count and ID	N/A	None

Table 2-3. Comparison of the Columbia Habitat Monitoring Program (CHaMP) and U.S. Geological Survey (USGS) habitat protocols for side channels to assess connectivity and changes over time.

[TS, Total station; VE, Visual estimate; N/A, Not applicable; ID, Identification]

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Site layout	TS	Measured	Low
Channel segment number	Measured	Measured	High
Stream length	TS	Measured	High
Stream width	TS	Measured	High
Maximum depth	TS	Measured	High
Mean depth	TS	Measured	High
Site gradient	TS	N/A	None
Site sinuosity	TS	N/A	None
Site wetted area and volume	TS	Calculated	High
Site bankfull area	TS	Calculated	High
Bankfull width	TS	Measured	High
Typical confinement	TS	N/A	None
Pool count and spacing	TS	Measured	High
Channel units			
Tier 1			
Fast water turbulent	VE and TS	VE	High
Fast water non-turbulent	VE and TS	VE	High
Slow water/pool	VE and TS	VE	High
Tier 2			
Riffle	VE and TS	N/A	None
Cascade	VE and TS	N/A	None
Rapid	VE and TS	N/A	None
Falls and steps	VE and TS	N/A	None
Scour pool	VE and TS	N/A	None
Plunge pool	VE and TS	N/A	None
Dam pool	VE and TS	N/A	None
Beaver pond	VE and TS	N/A	None
Fish cover elements			
Woody debris	VE	N/A	None
Overhanging vegetation	VE	N/A	None
Aquatic vegetation	VE	N/A	None
Artificial structure	VE	N/A	None
Total no fish cover	VE	N/A	None
Substrate composition	VE	N/A	None
Undercut bank	Measured	N/A	None
Woody debris	Count	N/A	None
Log jams	Count	N/A	None
Particle distribution	Count	N/A	None
Particle embeddedness	Count	N/A	None
Site map	Drawn	N/A	None
Photos	Yes	Yes	High
Solar input	Measured	N/A	None

CHaMP habitat measurement	CHaMP protocol	USGS protocol	Compatibility
Riparian structure			
Dominate vegetation/soil/rock	VE	N/A	None
Canopy	VE	N/A	None
Understory	VE	N/A	None
Ground	VE	N/A	None
Water temperature	Measured	Measured	High
Stream discharge	Measured	N/A	None
Water chemistry			
Conductivity	Measured	N/A	None
Alkalinity	Measured	N/A	None
Aquatic insects	Count and ID	N/A	None

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Appendix 2-1. Locations of the USGS data collected in the Methow River watershed from 2004 through 2012.

[Data are located in a Microsoft® Access database file (19 MB). USGS, U.S. Geological Survey; Reclamation, Bureau of Reclamation]

Location	Agency	Contact information	File path
Cook, WA	USGS	Kyle Martens (509 538-2299 ext 238; kmartens@usgs.gov)	Q:\WIND_RATT\Methow\USGS database.accdb
Portland, OR	Reclamation	Michael Newsom (mnewsom@usbr.gov)	
Moscow, ID	University of Idaho	Alex Fremier (afremier@uidaho.edu)	

Chapter 3. Survival Analysis of Steelhead and Chinook Salmon Using Passive Integrated Transponder (PIT) Tag Release Numbers and PIT Tag Interrogation Systems (PTIS) in the Methow River Watershed, Washington

By Kyle D. Martens, Patrick J. Connolly, Russell W. Perry, and Michael A. Newsom

Introduction

The U.S. Geological Survey (USGS) received funding from the Bureau of Reclamation (Reclamation) to assess the feasibility of current and potential PIT tag interrogation systems (PTIS) to evaluate the survival of target fish species in the Methow River watershed. Most of this work is being done as part of the 2008 Biological Opinion to protect or enhance listed salmon and steelhead populations in the Columbia River Basin. Reclamation and other Federal, State, Tribal, and non-governmental agencies currently fund numerous projects in the Methow River watershed aimed at improving the abundance and productivity of Methow/Upper Columbia salmonid populations. The target species for these efforts include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR summer steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*), all of which are listed as threatened or endangered under the Endangered Species Act.

Some of the planned actions include, but are not limited to nutrient enhancement (planned for 2015 in Twisp River), habitat improvement (planned from 2014 to 2017 in the M2 reach of the Methow River), barrier removal, and procurement of land and water rights. These types of actions are designed to improve fish survival and production, although many of these types of actions have had limited evaluation as to their effectiveness in benefitting ESA-listed species (Bednarek, 2001). One method to evaluate the effects on these projects is to assess differences in survival of juvenile migrating fish between control and treatment reaches or before and after a site has been treated (Tschaplinski and Hartman, 1983; Quinn and Peterson, 1996; Johnson and others, 2005). One of the largest problems with this type of analysis is the large number of fish that need to be tagged to estimate the survival with enough certainty to determine if a project is effective. The number of tags available for analysis may be limited by permit numbers or the amount of sampling effort required to collect enough fish.

Survival can be estimated over time or distance for migratory fish species (Skalski and others, 1998; White and Burnham, 1999). To use time to estimate survival, sampling needs to be done at the same location over a period of time. This can be problematic with mobile fish species in an open population because tagged fish that move out of an area and do not come back would be considered dead (White and Burnham, 1999). With survival over distance, the estimate of mortality is combined with fish that do not move.

In this report, we (1) estimate current survival from PIT tag detections of hatchery and wild fish, (2) assess effects of the number of tags released and the number of PTIS on survival estimates, and (3) assess our ability to detect difference in survival between two release groups.

Study Area

The Methow River is a fifth-order stream in north-central Washington that drains into the Columbia River at river kilometer (rkm) 843 in the Upper Columbia River Basin. The Methow River has two major tributaries, the Twisp River entering the Methow River at rkm 66 near the town of Twisp, Washington, and the Chewuch River that enters the Methow River at rkm 80 near the town of Winthrop, Washington. The Methow River currently has two PTIS in the mainstem (rkm 1 and 81), and one PTIS each in the Twisp (rkm 1) and Chewuch (rkm 1) Rivers. For installation in the near future, Reclamation funded the addition of two PTIS in the mainstem Methow River (rkm 43 and 67), and two PTIS in the Twisp River (rkm 21 and 23; fig. 3-1). Downstream migrating fish that exit the Methow River travel through nine Columbia River dams to reach the Pacific Ocean. Out-migrating PIT-tagged fish have the potential to be detected on PTIS located at Rocky Reach, McNary, John Day, and Bonneville Dams and in a PIT-tag trawl in the Columbia River Estuary.

Methods

Estimating Current Fish Survival

We queried and downloaded tagging and interrogation data, using the Columbia Basin PIT Tag Information System (PTAGIS) database (maintained by Pacific States Marine Fisheries Commission, Portland, Oregon), for 2011 PIT-tagged hatchery Chinook released in the Methow River, 2011 PIT-tagged hatchery steelhead released in the Methow River, and PIT-tagged wild steelhead released at the Twisp River screw trap in 2010 and 2011. In 2011, hatchery steelhead were released at five locations—three in the mainstem Methow River and one each in the Twisp and Chewuch Rivers. Hatchery spring Chinook were released at five locations—three in the mainstem Methow River and one each in the Twisp and Chewuch Rivers. Wild steelhead data from 2010 and 2011 (years that Rocky Reach PTIS were operational) were combined due to low sample sizes. Data were formatted using the program PitPro (University of Washington, Seattle, Washington). Once formatted, the data were used in the Live Recaptures (Cormack-Jolly-Serber) feature in the program MARK (Colorado State University, Fort Collins, Colorado) to gain estimates of survival over distance (d) and detection probability. Tests were run with the logit link. The hatchery steelhead and wild Twisp River steelhead survival and detection probability estimates for each segment were then compared by using a Folded Form F-test (SAS Institute, Inc., 1988) to see if the variances were equal. If the P-value from an F-test was <0.05, the variances were considered unequal.

Estimating Effects of Number Tagged and Detection Efficiency

To simulate release data, we used MARK's Set Up Simulation feature (Cooch and White, 2012) to test the effect of fish release numbers on accuracy and precision of survival estimates. All simulations were run with the logit link. Survival (ϕ) and detection (p) parameters used in the simulations were derived by a combination of our estimates and expert opinion. Survival estimates were made to equal 90 percent (1 segment = 90 percent, 2 segments = 0.94868330, 3 segments = 0.96548938, and 4 segments = 0.97400375) in the Methow River watershed and were set at 75 percent for each of the five segments of the Columbia River (Lower Methow River to Rocky Reach Dam, Rocky Reach Dam to McNary Dam, McNary Dam to John Day Dam, John Day Dam to Bonneville Dam, and Bonneville Dam to Estuary trawl). We used data to simulate seven release sites—Upper Methow (>80 rkm), Winthrop National Fish Hatchery (WNFH) in Winthrop, WA , Upper Chewuch (>1 rkm), Chewuch River screw trap (0.5 rkm), Upper Twisp River (>20 rkm), Twisp River screw trap (1 rkm), and the M2 reach of the

Methow River (65–80 rkm). These sites were used for simulating tag releases of 1,000, 5,000, and 25,000 (WNFH only). Based on a combination of expert opinion and USGS unpublished data (2012), detection probabilities of 30 percent at the Twisp River PTIS and 5 percent at the Lower Methow River PTIS were used for average low-flow conditions and 10 percent at Twisp River and 1 percent at Lower Methow River for high-flow conditions. The simulations were conducted with the current PTIS (n=4), and with the addition of four PTIS (two in the Methow River and two in the Twisp River). Based on a combination of expert opinion and USGS unpublished data (2012), we used 5 percent detection for all mainstem Methow River PTIS downstream of 80 rkm, and 30 percent detection for all tributary and Methow River PTIS upstream of 80 rkm. Detection at the Columbia River dams and estuary were based on estimates produced from the hatchery releases (Rocky Reach 35 percent, McNary Dam 14 percent, John Day Dam 18 percent, Bonneville Dam 5 percent, and the Columbia Estuary trawl 3 percent). All simulations were conducted with 1,000 replications. The median survival estimates and 95-percent confidence intervals were then subtracted from the true survival estimate (Δ ϕ; 0.75, 0.90, 0.94868330, 0.96548938, or 0.97400375).

Next, we estimated the survival of our target species through two sections in the Methow River watershed (release to Twisp River and Twisp River to Lower Methow River) to assess the effect of different detection levels and tag releases. Detection probabilities were simulated at six levels (1, 5, 10, 30, 40, and 50 percent for Twisp River and 0.5, 1, 5, 10, 15, and 20 percent for Lower Methow River) and two release groups (n =1,000 and 5,000 fish). Each simulation was performed with 1,000 replications. The simulations were executed with two scenarios—the present conditions and the planned addition of two PTIS in the middle Twisp River and Methow River at Carlton in the near future. These simulations were conducted using the same standard detection levels as the site simulations.

Ability to Detect Difference in Survival

To detect differences in survival between two release groups (g; control and treatment), we used the Set Up Simulation feature in MARK (Cooch and White, 2012). The Twisp River was used in this analysis to determine the potential to detect differences associated with a nutrient enhancement project planned for 2015. Using this feature, we constructed different models and used AIC model selection (Burnham and Anderson, 2002) to determine which model garnered the most support. In MARK, we examined two models—the first model (ϕ(d) p(d)) that compared differences between sites, while the second model (ϕ(g*d) p(d)) compared differences in survival in the section of stream between the release sites and the first PTIS (because the survival for all segments except the first were set to be equal) and differences between sites. To determine the most appropriate number of replications, we ran one of the simulations three times at 1,000, 2,000, and 3,000 replications. We selected 3,000 replications after we had less than 1.5 percent variation between the three simulations. Simulations where executed with three possible survival differences in the first segment (5, 10, and 20 percent). All other segments were simulated with the same survival between the groups. These simulations were executed with three scenarios—the current conditions, the planned addition of the middle Twisp River and Methow River at Carlton in 2012, and with three Twisp River PTIS and one Methow River PTIS. Based on a combination of expert opinion and USGS unpublished data (2012), we used 30 percent detection for the Twisp River PTIS, 10 percent for Twisp River screw trap and Middle River at Carlton, and 35 percent for Rocky Reach Dam. The Lower Method River and Lower Methow screw trap were left out of this analysis due to low detection at both sites and position in the watershed. We calculated the ΔAIC by subtracting the ϕ(g*d) p(d) model from the ϕ(d) p(d) model for each simulation. We used -2 as a cutoff value for detecting a difference between the two models, because it is roughly equivalent to $\alpha = 0.05$ in a likelihood ratio test with a 1-parameter difference between models (Burnham and Anderson, 2002).

Results

Estimating Current Fish Survival

Survival estimates of fish released in the Methow River ranged from 80 to 100 percent, and while in the Columbia River, survival estimates ranged from 48 to 100 percent (table 3-1). Detection at the Lower Methow River ranged from 0.3 to 1.1 percent (table 3-2). Rocky Reach Dam had the highest detection of PIT tagged fish ranging from 30 to 42 percent, while the other Columbia River dams ranged from 7 to 24 percent. Survival estimates of wild steelhead caught at the Twisp River screw trap in 2010 and 2011 were within the confidence intervals of the 2011 hatchery steelhead estimates and the *F-test* (*F-test* =1.03, $P = 0.9712$) determined that the variance between the two groups were equal (fig. 3-2).

Estimating Effects of Number Tagged and Detection Efficiency

All simulated fish releases from the Methow River watershed estimated survival over four segments of the Columbia River (Lower Methow River to Rocky Reach, Rocky Reach to McNary Dam, McNary Dam to John Day Dam, and John Day Dam to Bonneville Dam; fig. 3-3 to 3-9). Modeling the planned four PTIS (Methow above Twisp, Methow at Carlton, Middle Twisp River and Upper Twisp River) allowed us to simulate survival over more sections of the Methow River watershed. With simulated releases over the current PTIS network from the Winthrop National Fish Hatchery, M2 Reach, Chewuch screw trap and Twisp screw trap, we estimated survival (true survival = 0.90) from their respective release points to the Lower Methow River PTIS. With the planned PTIS network, these releases would estimate survival (true survival =0.96548938) over three sections of the Methow River watershed (figs. 3-3, 3-4, 3-5, 3-6). Simulated releases from the Upper Methow River, Upper Chewuch River, and Upper Twisp River with the current PTIS network estimated survival (true survival = 0.94868330) over two sections, and the planned PTIS network estimated survival (true survival = 0.97400375) over four sections (figs. 3-7, 3-8, 3-9). Confidence intervals on the survival estimates increased as fish were removed from the estimates, especially for survival estimates over the last two segments on the Columbia River (McNary Dam to John Day Dam and John Day Dam to Bonneville Dam). For every release site, the 5,000 tag release produced smaller confidence intervals than the 1,000 tag release.

Simulated fish traveling from a release point in the Twisp River to the Twisp River PTIS at low flow levels divergence from true survival ranged from 0.0% (CI = -7.1-5.1) to 5.1% (CI = -24.8-5.1) with 1,000 tags, and 0.0% (CI = -3.1-5.1) to 2.5% (CI = -14.4-5.1) with 5,000 tags based on a true survival of .94868330. At 30% detection (current low flow) the divergence from true survival was 0.07% (CI = -10.0-5.1) with 1,000 tags and 0.0% (CI = -4.9-5.1) with 5,000 tags. For low flow levels (10%) at the Lower Methow River PTIS, the divergence from true survival between the Twisp River PTIS to the Lower Methow River PTIS was 0.2% (CI = -21.0-5.1) with 1,000 tags and 0.2% (CI = -10.4-5.1) with 5,000 tags. Fish released in the Twisp River and traveling from the Twisp River PTIS to the Lower Methow River PTIS, the divergence from true survival ranged from 0.5% (CI = -14.9-5.1) to 5.1% (CI = -32.6-5.1) with 1,000 tags and from -0.1% (CI = -7.8-5.1) to 2.5% (CI = -14.4-5.1) with 5,000 tags (fig. 3-11)

Ability to Detect Difference in Survival

Using the present PTIS (Twisp River, Lower Methow River, and Rocky Reach Dam) and Twisp River screw trap for two fish release groups in the Twisp River, 64 percent of the simulations detected a 10 percent difference in survival with 1,000 tags per group, 89 percent of the simulations detected a 10 percent difference in survival with 2,000 tags per group, and 100 percent of the simulations detected a 10 percent difference with 5,000 tags per group (fig. 3-12). To detect a 5 percent difference in survival more than 80 percent of the time would require a release of more than 5,000 tags from each group.

We assessed the impact of two additional PTIS (Middle Twisp River and Methow River at Carlton) on our ability to detect differences in survival. Our simulations of 1,000 and 2,000 tagged fish resulted in 84 and 99 percent, respectively, of the simulations detecting a 10 percent difference in survival between the two groups (fig. 3-13). With 5,000 fish in each group, we detected a 5 percent difference in survival between groups in 95 percent of our simulations. We ran simulations to test the addition of four PTIS, three in the Twisp River and one in the Methow River. We determined that 1,000 and 2,000 fish releases resulted in 82 and 99 percent, respectively, of the simulations detecting a 10 percent difference in survival between the two groups (fig. 3-13). When 5,000 fish were in each group, we could detect a 5 percent difference in survival between groups in 100 percent of our tests.

Discussion

We estimated survival of hatchery steelhead released in 2011 and wild steelhead released at the screw trap in 2010 and 2011. The wild fish estimates were within the confidence intervals of the hatchery estimate and the *F-test* showed that the estimates were equal, leading us to conclude that the hatchery fish could be used as a surrogate for wild steelhead when wild fish numbers are low. We determined that the larger the release groups of fish, the smaller the error on the estimates, which had some major consequences to our ability to detect differences in survival between two groups (for example, before and after or treatment and control). Increased PIT tagging, increased detection probability at the PTIS, and/or combining multiple fish releases in nearby areas into a singular release should be explored to improve survival estimates of juvenile salmonids. The survival and detection probability estimates that we derived for McNary, John Day, and Bonneville Dams in the Columbia River were similar to the estimates of Faulkner and others (2012) for the 2011 migration of steelhead.

Assuming that the PTIS maintain or improve detection probabilities during high and low flow, survival estimates can be produced from PIT-tagged releases with as few as 1,000 PIT-tagged fish, although caution should be taken to evaluate the estimates when using a combination of low detection and small numbers of tags. The addition of the two Methow River and two Twisp River PTIS will allow the estimation of survival from different release groups over smaller sections of the Methow River. The new interrogators PTIS will break up the survival estimates into one or two more segments per release site. These smaller segments have the potential to help identify areas of lowest survival that could be targeted as key areas for salmonid recovery. Survival estimates over the last two segments (McNary Dam to John Day Dam and John Day Dam to Bonneville Dam) were questionable with a 1,000 tagged fish release, due to the low number of detections resulting from the accumulative mortality from the upper segments. We recommend estimating survival of these segments based on hatchery releases (>25,000 tagged fish) because of the large number of tags that can be released.

Due to the low detection probability of juvenile salmonids at the Lower Methow River, the confidence intervals of survival estimates will be higher for fish passing this PTIS, resulting in reduced power of the survival estimates. Increasing the Lower Methow River PTIS to at least 15 percent would much improve the survival estimates of all fish releases in the Methow River watershed. There was a diminishing return from our survival estimates as a result from the detection efficiency at the Twisp River (greater than 30 percent) and Lower Methow River (greater than 15 percent) PTIS, although we recommend improving detection efficiency through additional rows of antennas and incorporating new innovation as it is developed.

The new PTIS will help to determine differences in survival between two release groups (for example, treatment and. control or before and after). Assuming that enough fish (>5,000 tagged fish per group) can be tagged in the treatment and control groups, survival differences can be detected as low as 5 percent between two groups. This analysis is based on migrating fish, so the use of juvenile steelhead may be problematic because they can reside in a stream several years before migrating, although this is not as big of an issue with coho or spring Chinook, barring precociousness, that typically move after their first year (Wydoski and Whitney, 2003). The addition of four PTIS would increase the ability to detect a difference in survival by a small margin over adding just two PTIS, leading us to believe there is a diminishing return as more PTIS are added when determining differences in survival in a treatment and control reach. This analysis is site specific and only accounts for a difference in survival in the first section (that is, Twisp River treatment and control). The addition of more PTIS would help us determine if survival was different between the segments between the PTIS. It also may provide valuable data on within stream movement and help to exclude fish from the analysis that did not stay in the treatment area long enough to be affected by the treatment.

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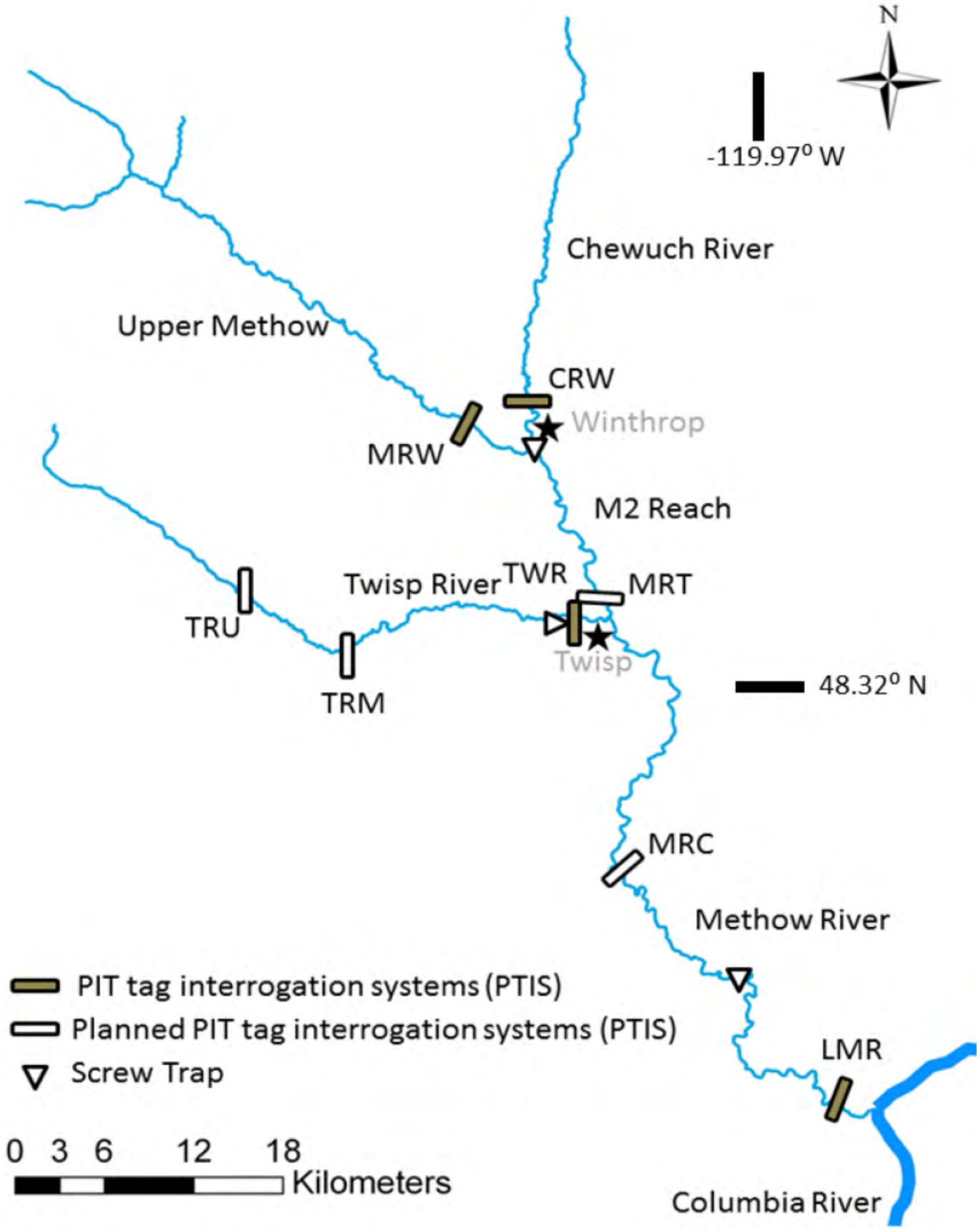

Figure 3-1. Map of the Methow River watershed, Washington, with PIT tag interrogation systems and screw traps. CRW, Chewuch River above Winthrop; LMR, Lower Methow River; MRC, Methow River at Carlton; MRT, Methow River above Twisp; MRW, Methow River above Winthrop; TRU, Upper Twisp River; TRM, Middle Twisp River; TWR, Twisp River.

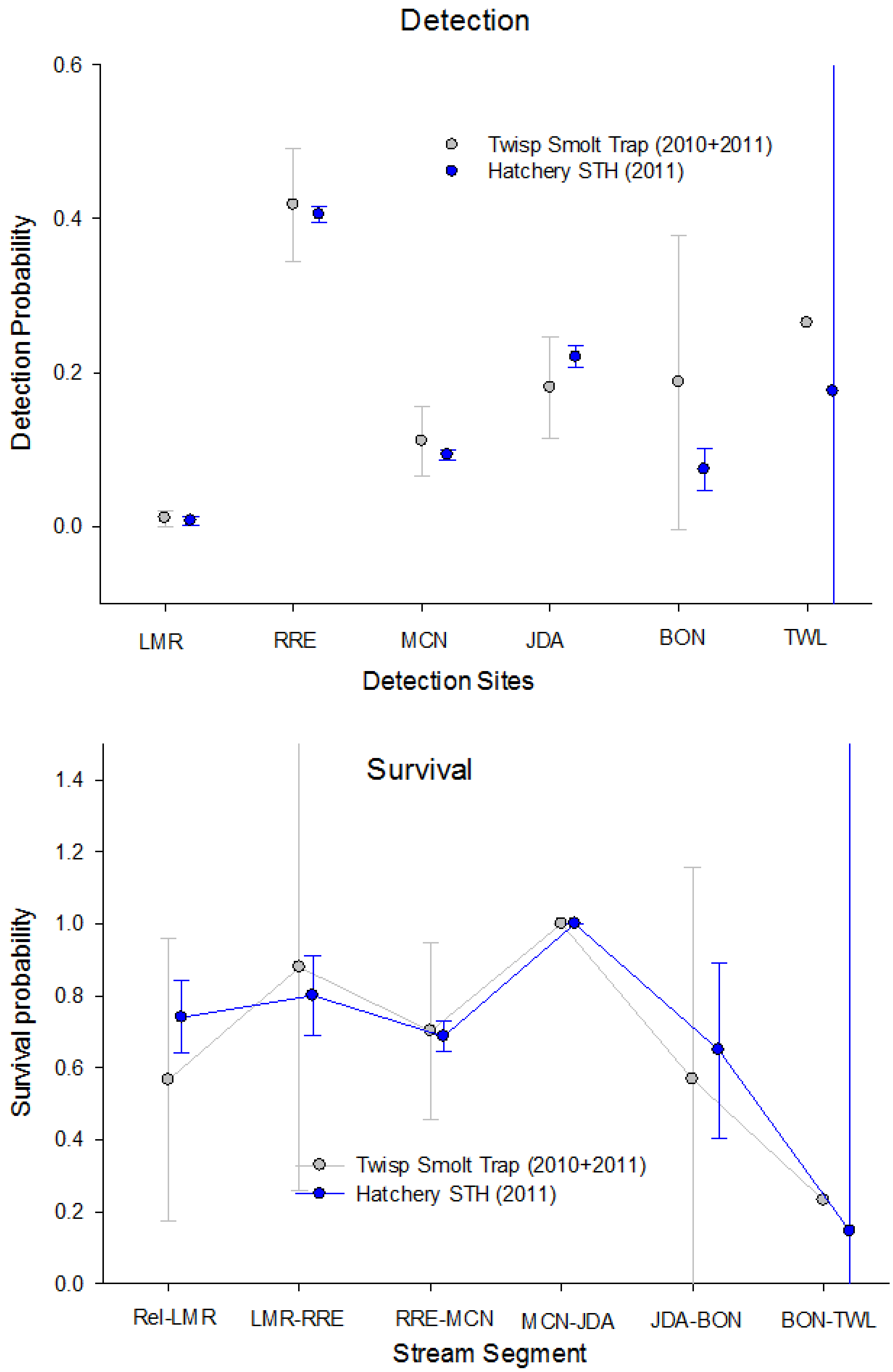

Figure 3-2. Comparison of survival (*F-test* = 1.11 *P* = 0.9110) and detection (*F-test* = 1.03 *P* = 0.9712) probability estimates for two groups of fish—Wild steelhead collected at the Twisp River screw trap in 2010 and 2011 (top) and a combination of all PIT tagged hatchery steelhead released in the Methow River watershed in 2011 (bottom). BON, Bonneville Dam; JDA, John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; Rel, release site; RRE, Rocky Reach Dam; TWL, Lower Twisp River.

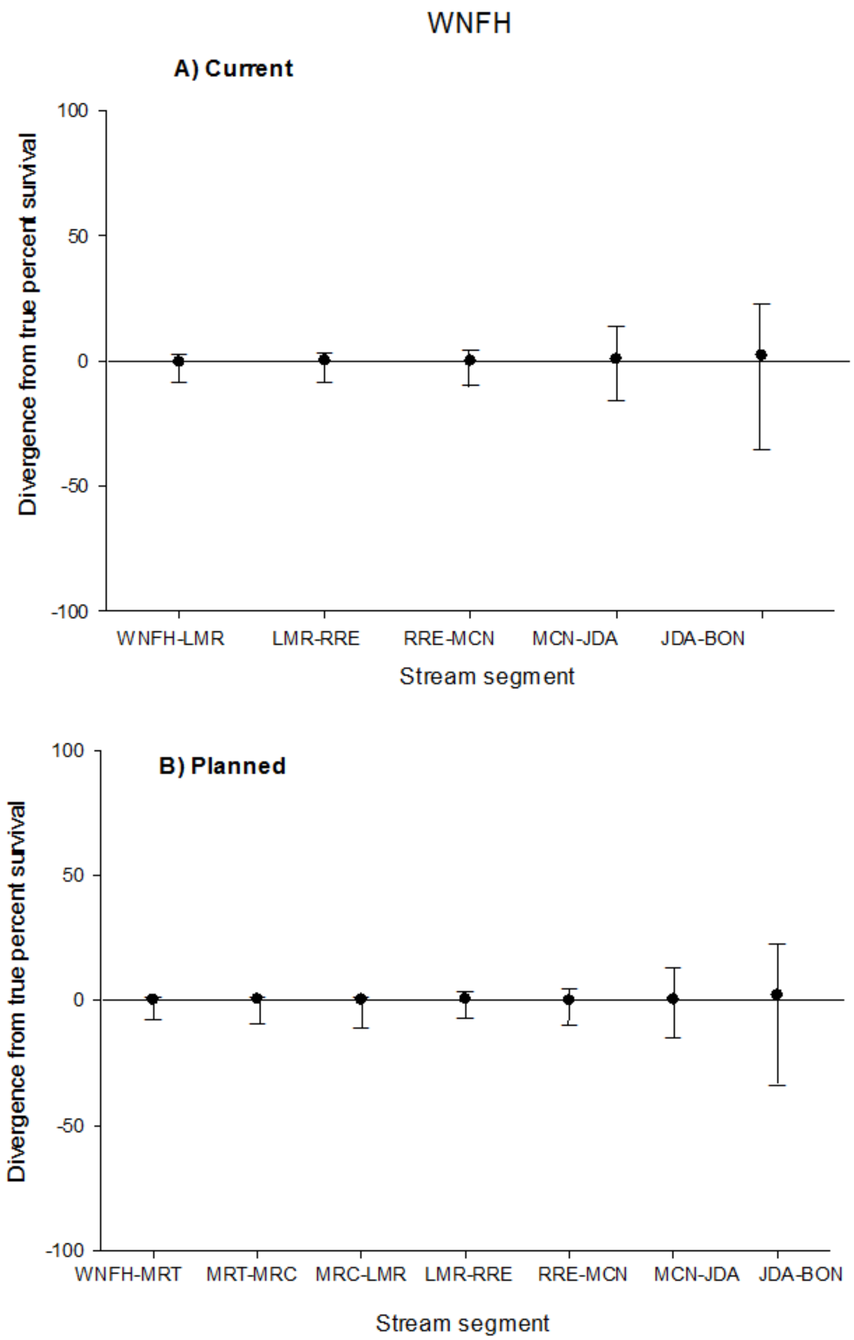

Figure 3-3. Simulated divergence from true survival (Current = 0.90 in the Methow River and 0.75 in the Columbia River; Potential = 0.96548938 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (25,000 tags) at the Winthrop National Fish Hatchery (WNFH) with current (n = 5) and planned (n = 7) PIT tag interrogation systems. BON, Bonneville Dam; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; MRT, Methow River above Twisp; MRW, Methow River above Winthrop; Rel, release site; RRE, Rocky Reach Dam; TRU, Upper Twisp River; TRM, Middle Twisp River.

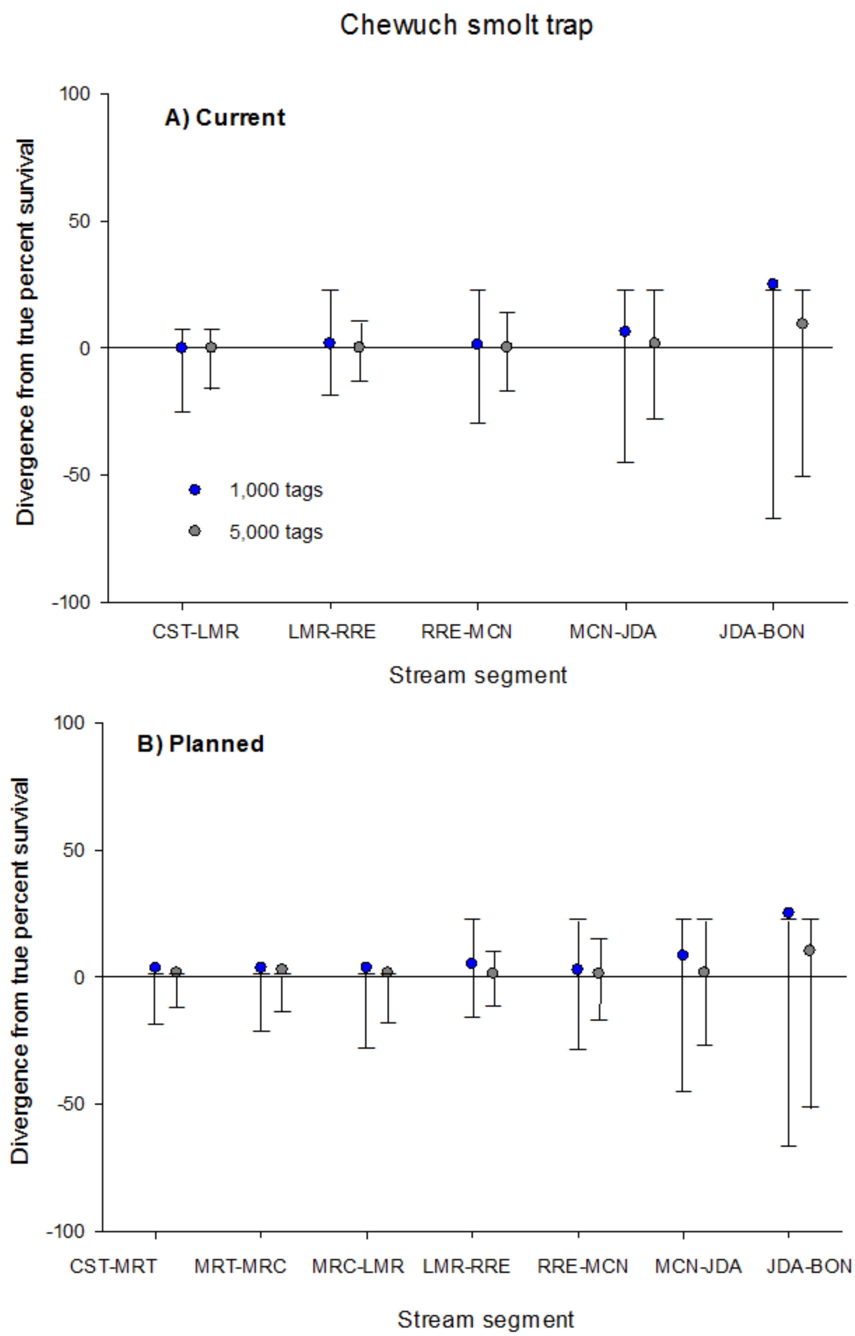

Figure 3-4. Simulated divergence from true survival (Current = 0.90 in the Methow River and 0.75 in the Columbia River; Potential = 0.96548938 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) at the Chewuch River screw trap with current and planned PIT tag interrogation systems. BON, Bonneville Dam; CRW, Chewuch River above Winthrop; CST, Chewuch screw trap; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; MRT, Methow River above Twisp; MRW, Methow River above Winthrop; Rel, release site; RRE, Rocky Reach Dam.

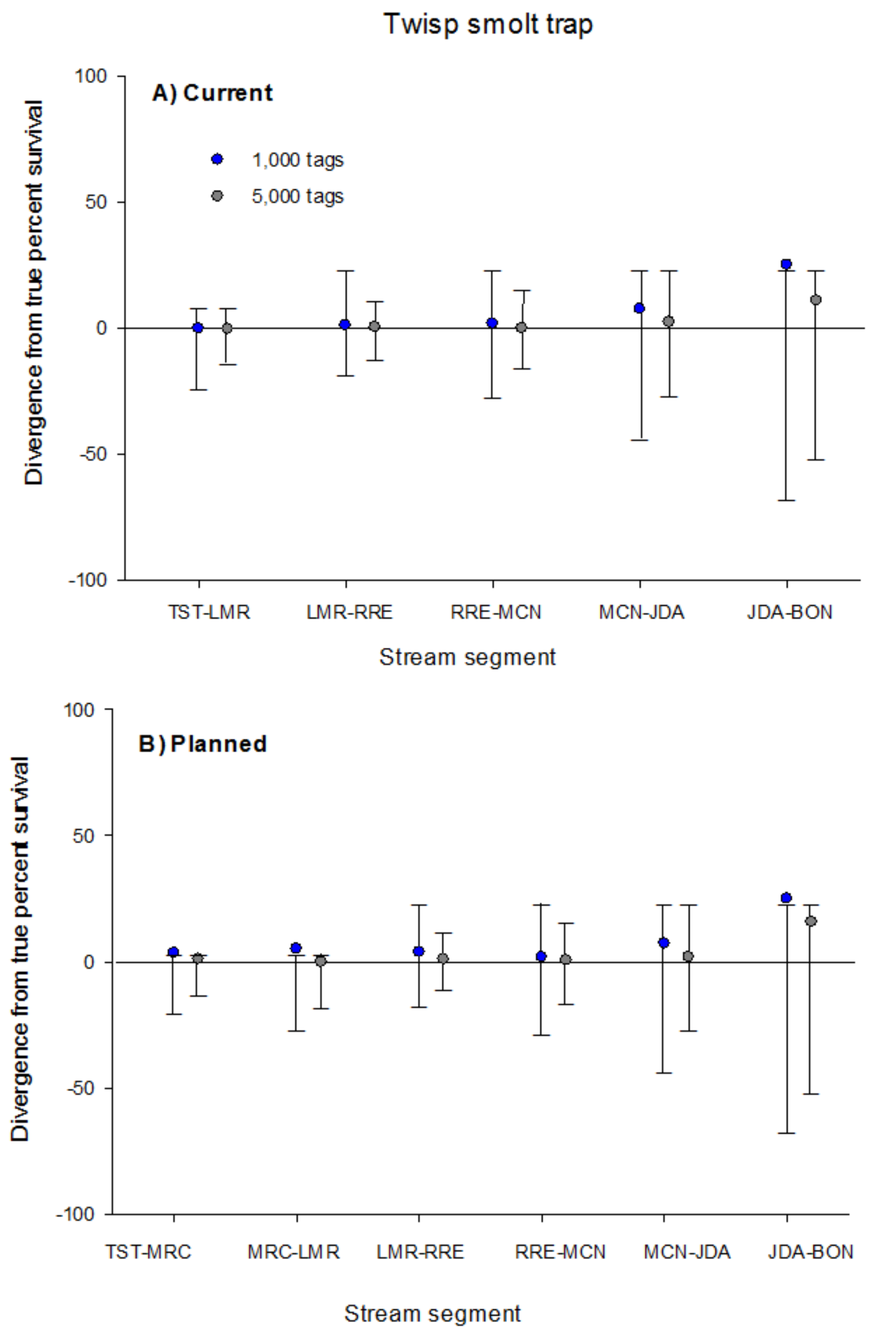

Figure 3-5. Simulated divergence from true survival (Current = 0.90 in the Methow River and 0.75 in the Columbia River; Potential = 0.94868330 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) at the Twisp River screw trap with current and planned PIT tag interrogation systems. BON, Bonneville Dam; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; RRE, Rocky Reach Dam; TST, Twisp screw trap.

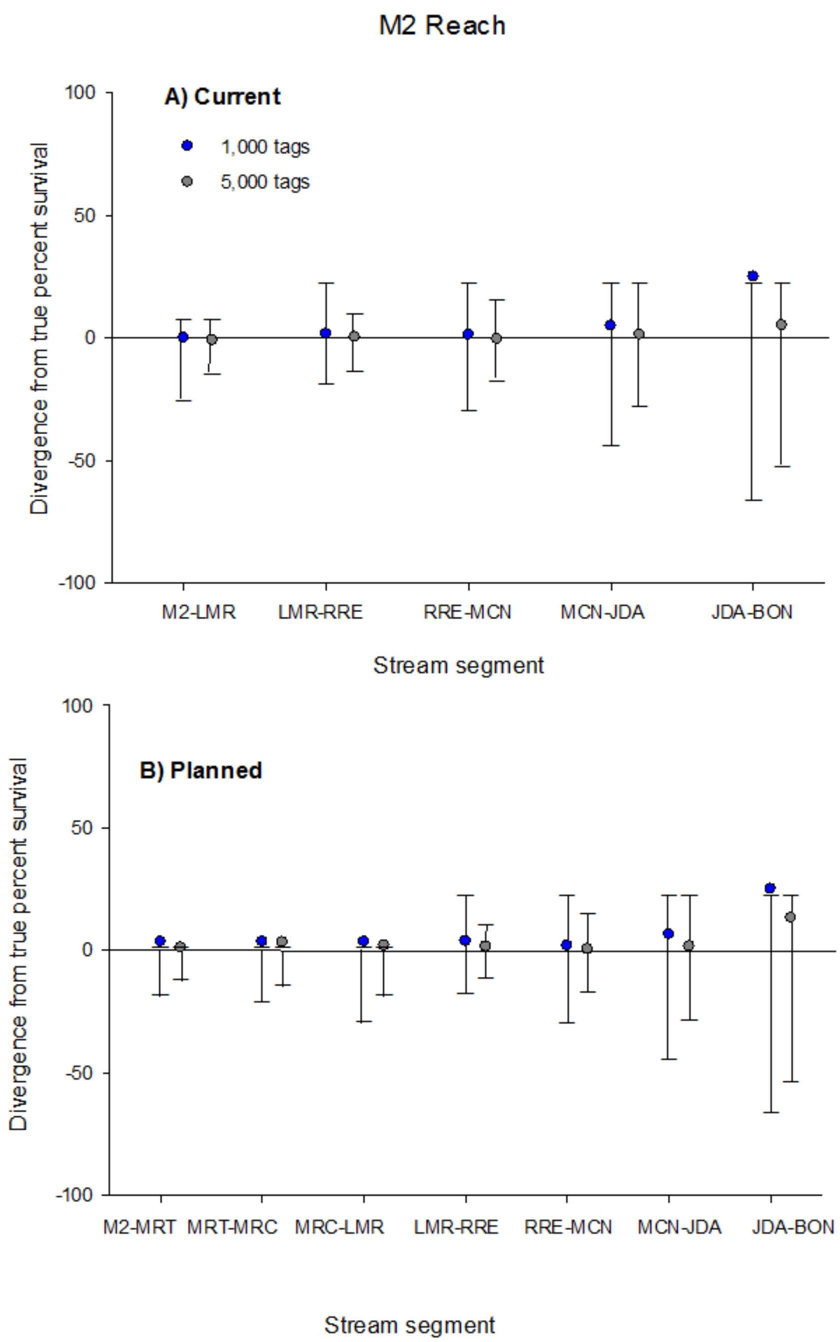

Figure 3-6. Simulated divergence from true survival (Current = 0.90 in the Methow River and 0.75 in the Columbia River; Potential = 0.96548938 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) in the M2 Reach (65–80 rkm) with current and planned PIT tag interrogation systems. BON, Bonneville Dam; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; MRT, Methow River above Twisp; RRE, Rocky Reach Dam; TWR, Twisp River.

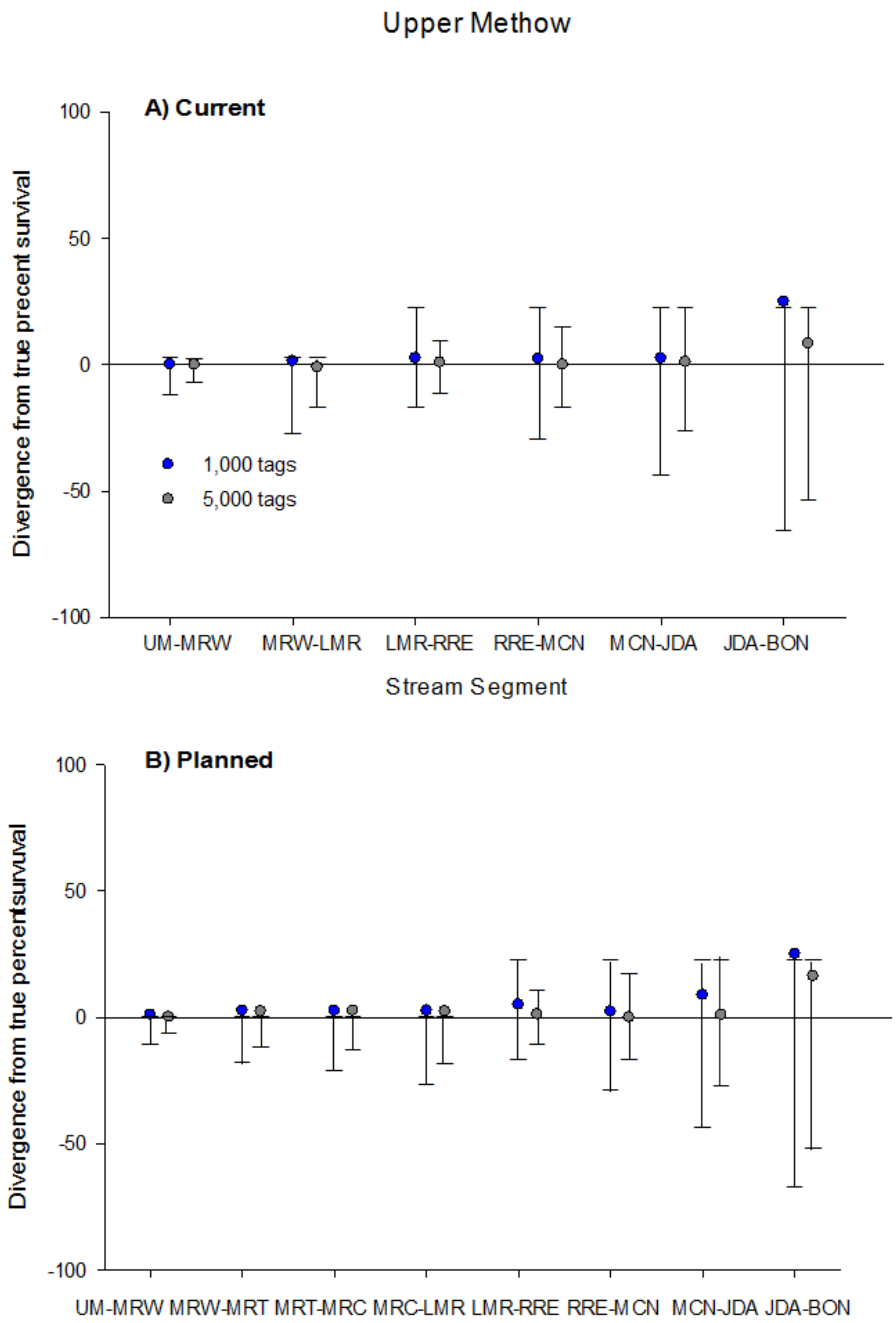

Figure 3-7. Simulated divergence from true survival (Current = 0.94868330 in the Methow River and 0.75 in the Columbia River; Potential = 0.97400375 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) in the Upper Methow (upstream of 80 rkm) with current and planned PIT tag interrogation systems. BON, Bonneville Dam; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; MRT, Methow River above Twisp; MRW, Methow River above Winthrop; Rel, release site; RRE, Rocky Reach Dam; UM, Upper Methow.

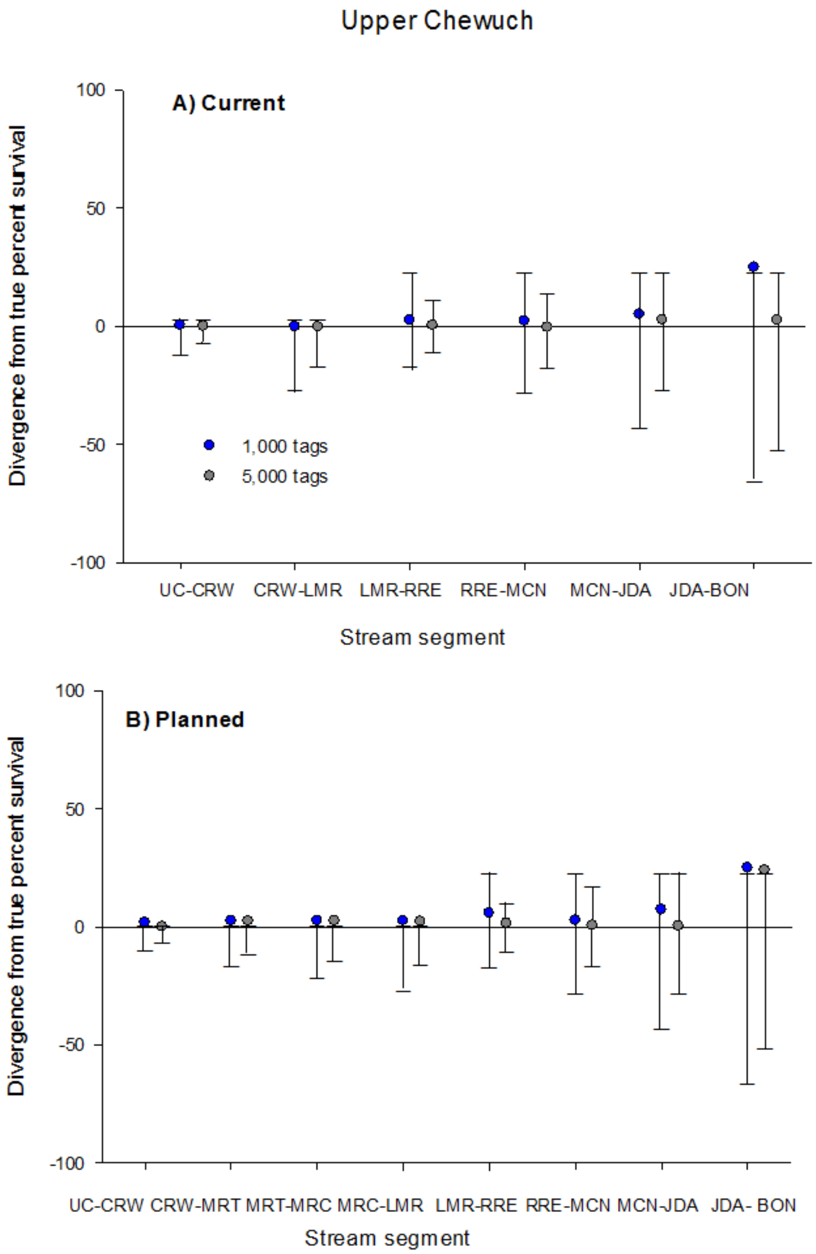

Figure 3-8. Simulated divergence from true survival (Current = 0.94868330 in the Methow River and 0.75 in the Columbia River; Potential = 0.97400375 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) in the Upper Chewuch (upstream of 80 rkm) with current and planned PIT tag interrogation systems. BON, Bonneville Dam; CRW, Chewuch River above Winthrop; JDA; John Day Dam; LMR, Lower Methow River; MRC, Methow River at Carlton; MRT, Methow River above Twisp; MRW, Methow River above Winthrop; Rel, release site; RRE, Rocky Reach Dam; UC, Upper Chewuch.

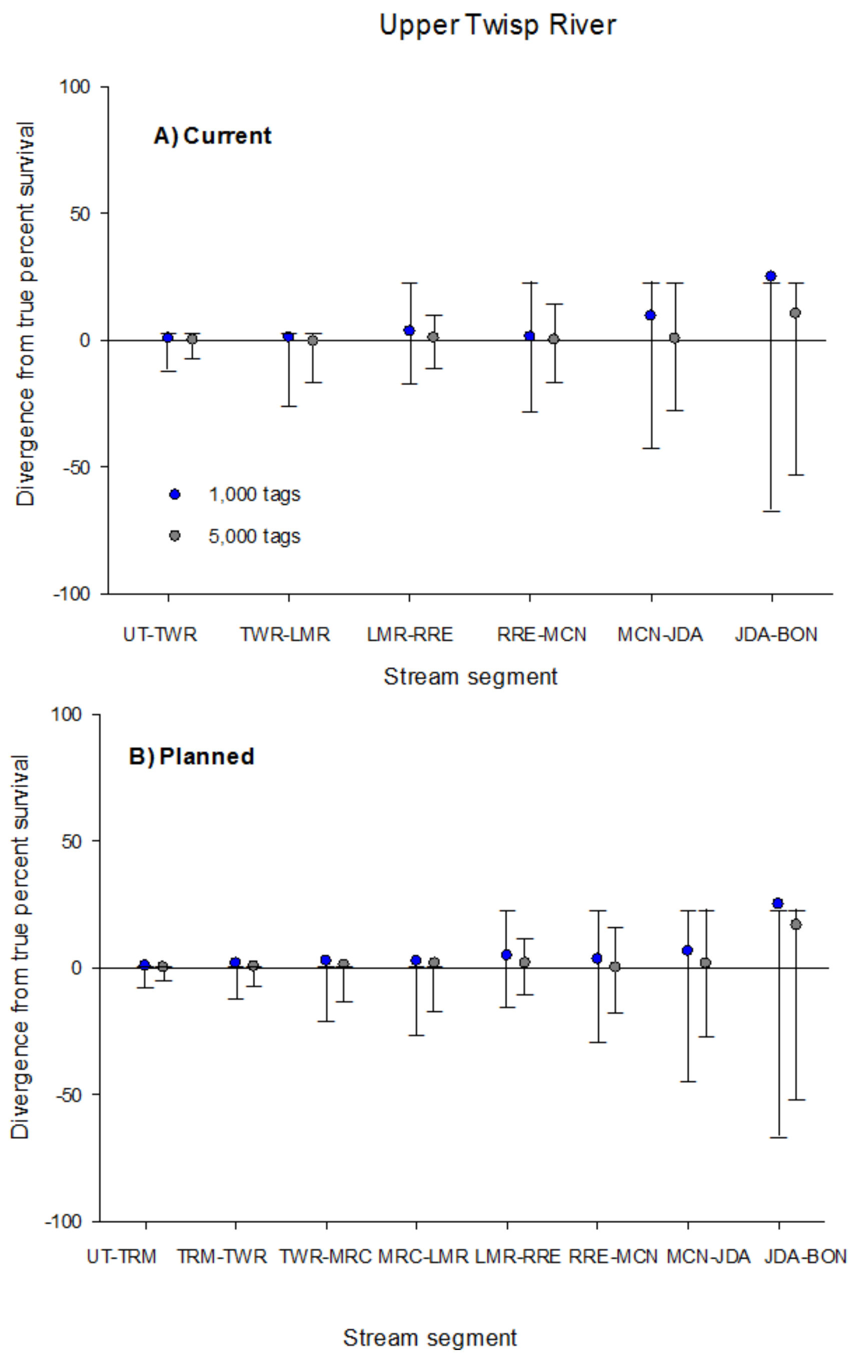

Figure 3-9. Simulated divergence from true survival (Current = 0.94868330 in the Methow River and 0.75 in the Columbia River; Potential = 0.97400375 in the Methow River and 0.75 in the Columbia River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) in the upper Twisp River with current and planned PIT tag interrogation systems. BON, Bonneville Dam; JDA; John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRC, Methow River at Carlton; RRE, Rocky Reach Dam; TWR, Twisp River; TRM, Middle Twisp River; UT, Upper Twisp.

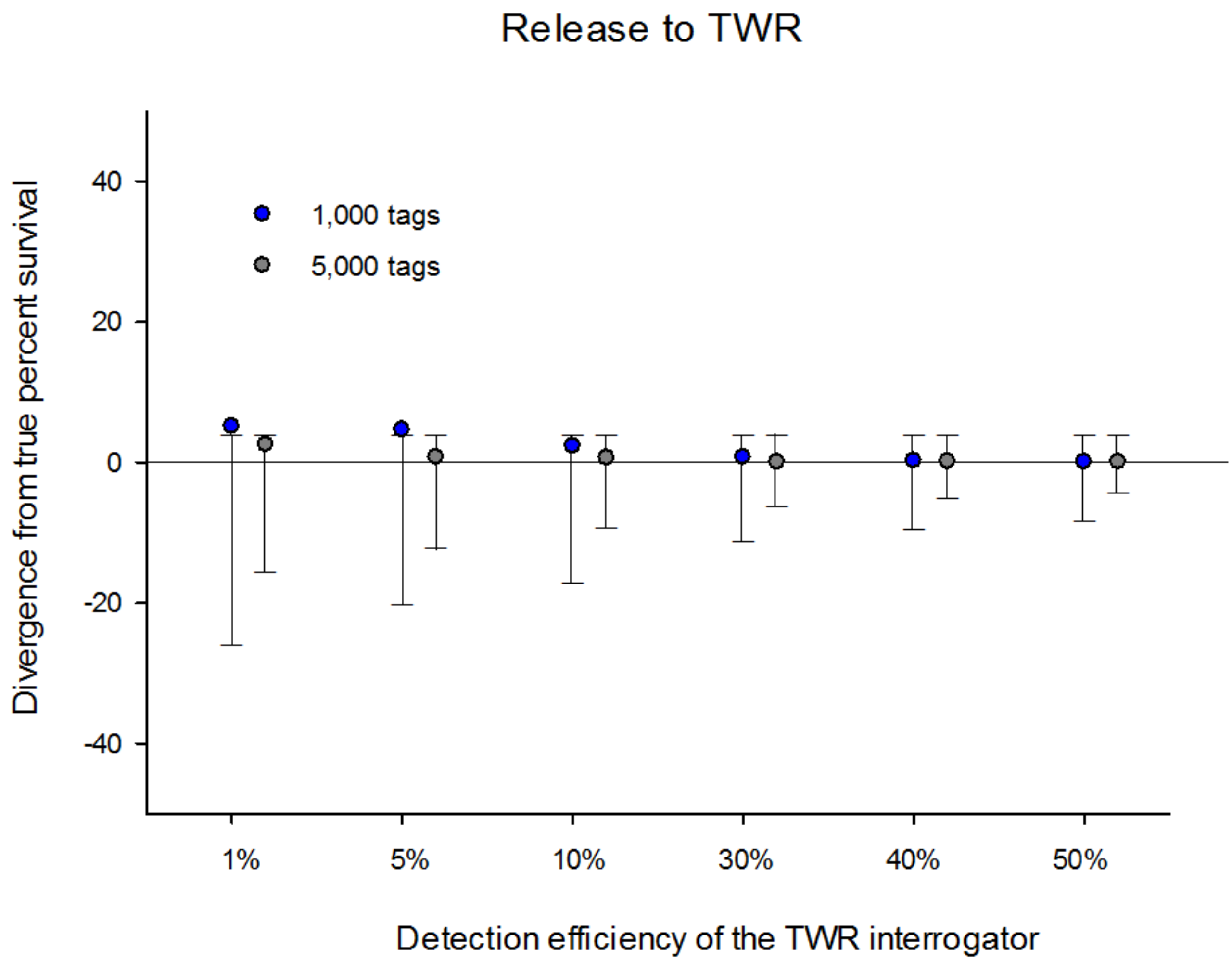

Figure 3-10. Simulated divergence from true survival (Current = 0.94868330 in the Methow River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) from the release point to the lower Twisp River interrogation system (TWR) using six detection probabilities. Current detection is estimated at 30 percent for low-flow conditions and 10 percent for high-flow conditions.

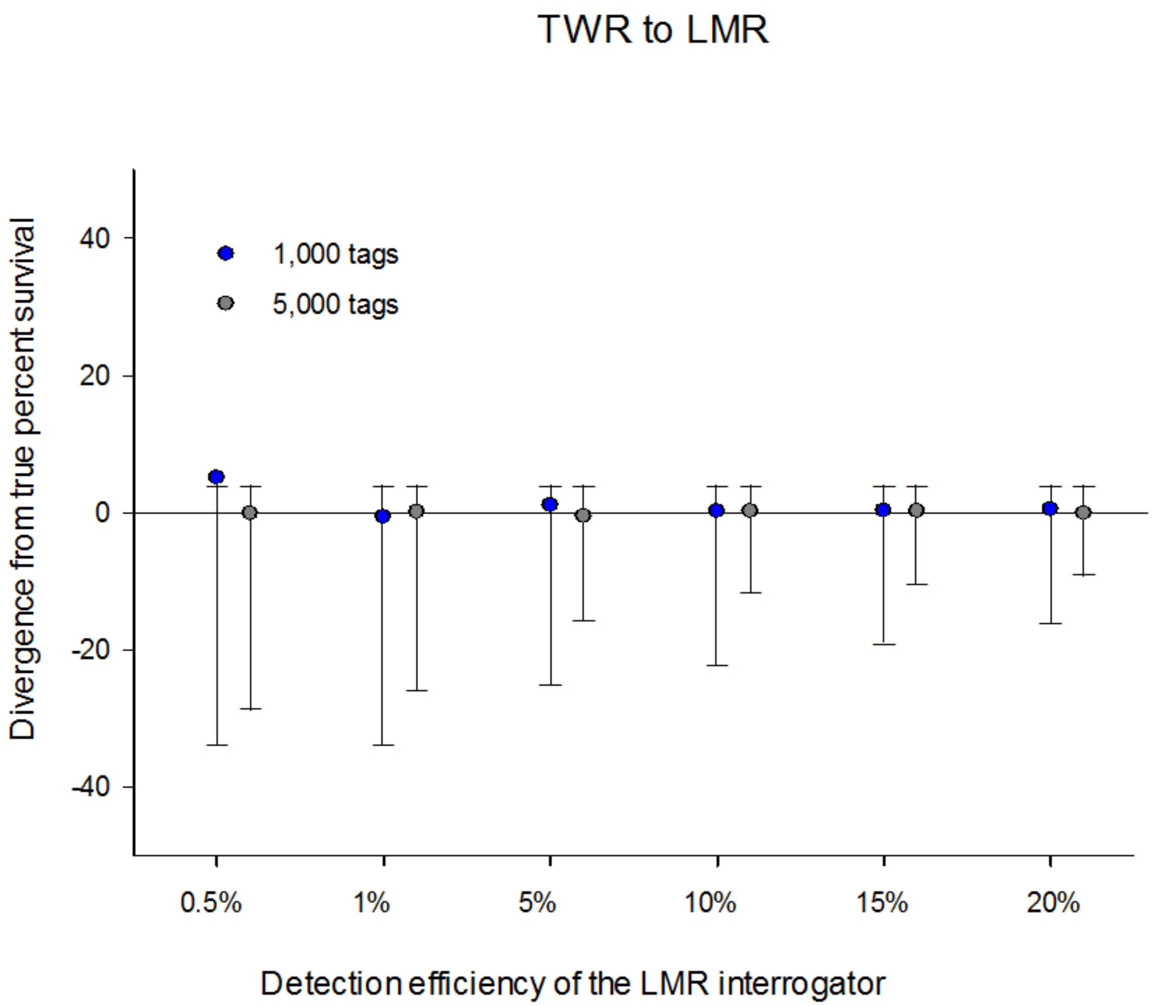

Figure 3-11. Simulated divergence from true survival (Current = 0.94868330 in the Methow River) with 95-percent confidence intervals for fish releases (1,000 and 5,000 tags) from the lower Twisp River interrogation system (TWR) to the lower Methow River interrogation system (LMR) using six detection probabilities. Current detection is estimated at 5 percent for low-flow conditions and 1 percent for high-flow conditions.

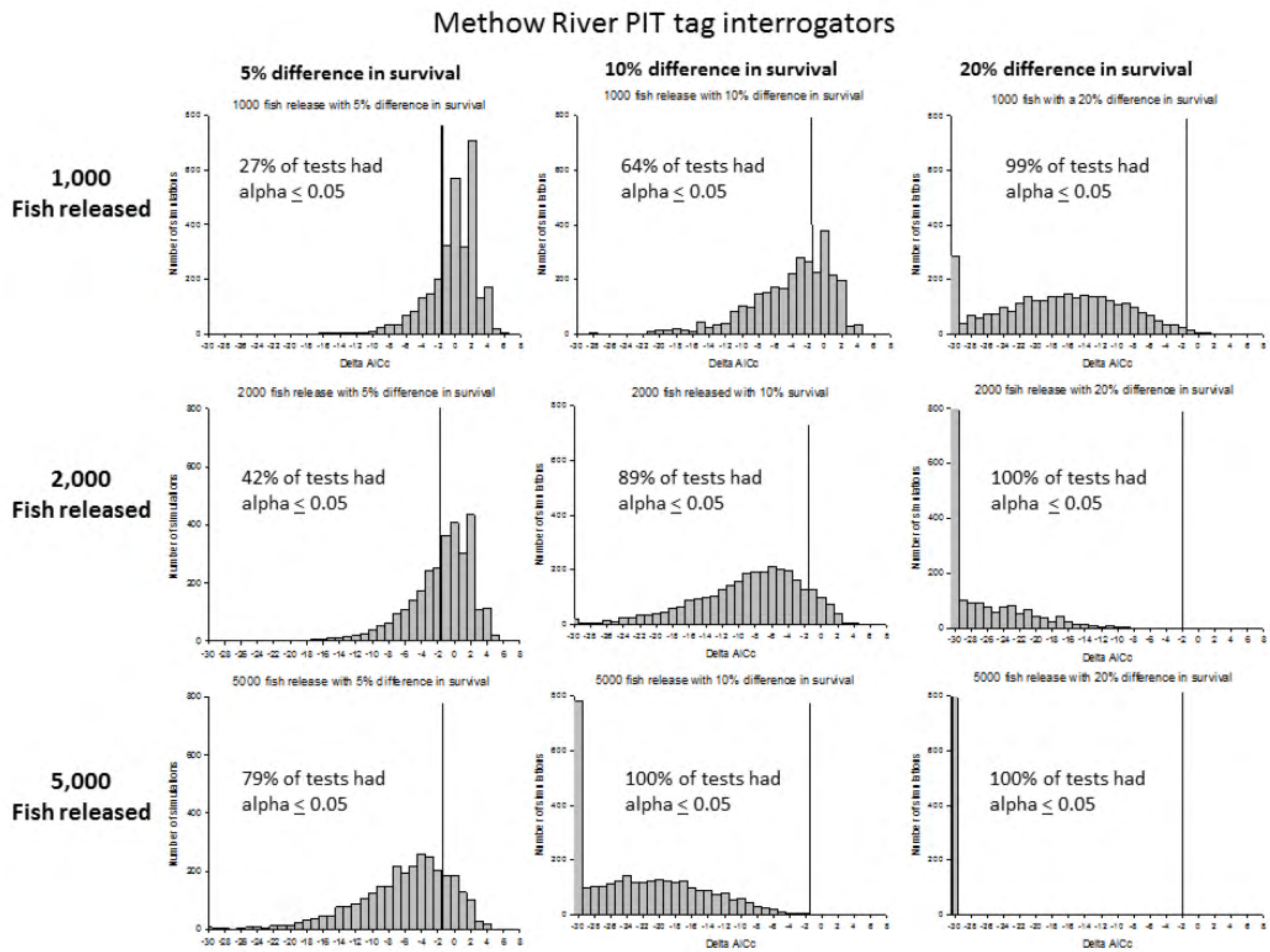

Figure 3-12. Delta AICc between two models (ϕ(g*d) p(d) and ϕ(d) p(d)) for 3,000 simulations to determine differences in survival (5, 10, and 20 percent) between two groups (treatment and control) using the current PIT tag interrogation systems (n=6) and Twisp River screw trap encountered for fish released in the Twisp River.

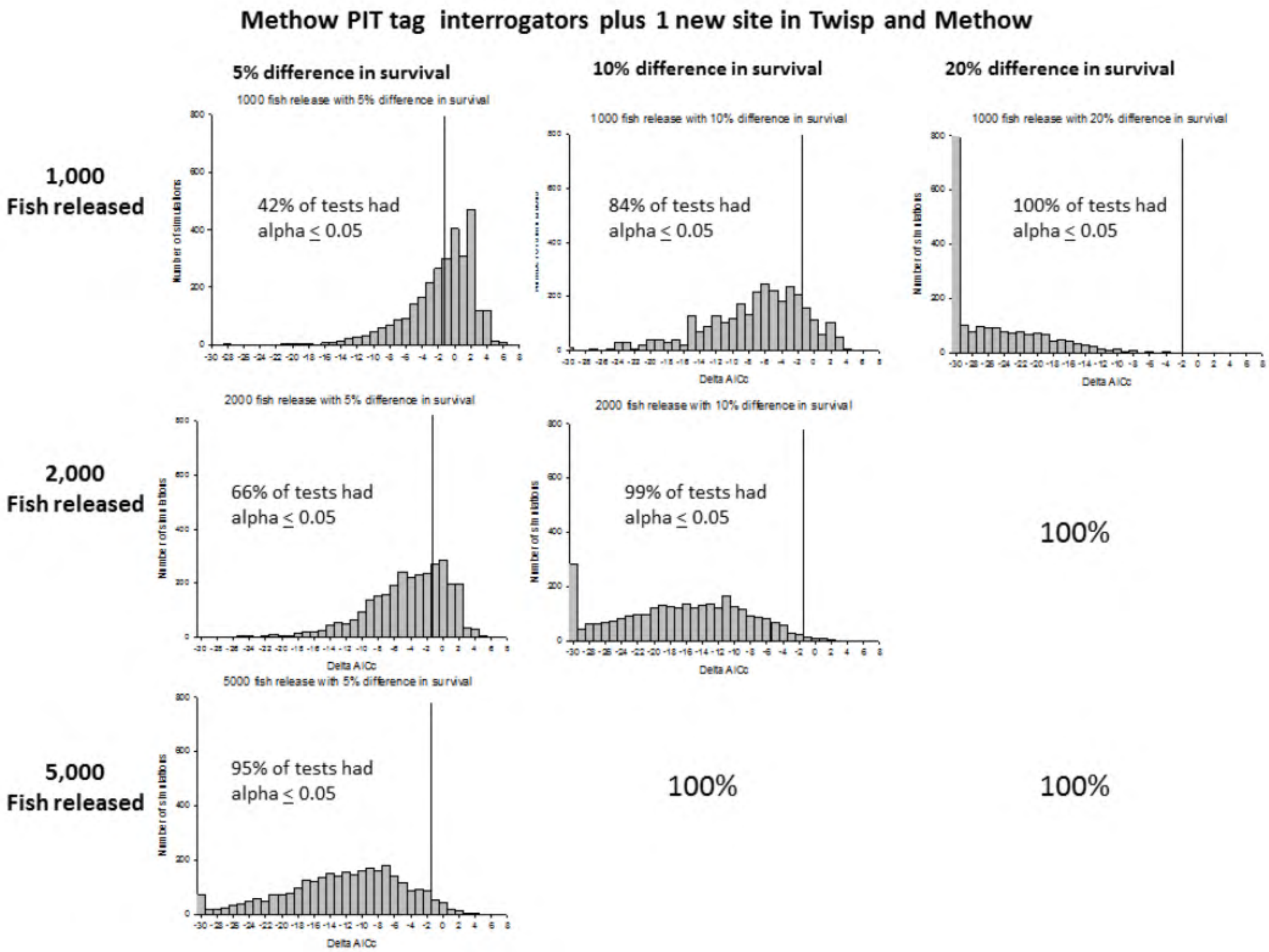

Figure 3-13. Delta AICc between two models (ϕ(g*d) p(d) and ϕ(d) p(d)) for 3,000 simulations to determine differences in survival (5, 10, and 20 percent) between two groups (treatment and control) using the current PIT tag interrogation systems (n=8) and Twisp River screw trap encountered for fish released in the Twisp River.

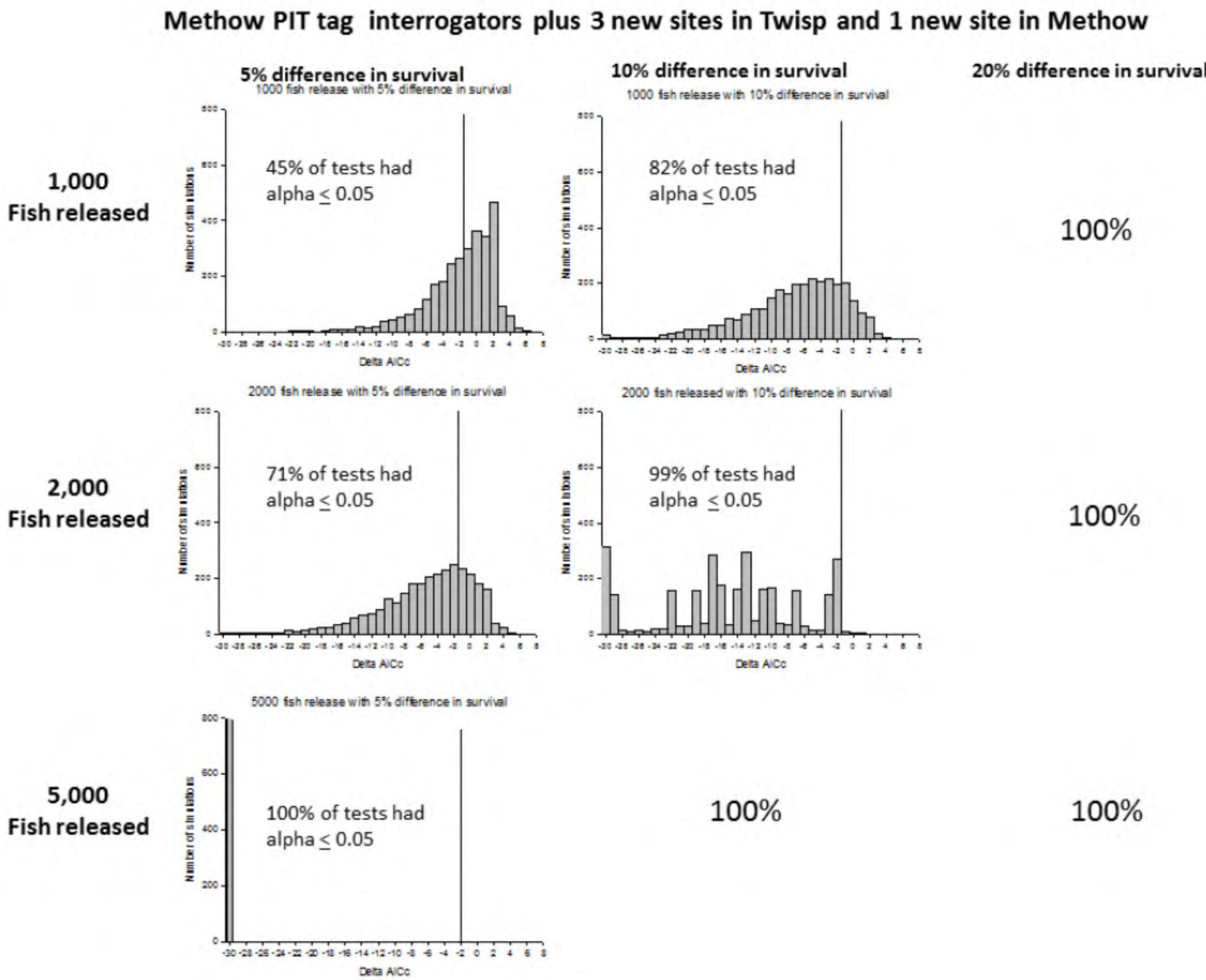

Figure 3-14. Delta AICc between two models (ϕ(g*d) p(d) and ϕ(d) p(d)) for 3,000 simulations to determine differences in survival (5, 10, and 20 percent) between two groups (treatment and control) using the current PIT tag interrogation systems (n=10) and Twisp River screw trap encountered for fish released in the Twisp River.

Table 3-1. Number of PIT tags released and survival estimates between PIT tag interrogation systems for juvenile steelhead and spring Chinook salmon released in the Methow River watershed, Washington.

[Release and interrogation data were downloaded from the PTAGIS database and includes Washington Department of Fish and Wildlife (WDFW) and U.S. Fish and Wildlife Service (USFWS) hatchery data. Species: CHN, spring Chinook salmon; STH, juvenile steelhead. Stream segment: BON, Bonneville Dam; JDA, John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRT, Methow River above Twisp; RRE, Rocky Reach Dam. --, Survival was not estimated, since one of the interrogators was not operating]

Species	Number of tags released	Survival estimates between PIT tag interrogation systems					
		Release to	MRT to LMR	LMR to RRE	RRE to MCN	MCN to JDA	JDA to BON
STH (2011)	49,988	0.9234	0.8014	0.8009	0.6871	1.0000	0.6489
CHN (2011)	28,688	0.9738	1.0000	0.7224	0.6368	1.0000	1.0000
STH[1] (2006–11)	4,882	0.3530	--	--	--	0.7601	0.4782
STH[2] (2010–11)	1,321	0.5664	--	0.8794	0.7018	0.9999	0.5676

[1]Wild steelhead tagged by WDFW at the Twisp River screw trap for all years (2006–11).

[2]Wild steelhead tagged by WDFW at the Twisp River screw trap (2010–11).

Table 3-2. Number of PIT tags released and detection probability between PIT tag interrogation systems for juvenile steelhead and spring Chinook salmon released in the Methow River watershed, Washington.

[Release and interrogation data were downloaded from the PTAGIS database and includes Washington Department of Fish and Wildlife (WDFW) and U.S. Fish and Wildlife Service (USFWS) hatchery data. Species: CHN, spring Chinook salmon; STH, juvenile steelhead. Stream segment: BON, Bonneville Dam; JDA, John Day Dam; LMR, Lower Methow River; MCN, McNary Dam; MRT, Methow River above Twisp; RRE, Rocky Reach Dam. --, PIT tag interrogation system was not operating]

Species	Number of tags released	Detection probability between PIT tag interrogation systems					
		MRT	LMR	RRE	MCN	JDA	BON
STH (2011)	49,988	0.0047	0.0073	0.4050	0.0932	0.2201	0.0742
CHN (2011)	28,688	0.0052	0.0027	0.2991	0.1439	0.1725	0.0332
STH[1] (2006–11)	4,882	--	--	--	0.1628	0.2025	0.2352
STH[2] (2010–11)	1,321	--	0.0107	0.4176	0.1107	0.1803	0.1875

[1]Wild steelhead tagged by WDFW at the Twisp River screw trap for all years (2006–11).

[2]Wild steelhead tagged by WDFW at the Twisp River screw trap (2010–11).

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