ANNUAL REPORT

ABUNDANCE, PRODUCTIVITY, AND LIFE HISTORY OF FIFTEENMILE CREEK STEELHEAD

August 16, 2011 – August 15, 2012

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ABSTRACT.

We evaluated the population and life history characteristics of Fifteenmile Creek steelhead between August 16 2011 and August 15 2012, a population listed as 'threatened' under the endangered species act. These steelhead are a part of the Mid-Columbia Distinct Population Segment for Columbia River steelhead. To achieve study objectives, we deployed a rotary screw trap to capture, tag and enumerate out-migrating juvenile steelhead, and operated a resistance panel weir to capture and enumerate returning adult steelhead. In addition, spawning ground surveys were conducted in accordance with methods established since 2003. We augmented the existing in-stream PIT arrays with two new sites, bringing the total number of sites to four located at tributary confluences thereby enhancing our ability to determine spawner distribution and estimate rotary screw trap efficiency; the estimated efficiency of the entire array was 94% during the 2011-2012 season for migrating adults. A total of 122 returning wild adult steelhead were captured, 22 wild steelhead kelts, and 36 wild steelhead carcasses. The estimate for wild adult steelhead escapement to Fifteenmile Creek during the 2011-2012 season was 557 ± 249 individuals (weir mark-recapture estimate). A total of 105 steelhead redds were counted providing an estimated total redd production in 2012 to be 223 ± 154 redds. We captured 2,531 juvenile steelhead, of which 2,519 were tagged using PIT tags. Using detection histories of PIT-tagged juvenile steelhead, we estimated smolt abundance to be 25,775 individuals (lower and upper 95% CI = 21,962 and 30,484, respectively). Juvenile survival estimates during the 2012 outmigration were unusable due to limited recapture rates at Bonneville Dam. Age compositions were determined for juvenile outmigrants and returning adults and are reported. The Smolt-to-Adult return (SAR) rates to Fifteenmile Creek were estimated for the 2007-2010 smolt outmigration years and ranged from a low 1.9% in 2009 to a high of 3.68% in 2008. We found significant differences ($p<\alpha=0.05$) between SAR rates to Bonneville Dam and SAR rates to Fifteenmile Creek in both 2008 and 2009, which is consistent with the survival observed between Bonneville Dam and Fifteenmile Creek. Survival of returning adults from Bonneville Dam to Fifteenmile Creek for spawning years 2010, 2011 and 2012 were estimated to be 60%, 52%, and 44% (95%cL, 43%-47%) respectively. These are alarmingly low survival rates for the 45 mile journey from Bonneville Dam to the mouth of Fifteenmile Creek, and necessitates further investigation.

SUMMARY TABLE OF KEY METRICS.

Metric	Estimate	95% CI Lower	95% CI Upper	Notes
Abundance and Life History:				
Adult Escapement, 2011-12	*557*	*308*	*806*	Based on weir mark-recapture experiment
Redd Abundance, 2012	*223*	*69*	*376*	Only 1 complete pass was conducted this season; second pass on index reaches yielded few new redds
Redd Distribution, 2012:				Based on number of redds counted
Fifteenmile	*60.0%*	-	-	
Eightmile	*32.3%*	-	-	
Fivemile	*2.8%*	-	-	
Ramsey	*4.8%*	-	-	
Adult Sex Ratio, 2012:				
Female	*60.0%*	-	-	
Male	*40.0%*	-	-	
Adult Freshwater Age, 2012:				
Age 1	*69.7%*	-	-	
Age 2	*29.3%*	-	-	
Age 3	*1%*	-	-	
Adult Total Age, 2012:				Total age = FW age + SW age + 1
Age 3	*29.8%*	-	-	
Age 4	*51.0%*	-	-	
Age 5	*16.8%*	-	-	
Age 6	*1.4%*	-	-	
Age 7	*1.0%*	-	-	
Smolt Abundance, 2012	*25775*	*21962*	*30484*	
Smolt Age, 2012:				
Age 1	*78.9%*	-	-	
Age 2	*19.3%*	-	-	
Age 3	*1.8%*	-	-	

SUMMARY TABLE OF KEY METRICS (CONT.)

Metric	Estimate	95% CI Lower	95% CI Upper	Notes
Survival:				
Smolt Migration, 2012:				
% Surviving To Bonneville	*	*	*	
% Surviving To Estuary	*	-	-	Insufficient sample size
Adult Migration, 2011-12:				Based on detections at Bonneville and Fifteenmile,
% Bonneville to Fifteenmile	*44%*	*43%*	*47%*	and Fifteenmile PIT array efficiency of 94%
Production:				
Smolt-to-Adult Return Rates:				To Fifteenmile Creek, years shown refer to smolt outmigration years. Return rates in percent.
2007	*2.62*	*1.27*	*4.35*	
2008	*3.68*	*2.85*	*4.62*	
2009	*1.90*	*1.48*	*2.32*	
2010	*0.63*	*0.38*	*0.95*	
Recruits-per-Spawner	*	-	-	Not enough data to calculate as of yet
Outside Influence & Straying:				
Hatchery Fraction, 2011-12	*4.9%*	-	-	
Stray Rates based on PIT Tag detections:				
of Fifteenmile Steelhead,2011-12	*3.1%*	-	-	
of Fifteenmile Steelhead, 2012-13*	*6.5%*	-	-	
into Fifteenmile Creek, 2011-12	*0.6%*	-	-	

INTRODUCTION.

Fifteenmile watershed in North Central Oregon hosts a native population of steelhead (*Oncorhynchus mykiss*) that is unique and without influence of previous hatchery augmentation (Newton and Nelson 2000). The Fifteenmile Creek steelhead are a subpopulation within the Distinct Population Segment (DPS) of the Middle Columbia River steelhead, which consists of all historical populations of steelhead in tributaries to the Columbia River upstream of the Hood River and Wind River systems, up to and including the Yakima River. This steelhead DPS was listed as 'threatened' by the National Marine Fisheries Service (NMFS) first on March 25, 1999 and relisted as a DPS on January 5, 2006 (71 FR 834, Figure 1).

Subsequently, a conservation and recovery management plan was developed for the Middle Columbia River steelhead DPS within Oregon state borders. The goal of the plan is to recover Middle Columbia River steelhead to a level that would allow the removal of threatened status, in addition to providing a long-term goal to recover the population sufficiently to provide "sustainable fisheries and other ecological, cultural, social and economic benefits for future generations" (Carmichael and Taylor 2010). The DPS-level recovery plan sets specific recovery goals for the areas within the DPS, which designates Fifteenmile Creek explicitly.

The Fifteenmile Creek steelhead population is considered the most inland winter race of steelhead in the Columbia River Basin, as designated by NOAA fisheries. However review of this designation may be necessary after a full generation of steelhead are observed because the run-timing of adult steelhead passing Bonneville Dam has been inconsistent with known winter run steelhead for the past two study years. The designation identified the population as a "must have viable" by the Interior Columbia technical recovery team (ICTRT) reaching viable status is essential for achieving DPS delisting. The ICTRT, Recovery Plan, and the Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) have all identified this population as high priority for improving precision and accuracy of abundance, productivity, diversity, and spatial structure information. This research by ODFW is designed to establish a comprehensive monitoring and evaluation program for abundance, productivity, and life history of steelhead in the Fifteenmile Creek population. This work is critical to gaining a better understanding of the status of the population and DPS, monitoring and adapting recovery actions, and improving the knowledge of steelhead critical habitat.

To establish pertinent management actions for Fifteenmile Creek steelhead, this research seeks to:

1. Improve spawner population estimates
2. Improve estimates of abundance of stray hatchery fish
3. Determine life history characteristics (through metrics associated with life history attributes)
4. Determine population dynamics for Fifteenmile Creek steelhead

In order to accomplish these critical goals, population performance metrics were evaluated for Fifteenmile steelhead in 2012 including: age structure, hatchery fraction; adult life history

characteristics; juvenile life history characteristics; smolt abundance; smolt migration survival; smolt-to-adult survival; spawner distribution; recruits-per-spawner; smolts-per-spawner; as well as to establish the relationship of adult abundance estimates from redd counts and weir counts.

Population metrics were evaluated from data collected through the installation and operation of a weir trap to sample adult steelhead, a juvenile outmigrant trap (rotary screw trap), spawning surveys, juvenile salmon surveys throughout the watershed, and from the installation of passive integrated transponder (PIT) tag arrays at strategic sites throughout the basin. Analyses integrate life stage specific survival and life history information in order to derive and assess the performance metrics. The 2012 sampling season marks the second year of monitoring and research that has specifically addressed these objectives; however smolt outmigration has been monitored since 2006 through the use of PIT-tagged out-migrating smolts (Macnab and Springston 2009) from which essential data has been provided, and is included in this report. Smolt returns from prior years were also used in our analyses.

The information generated from this project will not only significantly improve the quality of the viability status assessments but will also serve as a basis for evaluating long term changes in productivity that may result from tributary habitat improvement. An ongoing project that is funded through Bonneville Power Administration has addressed habitat issues on Fifteenmile Creek and its tributaries for almost twenty years (BPA, project #1993-040-00). This research project is a long term endeavor that will span multiple steelhead generations.

STUDY AREA.

The Fifteenmile Creek drains approximately 370 square miles (966 km^2) of the eastern slopes and foothills of the Cascade Range in north-central Oregon. From its headwaters in Mount Hood National Forest, Fifteenmile Creek flows northeast through the city of Dufur before turning north and then west before flowing into the Columbia River just downstream of The Dalles Dam (Figure 1). The watershed lies entirely within the boundary of lands originally occupied by member tribes of the Confederated Tribes of The Warm Springs. Current land-ownership is, except for the headwaters portions lying within the National Forest boundaries, largely private. The majority of private lands are used for agricultural production, including wheat and other grains, hay and alfalfa, orchard fruits, and cattle production. The major tributaries to Fifteenmile Creek, working downstream of the headwaters, are Ramsey Creek (entering Fifteenmile in the Dufur Valley), Pine Creek (entering in the city of Dufur), Dry Creek (entering Fifteenmile downstream of the city of Dufur), and Eightmile Creek (entering Fifteenmile approximately 2.5mi upstream of its confluence with the Columbia River). Eightmile Creek is the largest tributary to Fifteenmile Creek, and its main tributary is Fivemile Creek, which enters Eightmile Creek approximately one mile upstream of the confluence of Eightmile and Fifteenmile creeks.

The Fifteenmile basin is situated at the eastern end of the Columbia River Gorge, a zone where the cooler, moister conditions typically found in the Gorge transition to the warmer, drier conditions typically found in eastern Oregon. As a result, many characteristics of the basin exhibit greater diversity than would be found in either the Gorge or further east. General flora community structure in Fifteenmile watershed ranges from pine- and fir-dominated coniferous forest in the headwaters, to mixed-oak-pine woodland in the middle to lower elevations, and finally to bunchgrass- and sagebrush-dominated grasslands in the eastern and low-elevation portions of the watershed (Clark 2003). Mean annual precipitation can vary widely within the watershed, and generally ranges from upwards of 70 inches in the headwaters to approximately 10 inches near the confluence of Fifteenmile Creek and the Columbia River. Precipitation falls primarily as snow during the winter months, but moderate-to-heavy fall and spring rainfall events are not uncommon.

The hydrologic regime in Fifteenmile Creek is characterized by high spring runoff (resulting from snowmelt, sometimes in combination with warm spring rains) followed by low summer and fall flows. Normally low summer discharge is typically compounded by stream and water-table withdrawals made primarily for crop irrigation and livestock watering. High summertime air temperatures are common, and as a result, summertime temperatures in many stream reaches in the lower and middle portions of the watershed can exceed the salmonid rearing threshold temperature of 17.8°C (Macnab and Springston 2009).

In addition to the wild population of steelhead native to Fifteenmile Creek, the native fish community includes coho salmon (*O. kisutch*), cutthroat trout (*O. clarkii*), Pacific lamprey (*Lampetra tridentata*), western brook lamprey (*L. richardsoni*), northern pikeminnow (*Ptychocheilus oregonensis*), redside shiner (*Richardsonius balteatus*), chiselmouth (*Acrocheilus alutaceus*), mountain sucker (*Catostomus platyrhynchus*), largescale sucker (*C. macrocheilus*), and several species of dace (*Rhinichthys* spp.) and sculpin (family Cottidae).

METHODS.

Permitting

Section 4d permits granting authorization to conduct essential biological sampling of species protected under the Endangered Species Act (ESA) was obtained from the National Oceanographic and Atmospheric Administration (NOAA). Work conducted during 2011 was covered under permit number 15885, and work conducted during 2012 was covered under permit number 16714. All work completed during the 2011-2012 sampling season was conducted in compliance with the permit specifications.

Biological Sampling

Returning Adult Migrants

Returning adult steelhead were trapped using a resistance-panel weir (Tobin 1994, Stewart 2002, Stewart 2003; Figure 2). The weir was moved from its location in 2011 to a new location approximately 60m farther downstream, making the new location approximately 100m downstream of the confluence of Fifteenmile and Eightmile creeks. The weir was installed in the main channel of Fifteenmile Creek approximately midway between the exit and re-entry of a side channel that is regularly inundated during elevated winter flows. An "A-frame" picket weir (no trap box) was installed on the side channel such that adults were forced to migrate up the main channel where they could be intercepted by the resistance-panel weir.

The weirs were cleaned and the trap was checked at least once daily and trapped steelhead were sampled for sex, fork length, scales, genetics, presence of marks or tags, and source (wild or hatchery). All trapped wild steelhead were passed upstream of the weir, whereas known hatchery steelhead (as identified by presence of certain marks/tags) were euthanized and sent to the USFWS Pathology Lab in Willard, WA for pathological/parasitological evaluation. Previously untagged wild steelhead received uniquely coded, 12mm passive integrated transponder (PIT) tags inserted into the dorsal sinus cavity with sterilized, single-use needles (Biomark, Inc., Boise, ID). All individuals that received PIT tags also received a secondary mark (diamond-shaped operculum punch) prior to release.

Kelts (post-spawn steelhead returning to the ocean) were also trapped at the weir site using a passive-entry kelt trap. Kelts were sampled for the same information as returning adults before being passed downstream of the weir. Again, previously untagged kelts received PIT tags prior to release, and known hatchery kelts were euthanized and sent to the Willard Pathology Lab. Additionally, as part of a United States Army Corps of Engineers (USACE) kelt survival study, steelhead kelts received FLOY tags fitted with juvenile salmon acoustic telemetry system (JSATS) tags. In 2012 JSATS detection systems were deployed in arrays downstream from the McNary Dam to Bonneville Dam, and into the Columbia River estuary, whereby survival and passage routes (spillways, turbines, etc.) through the dams could be determined (Ploskey et al, 2012), and into the Columbia River Estuary. PIT-tag codes and biological data for all tagged adults were uploaded to the PIT Tag Information System (PTAGIS) database, in addition to the JSATS tagging database.

Juvenile Outmigrants

Juvenile salmonids were trapped using a rotary screw trap (E.G. Solutions, Inc., Corvallis, OR) with a 1.52m (5ft) cone. The trap was located on Fifteenmile Creek approximately 10m downstream of its confluence with Eightmile Creek. The trap was checked and cleaned at least once daily and trapped individuals were identified to species and counted. Salmonids were retained and sampled for fork length, weight, and presence of PIT tags. Approximately ten percent of trapped fish were sampled for genetics. All previously untagged juvenile salmonids were anesthetized using a dilute solution of Finquel® (tricaine methanesulfonate; Argent Chemical Laboratories, Redmond, WA) before receiving uniquely coded 12mm PIT tags inserted into the peritoneal cavity. Non-target by-catch, recaptured individuals, and individuals not tagged due to injuries or other health conditions were released downstream of the trap. Individuals that received PIT tags were allowed to recover fully before being released upstream of the trap to enable estimation of trapping efficiency. Efficiency releases were alternated daily between Fifteenmile and Eightmile Creeks; releases were automated through the use of a timed-opening release device, and daily release times were randomized to minimize any influence that diel variation in release timing may have on recapture probability. Additionally, this provided the potential to evaluate differences in recapture probability associated with time of release.

Spawning Ground Surveys

Oregon Department of Fish and Wildlife (ODFW) has partnered with the United States Forest Service (USFS) since the late 1980s to conduct foot surveys of spawning grounds in the Fifteenmile Creek watershed (Gerstenberger and Rossel 2008). The purpose of these surveys has been to enumerate steelhead redds; annual redd counts have been used to estimate adult steelhead escapement. In 2003, a stratified-random sampling design was implemented that was largely based on the standard methods for conducting steelhead redd surveys (Susac and Jacobs 1999, Jacobs et al. 2000, Jacobs et al. 2001). Under this new protocol, the majority of steelhead spawning grounds in each of Fifteenmile Creek (72km), Eightmile Creek(39km), Fivemile Creek(32km), and Ramsey Creek (16km) were divided into approximately 8km strata which were each further divided into five approximately 1.6km sub-reaches. Originally, one sub-reach from each stratum was randomly selected for inclusion into the survey set each year. However, in recent years the protocol has changed to include two contiguous sub-reaches from each stratum. In addition, six of the 100 1.6km reaches in the basin (two each in Fifteenmile Creek, Ramsey Creek, and Eightmile Creek) were identified as known high-density spawning "index" reaches, and were included automatically in each year's survey sample to provide escapement trend information.

For the 2012 spawning season, redd surveys were conducted according to the updated protocol developed in 2011, which added several components to the established protocol. In years past, surveys were conducted by one or two experienced surveyors moving in an upstream direction. Previously uncounted redds were identified, redd age was assessed, and redds were flagged and/or marked with a brightly-colored, painted rock in the depression. Live fish were identified to species, tallied, and, if possible, fin marks were identified. Beginning in 2008, Global positioning system (GPS) units were used to record redd location. We used Garmin® GPSMap model 78s GPS units to record redd positions. Up to three passes were conducted on each reach, and passes were conducted approximately bi-weekly. In

2011, the protocol was adjusted in the following ways. First, each survey was conducted by no less than two surveyors. At least one surveyor on each survey was an experienced surveyor with at least one year of prior redd survey experience. Second, previously uncounted redds were marked only with flagging, and the date of the survey, the redd number, and the redd condition were marked on the flagging.

PIT Tag Interrogation

Out-of-basin Interrogation Arrays

An extensive and growing array of Full Duplex (FDX) PIT tag interrogation sites are operated in the Columbia River basin. These include sites at mainstem and tributary dams as well as a growing number of in-stream sites installed in tributaries, similar to those installed in the Fifteenmile Creek watershed. Detection data from most of these sites are uploaded to PTAGIS, an internet-accessible data clearinghouse for Columbia River basin PIT tag data operated and maintained by the Pacific States Marine Fisheries Commission (PSMFC). We queried the PTAGIS detection database for several types of information. First, we used PTAGIS to identify the source of PIT-tagged out-of-basin adult steelhead caught at the Fifteenmile Creek weir. Second, we queried the PTAGIS database to construct detection histories of all fish tagged in the Fifteenmile Creek watershed. These detection histories were used (as described below) to produce estimates of rotary screw trap efficiency, trap-to-estuary survival for tagged smolts, smolt-to-adult survival, stray rates of tagged adults, proportion of repeat spawners, run timing of juveniles and adults, and travel time of smolts and adults within the Fifteenmile Creek watershed as well as in the main-stem Columbia River.

In-basin Array

Two in-stream, full-duplex (FDX-B) PIT tag interrogation arrays were installed in the Fifteenmile Creek watershed in 2011 at the confluences of Eightmile Creek and Fivemile Creek, as well as at the confluences of Fifteenmile Creek and Ramsey Creek for the purpose of detecting PIT-tagged juvenile and returning adult steelhead and to determine the broad-scale distribution of tagged adult steelhead spawners. Those arrays were installed by NOAA Fisheries as a part of a separate BPA contract. In addition, tags were interrogated at the Fifteenmile Creek weir. For 2012 the array was expanded to include new sites at the confluences of Fifteenmile and Eightmile creeks and Fifteenmile and Dry creeks. Similar to the existing sites, antennae at both new sites were installed in the horizontal “pass over” style and were operated by a FS1001M multiplexing reader (Destron Fearing™, South St. Paul, Minnesota) that logged PIT tag codes and detection times for each detection. For 2012, data offloads at all sites were automated and executed daily via AirLink™ Raven X cellular modems (Sierra Wireless™, Richmond, British Columbia). Detection data were compiled and uploaded to the PTAGIS database.

Data Analysis

Adult Escapement

Three methods were used to estimate adult steelhead escapement to Fifteenmile Creek in 2012. These included weir mark-recapture estimates, redd count estimates and smolt to adult return

estimates from fish PIT tagged as smolts. For the mark-recapture estimates, data from the weir were used to estimate escapement according to the less-biased, Schnabel form of the Lincoln-Petersen estimator (Chapman 1951):

Equation 1

$$\widehat{N} = \frac{(M+1)(C+1)}{R+1} - 1$$

where $\widehat{N}$ is the estimated abundance, *M* is the number of individuals initially marked, *C* is the number of individuals subsequently examined for marks, and *R* is the number of marked individuals from *M* that were recaptured in *C*. The variance of the escapement estimate was calculated, according to Seber (1982) as:

Equation 2

$$\widehat{Var}(\widehat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}.$$

Approximate 95 percent confidence intervals were constructed around the escapement estimate as:

Equation 3

$$95\%\ C.I. \approx\ \pm 2 * \sqrt{\widehat{Var}(\widehat{N})}.$$

The second method used to calculate adult escapement was based on redd counts in Fifteenmile Creek and estimates of the number of steelhead per complete redd (fish-per-redd). In this method, the total number of redds (estimated by expanding redd survey counts across the basin) was multiplied by the estimated number of fish-per-redd. Lower and upper 95 percent confidence bounds on the estimate were produced by multiplying the fish-per-redd estimate by the numbers of redds corresponding to the lower and upper 95 percent bounds on the estimated total number of redds. Fish-per-redd estimates from Deer Creek (tributary to the Wallowa River, Northeast Oregon) and Buck Hollow Creek (tributary to the Deschutes River, North-central Oregon) were used to produce escapement estimates with this method.

The third escapement estimation method involved using mark-recapture data queried from PTAGIS and entered into the Program MARK to estimate adult escapement based on known numbers of fish tagged and subsequent PIT tag detections at Bonneville Dam and at the Fifteenmile PIT-tag antenna array.

Smolt abundance and Smolt to Adult Returns

Smolt abundance was estimated from recapture probabilities at the screw-trap site using a Huggins closed-capture model with population and environmental covariates (Huggins 1989, 1991). This model assumes a 'closed' population where there is no movement away from study area, and there is no birth or death between the mark and time of capture. These are reasonable assumptions for

estimating the recapture probability for out-migrating smolt that are PIT-tagged and released upstream of the screw trap. We are able to generate a likelihood curve for the estimation in the Program MARK (White and Burnham 1999), including the standard error and the 95% confidence limit associated with the estimate.

We also used the Huggins model to generate a likelihood curve and recapture rate for the Smolt to Adult return (S_mAR) estimate. The use of the Huggins model to estimate S_mAR effectively calculates the probability that a smolt from Fifteenmile creek will return to the creek to spawn. In this case the recapture probability uses the assumption that stray spawners and mortality from smolt to adult are indistinguishable from each other, which is reflected in the recapture probability and variance.

Using mark, release and recapture methods, we generated individual capture histories at the screw trap for juvenile steelhead as either (1) captured or (0) not captured, at Bonneville Dam as an adult (1) or (0), and at Fifteenmile Creek as an adult (1) or (0) to produce the probability of capture estimation. For instance if a fish tagged in Fifteenmile Creek was recaptured at the screw-trap, recaptured at Bonneville (PIT tag array in ladder), and not seen at Fifteenmile Creek PIT tag array, it would have a capture history of (110). Therefore all possible capture histories for this detection series are: 111, 110, 101, 100, 011, 010, 001, 000, and the sum of all history probabilities equal one. Fish are observed (or detected) for all capture histories except (000). Therefore the probability to observe a PIT tagged fish is Pr = 1 –Pr(000). The Huggins model uses these capture histories to estimate capture probability and its associated likelihood.

The Huggins model is parameterized as follows:

Probability of obtaining capture histories: example of three fish (A,B, and C), where 1 is captured (or detected) and 0 is not captured or detected:

Equation 4

$$\begin{aligned}
&\text{A} - \ \Pr(111) = \ p_{11}c_{12}c_{13} \\
&\text{B} - \ \Pr(011) = (1 - p_{21})p_{22}c_{23} \\
&\text{C} - \ \Pr(001) = (1 - p_{31})(1 - p_{32})p_{33} \\
&\ldots \text{ etc.}
\end{aligned}$$

Probability of observing fish at capture site:
(e.g. Screw trap as juvenile (#1): Return to Bonneville as Adult (#2): Return to Fifteenmile as Adult (#3))

Equation 5

$$\begin{aligned}
\Pr(\text{Capture \#1}) &= \ 1 - (1 - p_{11})(1 - p_{12})(1 - p_{13}) \\
\Pr(\text{Capture \#2}) &= \ 1 - (1 - p_{21})(1 - p_{22})(1 - p_{23}) \\
\Pr(\text{Capture \#3}) &= \ 1 - (1 - p_{31})(1 - p_{32})(1 - p_{33})
\end{aligned}$$

The likelihood of capture history given that the fish was observed at either site:

Equation 6

$$\mathrm{L}(\mathrm{A}) = \frac{p_{11}c_{12}c_{13}}{1-(1-p_{11})(1-p_{12})(1-p_{13})}$$

$$\mathrm{L}(B) = \frac{(1-p_{21})p_{23}c_{23}}{1-(1-p_{21})(1-p_{22})(1-p_{23})}$$

$$\mathrm{L}(C) = \frac{(1-p_{31})(1-p_{32})p_{33}}{1-(1-p_{31})(1-p_{32})(1-p_{33})}$$

Log(likelihood):

$$\mathrm{Ln(L)} = \ln(\mathrm{L(A)}) + \ln(\mathrm{L(B)}) + \ln(\mathrm{L(C)}) \ldots$$

The probability estimates are then derived from maximizing the Log Likelihood by estimating $\beta \; and \; \gamma$ from Log(likelihood).

Huggins reparamerterized the likelihood model so covariates could be included in the estimate, with β as the asymptotic limit of the curve, and γ as the shape of the likelihood curve, each of which are estimated from either a numerical solution or a Markov-chain Monte Carlo (MCMC) estimator if a numerical solution is not possible; both methods are available in the Program MARK. Huggins reparameterization to include covariates (x and z):

Equation 7

$$p_{ij} = \frac{e^{(\beta_0+\beta_1 x_{ij1}+\cdots+\beta_a x_{ija})}}{1+e^{(\beta_0+\beta_1 x_{ij1}+\cdots+\beta_a x_{ija})}}$$

$$c_{ij} = \frac{e^{(\gamma_0+\gamma_1 z_{ij1}+\cdots+\gamma_b z_{ijb})}}{1+e^{(\gamma_0+\gamma_1 z_{ij1}+\cdots+\gamma_a z_{ijb})}}$$

Likelihood is based on inclusion of matrix of covariate variables, i.e. average forklength, sex, age …etc. We used average forklength (x) and Fifteenmile discharge at time of capture (z) for the matrix calculation as a product of capture histories because both have shown to influence recapture rate for our migrating smolt (Cheng and Gallinat, 2004). An example matrix for two capture histories and two covariates follows:

Equation 8

$$\begin{bmatrix}1 & 1 & 1\\ 0 & 1 & 0\end{bmatrix}\begin{bmatrix}x_{111} & x_{121} & x_{131}\\ x_{211} & x_{221} & x_{231}\end{bmatrix}\ldots\begin{bmatrix}z_{11b} & z_{12b} & z_{13b}\\ z_{12b} & z_{22b} & z_{23b}\end{bmatrix}$$

Variance estimates are then based on the 2nd derivative (curvature) of the likelihood surface near the maximum. The variance estimate was used to calculate a standard error, and a 95% CL for each capture probability.

Finally, the capture probability estimate was used to determine smolt abundance for each year of tagging, where:

Equation 9

$$Smolt\ Abundance\ = \frac{Total\ Number\ Captured}{Capture\ Probability}$$

In order to determine adult returns from smolt detections, the total smolt abundance was used to estimate the total adult returns to Bonneville Dam and Fifteenmile Creek from each smolt out-migrant year using the Fifteenmile smolt abundance estimates for that year, age ratio for returning adults, and recapture probabilities at Bonneville Dam and Fifteenmile Creek as adults, for example:

Equation 10

$$Adult\ Returns_{(year)}\ = [P_{A1}\ * S_{A1}] + [P_{A2}\ * S_{A2}] + [P_{A3}\ * S_{A3}] \ldots + [P_{An}\ * S_{An}]$$

Where year = year that adult steelhead return to detection location (Bonneville or Fifteenmile Creek), P_{A1} = probability recapture at detection site from smolt to adult 1-year after out-migrating, S_{A1}= Smolt abundance in (year – 1), S_{A2}= Smolt abundance in (year – 2), et cetera. This equation was used to estimate the total adult returns for each year for fish passing Bonneville Dam, and into Fifteenmile Creek. Estimates required a minimum of three years of out-migrant tagging prior to calculating the S_mAR estimate and confidence intervals, and changes each year as S_mAR estimates are updated for older and repeat spawners.

Survival Estimation

We used an open capture, single-release, Cormack (1964), Jolly (1965), Seber (1965) (CJS) model to estimate survival and its variance from release of steelhead out-migrants to the Fifteenmile Creek screw-trap, from the screw-trap to Bonneville Dam, and from Bonneville Dam to the Columbia River estuary. This model does not assume a 'closed' population, but rather uses differing probabilities of detection at detection or capture sites to estimate the survival probability between each detection or capture site (river reach). Survival was estimated from recaptures at the PIT arrays, rotary screw trap, recaptures at Bonneville Dam from PIT-tagged fish that passed through the Bonneville Juvenile Bypass Collection facility (JBS) or the second powerhouse corner collector (BCC), and finally from recaptures from the PIT-tag trawl that is operated in the Columbia River Estuary by NOAA Fisheries (TWX).

Similar to the closed-capture model, the three downstream survival detection points produced 2^3 = 8 possible capture histories for each release group (111, 011, 101, 001, 110, 010, 100, and 000). We input individual capture histories for each fish into the MARK program to estimate single release survival. The design for estimating reach survival rates is illustrated in Figure 3, with single-release survival estimates ($\hat{S}$) and probability of detection (p) shown on the right side of the diagram. For example, the survival of Fifteenmile smolts is estimated between the screw-trap and Bonneville Dam in Figure 3 as:

Equation 11

$$\hat{S}_{river\ reach} = \frac{\hat{S}_{11}}{\hat{S}_{21}}$$

Releases were pooled for the entire season because of low detection probability and sample size at Bonneville Dam and in the estuary.

Model Assumptions:

Each release group can provide estimates of reach survival based on the single release-recapture model (Skalski et al. 1998, Faber et al. 2011). The assumptions of the single release-recapture model include the following:

1. Fish marked for the study are a representative sample from the population of interest.
2. Survival and capture probabilities are not affected by tagging or sampling. That is, tagged fish have the same probabilities as untagged fish.
3. All sampling events are "instantaneous." That is, sampling occurs over a negligible distance relative to the length of the intervals between sampling events.
4. The fate of each tagged fish is independent of the fate of all others.
5. All tagged fish are alive at a sampling location have the same probability of surviving until the end of that event.
6. All tagged fish alive at a sampling location have the same probability of being detected at that event.
7. All tags are correctly identified and the status of the smolt (i.e., alive or dead), is correctly assessed.

The first assumption concerns making inferences from the sample to the target population. For example, these assumptions could be violated if smolts selected for PIT-tagging are, on the average, larger than the population of smolts in general. This is addressed in our length-frequency results.

Assumption (2) relates to making inferences about the population of interest (i.e., untagged fish). If tagging has a detrimental effect on survival, then survival estimates from the single release-recapture design will tend to be negatively biased (i.e., underestimated). It is assumed that the handling and PIT tagging of fish for this study had a negligible impact on the survival of individuals.

The third assumption specifies that mortality is negligible immediately in the vicinity of the sampling stations, so that the estimated mortality is related to the river reaches in question and not the sampling event. In the case of out-migrating smolts, the time they spend in the vicinity of a screw-trap or PIT array is very brief, relative to the size of the river reaches in question. Both screw-trap capture and PIT arrays have long histories of having little impact on the survival of out-migrating smolts.

The assumption of independence (4) implies that the survival or death of one smolt has no effect on the fates of others. In the larger river system with tens of thousands of smolts, this is likely true. Furthermore, this assumption is common to all tag analyses with little or no evidence collected to

suggest it is not generally true. Nevertheless, violations of assumption (4) have little effect on the point estimate but might bias the variance estimate with precision being less than calculated.

Assumption (5) specifies that a smolt's prior detection history has no effect on subsequent survival. This could be violated if some smolts were self-trained to repeatedly go through or avoid certain river routes because of prior experience. This occurrence is unlikely and can be determined from the detection histories of the individual smolts. The lack of handling following initial release of PIT-tagged smolts further minimizes the risk that subsequent detections influence survival. Similarly, assumption (6) could be violated if downstream detections are influenced by the upstream passage routes taken by the smolts. Violation of this assumption is highly unlikely due to the extended time that smolts have to mix in the river before they encounter Bonneville Dam, and the random sampling methods used by the estuary trawl.

Assumption (7) implies that the smolts do not lose their tags and are not subsequently misidentified as dead or not captured, nor are dead fish falsely recorded as alive at detection locations. The use of PIT-tags and the method of holding fish for a fixed period before release should minimize the chance of tag loss. Tag loss and tag failure would tend to result in a negative bias (i.e., underestimation) of smolt survival rates. Tag loss is much more likely in the first few hours after tagging which can be compensated for in the release group used, and PIT tags have an extremely low failure rate.

Redd Count Expansion

The total number of steelhead redds constructed in the Fifteenmile Creek watershed during the 2011 spawning season was estimated by expanding the survey counts first within each stratum, and then to the entire basin. Specifically, the total was estimated as

Equation 12

$$\hat{\tau}_{st} = \sum_{h=1}^{L} N_h \bar{y}_h$$

where $\hat{\tau}_{st}$ is the un-biased estimate of the total number of redds in the basin, $\bar{y}_h$ is the average number of redds observed during the spawning season in each survey reach within stratum *h*, N_h is the number of survey reaches in stratum *h*, and *L* is the total number of sampling strata in the basin (Thompson 1992). Variance of the estimate of the total can be estimated without bias as

Equation 13

$$\widehat{var}(\hat{\tau}_{st}) = \sum_{h=1}^{L} N_h (N_h - n_h) \frac{s_h^2}{n_h}$$

where n_h is the number of reaches sampled in stratum *h*, and s_h^2 is the sampling variance within stratum *h*. The s_h^2 component is calculated as

Equation 14

$$s_h^2 = \frac{1}{n_h - 1}\sum_{i=1}^{n_h}(y_{hi} - \bar{y}_h)^2$$

where y_{hi} is the number of redds observed during the spawning season in the i[th] survey reach in stratum *h*. Since sample sizes within strata were small and sometimes unequal between strata, the degrees of freedom for the estimate of the total can be approximated as

Equation 15

$$d \approx \left(\sum_{h=1}^{L} a_h s_h^2\right)^2 \Big/ \left[\sum_{h=1}^{L} \left(a_h s_h^2\right)^2/(n_h - 1)\right]$$

where $a_h = N_h(N_h - n_h)/nh$, and *d* is rounded to the nearest whole number (Satterthwaite 1946). Confidence intervals (95%) were constructed around the estimated total number of redds as

Equation 16

$$\hat{\tau}_{st} \pm t_{(\alpha=0.05, df\approx d)}\sqrt{\widehat{var}(\hat{\tau}_{st})}$$

where $t_{(\alpha=0.05, df\approx d)}$ is the value of the normal distribution with an alpha level of 0.05 and approximately *d* degrees of freedom. These methods were used to estimate the total number of redds constructed in Fifteenmile Creek and its major tributaries during the 2012 season.

Run Timing

Run timing for both adult and juvenile migrant steelhead was calculated using detection data queried from the PTAGIS database. Adult data was summarized as cumulative percent of total detected at Bonneville Dam interrogation sites over time. Juvenile data was summarized as cumulative percent of total caught at the screw trap over time.

Aging

Scale samples from all adults caught at the weir were aged independently by two scale readers; freshwater and saltwater residence times were determined. If readers disagreed about age determinations, the scale was re-examined and discussed until a consensus was reached. Adults recaptured at the weir that were originally tagged in previous years at the Fifteenmile screw trap were aged through a combination of PIT tag detection histories and analysis of scale samples from both juvenile and adult capture occasions. Approximately 10 percent of the scale samples collected from juveniles caught and tagged at the screw trap during 2012, plus scale samples from all juveniles detected at Bonneville Dam and in the PSMFC Columbia River estuary trawl sample during 2012, were aged by a pair of independent readers and, in the event of disagreement, results were discussed until consensus was reached.

RESULTS.

Biological Sampling

Returning Adult Migrants

The Fifteenmile Creek upstream-migrant weir was operated from 13 December 2011 to 25 June 2012. The weir sustained minor damages during a high flow event on 31 March 2012, and repairs were made when flows had receded sufficiently and fishing resumed on 10 April 2012. The weir trap was fished for a total of 183 days during the 2011-2012 season. Stream stage ranged from 3.60ft to 7.73ft, while stream temperature ranged from -1.0°C to 17.5°C. Adult steelhead began arriving at the weir in February, and arrivals peaked in April (Figure 4). A total of 122 wild steelhead adults and six hatchery-origin adult steelhead were caught at the weir during the season (Table 1). By-catch included 3 wild Chinook salmon adults, one hatchery-origin adult Chinook salmon, and 127 adult large-scale suckers. Of the wild steelhead caught, 10 were previously PIT-tagged individuals; 4 were individuals that were tagged as adults at the adult fish facility at Bonneville Dam, and 6 were returning individuals that were originally tagged in previous seasons at the Fifteenmile rotary screw trap.

The kelt trap portion of the weir was operated from April 12 through June 25 2012. A total of 22 wild steelhead kelts and three hatchery-origin steelhead kelts were trapped during the season. Six of the wild kelts were PIT-tagged recaptures from earlier in the season. We also recovered the carcasses from a total of 36 wild adult steelhead above the weir. Four of these were PIT-tagged recaptures from earlier in the season, while two of them were recaptures that were originally tagged in previous seasons at the Fifteenmile Creek screw trap.

The female-to-male sex ratio of adult steelhead captured in the weir live-box and kelt trap during the 2011-2012 season was 1.5:1 (Table 2).

Juvenile Outmigrants

The rotary screw trap was operated from January 3 to June 25 2011. Ice formation, high flows, and elevated debris loads rendered the trap inoperable a total of 27 days throughout the 174 day season. We captured 2,531 juvenile steelhead during the season, 2,519 of which received PIT tags and were released upstream via the release devices to test trap efficiency (Table 3). Peak juvenile steelhead out-migration occurred in May (Figure 5). By-catch included 133 trout fry and parr (less than 65mm fork length), seven juvenile cutthroat trout, six juvenile coho salmon, one coho salmon fry, 1414 juvenile dace, 986 juvenile sucker, four sculpin, 4,834 Pacific lamprey ammocoetes, and 3,656 Pacific lamprey macropthalmia. During the season, we recaptured 249 of the PIT-tagged juveniles from the efficiency releases.

Spawning Ground Surveys

For the 2012 redd surveys, 40 of the one-mile sub-reaches were selected for inclusion in the stratified random sample. These included one of the six index reaches. However, four of the reaches were de-selected due to foreseeable crew and funding shortages; these reaches were all in upper

Fivemile Creek, where surveys in recent years have revealed little to no redd construction. Elevated flows from spring rains caused persistently poor visibility. As a result, survey crews were only able to complete one of the three planned survey passes. A second pass was conducted only on the six index reaches and two of the randomly selected reaches.

ODFW crews conducted the first pass of the spawning ground surveys between 8 May and 18 May 2012. Water clarity in reaches within the boundaries of Mt. Hood National Forest was generally better and cleared up sooner than downstream reaches; as a result, USFS crews were able to complete first pass surveys between 19 April and 27 April 2012. The second pass surveys on the six index reaches were conducted between 19 June and 21 June 2012. However, USFS crews completed a second pass on two of the randomly selected reaches on 15 May 2012.

The first pass surveys yielded a total count of 81 redds in the random reaches (51 in Fifteenmile Creek, 27 in Eightmile Creek, three in Fivemile Creek, and zero in Ramsey Creek; Table 4) and 17 redds in the index reaches (five in Fifteenmile, five in Eightmile, and five in Ramsey). The second pass surveys yielded a total count of six additional redds in the index reaches, which all occurred in a single reach. No additional redds were observed in the random reaches.

Even though we were only able to conduct one complete pass, we felt the data we collected could be used to estimate total redd construction due to the following: the redds we found on the second pass were all in a single index reach (Reach 15-7-3); no redds were found in any of the other reaches on which second pass surveys were conducted. Additionally, a separate survey was conducted soon after the second pass surveys by a crew from the Confederated Tribes of Warm Springs (CTWS), who had previously assisted ODFW crews on steelhead redd surveys in Fifteenmile Creek during the 2012 season. This survey was conducted on a ten mile stretch of Fifteenmile Creek from the county road bridge in Dufur, OR, to the confluence of Fifteenmile and Ramsey creeks. The crew found no additional uncounted steelhead redds. Therefore, the redd count data was analyzed according to the stratified design laid out in this report's Methods section; the total number of redds constructed in Fifteenmile Basin in 2012 was estimated to be 223 ± 153 redds (Table 5).

PIT Tag Interrogation

In-basin Detections

During the 2011-2012 adult return season, the array of antennae in Fifteenmile Creek detected a total of 147 adult steelhead. Of those, 43 were originally tagged at the Fifteenmile Creek screw trap (32 were tagged in 2009, and 15 were tagged in 2010), four individuals were originally tagged at the adult facility at Bonneville Dam in 2011, and the remaining 100 individuals were tagged at the weir in 2012. The Huggins Closed-Captures model in Program MARK was used to estimate the efficiency of the entire array (eight detection sites, 24 antennas) from the detection histories of adult steelhead tagged at and released above the weir; array efficiency for tagged adult steelhead was estimated to be 94.0% (95% CL, 88.0%-97.4%). The confidence interval is asymmetrical due to the asymmetrical nature of the model likelihood. This was the detection percentage of adults tagged at Fifteenmile adult trap. This estimate includes all flow conditions, tag loss, adult fallback, mortality, and seasonal effects during

the 2012 trapping season, and assumes that adult fish trapped and tagged at the weir have the same detection probability as fish tagged as smolt that were not trapped at the weir. The PIT array detection efficiency located at the confluence of Fifteenmile Creek and Eightmile Creek, as measured by calculating the combined probability of detection (Equations 5 & 6) for known PIT tags passing over the antenna array, was 99.5%.

For each PIT-tagged adult steelhead that was detected on the in-stream array, we assumed that the stream reach in which the individual spent the most time was the stream reach in which that individual spawned. Through this assumption we were able to identify spawning reaches for 151 tagged adult steelhead and compare the results with the observed distribution of redds from our redd surveys (Table 6).

Out-of-Basin Detections

Since tagging operations started in the Fifteenmile Creek watershed in 2006, steelhead PIT-tagged in Fifteenmile Creek have been detected outside the Fifteenmile Creek watershed at interrogation sites spread throughout the Columbia River and its tributaries. In 2006 and 2007 only juveniles were detected, however beginning in 2008 returning adults were detected. Since 2009, individuals at every life-stage (juvenile, adult, and kelt) have been detected. Table 7 summarizes the numbers of individuals detected at each life stage by year and detection site.

Adult Escapement

Weir Mark-Recapture Estimate

The Schnabel form of the Lincoln-Peterson mark-recapture estimator was used to estimate the escapement of adult steelhead returning to Fifteenmile Creek in 2012. Using the weir and kelt trap numbers (M=122 individuals captured and marked at the weir; C=58 kelts and carcasses inspected for marks; R=12 individuals in C recaptured from M) escapement was estimated to be 557 adults with an approximate 95% confidence interval of ±249 adults (Table 8).

Fish-Per-Redd Based Estimates

For 2012, the Deer Creek fish-per-redd estimate was 3.09 (ODFW 2012). Using this number and our estimate of total redds constructed in 2012 (223 ± 153 redds), the estimated escapement of adult steelhead to Fifteenmile Creek in 2012 is 689 adults (± 473 adults, confidence interval calculated as fish-per-redd estimate multiplied by lower and upper bounds of confidence interval on total redd estimate; Table 8).

Another fish-per-redd analysis was conducted for wild steelhead in Buck Hollow Creek (East-side tributary to the Deschutes River, Oregon) and the resulting estimate was 2.56 fish-per-redd (Wayne Wilson, ODFW, personal communication). Using this estimate, the estimated adult steelhead escapement to Fifteenmile Creek is 570 ± 393 adults, which is more consistent with our mark-recapture estimate.

SAR-Based Estimates

The estimated escapement using the smolt to adult return (SAR) rates for each outmigration year were used to estimate the run size to the Bonneville Pool and then to the spawning grounds in the Fifteenmile Creek watershed for the 2008 through 2012 run years and the 2009 through 2012 spawning years. These results are also summarized in Table 8. The estimated escapement using this method for fish detected passing Bonneville Dam was 753 Fifteenmile Creek adult steelhead. We estimated 335 of those steelhead entered Fifteenmile Creek to spawn from detections at the PIT tag arrays. This estimate is within the range of both the weir mark-recapture and the redd-count estimates, suggesting that this new method of escapement estimation is effective at for this watershed using only the PIT tag detections of returning adults.

Smolt Abundance

Trapping Efficiency Estimates

Detection data from Fifteenmile Creek PIT tagged steelhead were analyzed with the Huggins Closed-Capture model to determine efficiencies for the Fifteenmile Creek screw trap, the Bonneville Dam corner collector and juvenile bypass system, and the Columbia River estuary trawl for the 2012 outmigration. The efficiency of the screw trap was estimated to be 9.83% (95% CL, 8.32%-11.54%). The PIT arrays at Bonneville Dam detected 2.7%, and the estuary trawl detected 1.2% of PIT tagged outmigrants (Table 9).

Smolt Abundance Estimates

Trapping efficiency of the Fifteenmile screw trap was estimated with the Huggins closed-capture model to generate two smolt abundance estimates for the 2012 season: one abundance estimate based on the total number of juvenile steelhead trapped and another based only on juvenile steelhead determined to be migrants because they were detected moving downstream passed the PIT tag arrays in the immediate vicinity of the trap. The juvenile steelhead abundance estimate based on all juvenile steelhead trapped is 25,775 (95% CL 21,962-30,484; Table 9). Using PIT-tag detection histories, the migrant fraction of the juvenile population was estimated to be 87.9% (95% CL 84.3%-91.5%), and the resulting steelhead smolt abundance was estimated to be 21,021 (95%CL 20,158-21,851).

Survival

Juvenile Survival

Survival of Fifteenmile Creek PIT-tagged juvenile steelhead at different migration-stages (survival from upstream release to the screw trap, from the screw trap to Bonneville Dam, and from Bonneville Dam to the estuary) was estimated for the 2012 outmigration using PIT detections and the Cormack-Jolly-Seber model in Program MARK using a Markov-chain Monte Carlo estimator. The estimate of survival between release and the screw-trap were 93.3% (95% CL, 76.8%-100%), from the screw-trap to Bonneville Dam was 47.1% (95% CL, 16.3%-97.3%) , and from Bonneville Dam to the estuary trawl could not be determined due to a low sample size (Table 10).

Smolt-to-Adult Return Rates

Smolt-to-adult return (SAR) rates to both Bonneville Dam and Fifteenmile Creek for steelhead from the 2007 through 2010 outmigration years were estimated using PIT detections and the Huggins closed-capture model. At Bonneville Dam, SARs ranged from 2.5% in 2010 to 6.8% (lower: 5.5%; upper: 8.3%; Table 11) in 2008, while SARs to Fifteenmile Creek ranged from 1.2% (lower: 0.8%; upper: 1.6%) in 2010 to 3.6% (lower: 2.7%; upper 4.8%) in 2009. The SAR estimates to Bonneville were significantly greater compared to those to Fifteenmile Creek ($p<0.05$) in both 2008 and 2009.

Life History Characteristics

Adult Run Timing

Using Bonneville Dam detections from all available years (2008-2012) of previously PIT-tagged Fifteenmile Creek steelhead, the mean timing of the returning adult run has been determined to be approximately August 10 (Standard Deviation of 25 days, Figure 6). This return timing at Bonneville Dam is consistent with other summer-type steelhead stocks in the area. However, three fish were observed that greatly deviated from traditional 'summer' type run timing for fish tagged in Fifteenmile Creek and were observed passing Bonneville Dam on May 8, May 21 in 2010, and April 24 in 2012. This return timing, coupled with the short amount of time spent in the main-stem Columbia River before entering Fifteenmile Creek, is consistent with other winter-type steelhead stocks in the area.

Adult Age Structure

The age structure of adult steelhead returning to Fifteenmile Creek in 2012 was determined through either visual scale analysis or a combination of scale analysis and PIT tag detection histories. We were able to determine freshwater age, saltwater age, and total age of 208 adult steelhead that were caught or detected in Fifteenmile Creek (Table 12). Of those, 145 (69.7%) individuals were determined to be freshwater age 1, 61 (29.3%) individuals were determined to be freshwater age 2, and 2 (0.96%) were determined to be freshwater age 3.

Steelhead that overwinter in the Columbia River and tributaries before reaching their spawning grounds do not show a final annulus on their scales before spawning (Lisa Borgerson, ODFW, personal communication). Therefore, the total age for Fifteenmile Creek steelhead was determined by adding an additional year to the sum of the number of freshwater and ocean years visible on the scale. Of the 208 adults with legible scales, 62 individuals (29.8%) were total age 3, 106 (51.0%) were total age 4, 35 (16.8%) were total age 5, three (1.4%) were total age 6, and two (0.96%) were total age 7. Seven out of the 208 individuals (3.3%) were determined through scale analysis to be repeat spawners.

Juvenile Age Structure

Approximately 10% of juvenile steelhead caught in the rotary screw-trap were aged through visual scale analysis, in addition to all of those detected at Bonneville Dam or in the estuary trawl. Using this subsample (342 individuals total), we estimated that 78.9 percent of the 2012 juvenile steelhead outmigrants were age 1, 19.3 percent were age 2, and 1.8 percent were age 3 (Table 13). However, we

found that a larger percentage of juvenile steelhead captured prior to 1 April 2012 were age 1 (age 1: 89.8%, age 2: 9.3%, age 3: 0.9%; Figure 8) as compared to those juvenile steelhead captured after 1 April 2012 (age 1: 73.2%, age 2: 24.6%, age 3: 2.2%).

Stray Rates

We recovered one steelhead carcass that bore a FLOY tag from the Sherars Falls trap on the Deschutes River during the 2011-2012 season. However, the presence of a FLOY tag is not enough information to determine the fish's natal origin. The fish could have strayed into the Deschutes as a Fifteenmile Creek steelhead, or into Fifteenmile Creek as a Deschutes River fish.

Fifteenmile Creek steelhead were detected at PIT arrays throughout the Columbia River basin. During 2011, four of the 98 PIT-tagged Fifteenmile adult steelhead with PTAGIS interrogation records were detected at locations other than Bonneville Dam. Three adults were detected at McNary Dam – one of these adults was later detected at Ice Harbor Dam, and one was later detected moving into Trout Creek on the Deschutes – and one adult was detected at the Lyle Falls fishway on the Klickitat River. The adult that was detected at Lyle Falls was later detected in Fifteenmile Creek. Thus, the apparent stray rate for Fifteenmile Creek origin fish in the 2011-2012 adult return year is three out of 98, or 3.1 percent.

The 2012-2013 adult return year is incomplete at the time of this report, but two of the 32 PIT-tagged Fifteenmile adult steelhead with PTAGIS interrogation data have been detected at locations other than Bonneville Dam – one adult has been detected at McNary Dam, and one adult has been detected in the Klickitat River at the Lyle Falls fishway – making the preliminary stray rate for Fifteenmile steelhead during the 2012-2013 return year 6.5 percent.

Hatchery Fraction

During the 2011-2012 weir trapping season, six hatchery adult steelhead were intercepted and euthanized at the Fifteenmile Creek weir. Three of the 61 steelhead kelts and carcasses encountered were of hatchery origin, making the effective hatchery fraction for the 2011-2012 return year 4.9 percent.

DISCUSSION.

Life History

The steelhead in Fifteenmile Creek watershed have the distinction as the population on the western-most edge of the Mid-Columbia Distinct Population Segment (DPS). They exist on the boundary between winter-run steelhead that are prolific on the coast, and summer-run steelhead that dominate inland tributaries of the Columbia River. Fifteenmile Creek steelhead were believed to be predominantly winter-run life-history type, on the eastern most edge of their range. However, the timing of PIT-tagged adults passing Bonneville Dam suggests that the dominant life history type is that of the summer-run steelhead, and if winter-run steelhead exist in the watershed they appear to be in very low numbers. Summer-run steelhead generally enter freshwater in a sexually immature state, pass Bonneville Dam in July and August migrate to the spawning grounds where they mature, spawning the next spring. Winter-type steelhead, on the other hand, are sexually mature when they enter freshwater and they navigate past Bonneville Dam between November and April, migrating directly to the spawning grounds and spawning soon thereafter (Busby et al. 1996). The majority of Fifteenmile Creek steelhead pass Bonneville Dam in the late summer, but do not enter the creek until flows are sufficient (mid to late winter) to allow passage upstream (Figures 6, 7). Other summer-run populations in the Mid-Columbia DPS enter their natal streams in the fall and early winter and stage in their natal streams until they are sexually mature to spawn (Zendt et al. 2010,Frederiksen et al. 2012, DART). However, populations from the John Day and Umatilla rivers exhibit similar behavior of delayed entry into their natal streams until flow and temperature conditions allow access. PIT tag detections of adults from these populations suggest that they winter somewhere in the Columbia River mainstem prior to entering their natal tributaries during March and April just prior to spawning. This behavior has raised concerns for elevated mortality rates for these populations.

This life history strategy also makes Fifteenmile Creek steelhead vulnerable to anthropogenic impacts within the Bonneville pool, including sport and commercial fisheries, in addition to prolonged exposure to potential adverse environmental conditions. Fifteenmile Creek steelhead spend between 6 and 9 months in the Columbia River above Bonneville Dam before entering Fifteenmile Creek. Through our observations of fish detected at Bonneville Dam, and subsequently detected in Fifteenmile Creek, the apparent survival in the Bonneville Pool has been decreasing in recent years, from a high in the 2009-2010 season of 60% to 44% in the 2011-2012 season (Table 11). These are low survival rates for the relatively short trip from Bonneville Dam to Fifteenmile Creek which deserves further investigation.

Although the majority of steelhead appear to be summer-type life history, extreme deviations in the typical summer-run ecotype have been observed using PIT tag detections. The expansion of the observations to the population scale would result in a small population of fish exhibiting run timing more consistent with the winter ecotype. This expansion assumes that the key metric for determining run-timing (thereby ecotype) is the upstream passage at Bonneville Dam. However this metric is somewhat arbitrary because Bonneville is simply the first place that PIT-tagged fish can be detected on their upstream migration. Therefore an alternative method may be necessary to definitively establish the ecotypes of steelhead spawning in Fifteenmile Creek. To that end, a microsatellite genetic test has

been developed to differentiate summer and winter ecotype for broodstock identification in the Hood River (Matala et al, 2009). Using this test, or another suitable genetic test, on fin and scale samples that have previously been collected from adult Fifteenmile Creek steelhead could provide a more definitive measure of ecotypes existing in the watershed.

In addition to steelhead produced in Fifteenmile Creek, the Fifteenmile population of steelhead consists of several other watersheds that may also harbor a winter race of steelhead (Carmichael and Taylor 2010). The other streams that make up the Fifteenmile MPG include Three Mile Creek, Mill Creek, and Chenoweth Creek – all draining into the Columbia River in the vicinity of The Dalles, Oregon, and Mosier Creek and Rock Creek, both of which drain into the Columbia River near Mosier, Oregon. The largest of these watersheds are Mill (334 km^2) and Mosier (133 km^2). Mosier Creek has a barrier to anadromy less than 1km upstream of its mouth, and so cannot harbor a large population of steelhead. Mill Creek, on the other hand, has a large enough area of barrier-free stream to sustain small populations of anadromous salmonids (Guess 2003). An effort to trap and tag juvenile steelhead on Mill Creek would provide data on run-timing of adult steelhead returning to spawn.

Escapement Estimates

Adult steelhead return estimates for Fifteenmile Creek for the 2010-2011 return year varied depending on the estimation method. We observed improved agreement between these estimates for the 2011-2012 return year. The Lincoln-Peterson mark-recapture estimate (557±249 adults) and the fish-per-redd (FPR) expansion of redd counts using the FPR estimate from Buck Hollow Creek on the Deschutes ($FPR_{Buck\ Hollow}$ = 2.56; escapement estimate = 570±393 adults) were equivalent and substantially overlapped by the FPR expansion using the Deer Creek FPR estimate ($FPR_{Deer\ Creek}$ = 3.09; escapement estimate = 689±473 adults). We believe the Lincoln-Peterson estimate to be the most accurate due to the fact that it relies solely on information from the Fifteenmile Creek steelhead population.

The overall efficiency of the Fifteenmile Creek adult weir during the 2011-2012 season (20.6%) was approximately doubled from that observed during the previous season (10.6%). The relatively low trapping efficiencies are attributed to trap avoidance and high flow events where the river flowed around the weir providing upstream access to returning adults. Trap avoidance was observed when we detected previously PIT tagged fish downstream of the trap entrance with a detection array located downstream of the weir. In an effort to reduce weir effects on migration and spawning of adult steelhead, the weir was opened to allow passage when fish were detected downstream of the weir on more than one day without being captured. We hope to further improve weir efficiency to improve the accuracy of our estimates and reduce confidence interval magnitude. To achieve this goal, we plan on modifying the live-box entrance from a fyke-style to a finger-weir style, as data from another steelhead trapping project in the vicinity suggests that the finger-weir style may reduce hesitation of adult steelhead entering the live-box (Jeremy Stahler, ODFW, personal communication). In addition, a section of the weir will be monitored with video to increase observations and the precision of our escapement estimates.

Spawning Surveys

The first pass of spawning surveys during the 2012 season was postponed for several weeks due to prolonged turbidity from a high flow event that occurred in late March. Subsequently, only one pass was conducted on the majority of the 42 (originally 46, four reaches dropped from the set due to lack of crew) reaches selected for inclusion in the 2012 survey set. A second pass was conducted on the six index reaches and two of the random reaches. Only one reach (reach 15_7-3, lower index reach in the Dufur Valley section of Fifteenmile Creek) surveyed a second time yielded previously uncounted redds. A subsequent survey of the entire Dufur Valley reach of Fifteenmile Creek conducted by a Confederated Tribes of the Warm Springs crew yielded no additional redds. For these reasons, we felt comfortable producing estimates of total redd abundance from our survey data. However, we realize that the estimate of redd abundance may be skewed low by the combined effects of high water (some redds may have been obscured by sediment transported by the flow) and low level of effort (a complete second pass may have yielded more redds). Nonetheless, redd counts were consistent with our mark-recapture estimates.

Using detection histories of PIT-tagged adult steelhead from the PIT array in Fifteenmile Creek, we were able to estimate the proportion of adults spawning in each of the main tributaries to Fifteenmile Creek and within separate sections of Fifteenmile Creek itself. When compared to the same numbers produced from redd counts, we found that the two methods produced similar results. We hope to increase the accuracy of this method in the future by increasing the temporal detail of individual detection histories – something we can do by modifying our current array data distillation methods. Given the low inter-annual reliability of the redd survey protocol for Fifteenmile Creek, and since the same spawning distribution information is attainable through a less resource intensive method, it may prove a more prudent use of limited resources to direct effort away from spawning surveys and apply that effort to another area of the project, such as additional juvenile trapping to increase numbers of juvenile migrants tagged each year, or investigating the contribution of steelhead from other watersheds within the Fifteenmile MPG.

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REFERENCES.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27.

Carmichael, R.W., B. Taylor. 2010. Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment. November 2010.

Chapman, D. H. 1951. Some properties of the hypergeometric distribution with applications to zoological censuses. *University of California Publications in Statistics* 1: 131-160.

Cheng, Y.W., M.P. Gallinat, 2004. Statistical analysis of the relationship among environmental variables, inter-annual variability and smolt trap efficiency of salmonids in the Tucannon River. *Fisheries Research*, Volume 70, Issues 2-3, December 2004, Pages 229-238.

Clark, J. S. 2003. Fifteenmile Watershed Assessment. Report prepared for Fifteenmile Watershed Council. Wasco County Soil and Water Conservation District, The Dalles, Oregon.

Cormack, R. M. 1964. Estimates of survival from the sighting of marked animals. *Biometrika* 51:429-438.

Cormack, R. M. 1992. Interval estimation for mark-recapture studies of closed populations. *Biometrics* 48:567-576.

DART. Data access in real time. School of Aquatic and Fishery Sciences. University of Washington. http://www.cbr.washington.edu/dart/dart.html

Faber DM, GR Ploskey, MA Weiland, Z Deng, JS Hughes, JA Kim, T Fu, ES Fischer, TJ Monter, and JR Skalski. 2011. Evaluation of Behavioral Guidance Structure on Juvenile Salmonid Passage and Survival at Bonneville Dam in 2009 . PNNL-20338, Pacific Northwest National Laboratory, Richland, WA.

Frederiksen, C. R., D. Fast, G. Temple. 2012. Yakima steelhead Viable Salmonid Population (VSP) Status and Trends Monitoring – Annual Report 2011. BPA Project 201003000, contract period October 15 2010 – December 14 2011.

Guess, K. 2003. The Dalles Watershed Assessment. Clark, J. S. Ed. Document prepared for The Dalles Watershed Council by Wasco County Soil and Water Conservation District, The Dalles, OR.

Huggins, R. M. 1989. On the statistical analysis of capture-recapture experiments. *Biometrika* 76:133-140.

Huggins, R. M. 1991. Some practical aspects of a conditional likelihood approach to capture experiments. *Biometrics* 47:725-732.

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration stochastic model. *Biometrika* 52:225-247.

Matala AP, French R, Olsen E, Ardren WR (2009) Ecotype distinctions among steelhead in Hood River, Oregon, allow real-time genetic assignment of conservation broodstocks. Transactions of the American Fisheries Society 138: 1490–1509.

Macnab, B.A., S.L. Springston. 2009. Fifteenmile Creek Habitat Restoration Project 1993-040-00 2009 Annual Report. Report to Bonneville Power Administration, Document Number P118121.

National Marine Fisheries Service. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act.

Newton, J., L. Nelson. June 2000. Fifteenmile Creek Subbasin Summary. Oregon Department of Fish and Wildlife, The Dalles, Oregon.

Ploskey, G., M. Weiland, C. Woodley, D. Faber. 2012. Evaluate Route-Specific Passage and Survival of Steelhead Kelts at The Dalles and Bonneville Dams, 2012. USACE Project ADS-P-2012-2.

Satterthwaite, F. E. 1946. An approximate distribution of estimates of variance components. *Biometrics Bulletin* 2: 110-114.

Seber, G. A. F. 1965. A note on the multiple recapture census. *Biometrika* 52:249-259

Seber, G. E. *The estimation of animal abundance and related parameters*, 2nd ed. Macmillan, New York.

Skalski, J.R., S.G. Smith, R.N. Iwamoto, J.G. Williams, and A. Hoffmann. 1998. "Use of PIT-tags to Estimate Survival of Migrating Juvenile Salmonids in the Snake and Columbia Rivers." *Canadian Journal of Fisheries and Aquatic Sciences* 55:1484-1493.

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

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A03-26, Fairbanks, Alaska.

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

Thompson, S. K. 1992. *Sampling*, 1st ed. Wiley, New York.

White, G.C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement, 120-138.

Zendt, J., N. Romero, S. Keep, and M. Babcock. 2010. Yakima-Klickitat Fisheries Project – Klickitat Monitoring and Evaluation: 2009 Annual Report. BPA Project 199506335, contract period May 1 2009 – April 30 2010.

PERSONAL COMMUNICATIONS.

Borgerson, Lisa. October, 2011. Oregon Department of Fish and Wildlife, Corvallis Research Lab. 28655 Hwy. 34, Corvallis, Oregon 97333.

Reagan, Robert. October 2012. Oregon Department of Fish and Wildlife, Hood River Research – The Dalles Screens Shop. 3561 Klindt Dr., The Dalles, Oregon 97058.

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detections. Expansions were calculated from smolt abundance for corresponding outmigration year, and are presented as the mean estimate.

Table 9. Trap efficiencies from upstream releases of PIT tagged juvenile steelhead at the Fifteenmile screw trap, Bonneville PIT detections at the Juvenile Bypass (JBS) or the Powerhouse II corner collector (BCC), and at the Columbia River Estuary Trawl (TWX). Based upon the trapping efficiency at the Fifteenmile screw trap, abundance estimates were also generated (lower table). The model used to generate trap efficiencies was a Huggins-Closed capture model (Huggins et al 1991).

Table 10. Single release survival estimates from releases upstream of the screw trap (actual release), at the screw trap (actual release), and at Bonneville Dam (virtual release) for subsequent detections at the Fifteenmile creek screw trap, Bonneville PIT tag arrays, and Estuary PIT tag trawl. We used a Cormak-Jolly-Seber survival model in the program Mark to generate the probability distributions using Markov Chain Monte Carlo simulations.

Table 11. Smolt-to-adult return (SAR) rates and apparent survival rates in the Bonneville Pool for Fifteenmile Creek steelhead. The top table shows the Huggins model-based return rate estimates by smolt outmigration year. The bottom table shows the return-year-specific apparent survival in the Bonneville Pool based on the numbers of tagged Fifteenmile Creek steelhead detected at Bonneville Dam and on the Fifteenmile Creek PIT array.

Table 12. Freshwater and total age for 208 adult steelhead trapped (including kelts and carcasses) and/or detected on the PIT array during the 2011-2012 season. Total age is the sum of freshwater and ocean ages, plus an additional year due to overwintering in the Bonneville Pool before arriving on the spawning grounds.

Table 13. Age composition by trapping year of a sample (approximately 10%) of juveniles captured and tagged at the Fifteenmile rotary screw trap.

TABLES.

Table 1. Summary of the number of wild and hatchery-origin upstream-migrant and kelt steelhead caught at the Fifteenmile Creek adult weir and kelt traps from December 13, 2011 to June 25, 2012. Also presented are the numbers of carcasses encountered above the weir during that same period.

Trap	Source	Status[1]	Number Caught	Male	Female
Upstream	Wild	New	112	37	75
		Native Recap	10	5	5
		Stray Recap	0	0	0
	Hatchery	New	6	2	3
		Recap	0	0	0
	subtotals	*Wild*	*122*		
		Hatchery	*6*		
Kelt (Downstream)	Wild	New	16	10	6
		2012 Recap	6	2	4
		Native Recap	0	0	0
	Hatchery	New	3	3	0
		Recap	0	0	0
	subtotals	*Wild*	*22*		
		Hatchery	*3*		
Carcass (Downstream)	Wild	New	30	16	14
		2012 Recap	4	1	3
		Native Recap	2	1	1
	Hatchery	New	0	0	0
		Recap	0	0	0
	subtotals	*Wild*	*36*		
		Hatchery	*0*		
	Grand Totals	**Wild**	**180**		
		Hatchery	**9**		

[1] Status refers to tag status upon capture. 'New' refers to individuals that had not been previously tagged or marked. 'Native Recap' refers to individuals that were tagged at the Fifteenmile Creek weir during a previous year, as well as to individuals we captured that were tagged at Bonneville Adult Fish Facility as adults (these fish were assumed to be of Fifteenmile origin). 'Stray recap' refers to wild individuals known to be straying from a population outside of the Fifteenmile Creek watershed (as evidenced by tags or marks that can be traced to specific sources). '2012 Recap' refers to individuals that were tagged at the Fifteenmile weir trap earlier in the 2012 trapping season.

Table 2. Sex ratio of wild adult steelhead captured at the Fifteenmile weir (live-box and kelt trap) during the 2010-2011 and 2011-2012 seasons.

Year	% Male	% Female	# Captured
2011	43.9%	54.1%	98
2012	40.0%	60.0%	180

Table 3. Numbers of juvenile fish trapped and recaptured in the Fifteenmile Creek rotary screw trap during the 2012 trapping year (January 3 – June 25).

Species	# Trapped	# PIT Tagged	# Mortalities
Steelhead	2531	2519	2
Steelhead, RECAP	249	NA	0
Trout fry	133	NA	0
Cutthroat trout	7	7	0
Coho salmon	6	6	0
Coho salmon RECAP	2	NA	0
Coho, fry	1	NA	0
Lamprey, ammocoete	4834	NA	0
Lamprey, juvenile	3656	NA	0
Dace spp.	1414	NA	0
Sucker spp	986	NA	0
Sculpin spp.	4	NA	0

Table 4. Reach information and associated redd counts for 40 randomly selected (including 2 index) reaches and four index reaches in Fifteenmile Creek and its three main tributaries during the 2011 spawning ground surveys. 'Type' indicates whether the reach was randomly selected (R), an index reach (I), or both (R,I). 'NS' indicates that no survey was conducted.

Reach Information					Redd Counts		
Stream	Stratum Number	Reach ID	Type	Length, mi	Pass 1	Pass 2	Total
Fifteenmile	1	3	R	1.09	4	NS	4
		4	R	1.04	1	NS	1
	2	2	R	0.65	0	NS	0
		3	R	1.19	15	NS	15
	3	3	R	0.98	0	NS	0
		4	R	1.02	0	NS	0
	4	4	R	1.09	2	NS	2
		5	R	0.92	5	NS	5
	5	2	R	1.02	5	NS	5
		3	R	0.94	7	NS	7
	6	2	R	0.98	1	NS	1
		3	R	0.95	3	NS	3
	7	1	R	0.77	0	NS	0
		2	R	1.01	2	NS	2
		3	I	1.46	5	6	11
	8	2	R	0.90	0	NS	0
		3	R	1.24	6	NS	6
		4	I	0.77	0	0	0
	9	2	R	1.02	0	0	0
		3	R	0.67	1	0	1
Eightmile	1	1	R	1.08	2	NS	2
		2	R	0.99	2	NS	2
	2	1	R	0.71	1	NS	1
		2	R	1.01	5	NS	5
	3	3	R	1.19	4	NS	4
		4	R, I	1.24	5	0	5
	4	2	I	0.88	7	0	7
		4	R	1.36	2	NS	2
		5	R	0.96	4	NS	4
	5	2	R	1.01	0	NS	0
		3	R	0.99	2	NS	2

Table 4(Continued). Reach information and associated redd counts for 40 randomly selected (including 2 index) reaches and four index reaches in Fifteenmile Creek and its three main tributaries during the 2011 spawning ground surveys. 'Type' indicates whether the reach was randomly selected (R), an index reach (I), or both (R,I). 'NS' indicates that no survey was conducted.

Reach Information					Redd Counts		
Stream	Stratum Number	Reach ID	Type	Length, mi	Pass 1	Pass 2	Total
Fivemile	1	1	R	0.92	0	NS	0
		2	R	1.10	2	NS	2
	2	4	R	0.68	0	NS	0
		5	R	0.75	1	NS	1
	3	3	R	1.20	NS	NS	-
		4	R	1.00	NS	NS	-
	4	2	R	1.03	NS	NS	-
		3	R	1.22	NS	NS	-
Ramsey	1	2	I	1.06	1	0	1
		3	R	0.92	0	NS	0
		4	R	1.13	0	NS	0
		5	I	1.00	4	0	4
	2	1	R	0.99	0	NS	0
		2	R	1.00	0	NS	0

Table 5. Estimates of the total numbers of steelhead redds constructed in the Fifteenmile Creek basin from 2003 to 2011. Estimates were produced using a stratified-random estimation process. For the 2006 and 2009 spawning seasons, too few complete (more than one pass) surveys were conducted to allow estimation. Although stratum size was originally designated at 5 miles, strata had to be combined to 10 miles to allow estimation with the Thompson equation, which requires at least two samples be conducted within each stratum. For comparison purposes, the 2011 data was analyzed at both 5 and 10 mile stratum sizes.

Year	Stratum Size, mi	Number of Survey Reaches		Estimated Total Redds	95% Confidence Interval	
		Completed[a]	Used[b]		Lower	Upper
2003	10	20	20	440	264	616
2004	10	16	16	520	281	759
2005	10	17	17	185	0	1174
2006	NA	5	0	NA	NA	NA
2007	10	18[c]	18	103	0	228
2008	10	15	13	68	24	112
2009	NA	0	0	NA	NA	NA
2010	10	21	20	388	132	643
2011	10	34	33	379	302	456
2011	5	34	34	379	309	449
2012	5	36[c]	36	223	69	376

[a] 'Number of Survey Reaches Completed' refers to the number of survey reaches that received at least two passes.

[b] 'Number of Survey Reaches Used' refers to the number of completed reaches that were used for this analysis. If this number is less than the number of reaches completed, it indicates that completed survey reaches were excluded from the analysis due to a lack of completed surveys existing in contiguous strata.

[c] In 2007 and in 2012, only one pass was conducted on the majority of the randomly selected reaches, and a second pass was conducted mainly on the six index reaches. In both years the first pass was conducted late in the season due to high flows and poor visibility. In 2007, the second pass surveys conducted on the six index reaches yielded no new redds. In 2012, only one of the eight reaches (six index reaches and 2 randomly selected reaches) surveyed on the second pass yielded new redds; a subsequent survey conducted by another agency found no new redds anywhere else in the 10 mile stretch of stream encompassing the reach where the new redds were found on the second pass. Since second pass surveys yielded no (or few) new redds, the data from both of these seasons were included in the analysis. However, the results of this analysis for these years should be viewed with caution.

Table 6. Distribution of brood year and spawning stream reach for 151 PIT-tagged wild adult steelhead detected on the Fifteenmile Creek PIT array. Brood year was determined from scale analysis, PIT detection history, or both. Spawning area was determined by PIT detection histories from the Fifteenmile PIT array; spawning area was assumed to be the location in which an individual spent the most time before being detected on another antenna downstream. Also shown are the percentages of the run in each reach as determined from redd surveys.

Stream Reach	Brood Year					Unknown	Total	Percent of Run	Percent of Run in Reach from Redd Counts
	2005	2006	2007	2008	2009				
Fifteenmile – Lower[a]		1	7[b]	29	7		*44*	29.1	37.1
Fifteenmile – Mid[a]			4	12	10	1	*27*	17.9	16.2
Fifteenmile – Upper[a]			1	6	2	1	*10*	6.6	6.7
Fivemile	2[b]		1	6	5	1	*15*	9.9	2.8
Eightmile			8[b]	19	8	1	*36*	23.8	32.3
Dry			3[b]	5	6	1	*15*	9.9	-
Ramsey			2	1	1		*4*	2.6	4.8
Total	*2*	*1*	*26*	*78*	*39*	*5*	**151**		
Percent of Run	0.01	0.7	17.2	51.7	25.8	3.3			

[a]Lower Fifteenmile refers to the section of Fifteenmile Creek between the Fifteenmile/Eightmile confluence and the Fifteenmile/Dry confluence. Mid Fifteenmile refers to the section of Fifteenmile Creek between the Fifteenmile/Dry confluence and the Fifteenmile/Ramsey confluence. Upper Fifteenmile refers to the section of Fifteenmile above its confluence with Ramsey Creek.

[b]These numbers include repeat spawners as determined from scales. Both individuals in Fivemile, two in lower Fifteenmile, and one each in Eightmile and Dry creeks were repeat spawners.

Table 7. Numbers of Fifteenmile Creek PIT-tagged individuals that were detected at PIT interrogation sites outside of the Fifteenmile Creek watershed. Totals presented are numbers of unique individuals detected in a given year. Also shown are the numbers of juveniles that were PIT-tagged at the Fifteenmile Creek screw trap each year.

	Year:	2006	2007	2008	2009	2010	2011	2012*
	Number juveniles tagged:	131	294	1247	2831	2154	2299	2527
Life Stage	Detection Site[1]							
Juvenile	BON	13	33	162	260	441	95	73
	TWX	3	5	22	57	49	23	30
	Total	*16*	*37*	*177*	*306*	*477*	*117*	*100*
Adult	BON	-	0	11	42	89	94	31
	WSH	-	0	0	0	0	1	0
	LFF	-	0	0	0	0	1	1
	JDJ	-	0	0	1	3	0	0
	JD1	-	0	0	0	1	0	0
	MC1	-	0	2	3	5	2	1
	MC2	-	0	0	1	3	2	0
	MCJ	-	0	0	0	2	0	0
	ORB	-	0	0	0	1	0	0
	ICH	-	0	0	0	1	2	0
	LMJ	-	0	0	0	1	0	0
	LTR	-	0	0	0	0	1	0
	GRA	-	0	0	0	0	1	0
	Total	-	*0*	*11*	*42*	*94*	*98*	*32*
Kelt	BON	-	0	0	0	3	6	15
	TWX	-	0	0	0	0	1	0
	WSH	-	0	0	0	0	0	0
	Total	-	*0*	*0*	*0*	*3*	*7*	*15*

[1] Detection Site codes refer to the following interrogation sites: BON = Bonneville Dam interrogation complex; TWX = Columbia River estuary trawl interrogation; WSH =Warm Springs Hatchery interrogation, Deschutes River; LFF = Lyle Falls Fishway, Klickitat River; JDJ = John Day Dam juvenile interrogation; JD1 = Lower John Day River interrogation; MC1 = McNary Dam Oregon shore interrogation; MC2 =McNary Dam Washington shore interrogation; MCJ = McNary Dam juvenile interrogation; ORB = Walla Walla River interrogation at Oasis Road Bridge; ICH = Ice Harbor Dam interrogation, Snake River; LMJ = Lower Monumental Dam juvenile interrogation, Snake River; LTR = Lower Tucannon River interrogation; GRA = Lower Granite Dam interrogation, Snake River.

*Adult numbers for 2012 are presented as preliminary as the run-year is in progress at the time of publication.

Table 8. Escapement estimates for adult steelhead returning to Fifteenmile Creek in 2012, using three different methods of estimation. The weir mark-recapture estimate uses the Schnabel form of the Lincoln-Peterson estimator. The fish-per-redd method expands the estimated total number of redds and its confidence interval by two estimates of the number of fish-per-redd from two stocks of summer steelhead – one from Deer Creek (a tributary to the Wallowa River in Northeast Oregon), and one from Buck Hollow Creek, a tributary to the Deschutes River in North-central Oregon. The third method estimates the number of adults returning to Fifteenmile Creek with a combination of smolt-to-adult return rates SARs and total smolt production estimates to estimate run and spawner-year abundance of adult Steelhead from PIT tag detections at Bonneville and Fifteenmile Creek (lower table). In this table steelhead adult returns were based on expanded adult estimates using smolt to adult return rates from PIT detections. Expansions were calculated from smolt abundance for corresponding outmigration year, and are presented as the mean estimate.

Method	Estimate	95% Lower	95% Upper	Comment
Weir Mark-Recapture	557	308	806	Based on 122 fish marked at the weir[1] and 12 marked fish found in 58 fish subsequently examined for marks
Fish-Per-Redd	688	214	1122	Based on Deer Creek fish/redd = 3.09
Expansion	570	177	962	Based on Buck Hollow Creek fish/redd = 2.56

[1]This number includes previously unmarked fish trapped and marked at the weir, as well as 'native recaptures' – individuals caught at the weir that were originally tagged at the Fifteenmile Creek rotary screw trap or at the Bonneville Adult Fish Facility (assumed to be of Fifteenmile origin).

SAR-based: To Bonneville (summer return year) To Fifteenmile Creek (spawning year)††

Run year	1-salt	2-salt	3-salt	Total	Spawn year	0-salt	1-salt	2-salt	Total
2007	*	*	*	*	2008	*	*	*	*
2008	174	*	*	174	2009	0	116	*	116
2009	234	58	*	294	2010	23	139	19	182
2010	280	228	0	508	2011	13	111	84	207
2011	380	367	6	753	2012	0*	177	157	335
2012	121	253	6	380	2013	†	†	†	†

*Could not be estimated because return for relevant age classes was insufficient. PIT tag releases began in 2006.

†Waiting on PIT detections at Fifteenmile Creek to complete estimate for 2013 spawners.

††Fifteenmile steelhead arrive to the Bonneville Pool in the summer of one year and move into Fifteenmile Creek to spawn in the late winter/early spring of the following year.

Table 9. Trap efficiencies from upstream releases of PIT tagged juvenile steelhead at the Fifteenmile screw trap, Bonneville PIT detections at the Juvenile Bypass (JBS) or the Powerhouse II corner collector (BCC), and at the Columbia River Estuary Trawl (TWX). Based upon the trapping efficiency at the Fifteenmile screw trap, abundance estimates were also generated (lower table). The model used to generate trap efficiencies was a Huggins-Closed capture model (Huggins et al 1991).

Trap Efficiency

		Screw Trap			Bonneville Dam			Estuary Trawl		
Year	n	Estimate	L95%CL	U95%CL	Estimate	L95%CL	U95%CL	Estimate	L95%CL	U95%CL
2007	286	3.8%	2.1%	6.8%	11.2%	8.0%	15.4%	1.7%	0.7%	4.1%
2008	1232	15.6%	13.7%	17.7%	13.4%	11.6%	15.4%	1.8%	1.2%	2.7%
2009	2735	16.5%	15.2%	18.0%	9.6%	8.5%	10.7%	2.1%	1.6%	2.7%
2010	2135	7.9%	6.8%	9.1%	20.6%	18.9%	22.4%	2.2%	1.7%	3.0%
2011†	1208	7.0%	5.6%	8.5%	3.8%	2.9%	5.0%	1.2%	0.7%	1.9%
2011††	994	11.8%	9.9%	13.9%	4.2%	3.1%	5.7%	0.9%	0.5%	1.7%
2012†	1489	11.6%	10.1%	13.3%	3.1%	2.4%	3.9%	1.4%	1.0%	2.0%
2012††	1038	7.3%	5.8%	9.0%	2.2%	1.5%	3.0%	0.9%	0.5%	1.5%
2012†††	2527	9.8%	8.8%	10.8%	2.7%	2.2%	3.3%	1.2%	0.9%	1.6%

† Fifteenmile Creek release only

†† Eightmile Creek release only

††† Fifteenmile and Eightmile combined releases

Fifteenmile Watershed Smolt Abundance Estimates – Based on Trapping Efficiency

		Fifteenmile Watershed		
Year	Released (n)	Estimate	L95%CL	U95%CL
2007	286	7436	4200	13349
2008	1232	7905	6953	9016
2009	2735	16549	15223	18016
2010	2135	26972	23361	31197
2011†	1208	17372	14158	21384
2011††	994	8445	7138	10031
2011	2202	25817	21296	31414
2012*	2527	25775	21962	30484
2012**	2229	21021	20158	21851

* Based on all juvenile steelhead tagged and released

** Based on individuals determined to be actual migrants (from PIT detection data)

Table 10. Single release survival estimates from releases upstream of the screw trap (actual release), at the screw trap (actual release), and at Bonneville Dam (virtual release) for subsequent detections at the Fifteenmile creek screw trap, Bonneville PIT tag arrays, and Estuary PIT tag trawl. We used a Cormak-Jolly-Seber survival model in the program Mark to generate the probability distributions using Markov Chain Monte Carlo simulations.

Single Release survival for fish released upstream to →

		Upstream release to Fifteenmile Screw Trap			Fifteenmile Screw trap to Bonneville			Bonneville Dam to Estuary Trawl		
Year	n	Estimate	L95%CL	U95%CL	Estimate	L95%CL	U95%CL	Estimate	L95%CL	U95%CL
2007	286	39.3%	24.0%	64.9%	85.3%	58.2%	98.9%	*	*	*
2008	1232	57.8%	49.4%	67.9%	88.2%	66.5%	98.8%	76.5%	46.3%	98.1%
2009	2735	82.8%	70.5%	95.7%	84.3%	64.8%	98.2%	69.0%	34.9%	97.7%
2010	2135	92.6%	81.3%	99.4%	81.8%	61.4%	98.1%	60.2%	25.1%	97.4%
2011†	1208	77.6%	46.4%	97.9%	*	*	*	*	*	*
2011††	994	82.3%	56.7%	91.5%	*	*	*	*	*	*
2012†	1485	93.5%	77.3%	99.5%	*	*	*	*	*	*
2012††	1034	71.4%	36.9%	99.5%	*	*	*	*	*	*
2012†††	2519	93.3%	76.8%	100%	*	*	*	*	*	*

* Lacked sufficient sample size to produce reasonable estimate.

† Released upstream of screw trap in Fifteenmile Creek.

†† Released upstream of screw trap in Eightmile Creek.

††† Fifteenmile and Eightmile creeks combined releases.

Table 11. Smolt-to-adult return (SAR) rates and apparent survival rates in the Bonneville Pool for Fifteenmile Creek steelhead. The top table shows the Huggins model-based return rate estimates by smolt outmigration year. The bottom table shows the return-year-specific apparent survival in the Bonneville Pool based on the numbers of tagged Fifteenmile Creek steelhead detected at Bonneville Dam and on the Fifteenmile Creek PIT array.

Smolt Outmigration year	Number Released (n)	Smolt to Adult % To Bonneville			Smolt to Adult % To Fifteenmile Creek			Bonneville Pool Apparent Survival
		Estimate	L95% CL	U95% CL	Estimate	L95% CL	U95% CL	
2006	130	1.96%	0.48%	4.29%	0.38%	0.00%	1.44%	*
2007	286	4.05%	2.27%	6.19%	2.62%	1.27%	4.35%	65%
2008	1232	6.61%	5.53%	7.80%	***3.68%***	2.85%	4.62%	56%
2009	2735	4.01%	3.43%	4.64%	***1.90%***	1.48%	2.32%	47%
2010	2135	2.37%	1.86%	2.92%	***0.63%***	0.38%	0.95%	*†

*Survival estimate not reported because 2007 returning adult year class is not present, PIT array was first installed in 2009.
Bold/Italic: significant difference ($p<0.05$) between Bonneville adult returns rate and adult returns to Fifteenmile Creek.
†Survival for 2010 smolt year is preliminary, not all year classes have returned.

Spawning Migration Year	Detection Efficiency of Fifteenmile Creek PIT array	Number passed Bonneville	Number Detected in Fifteenmile Ck.	Bonneville Pool Apparent Survival %	L95% CL	U95% CL
2009-2010	Unknown	44	26	60%	*	*
2010-2011	Unknown	87	45	52%	*	*
2011-2012	94%**	94	39	44%	43%	47%

*Confidence level not possible because efficiency of Fifteenmile Creek PIT array was not known. However, efficiency of PIT array was likely very high due to the configuration of pass-thru PIT antennas deployed adjacent to a fish passage barrier (weir). The only passage option was through the PIT antennas.

** Actual detection percentage of adults tagged at Fifteenmile adult trap. This efficiency estimate includes all flow conditions, tag loss, adult fallback, mortality, and seasonal effects. Actual detection efficiency of the PIT array located at the confluence of Fifteenmile Creek and Eightmile Creek, as measured by known PIT tags passing over array antennas, was 99.5%.

Table 12. Freshwater and total age for 208 adult steelhead trapped (including kelts and carcasses) and/or detected on the PIT array during the 2011-2012 season. Total age is the sum of freshwater and ocean ages, plus an additional year due to overwintering in the Bonneville Pool before arriving on the spawning grounds.

	Total Age						
Freshwater Age	3	4	5	6	7	total	% of total
1	62	77	5[a]		1[a]	*145*	69.7
2		29	29	2	1[a]	*61*	29.3
3			1	1		*2*	1.0
total	*62*	*106*	*35*	*3*	*2*	**208**	
% of total	29.8	51.0	16.8	1.4	1.0		

[a]These groups consist of known repeat-spawning individuals, as determined from scale analysis.

Table 13. Age composition by trapping year of a sample (approximately 10%) of juveniles captured and tagged at the Fifteenmile rotary screw trap.

Year	Age 1	Age 2	Age 3	# Fish Aged
2011	80.3%	19.3%	0.4%	226
2012	78.9%	19.3%	1.8%	342

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FIGURES.

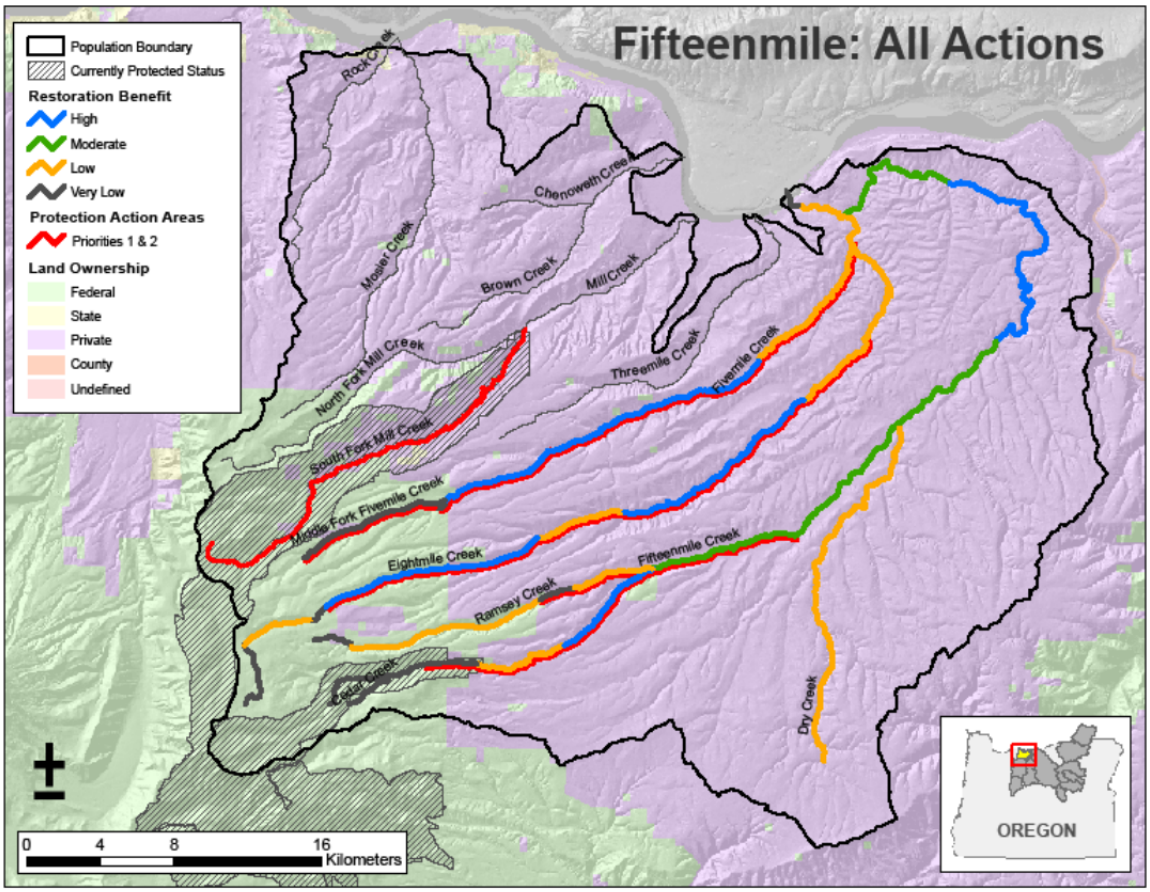

Figure 1. Map of the Fifteenmile Creek steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions. Restoration benefits are only shown for the Fifteenmile Creek watershed because no effectiveness modeling was completed for the other watersheds in the population. (*Oregon Mid-C Steelhead Recovery Plan*)

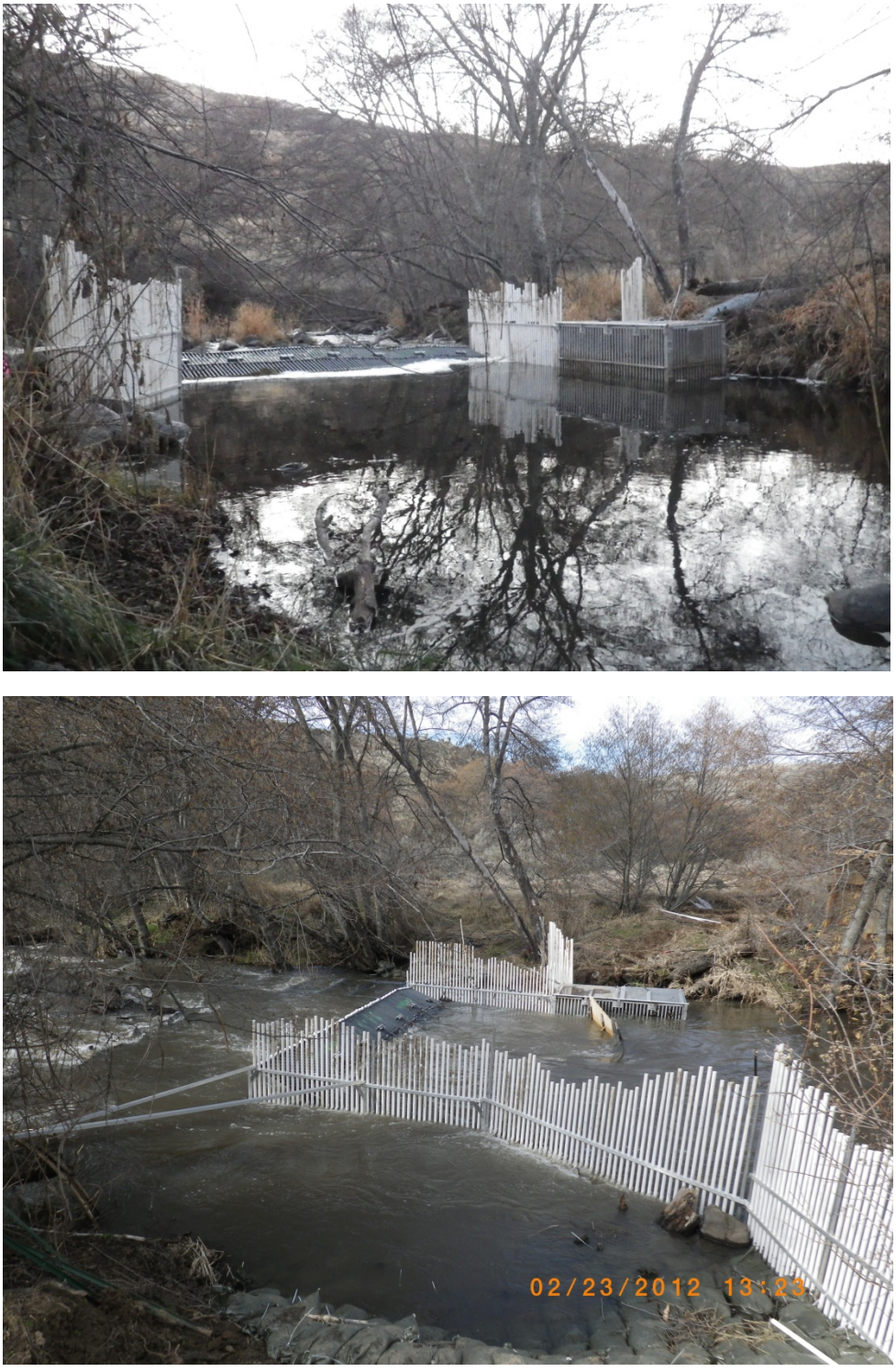

Figure 2. Resistance panel weir trap installed in its new location in Fifteenmile Creek for the 2011-2012 season. The new site is approximately 100m downstream of the previous season's weir site. Top image shows the weir at winter base flow, as viewed from upstream; bottom image shows the weir at moderate flow, as viewed from the bank adjacent to the trap.

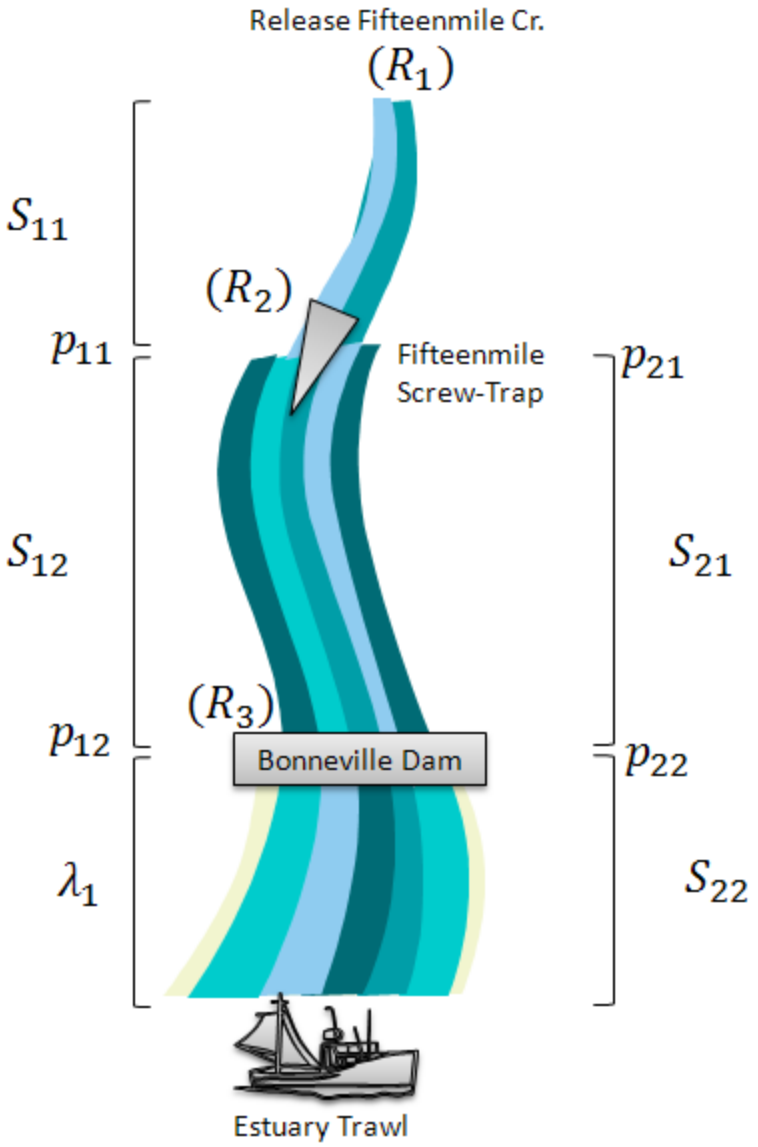

Figure 3. Schematic of the release-recapture design used to estimate reach survival for smolts passing from release location to screw-trap, screw-trap to Bonneville Dam, and Bonneville Dam to the Columbia River estuary.

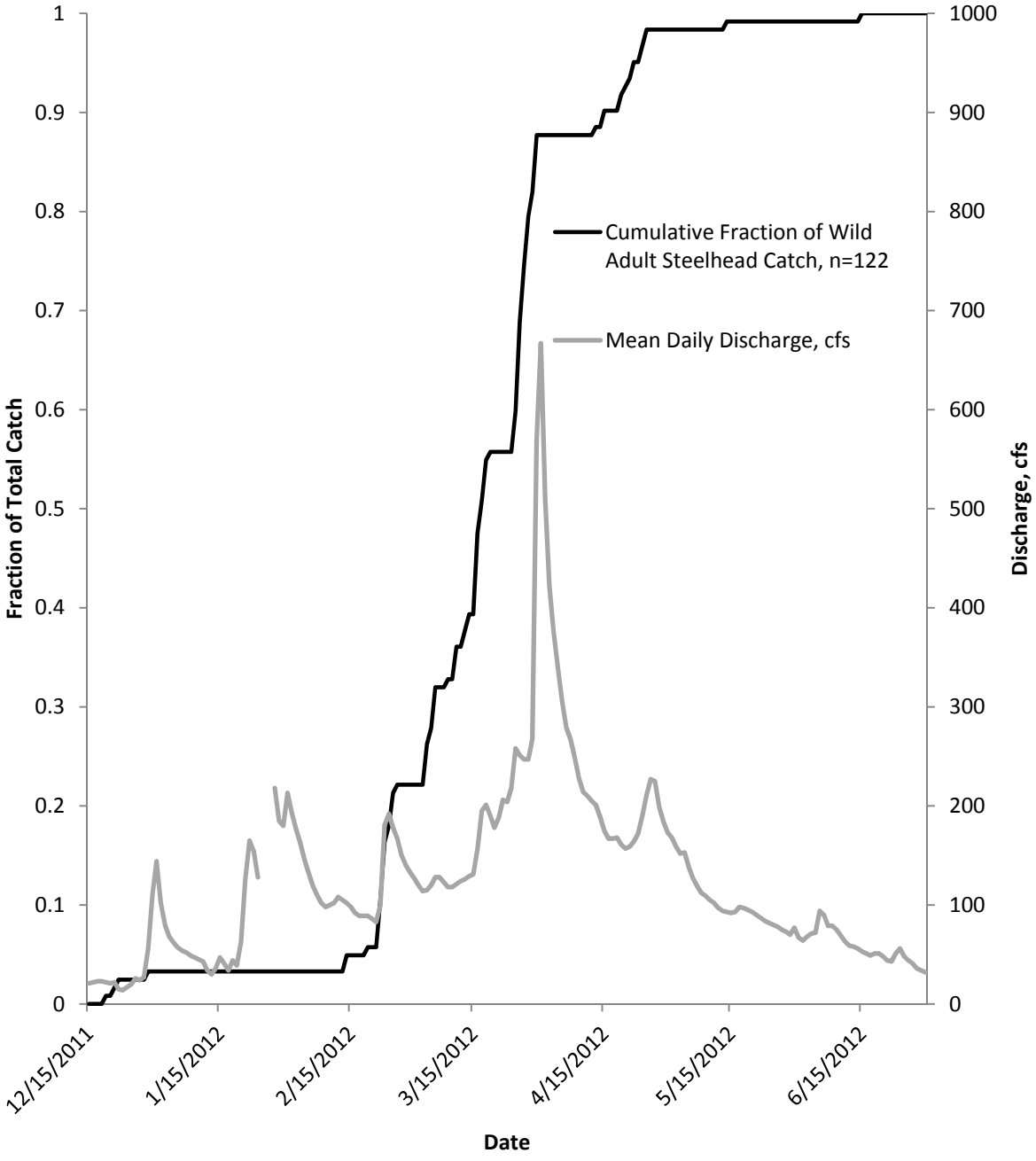

Figure 4. Wild adult steelhead catch at the Fifteenmile Creek weir (not including kelts) during the 2011-2012 trapping season (13 December 2011 – 25 June 2012), shown as cumulative fraction of total catch. Also shown is the mean daily discharge of Fifteenmile Creek as measured at Oregon Department of Water Resources gauging station on lower Fifteenmile Creek.

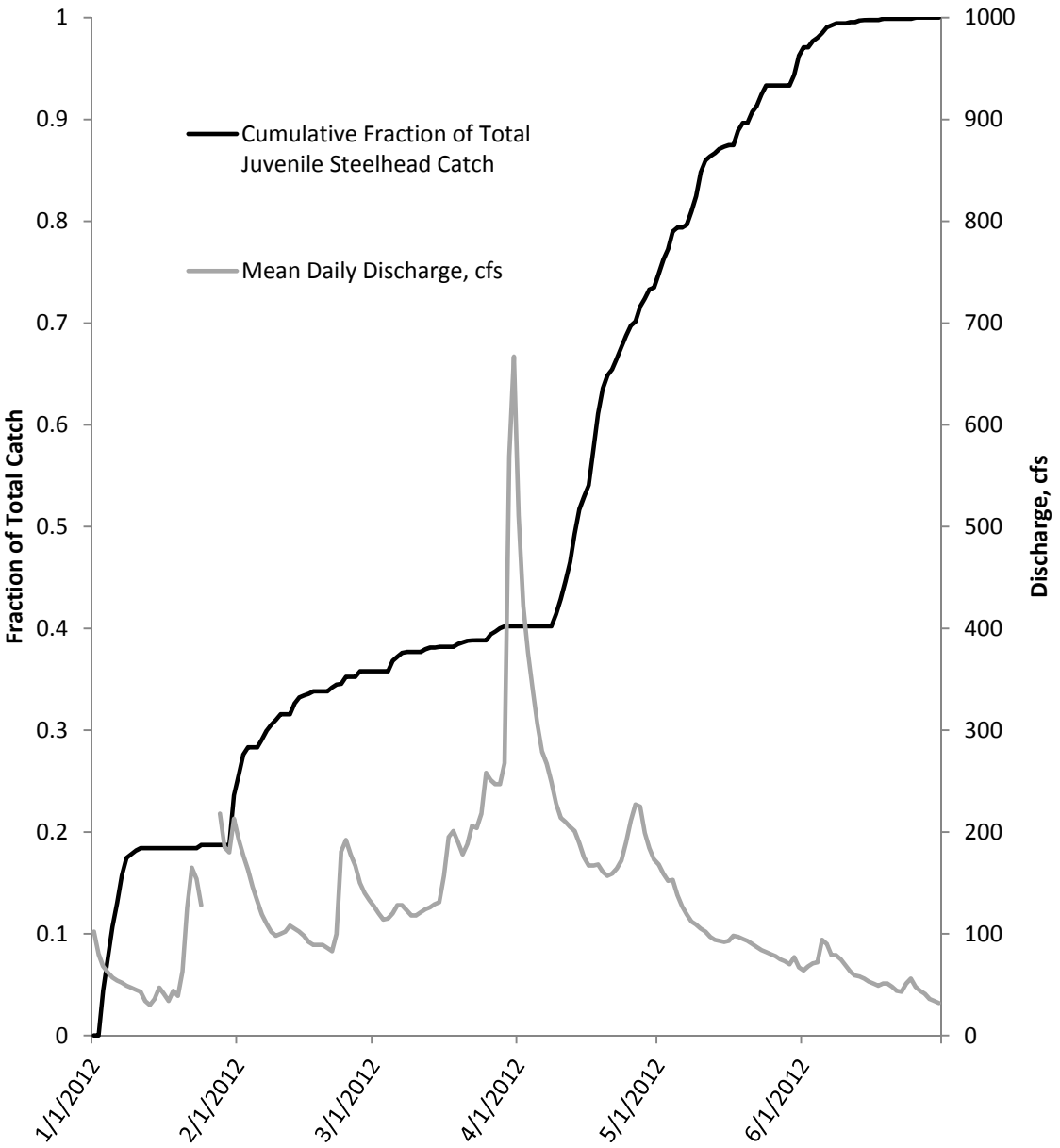

Figure 5. Captures of juvenile steelhead at the Fifteenmile Creek screw trap during 2012 – presented as cumulative percent of total catch plotted over time – and mean daily discharge at Oregon Department of Water Resources' gauging station on lower Fifteenmile Creek during the same period.

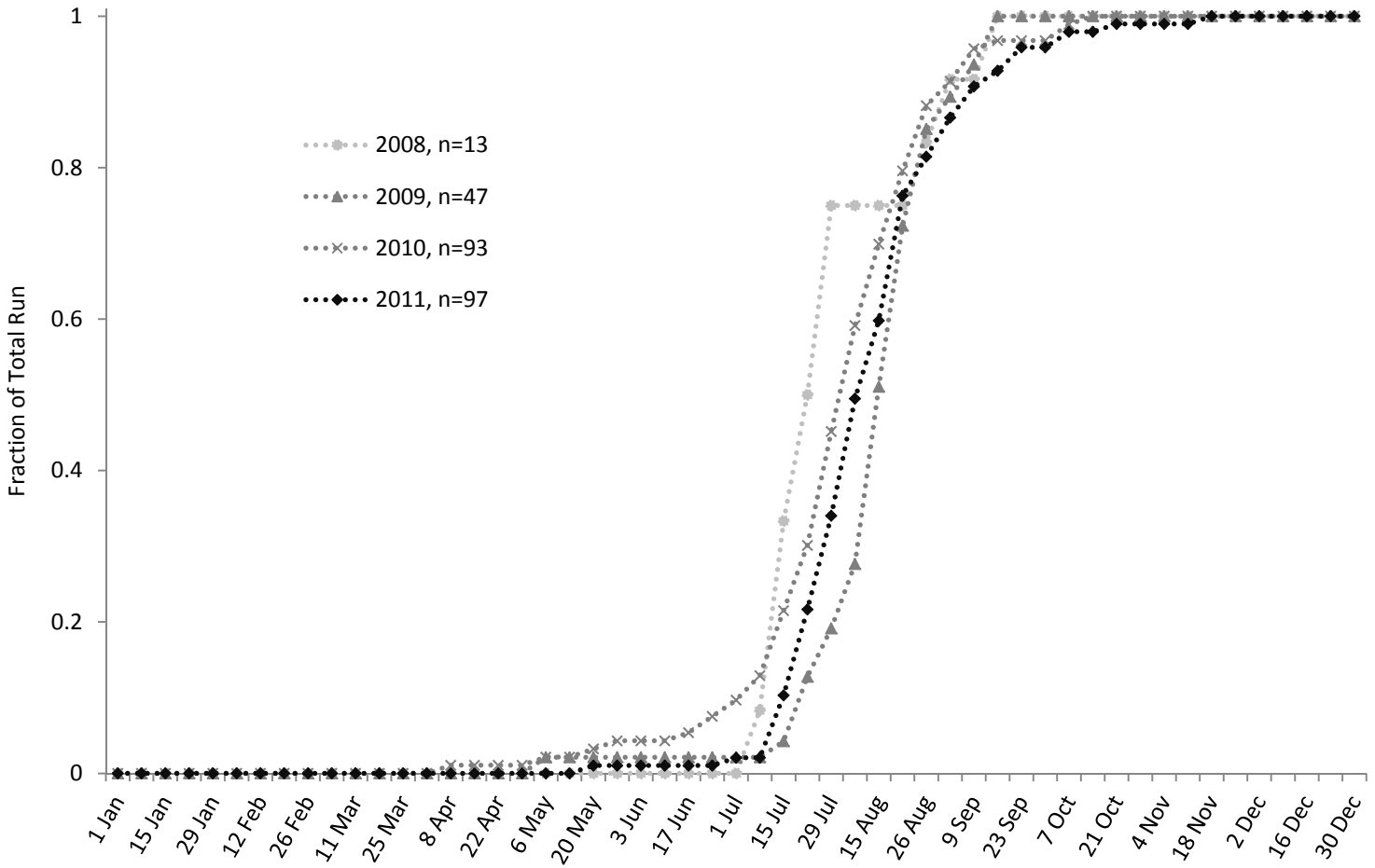

Figure 6. Timing of adult Fifteenmile Creek steelhead returns to Bonneville Dam from return years 2008 to 2011. Numbers of tagged adult Fifteenmile Creek steelhead detected at Bonneville each year are also shown.

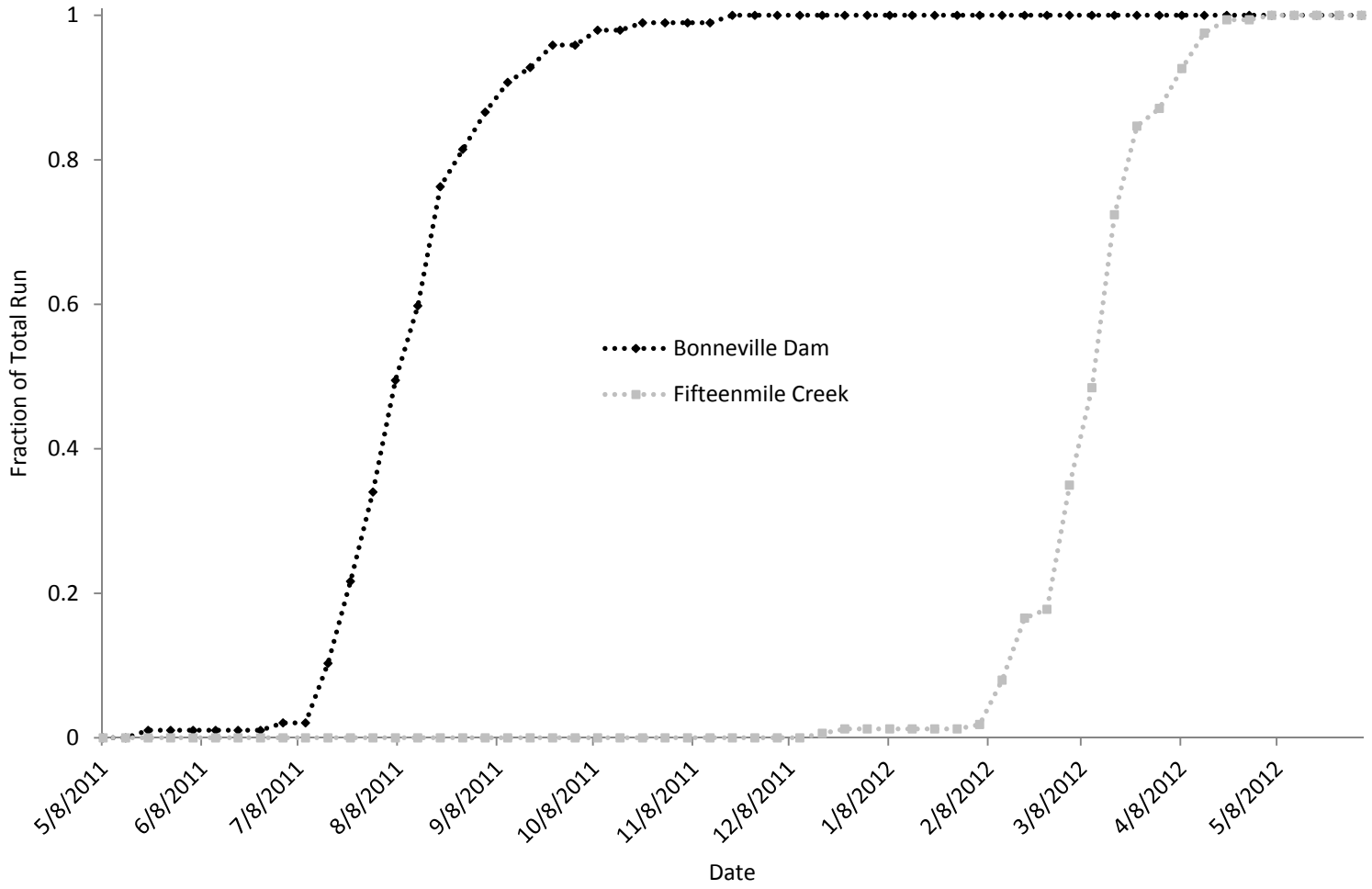

Figure 7. Timing of 2011-2012 Fifteenmile Creek adult steelhead run at Bonneville Dam and at Fifteenmile Creek. The timing at Fifteenmile was produced from initial capture date for fish captured at the weir or initial detection date of tagged fish detected on the in-stream PIT array.

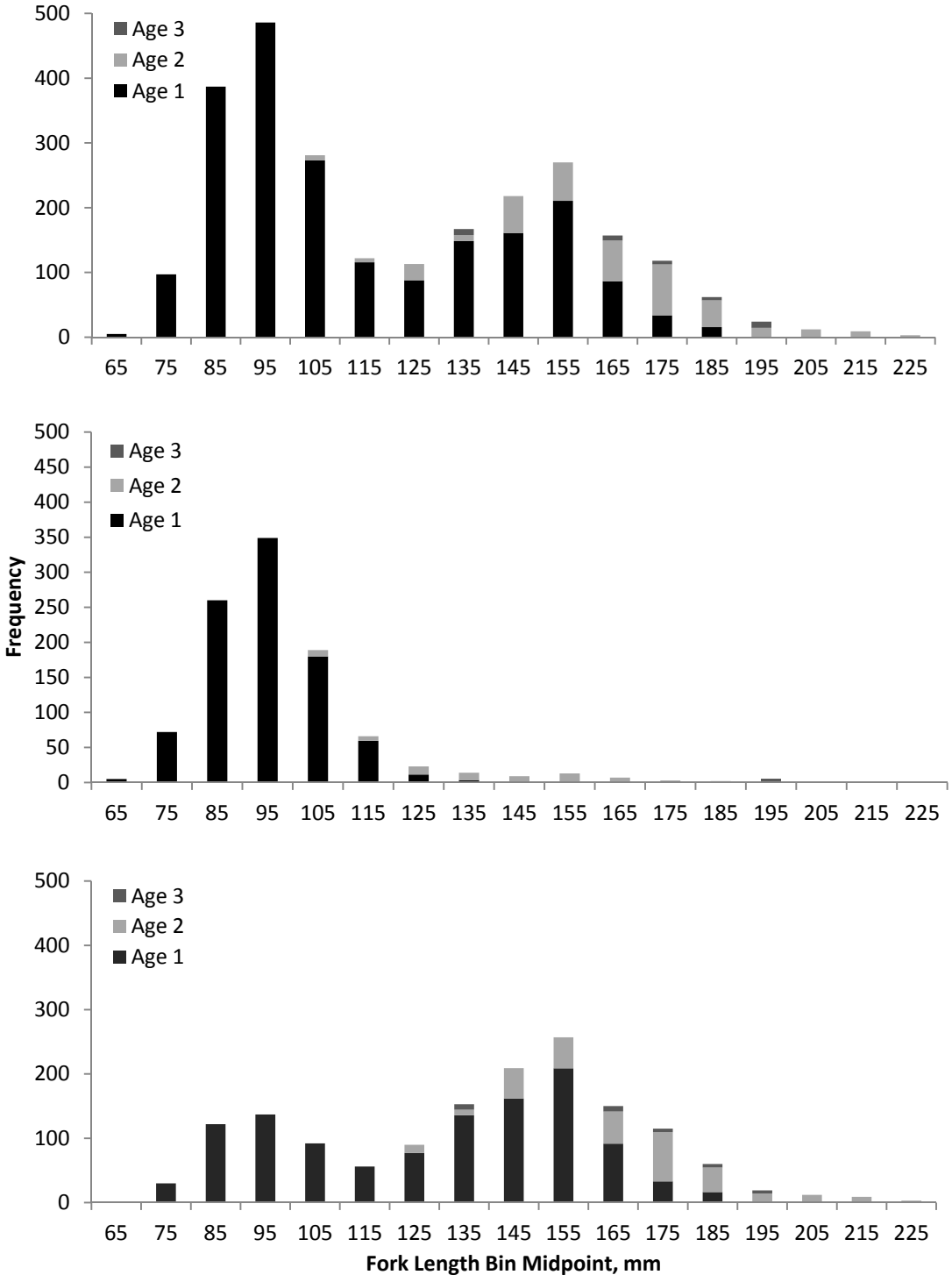

Figure 8. Length-frequency histogram and age of juvenile steelhead trapped in the Fifteenmile Creek screw trap in 2012. Top panel shows all individuals trapped during the entire season, while the middle panel shows individuals trapped prior to April 1 and the lower panel shows individuals trapped on or after April 1.