FISH POPULATION MONITORING IN THE MIDDLE FORK JOHN DAY RIVER INTENSIVELY MONITORED WATERSHED

ANNUAL TECHNICAL REPORT

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EXECUTIVE SUMMARY

Recovery efforts for federally threatened Mid-Columbia steelhead *Oncorhynchus mykiss* populations rely on habitat restoration efforts as a major approach to recovery. However, most effectiveness monitoring efforts accompanying restoration actions are not adequate to determine if the actions have benefited the target populations. Therefore, a series of Intensively Monitored Watersheds (IMWs), including one in the Middle Fork John Day River (MFJDR), have been developed to understand the interaction of fish and their habitat as well as the impact restoration actions have at watershed scales. We conducted summer steelhead and spring Chinook salmon *O. tschawytsha* population level monitoring within the MFJDR IMW. Here, we report on fish monitoring efforts funded through this IMW effort. Detailed information regarding spring Chinook escapement and steelhead and Chinook smolt emigration from this watershed will be reported elsewhere. During steelhead spawning surveys, we observed 195 redds constructed at 29 of 36 survey reaches. Using these observations, we estimate a redd density of 2.74 redds/km or 1,148 redds in the MFJDR IMW constructed by an estimated 3,494 returning adult steelhead. Collectively, we also tagged 7,933 juvenile steelhead, Chinook, and Bull trout *Salvelinus confluentus* from June through November 2012. Abundance, and survival estimates for juvenile steelhead and Chinook salmon varied among survey sites and seasons.

INTRODUCTION

The John Day River, located in northeastern Oregon, is unique in that it supports some of the last remaining wild populations of summer steelhead *Oncorhynchus mykiss* and spring Chinook salmon *O. tschawytsha* in the Columbia River basin with no hatchery supplementation. However, summer steelhead populations remain depressed relative to historic levels. In 1999, the National Marine Fisheries Service (NMFS) listed the Middle Columbia River summer steelhead distinct population segment (DPS), which includes the John Day River steelhead Major Population Group (MPG), as threatened under the Endangered Species Act (ESA). Both the 2000 and 2004 Biological Opinions that outline the recovery strategy for steelhead and salmon within the Columbia Basin rely on stream restoration as a major approach to recovery. However, past restoration efforts have rarely included effectiveness monitoring programs to determine if projects have provided a benefit to the target population (Roni et al. 2002; Roni et al. 2005), including restoration efforts within the John Day River MPG intended to improve steelhead and other salmonid freshwater production and survival (James et al. 2007). As a result, watershed scale coordinated restoration efforts, with the associated effectiveness monitoring programs, have been initiated in the Pacific Northwest, including the Middle Fork John Day River (MFJDR), to evaluate population level responses to restoration actions. These programs are programmatically referred to as Intensively Monitored Watershed (IMW) studies (PNAMP 2005). The goal of the IMW is to improve our understanding of the relationships between fish and their habitat (PNAMP 2005).

Within the Middle Fork John Day River IMW (MFJDR IMW), several habitat factors have been identified as limiting for the recovery of summer steelhead. Degraded floodplain and channel structure, altered sediment routing, altered hydrology, and water quality (temperature) are cited as limiting factors in the Draft Mid-Columbia Steelhead Recovery Plan (Carmichael 2008). Current and proposed restoration efforts for the MFJDR IMW are anticipated to address these key limiting factors. In order to assess restoration effectiveness on focal fish species, monitoring and analyses must emphasize population level spatial scales. Fish population monitoring for the MFDJR IMW includes evaluating steelhead and Chinook population productivity, survival, and abundance. While abundance is an important metric for population assessments, survival and production will be key indicators of population responses to restoration activities. Freshwater survival is assessed from the parr to smolt life stages (parr to smolt survival) and ocean or out-of-basin survival is estimated as a smolt to adult return ratio (SAR). Freshwater productivity is assessed as smolts produced for constructed redds (smolts/redd).

Project Objectives

1. Estimate spawner escapement of steelhead and Chinook to the MFJDR.
2. Estimate freshwater productivity (smolts/redd) of Chinook and steelhead.
3. Estimate parr-to-smolt survival for steelhead and Chinook.
4. Delineate seasonal rearing habitat for Chinook parr.

METHODS

Study Area

The MFJDR originates in the Blue Mountains of the Malheur National Forest, flows westerly for 120 km, and merges with the North Fork John Day River about 30 km above the town of Monument (Figure 1). The MFJDR is a fourth field watershed (USGS cataloging unit 17070203) that drains 2,090 km^2 with a perimeter of 250 km. Watershed elevations range from 700 m near the mouth to over 2,500 m in the headwater areas. The watershed receives approximately 40-60 cm of precipitation each year. The fish metrics reported here refer to the portion of this watershed upstream of our rotary screw trap near the town of Ritter, OR at river kilometer (RKM) 20 (Figure 2).

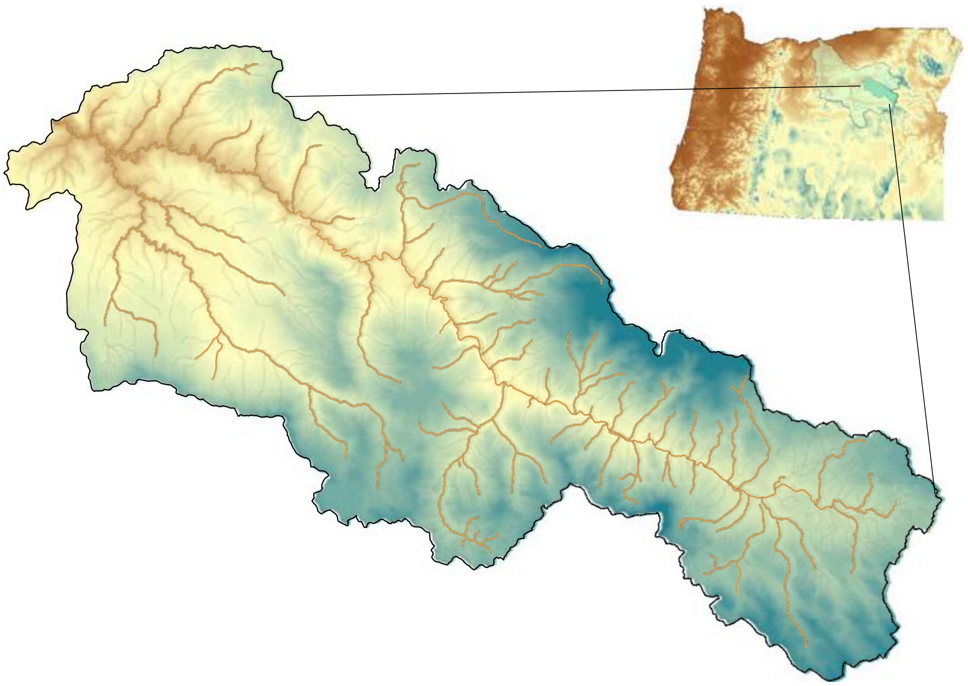

Figure 1. Map of the location of the MFJDR and its tributaries in relation to the John Day River sub-basin and the state of Oregon.

Passive In-stream PIT tag Antennae Arrays

An in-stream passive integrated transponder (PIT-tag) antenna array, installed on the MFJDR near the mouth of Mosquito Creek (RKM 68.5), detects PIT tagged fish as they migrate past the array. This array consists of six antennae; four antennae which are 4.57m in length and two which are 3.05 m in length. The antennae are oriented in two rows perpendicular to the stream channel to evaluate directional movement of detected fish (Figure 2). Each antenna is securely anchored to the streambed with nylon straps attached to duckbill anchors driven 500-800 cm into the stream substrate with a hydraulic post pounder. These antennae are operated by a Destron Fearing FishTracker Model 1001M Reader multilplexer which stores the date, time, antennae, and PIT tag code of each detection.

Additionally, two PIT-tag antenna arrays are operated in Bridge Creek, a tributary to the MFJDR, to evaluate fish movements into and out of Bates Pond (Figure 2). The upper array site, located just upstream of the inflow of Bates Pond, consists of two 30x80 cm antennae placed side by side across the stream channel and anchored to the stream bed. The lower array site, located downstream of the Bates Pond fish ladder and spillway, consists of one 30x80 cm antennae anchored to the streambed in the same manner as the mainstem array. Each antenna is powered by a Destron Fearing Model 2001F ISO portable transceiver system which store the date, time, and PIT tag code of each detection.

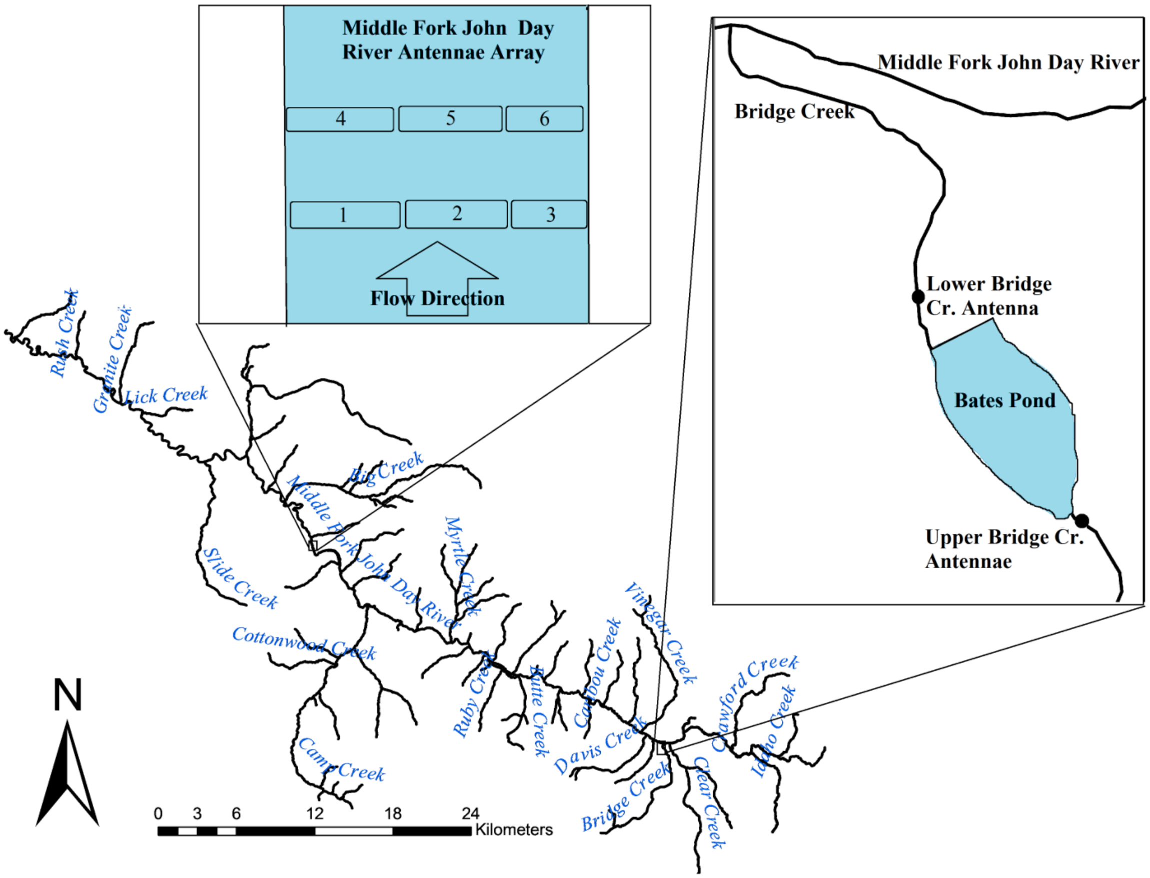

Figure 2. Map of the location of PIT-tag antenna arrays operated in the MFJDR IMW. The top left inset shows the configuration of the lower PIT tag antenna array, near Mosquito Creek with the numbered antenna sequence. The top right inset shows location of PIT tag arrays in Bridge Creek in reference to Bates Pond.

Summer Steelhead and Spring Chinook Adult Monitoring

Summer Steelhead Adult Escapement

Steelhead spawning surveys, based on standard ODFW methods (Susac and Jacobs 1999; Jacobs et al. 2000; Jacobs et al. 2001), were conducted during the spring (April to June) coinciding with spawn timing in the MFJDR. Survey sites were selected using a generalized random tessellation stratification (GRTS) design which randomly selects sites based on the spatial structure of the stream network of interest. Sites were assigned to one of three different panels: sites visited every year (Annual Sites), sites visited every other year beginning with year-1 (Two-1), or sites visited every other year beginning in year-2 (Two-2). Although site selection is usually performed in a discrete random fashion, we were able to incorporate sites utilized by another steelhead monitoring project in the John Day River MPG into our site selection to utilize their previously collected data and increase personnel and resource efficiencies. Thirty sites were selected to be surveyed each year and were equally distributed between Annual (n=15) and Two-year sites (n=15 for each panel). Additional sites were selected within each panel as replacement sites in the event that a site had to be removed due to access restrictions, unidentified in-stream barriers, or unsuitable spawning habitat conditions. In 2012, we targeted a total of 36 sites (18-Annual and 18 Two-2 sites) to survey since nearly a third of sites in previous years occur in the mainstem MFJDR and generally conditions are only amenable for surveying once during the later portion of the spawning season.

We used a 1:100,000 EPA river reach file of summer steelhead distribution in the MFJDR population for site selection (Figure 3). This spatial dataset is based on best professional knowledge provided by ODFW managers as well as other local agency biologists. The actual dataset utilized for site selection was modified to meet the objectives of this project. Specifically, stream segments downstream of a rotary screw trap (RST) operated by ODFW at river kilometer (RKM) 24 (River mile 15) were excluded since this area was outside of the target IMW area.

Sites were surveyed on multiple occasions, to quantify the number of unique redds constructed at each site, at approximately two week intervals to account for the temporal variation in spawning activity. Survey reaches were approximately 2 km in length and encompassed the sample point derived from the GRTS design. Surveyors walked upstream from the downstream end of each reach and counted all redds, live fish, and carcasses observed. New redds were flagged and the location marked with a GPS unit (dd.dd – WGS84). During each visit, surveyors recorded the number of previously flagged redds and new un-flagged redds.

Overall redd density (R_D) was estimated by:

$$R_D = \sum_{i=1}^{n} r_i/d_i \qquad (1)$$

where r_i is the number of unique redds observed at site i, d_i is the distance surveyed (km) at site i, and i is the individual sites surveyed. The total number of redds (R_T) occurring throughout the MF IMW was estimated by:

$$R_T = R_D \cdot d_u \qquad (2)$$

where d_u is the total kilometers available to steelhead for spawning (419 km). Steelhead escapement (E_S) was then estimated by:

$$E_S = C \cdot R_T \qquad (3)$$

where C is an annual fish per redd constant (3.09 fish/redd for 2012) developed from repeat spawner surveys in the Grande Ronde River basin (Flesher et al. 2005; (M. Dobos, 2012

ODFW memorandum). A locally weighted neighborhood variance estimator (Stevens 2004), which incorporates the pair-wise dependency of all points and the spatially constrained nature of the design, was utilized to estimate 95% confidence intervals of the escapement estimate using R statistical software (R Development Core Team 2005).

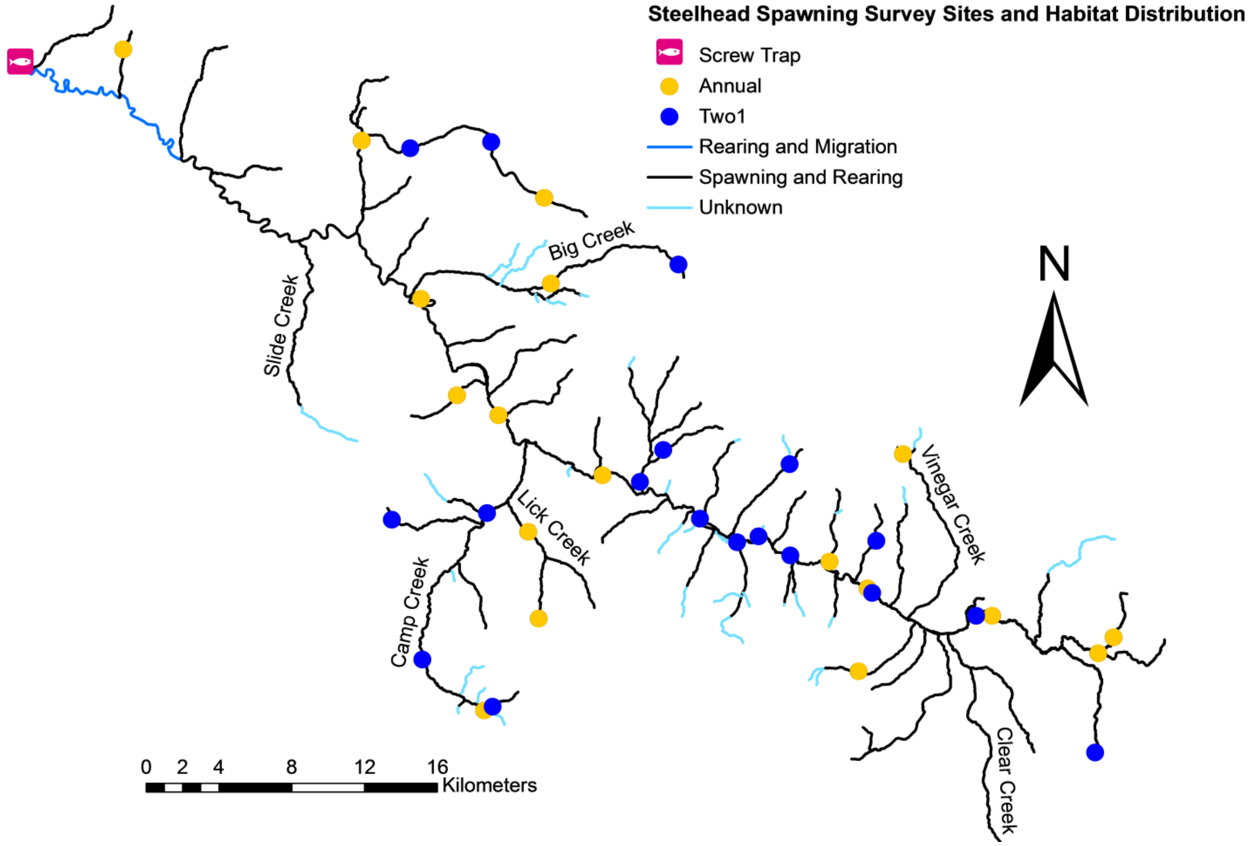

Figure 3. Map of summer steelhead habitat distribution used for selecting steelhead spawning survey sites with Annual and Two-1 sites sampled in 2012. The rotary screw trap (RST) near Ritter is shown for reference.

Spring Chinook Adult Escapement

Census surveys are conducted to monitor adult Chinook spawning escapement over the entire spawning habitat in the Middle Fork sub-basin and are generally conducted during mid to late September. Surveys are conducted by walking upstream through identified sampling reaches and counting observed redds, live fish, and sampling carcasses. Observed redds are flagged, enumerated, and a waypoint is taken with a hand-held GPS to map redd locations. Carcasses are sampled for middle of the eye to the posterior scale length (MEPS) and fork length (FL), scanned for PIT tags, sexed, and if female, a determination of spawning success is defined. For further details on Chinook spawning methods and results, refer to Bare et al. 2013 (in draft).

Summer Steelhead and Spring Chinook Parr Monitoring

Juvenile Summer Steelhead Closed Population Modeling (Barker Robust)

Granite Boulder Creek and Camp Creek were selected for juvenile steelhead parr to smolt survival monitoring because of the differences in temperature recorded during the summer rearing season. Camp Creek is generally warmer than Granite Boulder Creek during the summer months. Each stream was divided into reaches based on the current summer steelhead distribution and topographical features from 1:24,000 quad topographic maps. Although both steelhead and Chinook were targeted in this sampling, steelhead distribution was utilized for both species because steelhead distribution encompasses the entire suspected distribution of Chinook. Within each reach, three sites were selected for monitoring. Sites were selected using a GIS layer developed by EMAP for steelhead spawning surveys in the MFJDR IMW (see Summer Steelhead Escapement). Specifically, the first point encountered in each reach proceeding in an upstream direction was selected as a sampling site. Depending on whether that point was in the first third, middle third, or latter third of the reach, all other site locations in the reach were located a distance equal to 1/3 of the reach distance from the other sampling points within that reach, resulting in one sampling site occurring in each third of the reach. Coordinates were extracted for each site from ArcGIS to locate sites in the field. Because of logistical and time constraints four sites in Camp Creek and two sites in Granite Boulder Creek were sampled during 2012 (Figure 4). Site lengths were 20 times the average active channel width (ACW) measured at five locations near the site point. The site point was considered the mid-point of the sampling section, however in some instances the section was moved upstream or downstream to avoid constraints from secondary channels or tributaries. Block nets were deployed at the upstream and downstream extents of each sample section to eliminate fish movement during sampling. Sites were sampled using a backpack electrofisher (Smith-Root LR20B), once a day for three consecutive days. Block nets remained in place until sampling was completed on the third day at each site. Site CMP_UPR-1 was only sampled two of the three days during the summer of 2012 due to water temperatures exceeding 18°C.

Once collected, fish were placed into an aerated 19 L bucket and transferred to in-stream live boxes where they were held until the entire site was sampled and tagging operations commenced. Captured juvenile Chinook, steelhead, and Bull trout *Salvelinus confluentus* were anesthetized with tricane methane sulfonate (MS-222), interrogated for PIT-tags, PIT tagged if not previously tagged, weighed to the nearest 0.1 g, and fork length (FL) measured to the nearest millimeter (mm). Scales were taken from a subsample of steelhead collected that were longer than 60 mm FL. Scales were collected from a key area located between the dorsal and anal fin and slightly above the lateral line. Scale samples were grouped into 10 mm FL bins with 15 fish sampled in each bin during both summer and fall sampling. Scales were also taken from all bull trout captured. All anesthetized fish were allowed to recover in an aerated 19 L bucket until they regained equilibrium (~5-10 minutes). Once recovered, fish were released in small batches throughout the site and allowed to distribute themselves naturally within the sampling reach.

Encounter histories were developed for each tagged steelhead to estimate population abundance. A closed capture model (Otis et al. 1978) was used to analyze the encounter histories in Program MARK (White and Burnham 1999). This analysis utilizes a log maximum likelihood probability to estimate both capture (p) and recapture (c) probabilities as well as population abundance (N). Model parameters for capture and recapture estimates can vary temporally, or can be constant, either together or separately. For each site, three potential models were fit to the data (Table 1). The most parsimonious model was selected based on the lowest Akaike Information Criteria (AICc) value. When AICc values of two or more potential models differed by less than two, the model with fewer parameters was selected as the most parsimonious model.

Table 1. Models fit to closed capture population estimate data, description of the models, and the number of parameters in the associated model. All models also parameterized population abundance, which is not included in this table.

Model	Model Description	# of Parameters
p(.),c(.)	Capture and recapture are constant but not equal	2
p(.)=c(.)	Capture and recapture are constant and equal	1
p(t)=c(t)	Capture and recapture vary temporally but equal during individual sampling events	3

Juvenile Spring Chinook and Summer Steelhead Open Population Modeling (POPAN)

We monitored parr survival of juvenile Chinook at 10 sites in the MFJDR IMW consisting of eight sites in the mainstem MFJDR, one in Vinegar Creek, and one in Coyote Creek in 2012 (Figure 4). The eight sites in the MFJDR were distributed between treatment (n=4) and control (n=4) reaches as defined by the MFIMW Working Group (Curry et al. 2010 in draft). Tributary sites were selected at locations in streams with previous observations of juvenile Chinook (James et al. 2009, 2010). Sites were 20 times ACW in length with a maximum of 150 m for sites in the MFJDR and a minimum of 100 m for tributary sites.

Two methods of fish capture were employed during sampling at these sites depending on site specific characteristics. In the tributaries and the upper MFJDR, backpack electrofishing gear (Smith-Root LR20B) was used with two netters working in an upstream direction. Within the other seven MFJDR sites, fish were collected by snerding, where 1–2 snorkelers would move in an upstream direction to locate holding juvenile spring Chinook. Once located, the snorkeler would direct deployment of a bag seine (7.6 m wide x1.22 m high seine net with a 1.22 m wide x 0.6 m deep bag) approximately 5 m downstream of the fish ensuring a proper seal of the lead line to the stream bed. After the net was deployed the snorkeler would position themselves upstream of the fish while being cautious not to spook them. Once in position, the snorkeler would herd the fish downstream into the seine. When the snorkeler reached the seine, the net was lifted and the fish were removed from the bag with a dip net. We sampled each of these sites four times from early July 2012 through early October 2012 with approximately 3–-6 weeks between sampling intervals (Table A. 1). For simplification purposes, we will refer to these sampling periods as July (July 11–18, 2012), August (August 1–8, 2012), September (August 22-28, 2012), and October (October 2–11, 2012). No block nets were deployed during or between sampling intervals.

All fish captured were processed as previously described above, however, scales were only taken from juvenile Chinook >100 mm for age determination. All juvenile Chinook and steelhead captured which were < 60 mm FL were enumerated and released.

Encounter histories were developed for individual juvenile Chinook and steelhead captured at each site. An open population model, POPAN (Schwarz and Arnason1996), was used to estimate site specific parameters of survival (phi), probability of capture (p), probability of entry (PENT), and abundance (N) of a super population for fish ≥ 60 mm, using Program MARK over 3 week sampling periods (White and Burnham 1999). PENT parameters estimate the proportion of the super-population, a theoretical abundance of all animals in the surrounding 'population', that recruit to the site abundance between sampling interval t_i and $t_{i+1,}$ either through birth or immigration. For our purposes, recruitment occurred either through fish immigrating to a site and/or growing to the minimum 60 mm size required for tagging. Model variables for apparent survival, probability of capture, and probability of entry estimates can vary temporally or can be constant. We fit models in which the parameters phi and p varied temporally or remained constant through time (Table 2). All other parameters were consistent for each model tested and included temporally varying PENT and constant abundance (Table 2). We used model averaging techniques to account for model uncertainty in estimates of apparent survival, probability of capture, PENTs, and abundance at each site (White and Burnham 1999). In the fully time dependent models the final apparent survival and probability of capture are confounded.

Table 2. Models fit to open population encounter histories data, description of the models, and number of parameters in the associated models. phi = probability of survival, p = probability of capture, PENT= probability of entry, N = super-population abundance, (.) = constant parameter, (t) = temporally varying parameter.

Model	Model Description	# of Parameters
phi(t)p(t)PENT(t)N(.)	All parameters vary temporally	11
phi(.)p(t)PENT(t)N(.)	Survival is constant and probabiltiy of capture and probabiltity of entry vary temporally	9
phi(t)p(.)PENT(t)N(.)	Survival and Probability of entry vary temporally, probability of capture is constant	8
phi(.)p(.)PENT(t)N(.)	Survival and probability of capture remain constant, probability of entry varies temporally	6

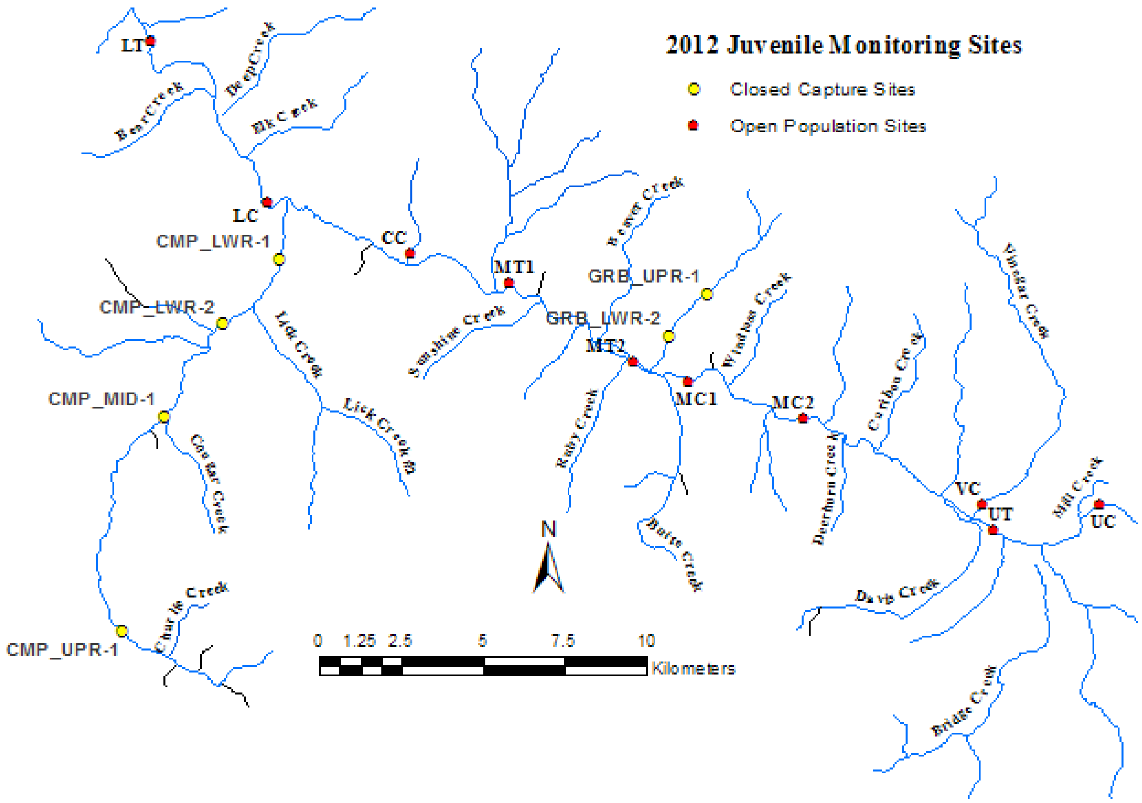

Figure 4. Map of the location of parr monitoring sites in the MFJDR IMW. Red points represent open population (POPAN) sites: LT = Lower Treatment, LC = Lower Control, CC = Coyote Creek, MT1 = Mid Treatment-l, MT2 = Mid Treatment-2, MC1 = Mid Control-1, MC2 = Mid Control-2, VC = Vinegar Creek, UT = Upper Treatment, and UC = Upper Control. Yellow points represent closed capture sites: CMP_LWR-1 = Lower Camp Creek-1, CMP_LWR-2 = Lower Camp Creek-2, CMP_MID-1 = Mid Camp Creek-1, CMP_UPR-1 = Upper Camp Creek-1, GRB_LWR-2 = Lower Granite Boulder Creek-2, and GRB_UPR-1 = Upper Granite Boulder Creek-1.

Spring Chinook Parr Summer Rearing Distribution

Summer rearing distribution of juvenile Chinook within the MFJDR IMW was assessed by snorkeling or electro-fishing pools in tributaries of the MFJDR. Sampling proceeded upstream from the tributary mouth noting the presence or absence of juvenile Chinook, steelhead, or Bull trout based on suspected Chinook distribution (Figure 5). Locations of all pools sampled were recorded with a handheld GPS along with focal fish presence and/or absence. Within tributary streams, we sampled every fifth pool beginning at the first pool upstream of the tributary confluence or a point where Chinook had been previously observed. In the event that no juvenile Chinook were observed in a sampled pool, we proceeded to sample every pool encountered, until a juvenile Chinook was encountered at which point we returned to sampling every fifth pool. If no juvenile Chinook were encountered after sampling a continuous reach including all usable habitat 300 m upstream of the last observation measured on a handheld GPS unit, sampling ceased in that tributary.

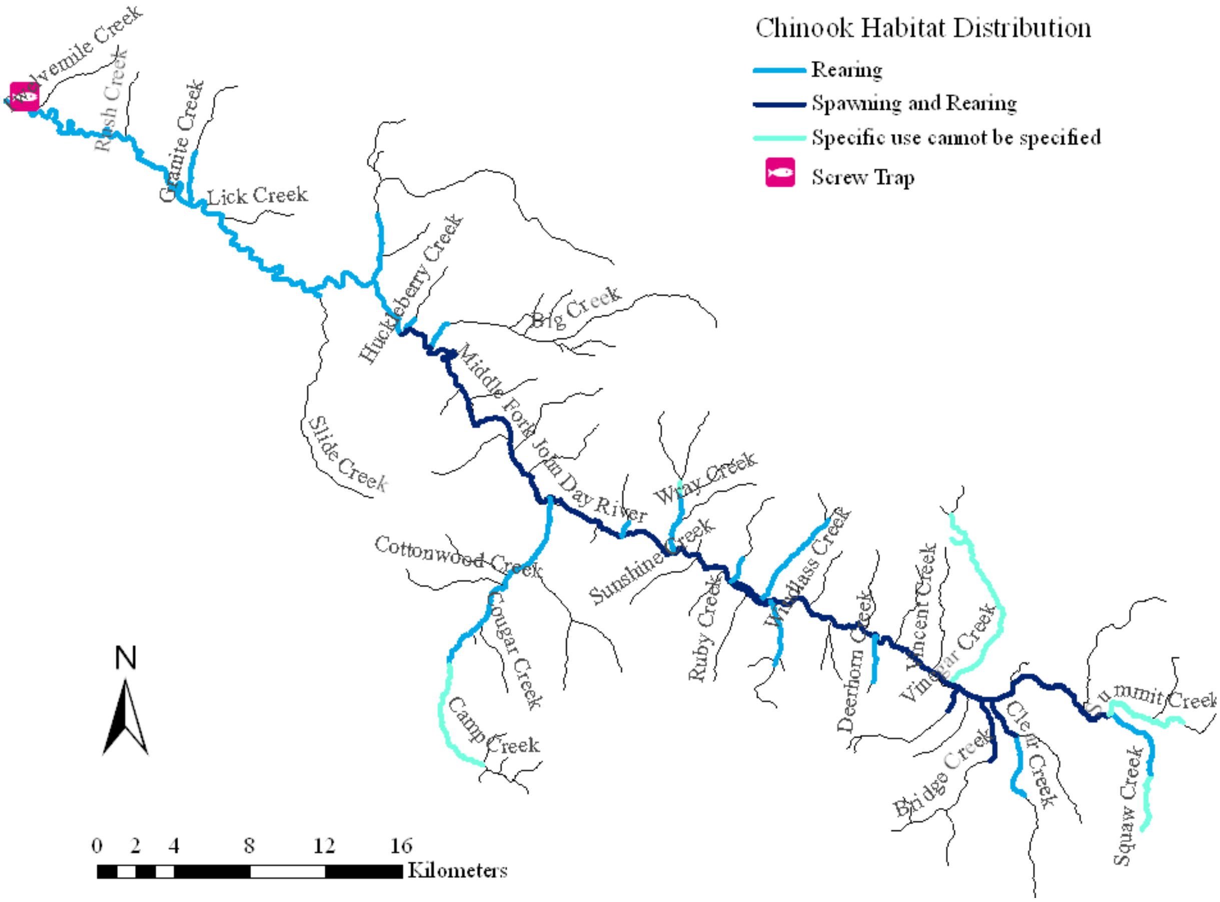

Figure 5. Spring Chinook habitat distribution in the MFJDR IMW from Ritter upstream. The location of the rotary screw trap is shown for reference.

Bates Pond Juvenile Passage

Recently, Oregon Parks and Recreation Department acquired property on the lower section of Bridge Creek, a tributary to the MFJDR, to develop Bates State Park. Included in this acquisition was Bates Pond. Currently, there is concern of the ability for juvenile fish, especially Chinook, to navigate the fish ladder leading into Bates Pond and through Bates Pond itself, to locate potential rearing habitat upstream of this reservoir. Therefore, we collected juvenile Chinook and steelhead by electrofishing from the confluence of Bridge Creek with the MFJDR upstream to the Bates Pond spillway and from the inflow Bridge Creek at Bates Pond upstream approximately 400 m. Fish were captured and processed using the previously described methods for electro-fishing, processing, and PIT tagging fish. However, no scales were collected from fish captured in Bridge Creek. Movement was assessed based on capture either upstream or downstream of Bates Pond and subsequent detections at passive in-stream PIT tag antenna arrays (Figure 2).

Summer Steelhead and Spring Chinook Smolt Monitoring

Juvenile PIT Tag Detection Histories

We assessed PIT tag detection histories of all fish tagged as part of the MFJDR IMW project by querying tagging and interrogation files for observations of these fish. Fish tagged in the MFJDR IMW have the potential to be interrogated at remote in stream PIT tag antennae arrays located in the MFJDR near Mosquito Creek, in the lower John Day River near McDonalds Ford, at John Day Dam, Bonneville Dam and the Columbia River estuary. Other observations are also possible during collection events within streams where surveys are being conducted as well as at the MF RST near Ritter, OR. Detection histories were grouped by species (Chinook or steelhead), tag site (Camp Creek, Granite Boulder Creek, or the MFJDR), and by tag year across observation site and year of observation where observation year began on July 1st and ended on June 30th the following year in order to align with in-stream tagging events and with migratory years that overlap from fall to spring.

Spring Chinook Salmon Smolt Survival Modeling

Using PIT tag detection histories throughout the John Day and Columbia River, we assessed the survival of juvenile Chinook as they migrated out of the MFJDR and through the Columbia River hydro-power system using a Jolley-Seber model in Program Mark (White and Burnham 1999). Interrogation sites included the MF Array, Middle Fork RST, John Day Dam, and Bonneville Dam. Binary encounter histories were developed based on detections at each of the aforementioned sites for two tagging cohorts: summer (July 5, 2012 – August 8, 2012) and fall (August 24, 2012 – November 2, 2012) tagged fish. Models were fit to the data to test for differences in survival between the seasonal tagging cohorts. Akaike Information Criteria (AICc) was used to assess the best fit model to the data. If AICc values differed by less than two, the model with the fewest parameters was selected.

Summer Steelhead and Spring Chinook Smolt Abundance

Juvenile Chinook and steelhead migrants were captured using a 1.52 m rotary screw trap (RST) operated on the MFJDR near Ritter (Figure 3). Trap operation typically begins during early October and continues into June of the following year to encompass a migration year. The trap was either removed or stopped during times of ice formation, high discharge, and during warm summer months after fish ceased migrating.

The RST is typically fished four days/week by lowering cones on Monday and raising cones on Friday, and is checked daily during the weekly fishing period. We assumed that all fish captured were migrants. Non-target fish species were identified, enumerated, and returned to the stream. Captured juvenile Chinook and steelhead migrants were anesthetized with tricane methane sulfonate (MS-222), interrogated for passive integrated transponder tags (PIT tags) or pan jet paint marks, enumerated, weighed to the nearest 0.1 g, and measured to the nearest mm FL. A sub-sample of fish were released above the trap to estimate migrant abundance using mark-recapture techniques. For further details of RST operation and methods see Dehart et al. (2013 in draft).

RESULTS

Summer Steelhead and Spring Chinook Adult Monitoring

Summer Steelhead Adult Escapement

We surveyed 36 sites for spawning adult steelhead in the MFJDR IMW from April 2, 2012 through June 14, 2012 (Table 3). We observed 195 total redds at 29 of the 36 sites surveyed (81%). Corresponding redd densities at all sites ranged from 0 to 12.6 redds per km (Table 4; Figure 6) and averaged 2.7 redds/km (Table 5). Given this redd density, we estimate that 1,148 redds were constructed in the MFJDR IMW by 3,494 returning adults (Table 5; Figure 7). Initiation of redd construction started in early April and continued through May (Figure 8). We observed more steelhead redds in 2012 than in 2011 but the escapement estimate for 2012 is slightly lower than that for 2011 (Figure 7). Although the 2012 escapement estimate was lower than the 2011 estimate, it still shows a statistically significant increase from the 2008 estimate (Figure 7).

Table 3. Stream name, start and end coordinates (DD = decimal degree, WGS-84), panel (Annual or Two-1), and dates surveyed for all steelhead spawning sites in 2012. MFJDR = Middle Fork John Day River.

		Start		End			Survey Dates					
Stream	Site ID	Latitude (DD)	Longitude (DD)	Latitude (DD)	Longitude (DD)	Panel	1	2	3	4	5	6
Rush Cr.	101	44.873140	-119.072950	44.890660	-119.070830	Annual	4/2/2012	4/16/2012	4/30/2012	5/14/2012	6/13/2012	
MFJDR	102	44.722600	-118.822890	44.706250	-118.814740	Annual	5/10/2012	5/23/2012	6/6/2012			
Summit Cr.	108	44.586520	-118.417050	44.580470	-118.396810	Annual	4/9/2012	4/23/2012	5/8/2012	5/21/2012	6/5/2012	
Indian Cr.	109	44.824560	-118.800190	44.813400	-118.779830	Annual	5/14/2012	6/12/2012				
Camp Cr.	110	44.569250	-118.849950	44.560600	-118.828690	Annual	4/10/2012	4/24/2012	5/7/2012	5/22/2012	6/6/2012	
MFJDR	113	44.762830	-118.871050	44.759790	-118.865720	Annual	4/16/2012	5/9/2012	5/22/2012	6/6/2012		
W.F. Lick Cr.	114	44.623500	-118.787790	44.605430	-118.789740	Annual	4/10/2012	4/24/2012	5/7/2012	5/22/2012	6/6/2012	
MFJDR	115	44.621570	-118.579130	44.616680	-118.561660	Annual	5/10/2012	5/21/2012	6/5/2012			
Davis Cr.	116	44.576680	-118.556410	44.577400	-118.580000	Annual	4/18/2012	5/2/2012	5/17/2012	6/4/2012		
Bear Cr.	118	44.722790	-118.832020	44.711590	-118.850230	Annual	4/12/2012	4/25/2012	6/13/2012			
MFJDR	119	44.674617	-118.749741	44.672656	-118.727233	Annual	4/16/2012	5/10/2012	5/22/2012	6/6/2012		
MFJDR	120	44.603903	-118.483976	44.598685	-118.464755	Annual	4/9/2012	5/3/2012	5/16/2012	6/5/2012		
Big Cr.	122	44.769164	-118.787206	44.776274	-118.769085	Annual	4/12/2012	5/9/2012	5/23/2012	6/7/2012		
Vinegar Cr.	123	44.672395	-118.522400	44.684121	-118.536880	Annual	5/2/2012	5/17/2012	6/4/2012			
Idaho Cr.	124	44.582520	-118.403160	44.594660	-118.387560	Annual	4/9/2012	4/23/2012	5/8/2012	5/21/2012	6/5/2012	
Indian Cr.	125	44.837020	-118.908840	44.845900	-118.893310	Annual	4/11/2012	4/30/2012	5/14/2012	5/29/2012	6/12/2012	
Little Boulder Cr.	127	44.627480	-118.590920	44.643530	-118.584640	Annual	4/4/2012	4/17/2012	5/2/2012	5/15/2012	5/30/2012	6/11/2012
Lick Cr.	130	44.657710	-118.806030	44.644770	-118.790630	Annual	4/3/2012	4/18/2012	5/1/2012	5/15/2012	5/30/2012	6/11/2012
Big Cr.	201	44.788021	-118.708159	44.779080	-118.687586	Two1	5/23/2012	6/7/2012				
Big Boulder Cr.	203	44.666147	-118.716129	44.682540	-118.711931	Two1	4/5/2012	4/18/2012	5/3/2012	5/16/2012	5/31/2012	6/14/2012
Caribou Cr.	204	44.625717	-118.566313	44.640109	-118.554933	Two1	4/4/2012	4/17/2012	5/2/2012	5/15/2012	5/30/2012	6/11/2012
Camp Cr.	205	44.598561	-118.870445	44.581861	-118.868087	Two1	4/3/2012	4/18/2012	5/1/2012	5/15/2012	5/30/2012	6/11/2012
Beaver Cr.	207	44.653062	-118.676446	44.666835	-118.664238	Two1	4/4/2012	4/17/2012	5/1/2012	5/15/2012	5/30/2012	6/11/2012
Butte Cr.	208	44.641116	-118.651086	44.623678	-118.646575	Two1	4/4/2012	4/17/2012	5/1/2012	5/15/2012	5/30/2012	6/11/2012
Camp Cr.	209	44.664121	-118.809709	44.653061	-118.827537	Two1	4/3/2012	4/18/2012	5/1/2012	5/15/2012	5/30/2012	6/11/2012
Granite Boulder Cr.	211	44.667020	-118.631332	44.679010	-118.613631	Two1	4/17/2012	5/9/2012	5/16/2012	5/31/2012	6/14/2012	

Table 3. Continued.

		Start		End			Survey Dates					
Stream	Site ID	Latitude (DD)	Longitude (DD)	Latitude (DD)	Longitude (DD)	Panel	1	2	3	4	5	6
MFJDR	215	44.633881	-118.614493	44.629765	-118.596531	Two1	5/10/2012	5/12/2012	6/5/2012			
Squaw Cr.	216	44.547916	-118.406039	44.530217	-118.409965	Two1	4/9/2012	4/23/2012	5/8/2012	5/21/2012	6/5/2012	
Camp Cr.	217	44.560599	-118.825166	44.569114	-118.805259	Two1	4/24/2012	5/7/2012	5/22/2012	6/6/2012		
MFJDR	220	44.616680	-118.561656	44.607720	-118.547387	Two1	4/4/2012	5/10/2012	5/21/2012	6/5/2012		
MFJDR	223	44.641813	-118.637917	44.635325	-118.621188	Two1	4/16/2012	5/10/2012	5/21/2012	6/11/2012		
MFJDR	224	44.593972	-118.500983	44.603903	-118.483976	Two1	4/5/2012	5/3/2012	5/16/2012	6/5/2012		
Cottonwood Cr.	225	44.652060	-118.868870	44.656070	-118.890590	Two1	4/10/2012	4/24/2012	5/7/2012	5/12/2012		
Indian Cr.	226	44.847190	-118.822240	44.832750	-118.813850	Two1	4/30/2012	5/15/2012	5/29/2012	6/12/2012		
Wray Cr.	227	44.681440	-118.711140	44.691790	-118.691100	Two1	4/5/2012	4/18/2012	5/3/2012	5/16/2012	5/31/2012	6/14/2012

Table 4. Total redds, redd density, and number of wild, hatchery, and unknown live steelhead observed during spawning ground survey sites in 2012. MFJDR = Middle Fork John Day River.

Stream	Site ID	Redds	Distance	Redd Density Redds/KM	Wild Steelhead	Hatchery Steelhead	Unknown Steelhead
Beaver Cr.	207	24	1.9	12.6	12	0	1
Butte Cr.	208	21	2	10.5	11	0	3
Davis Cr.	116	16	2	8.0	6	0	0
Summit Cr.	108	15	2.1	7.1	2	0	1
W.F. Lick Cr.	114	13	2	6.5	11	0	0
Camp Cr.	110	12	2	6.0	8	0	1
Rush Cr.	101	11	2	5.5	1	0	0
Little Boulder Cr.	127	10	2	5.0	4	0	0
Indian Cr.	125	9	2.1	4.3	4	0	0
Caribou Cr.	204	9	2	4.5	2	0	0
Camp Cr.	217	7	2	3.5	4	0	0
Camp Cr.	205	5	2	2.5	0	0	2
Camp Cr.	209	5	2	2.5	3	0	0
MFJDR	120	4	2.1	1.9	0	0	2
Idaho Cr.	124	4	2.1	1.9	0	0	0
Lick Cr.	130	4	2	2.0	2	0	4
Wray Cr.	227	4	2.1	1.9	6	0	1
Big Cr.	122	3	2	1.5	1	0	1
Indian Cr.	214	3	1.8	1.7	4	0	2
MFJDR	215	3	1.6	1.9	0	0	0
MFJDR	223	3	2	1.5	0	0	0
MFJDR	102	2	2	1.0	1	0	0
Big Boulder Cr.	203	2	2	1.0	3	0	0
MFJDR	115	1	1.9	0.5	0	0	0
MFJDR	119	1	2	0.5	0	0	1
Vinegar Cr.	123	1	2	0.5	0	0	1
Granite Boulder Cr.	211	1	2	0.5	3	0	0
Squaw Cr.	216	1	2.1	0.5	0	0	0
MFJDR	224	1	2.3	0.4	0	0	0
Indian Cr.	109	0	2.1	0.0	0	0	0
MFJDR	113	0	1.9	0.0	0	1	0
Bear Cr.	118	0	2	0.0	0	0	0
Big Cr.	201	0	2	0.0	0	0	0
MFJDR	220	0	2	0.0	0	0	0
Cottonwood Cr.	225	0	2	0.0	0	0	0
Indian Cr.	226	0	1.9	0.0	0	0	0

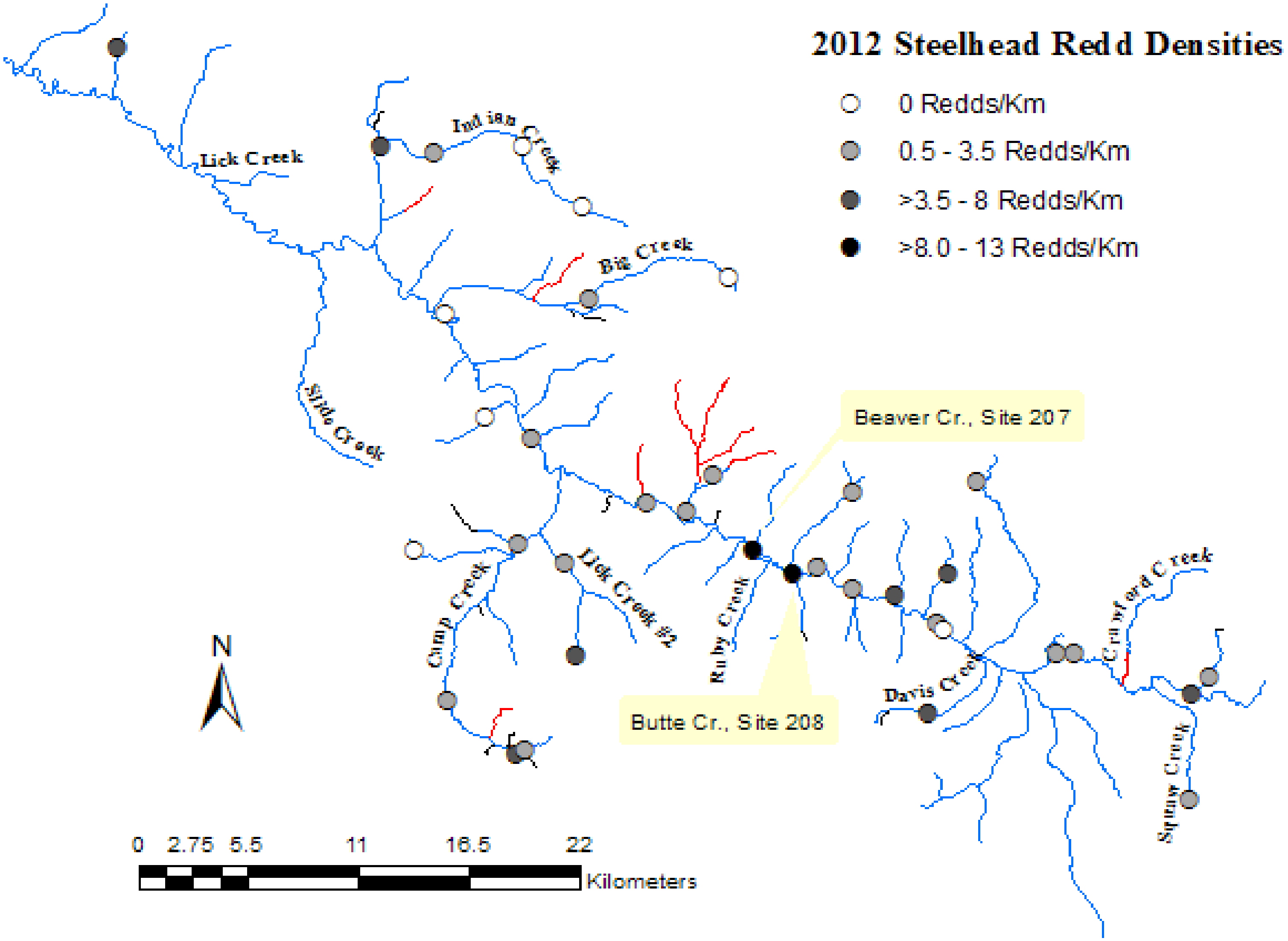

Figure 6. Redd densities at steelhead spawning sites surveyed in the MFJDR IMW during 2012.

Table 5. Distance surveyed, number of redds observed, estimated redd density, and steelhead spawner escapement estimates (± 95% CI) from 2008 through 2012 in the MFJDR IMW.

Year	Kilometers Surveyed	Unique Redds	Redd/km	Total Redds	Escapement
2008	57.5	24	0.41	192	769 (-135-1675)
2009	57.9	76	1.30	556	2,114 (1,326-2,901
2010	60.3	163	2.70	1,141	1,820 (1,041-2,598)
2011	61.0	116	1.90	777	3,692 (2,055-5,327)
2012	72.0	195	2.74	1,148	3,494 (2,420-4,570)

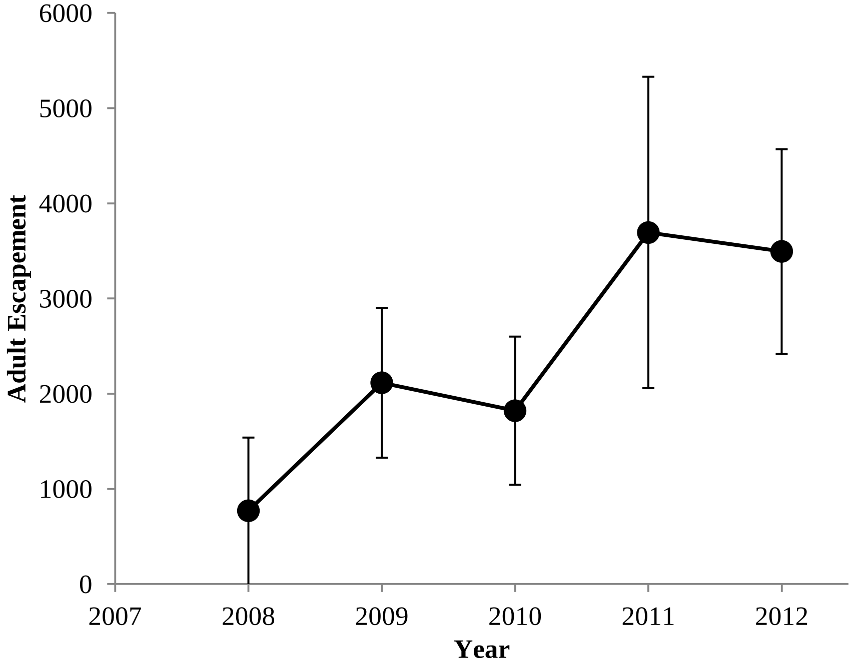

Figure 7. Annual adult steelhead escapement estimates in the MFJDR IMW from 2008 to 2012. Error bars represent ±95% CI.

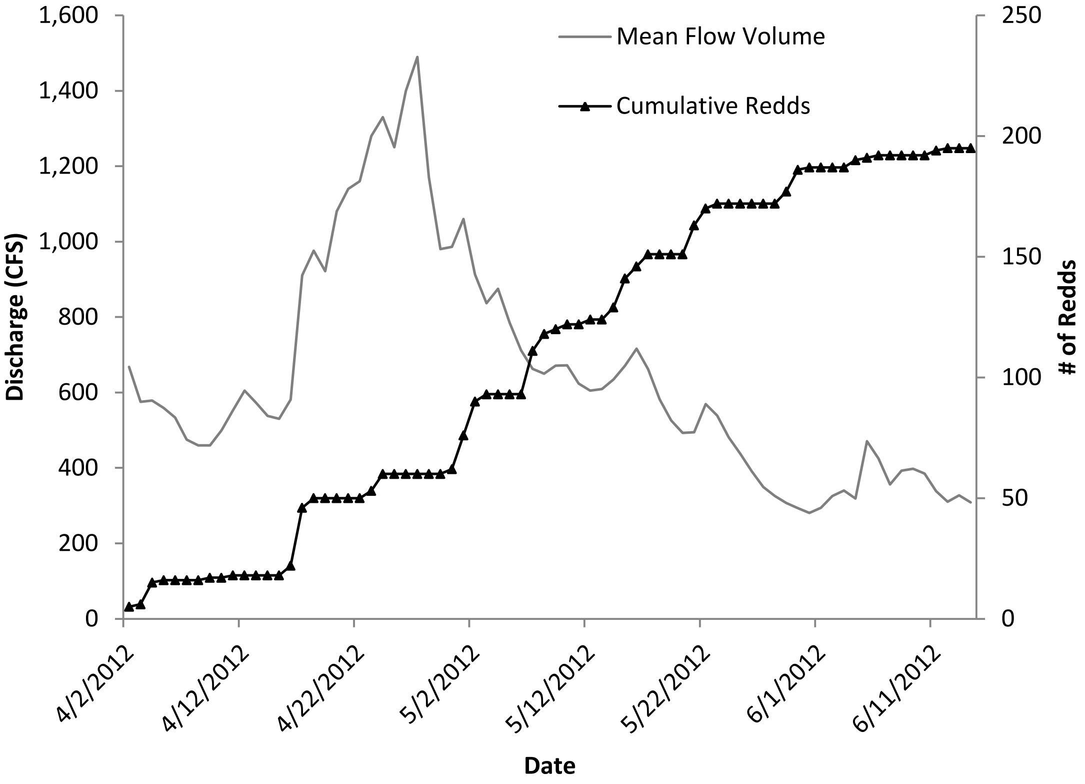

Figure 8. Cumulative redd construction in the MFJDR IMW and mean daily discharge in cubic feet per second (USGS provisional data October 2012) measured at the USGS gauging station near Ritter, OR from April 2, 2012 through June 14, 2012.

Spring Chinook Adult Escapement

We counted a total of 492 Chinook redds in the MFJDR sub-basin and 727 adult carcasses. For a more detailed description of Chinook escapement see Bare et al. (2013 in draft).

Adult PIT tag Detections

Twenty-two adult steelhead were detected at the Middle Fork array during the 2012 spawning season. Of those, 17 were tagged either as parr or smolts within the MFJDR IMW and five were tagged outside of the MFJDR as adults (Table A. 2). Four of the adult steelhead detected in the MFJDR were also detected at McNary Dam (Table A. 2). Additionally, two adult steelhead were detected downstream of Bates Pond in Bridge Creek during 2012 (Table A. 2). Forty-six adult spring Chinook salmon were detected in 2012 at the MFJDR PIT tag array (Table A. 3). Twenty-eight of these fish were tagged in the MFJDR as either parr or smolts and 17 were tagged outside the John Day Basin as adults (Table A. 3).

Summary Steelhead and Spring Chinook Parr Monitoring

We PIT tagged a total of 7,933 fish in 2012 including 4,659 juvenile Chinook, 3,269 juvenile steelhead (Table 6). Five new bull trout were captured and tagged and one bull trout was recaptured in Granite Boulder Creek (Table 6).

Table 6. Number of fish by species tagged at parr monitoring sites in the MFJDR IMW duing 2012.

Tag Site	Chinook	Steelhead	Bull Trout	Total
Camp Lower 1	771	549	0	1,294
Camp Lower 2	187	560	0	757
Camp Middle 1	57	565	0	624
Camp Upper 1	0	166	0	166
GRB Lower 2	1	183	3	187
GRB Upper 1	0	86	2	88
Bridge Creek	36	145	0	181
Lower Vinegar Cr.	393	215	0	608
Coyote Cr.	6	55	0	61
MF Lower Treatment	193	17	0	210
MF Lower Control	165	64	0	229
MF Mid Treatment 1	516	16	0	532
MF Mid Treatment 2	583	88	0	671
MF Mid Control 1	614	48	0	662
MF Mid Control 2	550	215	0	765
MF Upper Treatment	227	94	0	321
MF Upper Control	360	203	0	563
TOTAL	**4,659**	**3,269**	**5**	**7,933**

Juvenile Summer Steelhead Closed Population Modeling

Abundance estimates of juvenile steelhead in Camp Creek and Granite Boulder Creek yielded varying results among both streams and sites (Figure 8). Abundance estimates were highest in the Fall at all sites except GRB_UPR-1. Abundance estimates at the two lowest Camp Creek sites; CMP_LWR-1 and CMP_LWR-2, showed nearly a 60% and 81% increase, respectively, in abundance from Summer to Fall (Figure 8).

Juvenile Chinook were abundant at both lower Camp Creek sites. A total of 357 juvenile Chinook were tagged at sites in Camp Creek in the Summer and an additional 644 were captured and tagged in the Fall (Table 7). Twenty-two of the juvenile Chinook tagged in the Summer at closed population sites were recaptured in the Fall (Table 7).

Parr monitoring at closed population sites in Camp Creek showed similar abundance of steelhead parr to 2011 estimates (Handley et al. 2012) with the exception of CMP_LWR-2 (Figure 10). Abundance estimates at CMP_LWR-2 showed a statistically significant increase in abundance from 2011 to 2012 (Figure 10). Abundance estimates for juvenile steelhead at this site showed an increase of 263% from Summer 2011 to Summer 2012 and nearly a 400% increase in abundance of juvenile steelhead from Fall 2011 to Fall 2012 (Figure 10).

Table 7. Camp Creek and Granite Boulder Creek fish captures during Summer (June, July) and Fall (October) of 2012. Numbers in parentheses were recaptured from previous sampling events.

Site	Steelhead		Chinook		Bull Trout	
	Summer	Fall	Summer	Fall	Summer	Fall
CMP_LWR-1	274 (42)	434 (117)	373	408 (10)	0	0
CMP_LWR-2	161 (20)	492 (75)	3	194 (10)	0	0
CMP_MID-1	270 (6)	402 (102)	17	42 (2)	0	0
CMP_UPR-1	52 (11)	146 (21)	0	0	0	0
GRB_LWR-2	105 (15)	120 (28)	0	1	4	0
GRB_UPR-1	60 (5)	48 (17)	0	0	1	1

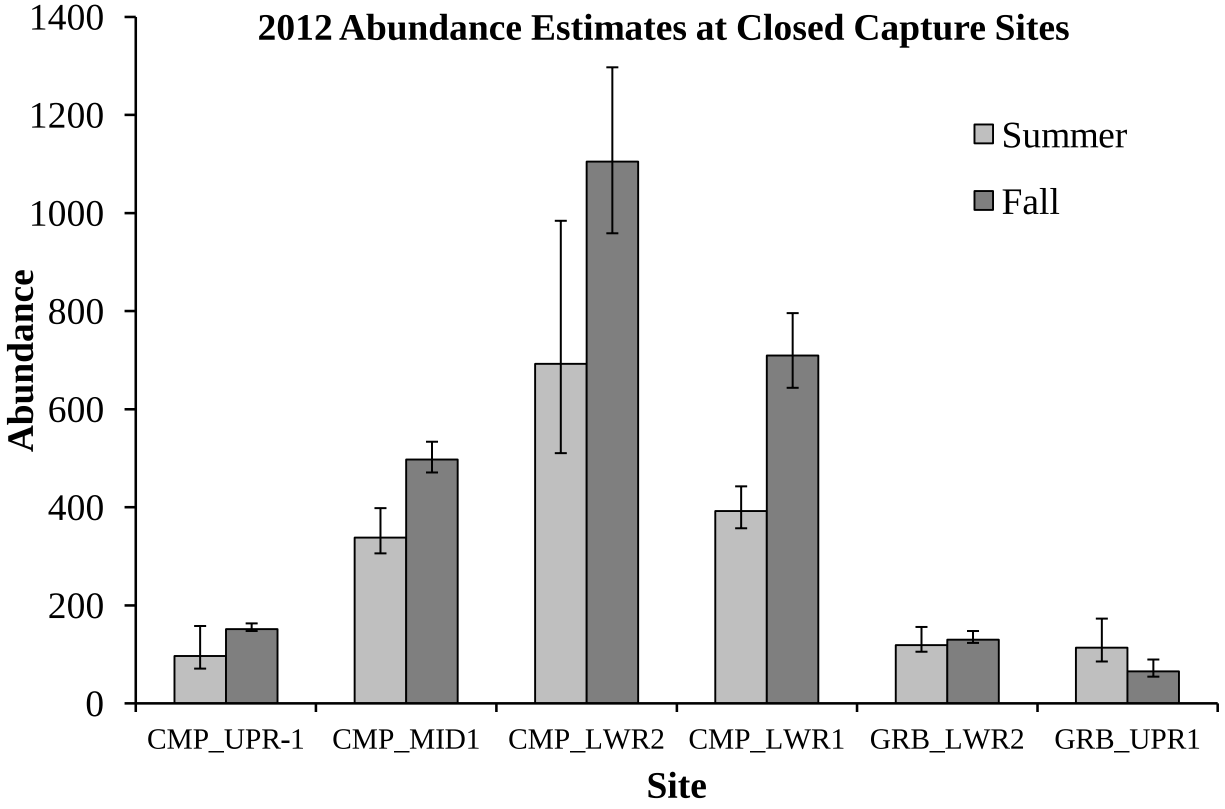

Figure 9. Abundance estimates (± 95% CI) for juvenile steelhead in Camp Creek (CMP prefix) and Granite Boulder Creek (GRB prefix) for Summer (June-July) and Fall (October-November) sampling during 2012.

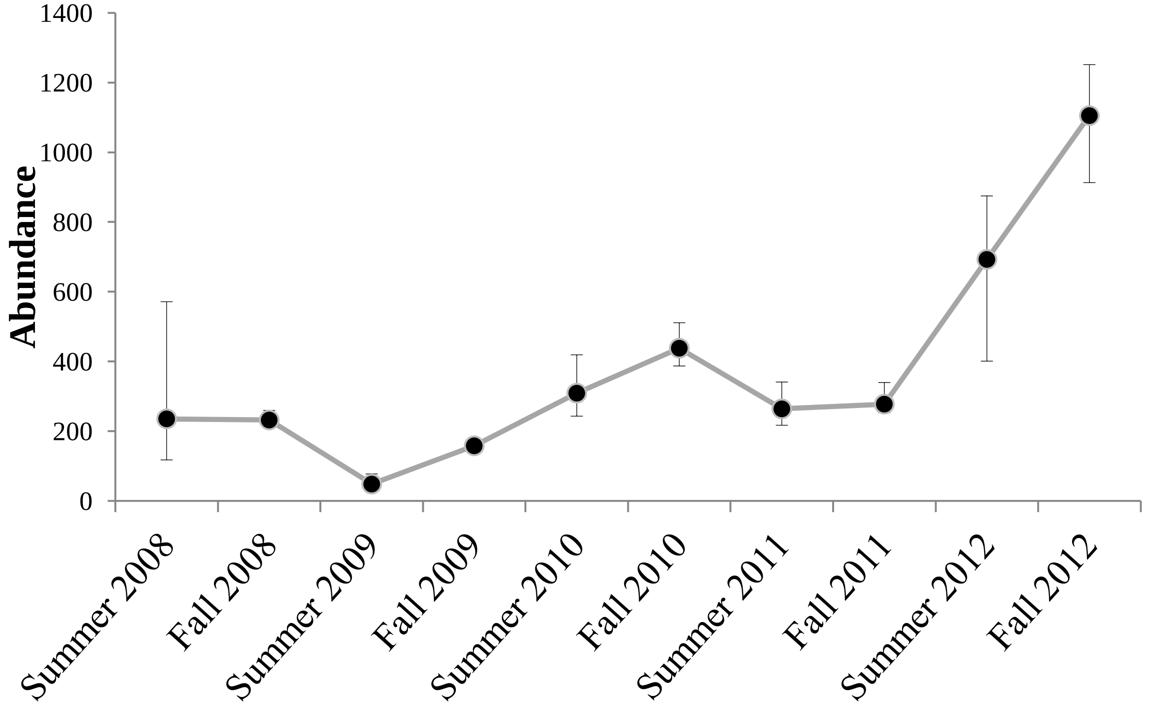

Figure 10. Abundance estimates for CMPLWR-2 in Camp Creek from Summer 2008 to Fall 2012. Error bars represent ±95% confidence intervals.

Juvenile Chinook and Steelhead Open Population Modeling (POPAN)

Open population model results varied for each parameter at each site. The estimates for apparent survival during the last interval are confounded with the final probability of capture at all sites. Apparent survival rates for juvenile Chinook varied from 78% at Mid Control-1 to 39% at Mid Treatment-1 for August to September (Table 8). Model averaged survival parameters were not estimable for August to September at the Upper Treatment site (Table 8). Model results indicate apparent survival was highest for July to August at the Upper and Lower Control sites and lowest at the Mid Treatment-1 site for August to September (Table 8). Apparent survival rates were lowest between July and August at three of the nine sites and lowest between August and September at five of the nine sites (Table 8).

It is likely that the PENT parameters were substantially influenced by recruitment of juvenile Chinook to tagging gear, especially prior to September captures. During July, 39% of juvenile Chinook captured were less than 60 mm FL, 13% were less than 60 mm FL in August , and by September less than 3% were less than 60mm FL (Table 11). Net new entrants were greatest between July and August at seven of the nine sites (Table 9). The greatest number of net new entrants occurred at Mid Treatment-2 during this period (Table 9).

Model results for abundance are not reliable for the final interval due the confounded survival and probability of entry parameters. Abundance estimates ranged from a low of 54 juvenile Chinook at the Upper Treatment site in July to a high of 610 juvenile Chinook at the Mid Control-1 site in September (Table 10). Abundance estimates decreased from July to September at two of the nine sites, and increased from July to September at seven sites (Table 10).

We recaptured two juvenile Chinook outside of the sites where they were first tagged during 2012 sampling. One was tagged at Mid Control-2 on July 13, 2012 and recaptured October 8, 2012 at Mid Treatment-2, approximately 7 km apart. The other emigrant recapture was tagged at Mid Control-1 on October 5, 2012 and recaptured at Lower Control on October 12, 2012, approximately 17 km apart. One juvenile Chinook tagged during sampling in 2011 at Mid Treatment-2 was recaptured at the same site on July 15, 2012 and again on August 8, 2012.

Table 8. Estimates (95% CI) of apparent survival for juvenile Chinook at open population sites during 2012. Shaded cells indicate estimates which are inestimable. For the final interval, survival estimates are confounded with probability of capture.

Site	July - August	August - September	September - October
Lower Treatment	0.456 (0.222–0.711)	0.465 (0.207–0.743)	0.448 (0.299–0.607)
Lower Control	0.727 (0.565–0.846)	0.690 (0.487–0.840)	0.718 (0.536–0.849)
Mid Treatment 1	0.430 (0.259–0.619)	0.392 (0.240–0.568)	0.500 (0.000–1.000)
Mid Treatment 2	0.534 (0.406–0.658)	0.433 (0.272–0.610)	0.488 (0.381–0.596)
Mid Control 1	0.625 (.0490–0.743)	0.780 (0.257–0.973)	0.471 (0.187–0.775)
Mid Control 2	0.546 (0.451–0.638)	0.572 (0.422–0.710)	0.479 (0.309–0.654)
Upper Treatment	0.394 (0.245–0.567)	1.000 (0.998–1.002)	0.815 (0.520–0.947)
Upper Control	0.740 (0.518–0.883)	0.693 (0.481–0.846)	0.652 (0.373–0.856)
Vinegar Cr.	0.598 (0.456–0.725)	0.558 (0.410–0.696)	0.623 (0.385–0.813)

Table 9. Estimates (95% CI) of net new entrants between sampling intervals for juvenile Chinook at open population sites during 2012.

Site	July - August	August - September	September - October
Lower Treatment	179 (64–294)	0 (0–1)	39 (2–76)
Lower Control	8 (-44–59)	0 (0–1)	68 (28–108)
Mid Treatment 1	193 (87–229)	357 (167–547)	0 (-1–1)
Mid Treatment 2	487 (383–590)	4 (-37–45)	36 (11–62)
Mid Control 1	388 (296–480)	208 (54–362)	90 (38–218)
Mid Control 2	326 (131–520)	13 (-40–67)	20 (-3–43)
Upper Treatment	114 (57–172)	67 (11–124)	36 (9–64)
Upper Control	364 (160–569)	30 (-50–109)	77 (5–149)
Vinegar Creek	153 (56–250)	115 (48–182)	71 (5–137)

Table 10. Estimates (95% CI) of overall abundance at open population sites for spring Chinook salmon parr during 2012. Shaded estimates during the final interval are not accurate due to confounded parameters.

Site	July	August	September	October
Lower Treatment	100 (83–117)	225 (92–358)	104 (33–176)	60 (4–116)
Lower Control	203(122–285)	156 (116–196)	108 (70–146)	124 (62–186)
Mid Treatment-1	389 (358–420)	360 (192–529)	497 (276–718)	145 (-7,025–7,316)
Mid Treatment-2	216 (190–243)	602 (481–723)	264 (152–375)	100 (44–155)
Mid Control-1	207 (181–233)	517 (407–628)	610 (293–926)	228 (60–517)
Mid Control-2	379 (102–656)	532 (431–633)	317 (229–405)	95 (23–167)
Upper Treatment	55 (24–85)	136 (81–191)	203 (172–234)	174 (88–260)
Upper Control	162 (-9–334)	483 (343–623)	363 (237–489)	239 (43–436)
Vinegar Creek	207 (41–372)	279 (203–354)	270 (181–359)	177 (43–311)

Table 11. Proportion of juvenile spring Chinook captured at all POPAN sites < 60 mm FL at each sampling interval.

	July	August	September	October
Proportion <60 mm FL	0.391	0.127	.024	0.001

Model averaging for steelhead only generated meaningful results at only five of the ten sites modeled due to sparse data and was most successful at sites that were electro-fished: Upper Control, Vinegar Creek, and Coyote Creek. The estimates for apparent survival during the last interval are confounded with the final probability of capture at all sites. The lowest apparent survival estimate was at the Upper Treatment site for July to August (Table 12). The highest apparent survival estimate was at the Lower Control site for July to August but was imprecise (Table 12). Model results indicate a declining survival rate at the Upper and Lower Control sites and an increasing survival rate at the Upper Treatment and Vinegar Creek sites from July through October (Table 12). Estimates for apparent survival rates remained relatively constant in Coyote Creek throughout the study period (Table 12).

Entry to these populations was highest for the Upper and Lower Control sites from July to August and September to October, respectively (Table 13). Entry was lowest for the Lower Control site from August to September and at Coyote Creek from July to August (Table 13). Entry later in the summer at these sites can be partially attributed to age zero steelhead recruiting to our tagging gear by growing to 60mm FL (Tables 14 and 15).

Model results for these sites showed the highest abundance at the Vinegar Creek site in September and Upper Control in August (Table 15). Abundance estimates increased from July to September at all sites except at the Lower Control site (Table 15). Coyote Creek had the lowest abundance estimate during all sampling intervals (Table 15). The absolute number of steelhead < 60 mm FL counted in Coyote Creek was greater than the abundance estimate of steelhead ≥ 60mm FL for all sampling intervals (Tables 14 and 15).

Table 12. Estimates (95% CI) of apparent survival for juvenile steelhead at open population sites during 2012. Shaded estimates during the final interval are confounded with probability of capture and are not accurate.

Site	July - August	August - September	September - October
Lower Control	0.955 (0.098–1.000)	0.736 (0.244–0.960)	0.605 (0.153–0.928)
Upper Treatment	0.515 (0.125–0.888)	0.791 (0.096–0.993)	0.679 (0.280–0.920)
Upper Control	0.890 (0.508–0.985)	0.763 (0.492–0.915)	0.788 (0.464–0.941)
Vinegar Creek	0.623 (0.444–0.774)	0.854 (0.455–0.976)	0.809 (0.304–0.976)
Coyote Creek	0.814 (0.647–0.913)	0.811 (0.621–0.919)	0.813 (0.645–0.912)

Table 13. Estimates (95% CI) of net new entrants of juvenile steelhead between sampling intervals at open population sites during 2012.

Site	July - August	August - September	September - October
Lower Control	2 (-313–317)	0 (0–0)	131 (-152–414)
Upper Treatment	38 (-15–91)	88 (4–173)	27 (-17–71)
Upper Control	133 (57–210)	6 (-27–40)	57 (13–100)
Vinegar Creek	86 (-1–174)	46 (-5–98)	20 (-16–57)
Coyote Creek	0 (0–1)	11 (2–20)	25 (13–38)

Table 14. Count of juvenile steelhead <60 mm FL captured at open population sites modeled during sampling intervals in 2012.

Site	July	August	September	October
Lower Control	1	13	2	0
Upper Treatment	3	1	1	0
Upper Control	7	23	18	1
Vinegar Cr.	11	27	82	112
Coyote Cr.	90	60	106	95

Table 15. Estimates (95% CI) of abundance for juvenile steelhead parr at open population sites during 2012. Shaded estimates during the final interval are not reliable due to confounded parameters.

Site	July	August	September	October
Lower Control	89 (-231–408)	86 (36–136)	63 (10–117)	156 (-159–472)
Upper Treatment	41 (-10–93)	60 (-4–125)	135 (11–259)	91 (-13–194)
Upper Control	80 (17–144)	204 (149–259)	162 (114–209)	160 (48–273)
Vinegar Cr.	162 (20–305)	187 (129–245)	205 (144–267)	159 (26–292)
Coyote Cr.	30 (20–41)	25 (16–34)	32 (21–43)	46 (29–64)

Spring Chinook salmon Parr Summer Rearing Distribution

We sampled six tributary streams in the MFJDR IMW to assess summer rearing distribution of juvenile Chinook in 2012 (Figure 11). The observed summer distribution of juvenile Chinook during 2012 was similar in comparison to that observed from 2008- 2011 in streams sampled all years (James et al. 2009, 2010, 2011; Handley et al. 2012). No juvenile Chinook were observed in Summit Creek upstream of the Squaw and Summit Creek confluence (Figure 11). We did not reach the end of the Chinook parr distribution in Little Boulder Creek but we did confirm the presence of juvenile Chinook at least one kilometer upstream of the mouth. In Lick Creek, the distribution of juvenile Chinook ended approximately 1.7 km downstream of the confluence with West Fork Lick Creek (Figure 9) and was 1.3 km lower than the 2011 distribution (Handley et al. 2012). Juvenile Chinook distribution in Camp Creek appears to be restricted to the lower 12.5 km of stream due to a 2-3 m high log debris jam. In Big Creek, juvenile Chinook were observed as far as 1.2 km upstream of the mouth of Deadwood Creek (Figure 11). Juvenile Chinook distribution in Bridge Creek was 1.5 km farther than previously documented (James et al. 2009, 2010, 2011; Handley et al. 2012).

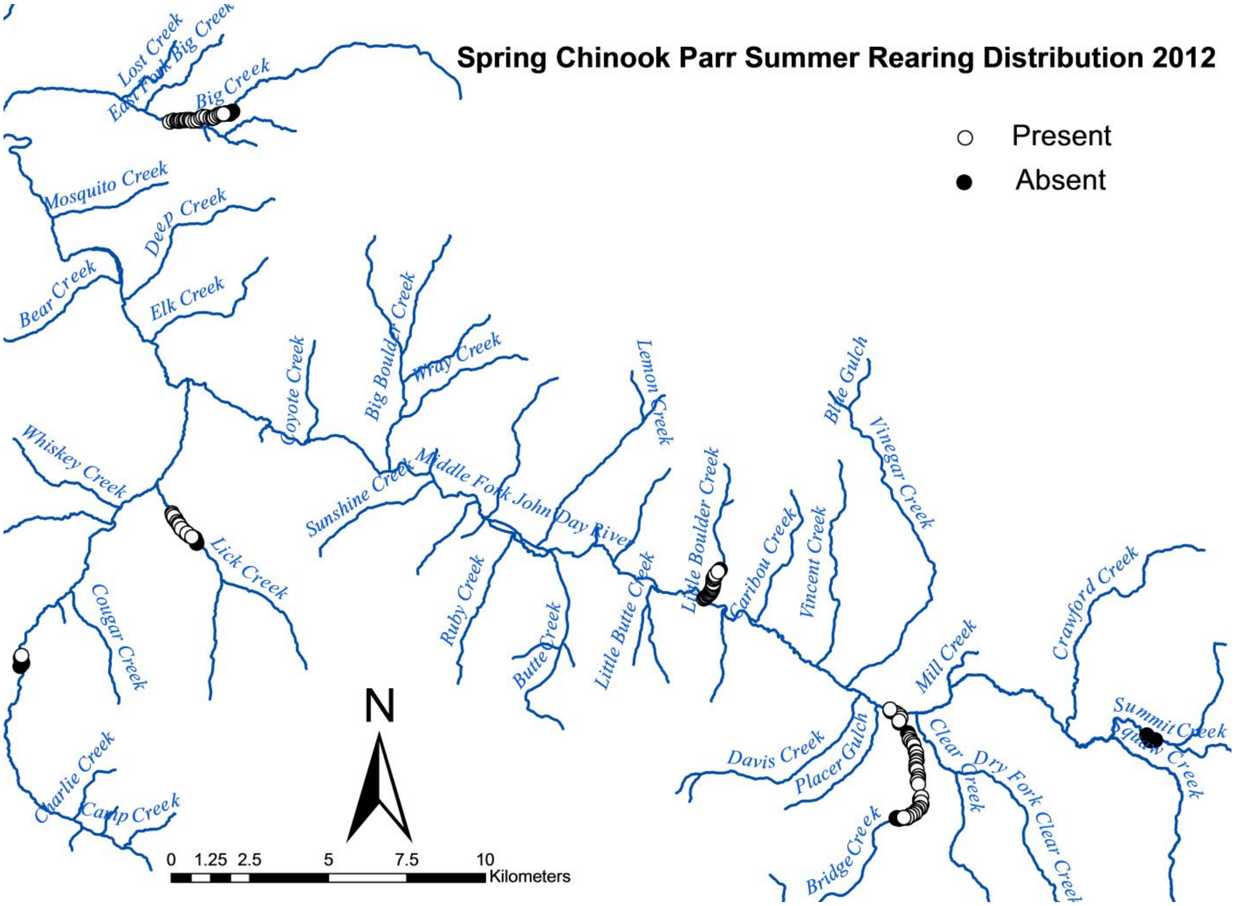

Figure 11. Map of pools surveyed for juvenile Chinook presence or absence in 2012. Open circles represent pools where juvenile Chinook were observed and closed circles represent pools where no juvenile Chinook were observed.

Bates Pond Juvenile Passage

In June 2012, 181 previously unmarked salmonids were captured and PIT-tagged upstream and downstream of Bates Pond (Table 16, Table 17). Juvenile detections at the Bridge Creek PIT-tag arrays totaled 20 Chinook and 99 steelhead from January 1, 2012 through November 26, 2012 (Tables 16 and 17). Eight juvenile steelhead and five juvenile Chinook tagged downstream of Bates Pond were detected at the upper Bridge Creek array (Tables 16 and 17). Five of the juvenile steelhead detected at the upper Bridge Creek array were tagged outside of Bridge Creek: one at CMP_LWR-2 in July 2011, and four in the MFJDR from RKM 99 to RKM 109 in July 2011. Three of the five juvenile spring Chinook detected at the upper Bridge Creek antennae were tagged outside of Bridge Creek: two were tagged in July 2011 at RKM 109 in the MFJDR and one at the Mid Control-2 site in August 2011.

Table 16. Number, year, and location of juvenile steelhead tagged in Bridge Creek and subsequent detections at Bridge Creek arrays by year.

			Lower Antennae			Upper Antennae		
Tagging Location	Year Tagged	# Tagged	2010	2011	2012	2010	2011	2012
Lower Bridge Cr.	2010	256	14	2	0	0	0	0
	2011	45		1	1		0	1
	2012	52			8			2
Upper Bridge Cr.	2010	85	3	21	2	91	23	3
	2011	30		5	3		18	8
	2012	94			1			52
Outside Bridge Cr.	2010	2089	0	0	0	0	0	0
	2011	1995		2	5		0	5
	2012	3120			8			0

Table 17. Number, year, and location of juvenile Chinook tagged in Bridge Creek and subsequent PIT tag detection locations at Bridge Creek antennae by year.

			Lower Antennae			Upper Antennae		
Tagging Location	Year Tagged	# Tagged	2010	2011	2012	2010	2011	2012
Lower Bridge Cr.	2010	50	6	2	-	0	0	-
	2011	3		3	0		0	0
	2012	35			6			2
Upper Bridge Cr.	2010	3	0	1	-	2	0	-
	2011	0		0	0		0	0
	2012	1			0			0
Outside Bridge Cr.	2010	1,920	0	0	-	0	0	-
	2011	3,651		1	1		0	3
	2012	4,623			8			0

Summer Steelhead and Spring Chinook Smolt Monitoring

Juvenile PIT Tag Detections

Only 34% of fish PIT-tagged in the MFJDR IMW from 2008-2011 were re-observed during subsequent capture or interrogation events (Tables18-22). The fewest capture events occurred at the MFJDR RST near Ritter with a total of 399 recaptures (<3%) of all fish tagged as part of the IMW project from July 1, 2008 to July 1, 2012.

For 2012, in-stream recapture rates for steelhead tagged in 2011 were 4% in Granite Boulder Creek and 3% in Camp Creek. Detections of fish tagged in 2011 at the MFJDR PIT tag array for steelhead tagged in 2011 during the 2012 migration year are 7% for Camp Creek and 3% for Granite Boulder Creek.

Table 18. Juvenile steelhead PIT-tagged in Camp Creek and subsequent detections at various interrogation/capture sites in the MFJDR and smolt migration corridor.

Tag Year	Unique Tags	In-stream Recaptures				MF Array Detections				MF RST Recaptures				Out-of-basin Detections			
		2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
2008	1055	56	4	1	0	40	31	5	1	2	5	1	0	35	19	3	0
2009	962		75	2	0		102	26	4		2	2	0		15	43	3
2010	1717			42	4			119	83			3	17			55	53
2011	1837				59				129				3				24

Table 19. Juvenile steelhead PIT-tagged in Granite Boulder Creek and subsequent detections at various interrogation/capture sites in the MFJDR and smolt migration corridor.

Tag Year	Tags	In-stream Recaptures				MF Array Detections				MF RST Recaptures				Out-of-basin Detections			
		2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
2008	461	56	17	1	1	3	14	2	0	1	0	0	0	4	10	5	0
2009	359		33	2	0		14	2	0		0	0	0		3	6	2
2010	233			9	2			1	2			0	0			3	3
2011	268				11				8				0				4

Table 20. Juvenile Chinook PIT-tagged in Camp Creek and subsequent detections at various interrogation/capture sites in the MFJDR and smolt migration corridor.

		MF Array Detections				MF RST Recaptures				Out-of-basin Detections			
Tag Year	Tags	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
2008	42	0	0	0	0	0	0	0	0	6	0	0	0
2009	292		71	0	0		6	0	0		20	0	0
2010	247			59	1			11	0			47	0
2011	1015				21				8				13

Table 21. Juvenile Chinook PIT-tagged in Granite Boulder Creek and subsequent detections at various interrogation/capture sites in the MFJDR and smolt migration corridor.

		MF Array Detections				MF RST Recaptures				Out-of-basin Detections			
Tag Year	Tags	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
2008	94	0	0	0	0	7	0	0	0	12	0	0	0
2009	254		44	0	0		8	0	0		20	0	0
2010	2			0	0			0	0			0	0
2011	4				1				0				2

Table 22. Juvenile Chinook PIT-tagged in the MFJDR and subsequent detections at various interrogation/capture sites in the Middle Fork John Day River and smolt migration corridor.

		MF Array Detections				MF RST Recaptures				Out-of-basin Detections			
Tag Year	Tags	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
2008	950	0	0	0	0	39	0	0	0	115	0	0	0
2009	1285		234	0	0		36	0	0		97	0	0
2010	1671			176	0			14	0			116	0
2011	3208				445				234				453

Spring Chinook Smolt Survival Monitoring

Survival rates for Chinook smolts during the 2012 migration year (MY) show a consistent survival rate between summer and fall tag groups to the MFJDR PIT-tag array (Table 23). Model results suggest a positive relationship in survival and FL for Chinook tagged as parr (Figure 12). However, this relationship was only informative for survival estimates from tagging to the MFJDR Array. Model estimates for survival indicate an increasing survival rate as smolts migrate downstream. Model results suggest the lowest detection rate of MFIMW tagged smolts was at the RST where 18.3% of all IMW tagged smolts were recaptured. The highest detection probability during the 2012 MY occurred at John Day Dam with a 38% detection rate, only slightly higher than the MFJDR array at 31%.

Table 23. Estimates (95% CI) of survival and probability of detection of PIT tagged Chinook salmon during the 2012 migration year. Shaded estimates of survival and detection probability during the final interval are confounded.

Parameter	MFJDR Array	MFJDR RST	John Day Dam	Bonnevile Dam
Survival	0.422 (0.381–0.464)	0.844 (0.651–0.940)	0.901 (0.372–0.993)	1.000 (0.000–1.000)
Detection	0.308 (0.273–0.344)	0.183 (0.153–0.219)	0.380 (0.290–0.479)	0.043 (0.030–0.062)

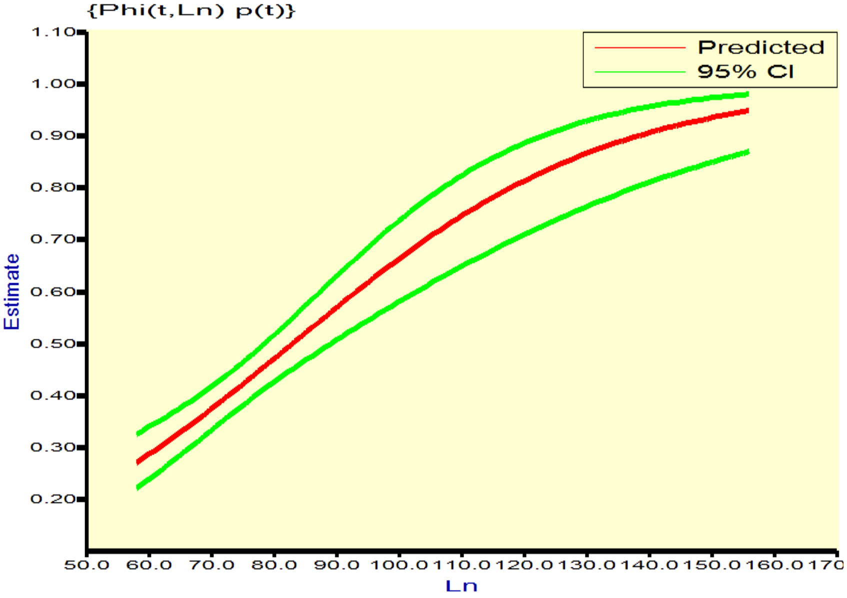

Figure 12. Relationship of length of juvenile Chinook at tagging and estimate of survival from tagging to the Middle Fork Array during the 2012 Migratory Year.

Summer Steelhead and Spring Chinook Smolt Abundance

Smolt abundance estimates at the MFJDR RST during MY 2012 were 47,869 for Chinook and 27,857 for steelhead (Table 24). For more information on fish captured and tagged at this trap, see Dehart et al. (in draft).

Table 24. Smolt abundance estimates (95% CI) for spring Chinook salmon and summer steelhead from the MF RST 2012 migration year. LCI = Lower 95% CI, UCI = Upper 95%CI.

Species	Trapping Period	Captured	Marked	Abundance
Chinook	10/10/2011–6/14/2012	10,110	3,492	47,869 (45,911–46,986)
Steelhead	10/10/2011–6/14/2012	2,236	1,462	27,857 (23,740–32,431)

DISCUSSION

Higher steelhead escapement in 2011 and 2012 has likely contributed to the increase in abundance of juvenile steelhead in Camp Creek, especially at sites lower in this stream (Handley et al. 2012). The disproportionate increase in steelhead abundance at CMP_LWR-2 from 2011 to 2012 may have been influenced by stream restoration work at this site, which underwent extensive habitat modifications in the summer of 2011. Although abundance at this site has increased, survival estimates will be an important metric to evaluate the true potential of such activities. We will continue to collect data at these sites and refine our modeling to generate estimates for survival.

Parr monitoring at open population sites during the 2012 summer season showed high abundance of spring Chinook in the MFJDR early in the summer and lower abundance later in the summer. Abundance estimates were highly variable temporally and spatially between sites and only reflect the number of spring Chinook parr ≥ 60 mm FL. We were unable to mark many of these fish early in the summer due to their small size. Therefore abundance estimates later in the season better reflect the overall abundance of juvenile Chinook since fewer fish < 60 mm were captured after September. A high estimate of new entrants to the Mid Treatment-2 site from July to August was likely due to a fish salvage operation on the Oxbow Conservation Area. Further, the relatively high number of new entrants to the Lower Treatment site during October sampling may be an indication of some juvenile Chinook initiating downstream migrations in early fall.

The steelhead smolt abundance estimate for the MFJDR during MY 2012 was nearly 40% greater than the nine year mean. This compares to a 31% increase in the nine year mean in the South Fork John Day River control watershed (Dehart et al 2013 in draft). This is the highest MFJDR smolt abundance estimate from 2004 to 2012 but due to a low degree of precision in these estimates, this is only a statistically significant increase when compared to the 2008 and 2009 abundance estimates. The Chinook smolt abundance estimates for the MY 2012 in the MFJDR was nearly 100% greater than the nine year mean and is statistically significant compared to all previous years (2004–2012; Dehart et al, in draft).

Detection of juvenile salmonids tagged downstream of Bates Pond at the upper Bridge Creek antennae confirms that juvenile fish are capable of ascending the fish ladder over Bates Pond dam. Future research should focus on the thermal influence of Bates Pond on water temperature in Lower Bridge Creek and the MFJDR.

The MF array experienced periodic failure throughout the 2011-2012 winter during periods of inclement weather and minimal sunlight which decreased our detection capabilities. Efforts are being made to keep the array functional through these periods to increase detections of migrating PIT tagged fish.

Progress is being made on smolt per redd estimates for spring Chinook salmon and smolt to adult estimates for summer steelhead. For these estimates it is necessary to combine estimates of variance from estimates of adult escapement with smolt abundance for summer steelhead, and redd abundance (which has no variance) with smolt abundance for spring Chinook salmon.

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APPENDIX

Table A.1. Tagged adult steelhead detected at the MF array during 2012. Table includes life stage at tagging (LST), years spent in salt water (SY), and detection at McNary Dam (MCD).

PIT_ID	Detection Site	Detection Date	Tag Site	Tag Date	LST	FL	SY	MCD
3D9.1C2D4A009A	MF Array	3/16/2012	Middle Fork RST	4/29/2010	Smolt	181	1	N
3D9.1C2CFE7A0E	MF Array	3/24/2012	Middle Fork RST	5/14/2009	Smolt	190	2	N
3D9.1C2CFD87E0	MF Array	3/25/2012	Middle Fork RST	4/30/2009	Smolt	171	2	N
3D9.1C2CFECC0F	MF Array	3/26/2012	Middle Fork RST	5/15/2009	Smolt	172	2	N
3D9.1C2D496903	MF Array	4/1/2012	Middle Fork RST	5/18/2010	Smolt	170	1	N
3D9.1C2D4AAFCB	MF Array	4/2/2012	Middle Fork RST	5/11/2010	Smolt	198	1	N
3D9.1C2D49674D	MF Array	4/10/2012	Middle Fork RST	5/18/2010	Smolt	149	1	N
3D9.1C2D4AC2FD	MF Array	4/13/2012	Middle Fork RST	5/18/2010	Smolt	160	1	N
3D9.1C2D4B14F3	MF Array	4/14/2012	Middle Fork RST	4/23/2010	Smolt	156	1	N
3D9.1C2D4AD251	MF Array	4/15/2012	Middle Fork RST	5/6/2010	Smolt	187	1	Y
3D9.1C2C855CF7	MF Array	4/15/2012	Camp Creek	10/15/2008	Parr	179	U	N
3D9.1C2D57DF44	MF Array	4/16/2012	Camp Creek	10/12/2009	Parr	124	1	N
3D9.1C2D49F7A3	MF Array	4/25/2012	Middle Fork RST	5/12/2010	Smolt	209	1	Y
3D9.1C2D4B9A44	MF Array	5/9/2012	Middle Fork RST	5/6/2010	Smolt	158	1	N
3D9.1C2D4900E2	MF Array	5/9/2012	Middle Fork RST	5/12/2010	Smolt	154	1	Y
3D9.1C2D56D7CB	MF Array	5/10/2012	MFJDR	7/28/2009	Parr	102	1	N
3D9.1C2DB5472E	MF Array	3/26/2012	Bonneville Dam	8/8/2011	Adult	580	U	N
3D9.1C2DAC16C9	MF Array	3/31/2012	Bonneville Dam	7/5/2011	Adult	700	U	N
3D9.1C2DB1AC4C	MF Array	4/7/2012	Bonneville Dam	7/4/2011	Adult	565	U	Y
3D9.1C2DB33413	MF Array	4/17/2012	Bonneville Dam	7/8/2012	Adult	665	U	N
3D9.239F870B87	MF Array Lwr Bridge	5/2/2012 5/9/2012	Bonneville Dam	8/18/2011	Adult	560	U	N
3D9.1C2CFD87E0	Lwr Bridge	4/3/2012	Middle Fork RST	4/30/2009	Smolt	171	2	N

Table A.2. Adult spring Chinook Detections at the Middle Fork PIT tag array for the 2012 migration year. Table includes river kilometer of tag site (Tagging RKM) and life stage at tagging (LST)

PIT Code	Detection Date	Tag Site	RKM	LST
3D9.1C2DA66681	5/29/2012	Columbia River	0.045	Adult
3D9.1C2DA6725F	6/4/2012	Columbia River	0.045	Adult
3D9.1C2DD5A5D2	6/12/2012	Columbia River	0.045	Adult
3D9.1C2DA6B1B6	6/13/2012	Columbia River	0.045	Adult
3D9.1C2DE8C43B	5/27/2012	Bonneville Dam	0.045	Adult
384.1B7976A040	5/29/2012	Bonneville Dam	0.045	Adult
3D9.1C2DE883F9	6/1/2012	Bonneville Dam	0.045	Adult
3D9.1C2DE800AE	6/3/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB4EE8D	6/4/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB53283	6/4/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB53D19	6/4/2012	Bonneville Dam	0.045	Adult
3D9.1C2DE8516F	6/11/2012	Bonneville Dam	0.045	Adult
3D9.1C2DE8AEAA	6/12/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB4C6CC	6/14/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB6B09D	6/23/2012	Bonneville Dam	0.045	Adult
3D9.1C2DAFDB6C	6/25/2012	Bonneville Dam	0.045	Adult
3D9.1C2DB1FD28	6/7/2012	Lwr Granite Dam	522.173	Adult
3D9.1C2DB06EC2	7/5/2012	Lwr Granite Dam	522.173	Adult
3D9.1C2D4B2B60	5/28/2012	John Day River	296	Smolt
3D9.1C2D4B12DD	5/28/2012	John Day River	296	Smolt
3D9.1C2D4A7B38	6/2/2012	John Day River	296	Smolt
3D9.1C2D4AA173	6/10/2012	John Day River	296	Smolt
3D9.1C2D4AB0A7	6/11/2012	John Day River	296	Smolt
3D9.1C2D4AAFC0	6/13/2012	John Day River	296	Smolt
3D9.1C2CFD7280	6/14/2012	John Day River	296	Smolt
3D9.1C2D4B97D9	6/23/2012	John Day River	296	Smolt
3D9.1C2D4A8CC9	5/24/2012	MFJDR	24	Smolt
3D9.1C2CFE46BE	5/28/2012	MFJDR	24	Smolt
3D9.1C2D4A3899	5/29/2012	MFJDR	24	Smolt
3D9.1C2D4B2BC5	5/29/2012	MFJDR	24	Smolt
3D9.1C2D49117C	5/29/2012	MFJDR	24	Smolt
3D9.1C2D4AF7B8	5/31/2012	MFJDR	24	Smolt
3D9.1C2D4B0288	6/1/2012	MFJDR	24	Smolt
3D9.1C2D4B2B85	6/3/2012	MFJDR	24	Smolt
3D9.1C2D4B7EA3	6/3/2012	MFJDR	24	Smolt
3D9.1C2CFED478	6/3/2012	MFJDR	24	Smolt
3D9.1C2D497414	6/5/2012	MFJDR	24	Smolt

Table A.2. Continued

PIT Code	Detection Date	Tag Site	RKM	LST
3D9.1C2D4B2D4C	6/10/2012	MFJDR	24	Smolt
3D9.1C2D4B1B77	6/11/2012	MFJDR	24	Smolt
3D9.1C2D4AF105	6/12/2012	MFJDR	24	Smolt
3D9.1C2D57297D	6/14/2012	MFJDR	83	Parr
3D9.1C2D57FBC1	5/28/2012	Camp Cr.	5	Parr
3D9.1C2C42E967	5/30/2012	Camp Cr.	5	Parr
3D9.1C2D56D303	6/1/2012	Camp Cr.	5	Parr
3D9.1C2D58EFF0	6/2/2012	Camp Cr.	2	Parr
3D9.1C2C85070F	5/29/2012	Granite Boulder Cr.	1	Parr

Table A.3. Model selection results and associated parameter estimates of encounter histories for juvenile steelhead tagged in Camp Creek and Granite Boulder Creek during the summer (June-July) and fall (October) of 2012 (± 95% CI). Parameters are defined as: p = probability of capture, c = probability of recapture, N = abundance estimate, (.) = constant parameter, (t) = parameter varies temporally.

Summer						Fall				
Site	Model	Parameter	Estimate	LCI	UCI	Model	Parameter	Estimate	LCI	UCI
CMP_UPR1	p(.)=c(.)	p	0.32615	0.19551	0.490825	p(.), c(.)	p	0.65891	0.566645	0.740527
		N	96.58144	71	158		c	0.240343	0.189801	0.299372
							N	151.526	148	163
CMP_MID1	p(.), c(.)	p	0.412567	0.324619	0.506473	p(t)=c(t)	p_1	0.434228	0.383806	0.486049
		c	0.269444	0.226133	0.317646		p_2	0.454331	0.402878	0.506779
		N	338.1465	306	398		p_3	0.375929	0.32871	0.425629
							N	497.4346	471	534
CMP_LWR2	p(.)=c(.)	p	0.112132	0.078	0.158629	p(t)=c(t)	p_1	0.207208	0.170442	0.24952
		N	692.6394	511	984		p_2	0.137536	0.110898	0.169353
							p_3	0.190921	0.156508	0.230831
							N	1105.168	959	1297
CMP_LWR1	p(.)=c(.)	p	0.330332	0.287418	0.376271	p(t)=c(t)	p_1	0.287549	0.24449	0.33483
		N	392.5339	357	443		p_2	0.288958	0.245756	0.336368
							p_3	0.243852	0.205293	0.287038
							N	709.4455	644	796
GRB_LWR2	p(.), c(.)	p	0.436004	0.297448	0.585329	p(.), c(.)	p	0.569585	0.456676	0.675692
		c	0.212121	0.150653	0.290102		c	0.329609	0.264715	0.40172
		N	118.9229	106	156		N	129.8933	124	148
GRB_UPR1	p(.)=c(.)	p	0.219577	0.141842	0.323839	p(.)=c(.)	p	0.343132	0.243859	0.458324
		N	113.8552	86	173		N	65.08663	55	90

Table A. 4. POPAN model parameter estimates at individual sites monitored for juvenile spring Chinook. Parameter estimates of Survival (Phi), probability of capture (p), probability of entry (PENT), and abundance estimates (N) for each site vary temporally (t) or remain constant (.) through all sampling intervals. Lower and upper 95% confidence intervals are noted as LCI and UCI, respectively.

Lower Treatment				Lower Control			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.456	0.222	0.711	Phi$_1$	0.727	0.565	0.846
Phi$_2$	0.465	0.207	0.743	Phi$_2$	0.690	0.487	0.840
Phi$_3$	0.448	0.299	0.607	Phi$_3$	0.718	0.536	0.849
p_1	1.000	0.977	1.023	p_1	0.425	0.155	0.749
p_2	0.049	0.021	0.112	p_2	0.373	0.284	0.472
p_3	0.555	0.209	0.854	p_3	0.380	0.272	0.502
p_4	0.873	0.008	1.000	p_4	0.430	0.154	0.757
PENT$_1$	0.563	0.388	0.724	PENT$_1$	0.034	0.000	0.974
PENT$_2$	0.000	-0.006	0.006	PENT$_2$	0.001	-0.032	0.034
PENT$_3$	0.123	0.049	0.276	PENT$_3$	0.242	0.144	0.376
N	318.247	197	440	N	279.271	215	344

Mid Treatment 1				Mid Treatment 2			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.430	0.259	0.619	Phi$_1$	0.534	0.406	0.658
Phi$_2$	0.392	0.240	0.568	Phi$_2$	0.433	0.272	0.610
Phi$_3$	0.500	0.000	1.000	Phi$_3$	0.488	0.381	0.596
p_1	1.000	0.977	1.023	p_1	1.000	0.975	1.025
p_2	0.319	0.209	0.453	p_2	0.616	0.481	0.736
p_3	0.038	0.020	0.071	p_3	0.264	0.160	0.404
p_4	0.867	0.000	1.000	p_4	0.928	0.039	1.000
PENT$_1$	0.205	0.120	0.328	PENT$_1$	0.655	0.571	0.730
PENT$_2$	0.380	0.253	0.527	PENT$_2$	0.005	-0.051	0.061
PENT$_3$	0.000	-0.002	0.002	PENT$_3$	0.049	0.024	0.097
N	939.304	742	1136	N	743.020	657	829

Mid Control 1				Mid Control 2			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.625	0.490	0.743	Phi$_1$	0.546	0.451	0.638
Phi$_2$	0.780	0.257	0.973	Phi$_2$	0.572	0.422	0.710
Phi$_3$	0.471	0.187	0.775	Phi$_3$	0.479	0.309	0.654
p_1	1.000	0.957	1.043	p_1	0.851	0.135	0.995
p_2	0.694	0.529	0.820	p_2	0.457	0.360	0.557
p_3	0.231	0.136	0.363	p_3	0.549	0.389	0.700
p_4	0.686	0.081	0.982	p_4	0.662	0.162	0.952
PENT$_1$	0.434	0.337	0.537	PENT$_1$	0.454	0.195	0.740
PENT$_2$	0.234	0.111	0.429	PENT$_2$	0.016	0.000	0.557
PENT$_3$	0.099	0.025	0.319	PENT$_3$	0.027	0.009	0.083
N	893.217	731	1056	N	738.266	600	877

Table A. 4. Continued.

Upper Treatment				Upper Control			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi_1	0.394	0.245	0.567	Phi_1	0.740	0.518	0.883
Phi_2	1.000	0.998	1.002	Phi_2	0.693	0.481	0.846
Phi_3	0.815	0.520	0.947	Phi_3	0.652	0.373	0.856
p_1	0.758	0.273	0.963	p_1	0.703	0.097	0.981
p_2	0.568	0.367	0.749	p_2	0.320	0.226	0.431
p_3	0.607	0.500	0.706	p_3	0.379	0.247	0.533
p_4	0.758	0.273	0.963	p_4	0.491	0.095	0.899
PENT_1	0.423	0.209	0.671	PENT_1	0.582	0.247	0.856
PENT_2	0.246	0.096	0.500	PENT_2	0.045	0.003	0.449
PENT_3	0.133	0.064	0.256	PENT_3	0.121	0.048	0.273
N	272.791	233	313	N	633.522	517	750

Vinegar Creek			
Parameter	Estimate	LCI	UCI
Phi_1	0.598	0.456	0.725
Phi_2	0.558	0.410	0.696
Phi_3	0.623	0.385	0.813
p_1	0.880	0.098	0.998
p_2	0.515	0.372	0.656
p_3	0.404	0.274	0.549
p_4	0.797	0.143	0.989
PENT_1	0.290	0.133	0.519
PENT_2	0.214	0.111	0.374
PENT_3	0.127	0.059	0.251
N	546.096	415	678

Table A.5. POPAN model parameter estimates at individual sites monitored for juvenile steelhead. Parameter estimates of Survival (Phi), probability of capture (p), probability of entry (PENT), and abundance estimates (N) for each site vary temporally (t) or remain constant (.) through all sampling intervals. Upper and lower 95% confidence intervals are noted as UCI and LCI, respectively.

Coyote Creek				Lower Vinegar Creek			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.814	0.647	0.913	Phi$_1$	0.623	0.444	0.774
Phi$_2$	0.811	0.621	0.919	Phi$_2$	0.854	0.455	0.976
Phi$_3$	0.813	0.645	0.912	Phi$_3$	0.809	0.304	0.976
p$_1$	0.716	0.457	0.883	p$_1$	0.719	0.128	0.978
p$_2$	0.691	0.507	0.830	p$_2$	0.435	0.301	0.580
p$_3$	0.684	0.484	0.833	p$_3$	0.401	0.283	0.531
p$_4$	0.702	0.442	0.875	p$_4$	0.690	0.142	0.968
PENT$_1$	0.007	-0.048	0.063	PENT$_1$	0.289	0.077	0.664
PENT$_2$	0.166	0.074	0.332	PENT$_2$	0.151	0.041	0.423
PENT$_3$	0.376	0.238	0.537	PENT$_3$	0.062	0.011	0.286
N	67.553	54	80	N	315.415	240	391

Lower Treatment				Lower Control			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.834	0.046	0.998	Phi$_1$	0.955	0.098	1.000
Phi$_2$	0.995	0.830	1.160	Phi$_2$	0.736	0.244	0.960
Phi$_3$	0.971	0.018	1.000	Phi$_3$	0.605	0.153	0.928
p$_1$	0.616	0.154	0.934	p$_1$	0.209	0.001	0.981
p$_2$	0.395	0.106	0.782	p$_2$	0.205	0.100	0.374
p$_3$	0.457	0.132	0.823	p$_3$	0.190	0.085	0.372
p$_4$	0.597	0.112	0.946	p$_4$	0.283	0.029	0.838
PENT$_1$	0.231	0.004	0.954	PENT$_1$	0.009	-2.549	2.567
PENT$_2$	0.173	0.018	0.704	PENT$_2$	0.000	0.000	0.000
PENT$_3$	0.451	0.058	0.917	PENT$_3$	0.541	0.253	0.803
N	24.441	10	39	N	221.254	-73	515

Mid Treatment 1				Mid Treatment 2			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.132	0.018	0.563	Phi$_1$	1.000	0.998	1.002
Phi$_2$	0.052	0.001	0.710	Phi$_2$	0.734	0.058	0.992
Phi$_3$	0.052	0.001	0.710	Phi$_3$	0.979	0.729	0.999
p$_1$	1.000	1.000	1.000	p$_1$	0.970	0.004	1.000
p$_2$	1.000	1.000	1.000	p$_2$	0.433	0.149	0.769
p$_3$	0.441	0.015	0.976	p$_3$	0.046	0.001	0.704
p$_4$	1.000	1.000	1.000	p$_4$	0.179	0.045	0.498
PENT$_1$	0.235	0.091	0.486	PENT$_1$	0.693	0.127	0.972
PENT$_2$	0.000	0.000	0.000	PENT$_2$	0.264	0.016	0.888
PENT$_3$	0.353	0.168	0.596	PENT$_3$	0.008	-0.062	0.077
N	17.000	17	17	N	214.462	87	342

Table A.5. Continued.

Mid Control 1				Mid Control 2			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.989	0.000	1.000	Phi$_1$	0.866	0.246	0.992
Phi$_2$	0.796	0.081	0.994	Phi$_2$	0.993	0.877	1.108
Phi$_3$	0.538	0.076	0.943	Phi$_3$	0.979	0.000	1.000
p_1	0.565	0.000	1.000	p_1	0.493	0.041	0.957
p_2	0.522	0.260	0.773	p_2	0.175	0.126	0.238
p_3	0.227	0.038	0.684	p_3	0.169	0.114	0.242
p_4	0.571	0.052	0.970	p_4	0.202	0.000	1.000
PENT$_1$	0.337	0.000	1.000	PENT$_1$	0.479	0.068	0.920
PENT$_2$	0.076	0.000	0.975	PENT$_2$	0.000	0.000	0.000
PENT$_3$	0.296	0.032	0.841	PENT$_3$	0.085	0.008	0.508
N	111.231	-63	286	N	468	348	587
Upper Treatment				Upper Control			
Parameter	Estimate	LCI	UCI	Parameter	Estimate	LCI	UCI
Phi$_1$	0.515	0.125	0.888	Phi$_1$	0.890	0.508	0.985
Phi$_2$	0.791	0.096	0.993	Phi$_2$	0.763	0.492	0.915
Phi$_3$	0.679	0.280	0.920	Phi$_3$	0.788	0.464	0.941
p_1	0.483	0.074	0.916	p_1	0.720	0.155	0.973
p_2	0.334	0.088	0.722	p_2	0.445	0.322	0.574
p_3	0.330	0.109	0.664	p_3	0.489	0.346	0.634
p_4	0.443	0.067	0.899	p_4	0.682	0.169	0.958
PENT$_1$	0.200	0.043	0.582	PENT$_1$	0.492	0.211	0.778
PENT$_2$	0.457	0.187	0.756	PENT$_2$	0.022	0.000	0.845
PENT$_3$	0.135	0.019	0.563	PENT$_3$	0.201	0.099	0.367
N	194.743	88	301	N	277	227	326