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 116 redds constructed at 19 of 31 survey reaches. Using these observations, we estimate a redd density of 1.9 redds/km or 777 redds in the MFJDR IMW constructed by an estimated 3,692 returning adult steelhead. Collectively, we also tagged 5,733 juvenile steelhead, Chinook, and bull trout *Salvelinus confluentus* from June through Nov 2011. Abundance estimates for juveniles varied among survey sites and season.

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 John Day River summer steelhead, 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 basin 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 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 summer steelhead and spring 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 summer steelhead and spring Chinook to the MFJDR.
2. Estimate freshwater productivity (smolts/redd) of spring Chinook and summer steelhead.
3. Estimate parr-to-smolt survival for summer steelhead and spring Chinook.
4. Delineate seasonal rearing habitat for Chinook parr.

METHODS

Study Area

The Middle Fork John Day River (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 screw trap near the town of Ritter at river kilometer (RKM) 20 (Figure 2).

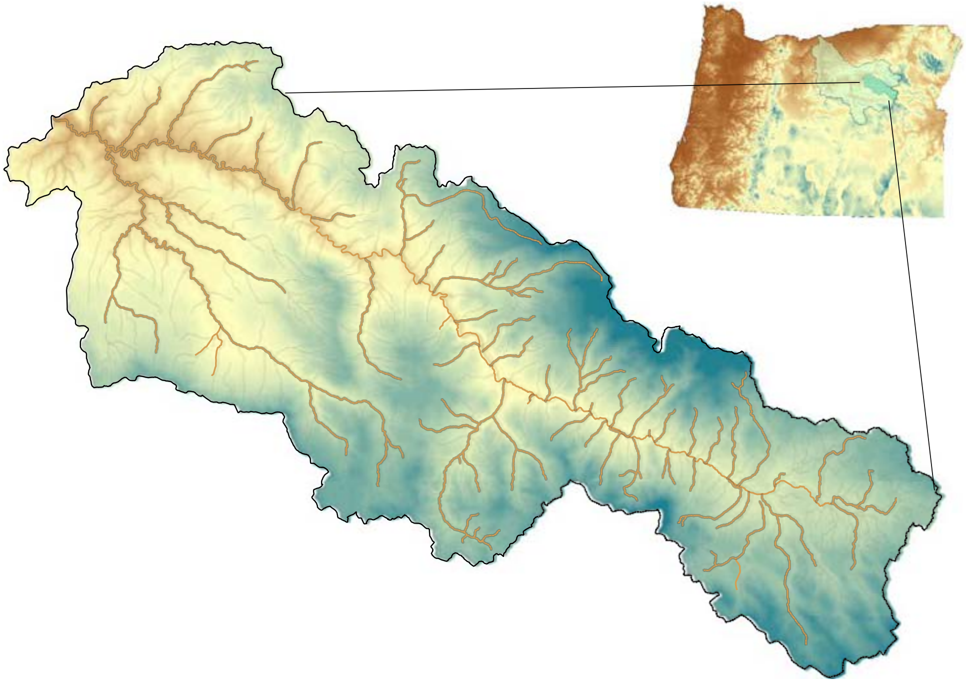

Figure 1. Map of the location of the MFJDR and its tributaries in relation to the John Day River sub-basin and the state of Oregon.

Passsive In-stream PIT tag Antennae Arrays

We operate a passive instream PIT tag antennae array near the MFJDR Mosquito Creek confluence in the MFJDR at RKM 68.5. This array consists of six antennae four of which are 4.57m in length, and two are 3.05 m in length. These antennae are placed across two stream transects perpendicular to the stream channel. 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. This antennae configuration allows us to determine the direction of fish movement. These antennae are run by a Destron Fearing FishTracker model 1001M Reader multilplexer which stores the date, time, antennae, and PIT tag code of each fish detection.

Additionally, we operated two PIT tag antennae sites in Bridge Creek to examine fish movements into and out of Bates Pond. The upper antennae site, located just upstream of the mouth 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 antennae 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. These transceivers store the date, time, and PIT tag code of each fish detection.

Summer Steelhead and Spring Chinook Adult Monitoring

Summer Steelhead Adult Escapement

Steelhead redd 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 steelhead spawn timing in the MFJDR IMW. 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 then 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 assigning sites to a panel is usually performed in a random fashion, we were able to incorporate sites utilized by another steelhead monitoring project in the John Day River Basin 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.

We used a 1:100,000 EPA river reach file of summer steelhead distribution in the MFJDR sub-basin for site selection (Figure 2). 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:

$$R_D = \sum_{i=1}^{n} r_i/d_i \tag{1}$$

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:

$$R_T = R_D \cdot d_u \tag{2}$$

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

$$E_S = C \cdot R_T \tag{3}$$

where C is an annual fish per redd constant (4.75 fish/redd for 2011) developed from repeat spawner surveys in the Grande Ronde River basin (Flesher et al. 2005 in press; M. Dobos, 2011 ODFW memorandum to J.R. Ruzycki). 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).

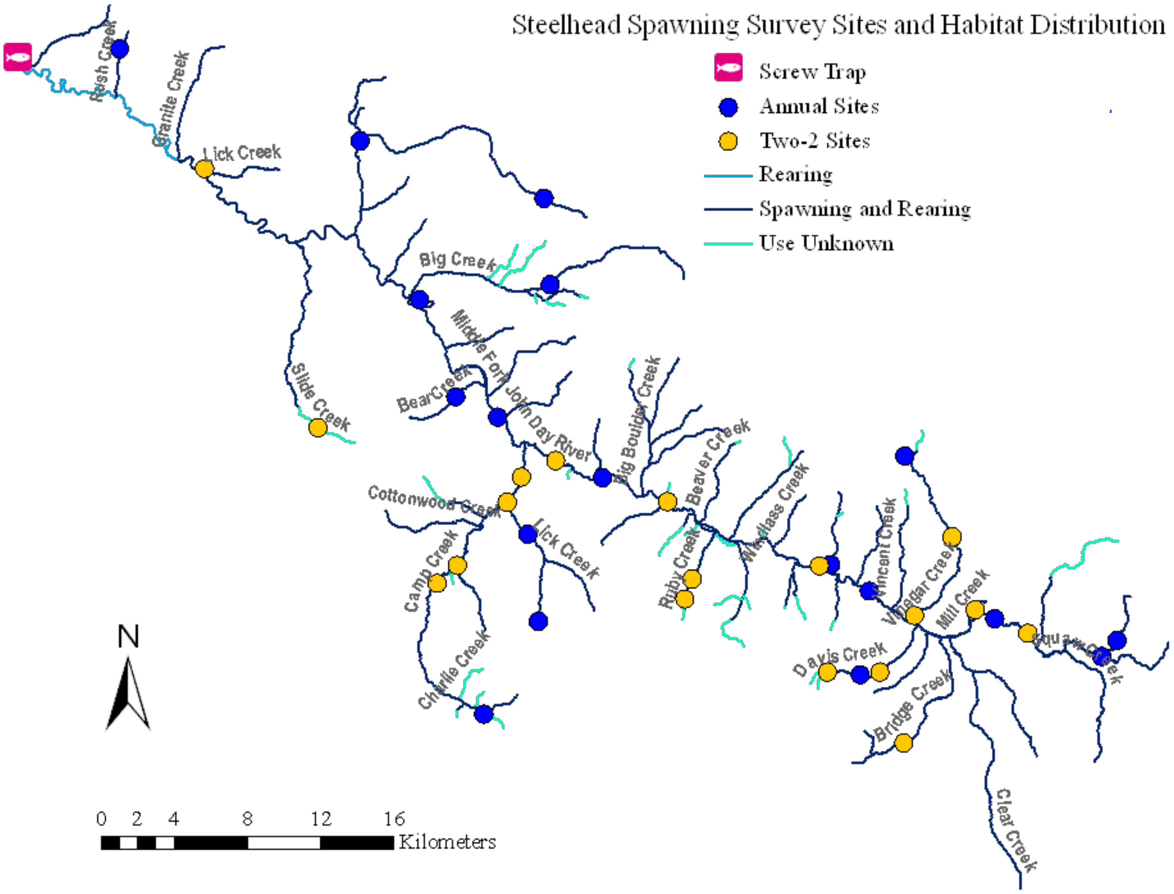

Figure 2 Map of summer steelhead habitat distribution used for selecting steelhead spawning survey sites with Annual and Two-2 sites sampled in 2011. The rotary screw trap (RST) near Ritter is shown for reference.

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, numbered, 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), assessed for gill lesions, 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. 2012 (in draft).

Adult PIT-tag Detections

Operation of the in stream PIT tag antenna arrays in the MFJDR (MF array) and Bridge Creek allow us to interrogate returning adult fish for PIT tags that cross our antenna to spawn upstream. At Bridge Creek we can evaluate the passage of adult fish through bates pond using these arrays.

Summer Steelhead and Spring Chinook Parr Monitoring

Juvenile 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 summer steelhead and spring Chinook were targeted in this sampling, summer steelhead distribution was utilized for both species because steelhead distribution encompasses the entire suspected distribution of spring 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 only three sites in Camp Creek and one site in Granite Boulder Creek were sampled during 2011 (Figure 3). 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.

Once collected, fish were placed into an aerated 19 l bucket and transferred to instream live boxes where they were held until the entire site was sampled and tagging operations commenced. Captured juvenile spring Chinook, steelhead, and bull trout *Salvelinus confluentus* were anesthetized with tricane methane sulfonate (MS-222), interrogated for passive integrated transponder tags (PIT tags), PIT tagged if not previously tagged, weighed to the nearest 0.1 g, and 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 bull trout captured at all sites. All anesthetized fish were allowed to recover in an aerated 19 l bucket until they regained equilibrium (~5-10 min). Once recovered, fish were released in small groups throughout the site and allowed to distribute themselves naturally within the sampling reach.

Encounter histories were developed for each tagged steelhead in Granite Boulder Creek and Camp Creek to estimate population abundance. A closed capture model (Otis et al. 1978) was used to analyze the encounter histories by site 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 variables 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.

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 Chinook and Steelhead Open Population Modeling (POPAN)

We monitored parr survival of juvenile spring Chinook salmon at 12 sites in the MFJDR IMW consisting of eight sites in the mainstem MFJDR, two in Vinegar Creek, one in Coyote Creek, and one in Deerhorn Creek (Figure 3). 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). Tributary sites were selected at locations in streams with previous observations of juvenile Chinook (James et al. 2009, 2010, 2011). Sites were 20 times ACW with a maximum of 150 m for sites in the MFJDR and a minimum of 100 m for tributary sites.

Juvenile Chinook were captured in the tributaries and the upper control MFJDR site using backpack electrofishing gear (Smith-Root LR20B) 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 2011 through early October 2011 with approximately 3-4 weeks between sampling intervals. No block nets were deployed during or between sampling intervals.

Additionally, Chinook parr were collected throughout the MFJDR with the aforementioned snerding technique during July to increase sample size for assessing parr to smolt survival (see SURPH modeling below) and to assess potential immigration into our sampling sites. This additional tag dispersal sampling was conducted in areas where tags had been deployed in previous years, where juvenile Chinook were known to occupy, and in somewhat close proximity to the eight MFJDR sampling reaches.

All fish captured were processed as previously described above, however, scales were only taken from juvenile Chinook >100mm for age determination.

Encounter histories were developed for individual juvenile Chinook captured at each site. Additional encounter histories were developed for juvenile steelhead in Coyote Creek, both Vinegar Creek sites, and Deerhorn Creek. An open population model, POPAN (Schwarz and Arnason1996), was used to estimate survival (phi), probability of capture (p), probability of entry (PENT), and abundance (N) of a super population for these sites in Program MARK (White and Burnham 1999). The PENT parameter estimates 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, births were only observed for fish recuiting to our tagging gear (i.e. $\geq$60 mm FL). Model variables for survival, probability of capture, and probability of entry estimates can vary temporally or can be constant. We selected models with constant probability of capture for all sampling events to avoid confounding the last survival parameter and the first and last probability of capture parameters. The most parsimonious model with constant (p) was selected for each site based on the lowest Akaike Information Criteria (AICc) value. Out of four potential models tested, two models fit our encounter history data (Table 2). We were unsuccessful in fitting models to the upper Vinegar Creek or Deerhorn Creek sites for juvenile Chinook because only one individual was captured at each of those sites during all sampling intervals. We were also unsuccessful at fitting a model to the Deerhorn Creek site for steelhead due to the sparseness of that data.

Table 2. Models fit to open population encounter histories data, description of the model, and number of parameters in the associated model. All models parameterized survival (phi), probability of capture (p), probability of entry, (PENT), and super-population abundance (N).

Model	Model Description	# of Parameters
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

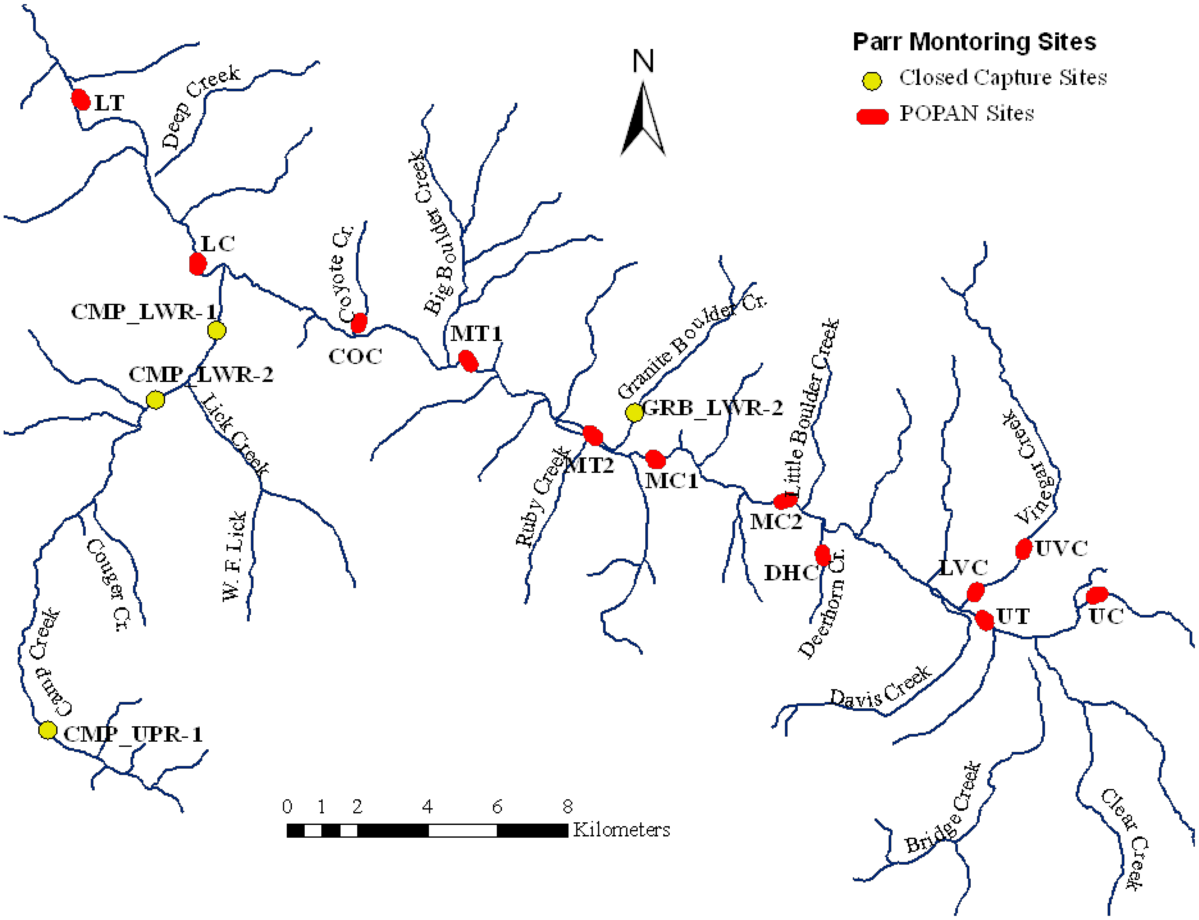

Figure 3. Map of the location of parr monitoring sites in the MFJDR IMW. Reaches in red are open population (POPAN) sites and include Lower Treatment (LT), Lower Control (LC), Coyote Creek (COC), Mid Treatment l (MT1), Mid Treatment 2 (MT2), Mid Control 1 (MC1), Mid Control 2 (MC2), Deerhorn Creek (DHC), Lower Vinegar Creek (LVC), Upper Vinegar Creek (UVC), Upper Treatment (UT), and Upper Control (UC). The yellow dots represent closed capture sites and include Lower Camp Creek 1 (CMP_LWR-1), Lower Camp Creek 2 (CMP_LWR-2), Upper Camp Creek 1 (CMP_UPR-1), and Lower Granite Boulder Creek 2 (GRB_LWR-2).

Parr Length at Age

Scales collected from juvenile steelhead, Chinook, and bull trout were mounted between two microscope slide glass cover slips and viewed using a Micron 780 microfiche reader with a 12mm lens. We determined the age of each fish by counting the patterns of widely and narrowly spaced circuli of each scale. Scales were independently read by two different readers. Scale ages that were not consistent with both readers were read again by both readers. If an agreement on final age was not met, a third reader read the scales and the majority vote was used to determine the final age.

Chinook Parr Summer Rearing Distribution

Summer rearing distribution of juvenile Chinook salmon 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 4). 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.

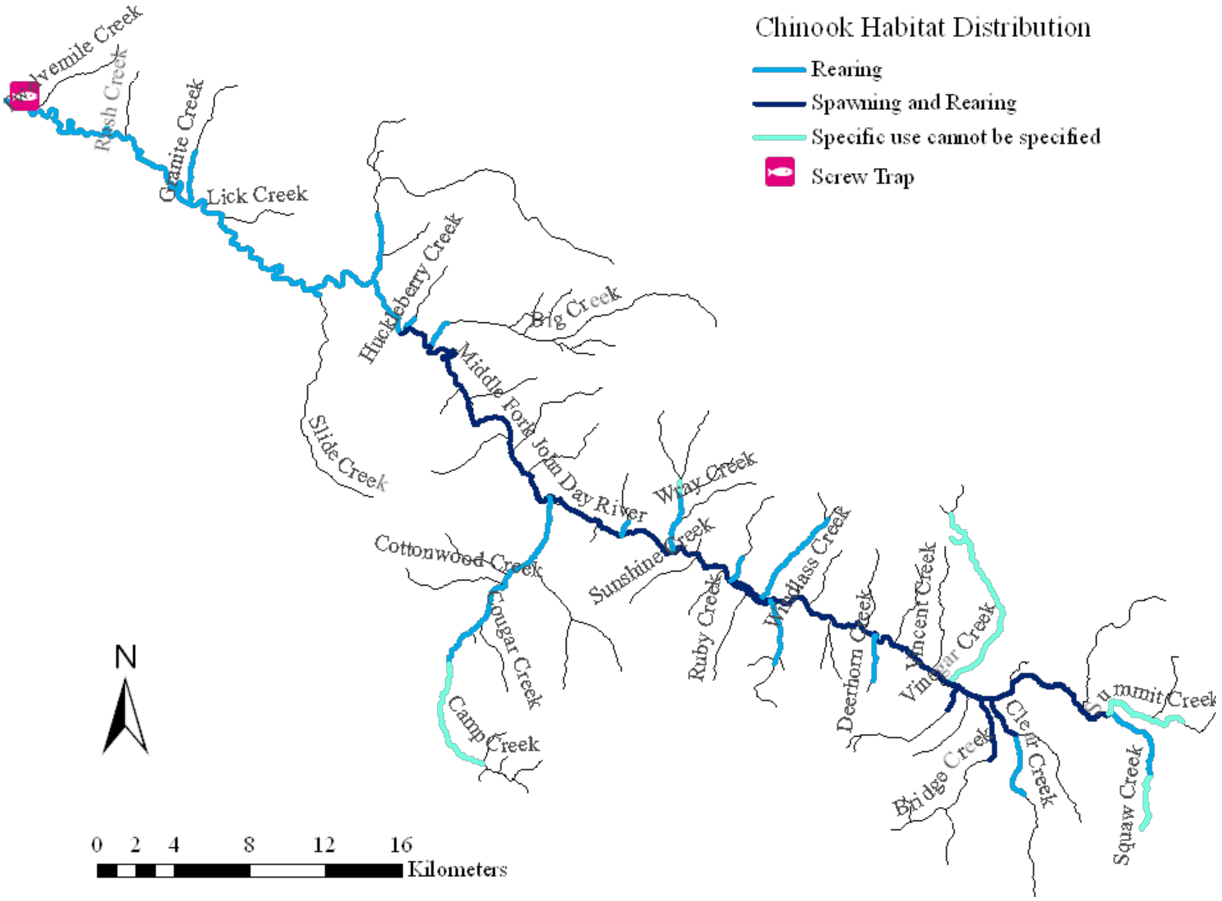

Figure 4. Spring Chinook habitat distribution in the MFJDR IMW from Ritter upstream. The location of the screw trap is shown for reference.

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 spring 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 in Bridge Creek from the confluence of Bridge Creek with the MFJDR, upstream to the Bates Pond spillway and also from the mouth of Bridge Creek at Bates Pond, upstream approximately 400 m. All previously unmarked juvenile steelhead and Chinook captured were PIT-tagged using the previously described methods for processing and PIT tagging fish. Movement was assessed based on location of tagging, upstream or downstream of Bates Pond, and subsequent detection upstream and/or downstream of Bates Pond at the passive in-stream PIT tag antennae arrays.

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 observation of these fish. Fish tagged in the MFJDR IMW have the potential to be interrogated at remote in stream 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 (spring Chinook or summer steelhead), tag site (Camp Creek, Granite Boulder Creek, or the MFJDR), and by tag year. Subsequent interrogations were grouped by observation site and year of observation where observation year began on 1 July and ended on 30 June the following year to incorporate in-stream tagging events and align with migratory years that overlap from fall to spring. This information allows us to assess the origin of these fish as they migrate past our array by querying tag files within PTAGIS (PTAGIS).

SURPH Modeling

Using PIT tag detection histories throughout the John Day and Columbia River, we assessed survival of juvenile Chinook as they migrated out of the MFJDR and through the Columbia River hydro-power system using program SURPH (Lady et al. 2002). Detection 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) and fall (October) tagged fish. Models were fit to the data to test for differences in survival between the two 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 fewer parameters was selected.

Summer Steelhead and Spring Chinook Smolt Abundance

Juvenile spring Chinook and summer steelhead migrants were captured using a 1.52 m rotary screw trap (RST) operated on the MFJDR near Ritter (Figure 2). 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 (fork length, FL; mm). 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. (2012 in draft).

RESULTS

Summer Steelhead and Spring Chinook Adult Monitoring

Summer Steelhead Adult Escapement

We surveyed 31 sites for spawning adult summer steelhead in the MFJDR IMW from 4 April 2011 to 30 June 2011 (Table 3). We observed 116 total redds at 19 of the 31 sites surveyed (61%). Corresponding redd densities at all sites ranged from zero to 10.95 redds per km (Table 4; Figure 5) and averaged 1.9 redds/km (Table 5). Given this redd density, we estimate that 777 redds were constructed in the MFJDR IMW by 3,692 returning adults (Table 5; Figure 7). Initiation of redd construction started in early April 2011 with spawning activity peaking during May (Figure 6). A major flow event that occurred on May 15 2011 (Figure 6), may have obscured observation of any redds constructed prior to this event that were not already counted in our surveys.

Table 3. Stream name, start and end point locations in decimal degrees (DD), panel (Annual or Two-2), and dates surveyed for all steelhead spawning ground sites in 2011.

	Site ID	Start		Finish		Panel	Distance	Survey Dates					
		Latitude (DD)	Longitude (DD)	Latitude (DD)	Longitude (DD)			1	2	3	4	5	6
Rush Cr.	101	44.87314	-119.07295	44.89066	-119.07083	Annual	2	4/11	4/21	5/10	6/9		
Summit Cr.	108	44.58652	-118.41705	44.58047	-118.39681	Annual	2.1	6/8	6/16				
Indian Cr.	109	44.82456	-118.80019	44.81340	-118.77983	Annual	2.1	6/13					
Camp Cr.	110	44.56925	-118.84995	44.56060	-118.82869	Annual	2	5/11	5/24	6/8	6/14		
W.F. Lick Cr.	114	44.62350	-118.78779	44.60543	-118.78974	Annual	2	4/26	5/9	5/24	6/2	6/14	
MFJDR	115	44.62157	-118.57913	44.61668	-118.56166	Annual	1.9	6/30					
Davis Cr.	116	44.57668	-118.55641	44.57740	-118.58000	Annual	2	5/3	5/12	5/25	6/6	6/15	
Bear Cr.	118	44.72279	-118.83202	44.71159	-118.85023	Annual	2	4/7	4/25	5/5	6/7		
MFJDR	120	44.60390	-118.48398	44.59869	-118.46475	Annual	2.1	6/27					
Big Cr.	122	44.76916	-118.78721	44.77627	-118.76908	Annual	2	4/19	5/9	6/1			
Vinegar Cr.	123	44.67240	-118.52240	44.68412	-118.53688	Annual	2	5/23	6/6				
Idaho Cr.	124	44.58252	-118.40316	44.59466	-118.38756	Annual	2.1	6/2	6/15				
Indian Cr.	125	44.83702	-118.90884	44.84590	-118.89331	Annual	2.1	5/10	5/31	6/13			
L. Boulder Cr.	127	44.62748	-118.59092	44.64353	-118.58464	Annual	2	4/14	4/28	5/4	5/26	6/7	6/22
Lick Creek	130	44.65771	-118.80603	44.64477	-118.79063	Annual	2	4/13	4/28	5/11	6/1	6/14	
Davis Cr.	301	44.58896	-118.53550	44.87698	-118.55567	Two2	2.1	4/20	5/3	5/12	5/25	6/6	6/15
Vinegar Cr.	302	44.63473	-118.49835	44.65018	-118.50961	Two2	2	5/5	5/23	6/6	6/16		
Camp Cr.	304	44.69325	-118.79578	44.67659	-118.79918	Two2	1.9	4/13	6/1	6/14			
MFJDR	305	44.62962	-118.59648	44.62157	-118.57913	Two2	1.9	6/30					
Vinegar Cr.	306	44.60123	-118.53569	44.61079	-118.51521	Two2	2	4/20	5/4	5/23	6/6	6/15	
Camp Cr.	307	44.67659	-118.79918	44.66412	-118.44189	Two2	1.7	4/13	6/1	6/14			
Ruby Cr.	309	44.63789	-118.67580	44.62154	-118.68518	Two2	2	4/5	5/4	5/25	6/7	6/15	
MFJDR	310	44.89599	-118.46317	44.58688	-118.44796	Two2	2	6/23					
Bridge Cr.	313	44.54829	-118.85995	44.53901	-118.54863	Two2	2	5/3	5/26	6/7	6/15		
Slide Cr.	315	44.71352	-118.95212	44.70138	-118.93543	Two2	2	4/4	4/21	5/3	5/31	6/9	6/16
Davis Cr.	317	44.57740	-118.58000	44.57191	-118.60369	Two2	2.2	5/25	6/16				
Camp Cr.	319	44.62607	-118.85866	44.61147	-118.86519	Two2	2	4/14	5/24	6/8	6/14		
Sunshine Cr.	321	44.66331	-118.69825	44.65705	-118.71475	Two2	1.6	4/6	4/25	5/5	6/7		
Mill Cr.	322	44.60051	-118.49310	44.61039	-118.48166	Two2	2.1	4/25	6/15				
Camp Cr.	323	44.63635	-118.84182	44.61147	-118.86519	Two2	2	4/14	5/24	6/8	6/14		
Ruby Cr.	325	44.62154	-118.68518	44.60488	-118.69056	Two2	1.9	5/25					

Table 4. Total redds, redd density, and number of wild, hatchery, and unknown live steelhead observed during spawning ground survey sites in 2011.

Stream	Site ID	Total Redds	Redd Density (Redds/km)	Wild Steelhead	Hatchery Steelhead	Unknown Origin Steelhead
Davis Cr.	301	23	10.95	7	0	4
Little Boulder Cr.	127	16	8.00	8	0	1
Rush Cr.	101	10	5.00	4	0	1
Vinegar Cr.	302	10	5.00	12	1	6
Ruby Cr.	309	10	5.00	0	0	2
Davis Cr.	116	8	4.00	1	0	0
Lick Cr.	130	6	3.00	2	0	0
Indian Cr.	125	6	2.86	0	0	0
Vinegar Cr.	306	5	2.50	2	0	5
Camp Cr.	319	4	2.00	2	0	4
Sunshine Cr.	321	3	1.88	3	0	1
Camp Cr.	110	3	1.50	1	0	0
Camp Cr.	323	3	1.50	0	0	0
W.F. Lick Cr.	114	2	1.00	5	0	1
Vinegar Cr.	123	2	1.00	1	0	0
Bridge Cr.	313	2	1.00	2	0	0
Big Cr.	122	1	0.50	0	0	1
Slide Cr.	315	1	0.50	3	1	0
Idaho Cr.	124	1	0.48	0	0	0
Summit Cr.	108	0	0.00	0	0	0
Indian Cr.	109	0	0.00	0	0	0
MFJDR	115	0	0.00	0	0	0
Bear Cr.	118	0	0.00	0	0	0
MFJDR	120	0	0.00	0	0	0
Camp Cr.	304	0	0.00	0	0	0
MFJDR	305	0	0.00	0	0	0
Camp Cr.	307	0	0.00	0	0	1
MFJDR	310	0	0.00	0	0	0
Davis Cr.	317	0	0.00	0	0	0
Mill Cr.	322	0	0.00	0	0	0
Ruby Cr.	325	0	0.00	0	0	0

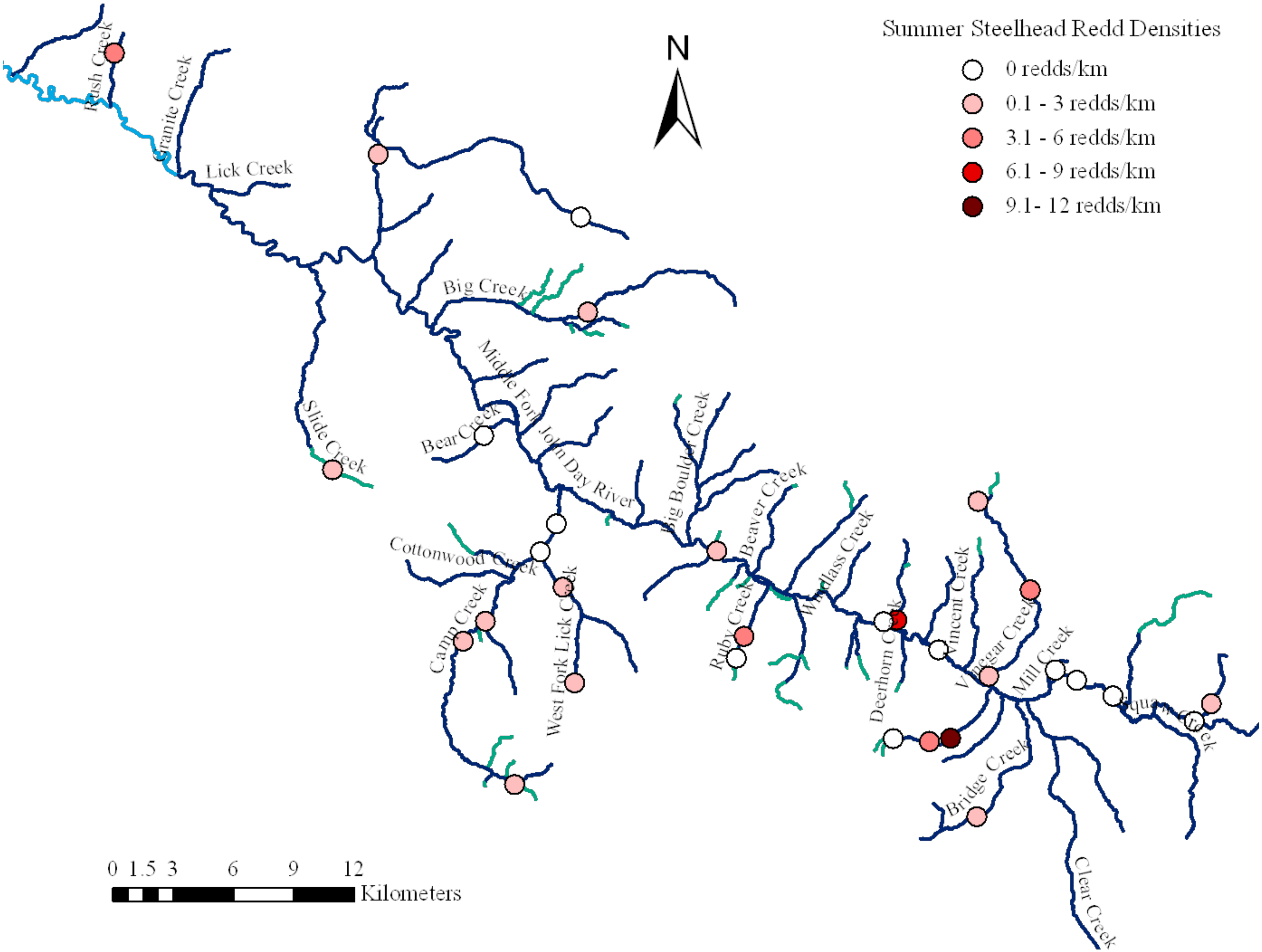

Figure 5. Redd densities at steelhead spawning sites surveyed in the MFJDR IMW during 2011.

Table 5. Distance surveyed, number of redds observed, estimated redd density, and summer steelhead spawner escapement estimates (± 95% CI) from 2008 through 2011 in the MFJDR IMW.

Year	**Kilometers Surveyed**	**Unique Redds**	**Redd/km**	**Total Redds**	**Escapement**	**95% LCI**	**95% UCI**
2008	57.5	24	0.41	192	769	-135	1,675
2009	57.9	76	1.3	556	2,114	1,326	2,901
2010	60.3	163	2.7	1,141	1,820	1,041	2,598
2011	61.8	116	1.9	777	3,692	2,055	5,327

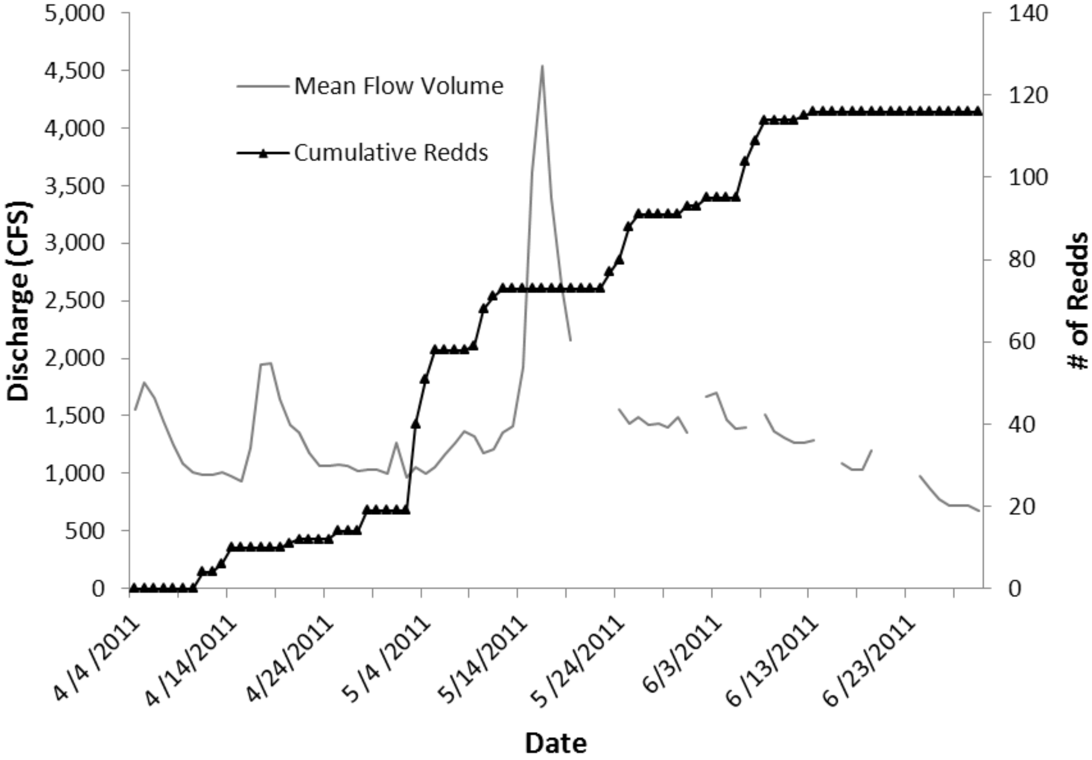

Figure 6. Cumulative redd construction in the MFJDR IMW and mean daily discharge in cubic feet per second (USGS provisional data December 2011) measured at the USGS gauging station near Ritter, OR from 4 April 2011 through 30 Jun 2011.

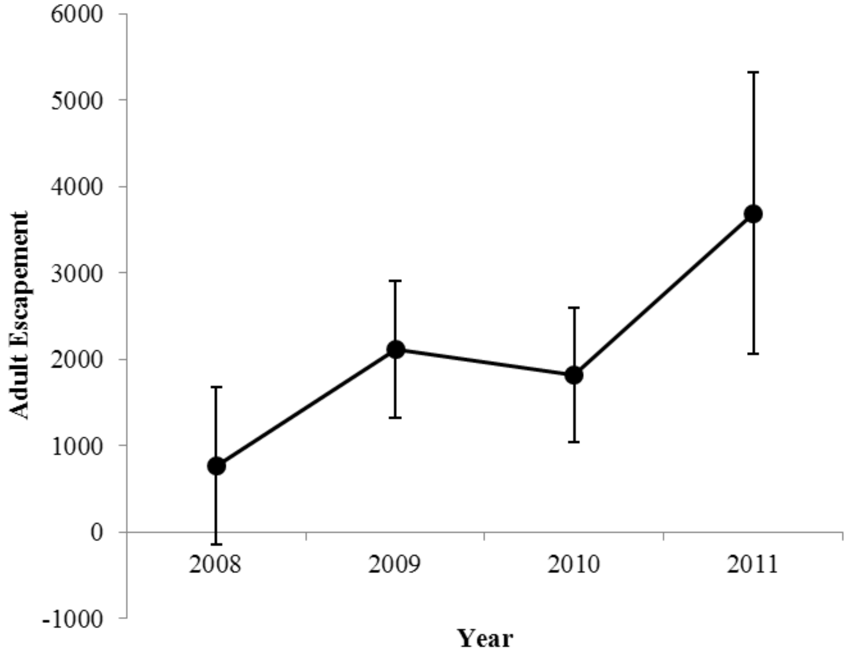

Figure 7. Annual adult steelhead escapement estimates in the MFJDR IMW from 2008 to 2011. Error bars represent ±95% CI.

Spring Chinook Adult Escapement

We estimate a total return of 1,982 adult spring Chinook salmon to the MFJDR IMW for 2011. We counted a total of 505 redds in the MFJDR sub-basin and 887 adult carcasses. For a more detailed description of Chinook escapement please see Bare et al. (2012 in draft).

Adult PIT tag Detections

The MF array was damaged during a flood that occurred around 15 May 2011 and was completely inoperable from that date until 11 Aug 2011. Prior to the damage eight adult steelhead were detected at the MF array in 2011. Five of these steelhead were tagged as juveniles within the Middle Fork basin and three were tagged out side of the Middle Fork basin as adults (Table 6). Two adult Chinook were detected in 2011 at the MF array on 13 Sept 2011. Both of these fish were tagged in the MFJDR during tag dispersal operations as parr, one at RKM 83 and the other at RKM 87 in July of 2008.

One adult steelhead was detected in 2011 both downstream (4 April 2011) and upstream of Bates Pond (10 April 2011) in Bridge Creek. This fish was tagged at the Middle Fork RST as a smolt in February 2009. One adult Chinook tagged as a smolt at the Middle Fork RST in March 2009 was detected at our lower Bridge Creek antennae 29 June 2011 and at the upper Bridge Creek antennae 8 August 2011.

Table 6. Tagged adult steelhead detected at the MF array during 2011. Adult steelhead tagged at Bonneville Dam were tagged by CRITFC (Columbia River Inter-Tribal Fisheries Commission), the steelhead tagged in the Lower John Day River was captured with hook and line and tagged by NMFS (National Marine Fisheries Service).

PIT_ID	Tag Date	Tag Site	Life Stage at Tagging	Date Detected
3D9.1C2CF1FF67	27-Mar-09	Middle Fork RST	Juvenile	19-Mar-11
3D9.1C2CFD86D4	20-Mar-09	Bonneville Dam	Juvenile	20-Mar-11
3D9.1C2C7F7E01	28-Jul-08	Bonneville Dam	Juvenile	22-Mar-11
3D9.1C2C83D1EF	20-Oct-08	Camp Creek.	Juvenile	24-Mar-11
3D9.1C2C855EA6	11-May-08	Middle Fork RST	Juvenile	22-Apr-11
3D9.1C2D412BDF	12-Aug-10	Bonneville Dam	Adult	12-Mar-11
3D9.1C2C4A6C40	12-Oct-10	Lower J. D. River	Adult	4-Mar-11
3D9.1C2D3F1CC4	20-Jul-10	Bonneville Dam	Adult	26-Apr-11

Summer Steelhead and Spring Chinook Parr Monitoring

We PIT tagged a total of 5,733 fish in 2011consisting of 3,654 juvenile Chinook, 2,077 juvenile steelhead, and two bull trout (Table 7). The majority of steelhead were tagged in tributary streams (83%), and most Chinook were tagged in the mainstem Middle Fork (93%). (Table 7).

Table 7. Number of fish species tagged at parr monitoring sites in the MFJDR IMW in 2011.

Tag Site	Chinook	Steelhead	Bull trout	Total
Camp Lower 1	79	549	0	628
Camp Lower 2	43	298	0	341
Camp Upper 1	0	215	0	215
GRB Lower 2	4	179	1	184
Bridge Creek	3	75	0	78
Lower Vinegar Cr.	33	159	1	193
Upper Vinegar Cr.	1	171	0	172
Coyote Cr.	83	52	0	135
Deerhorn Cr.	1	30	0	31
MF Lower Treatment	69	1	0	70
MF Lower Control	143	21	0	164
MF Mid Treatment 1	295	3	0	298
MF Mid Treatment 2	273	10	0	283
MF Mid Control 1	731	27	0	758
MF Mid Control 2	441	44	0	485
MF Upper Treatment	225	32	0	257
MF Upper Control	73	90	0	163
MF Tag Dispersal	1,157	121	0	1,278
TOTAL	**3,654**	**2,077**	**2**	**5,733**

Juvenile Steelhead Closed Population Modeling (Barker Robust)

Abundance estimates of juvenile steelhead in Camp Creek and Granite Boulder Creek yielded varying results among both streams and sites (Table 8). Although we tagged a greater number of fish in Camp Creek in the fall compared to summer (Table 9), we only observed a statistically higher abundance estimate at our upper Camp Creek site (CMPUPR-1; Figure 8). The Camp Creek CMP_LWR2 and Granite Boulder Creek GRB_LWR-2 abundance estimates were similar during summer and fall (Figure 8). One bull trout was captured and tagged at GRB_LWR-2 in July 2011 and recaptured in October 2011 at the same site (Table 9).

Table 8. 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-November) of 2011 (± 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_LWR1	p(.)=c(.)	p	0.112	0.078	0.159	p(t)=c(t)	p_1	0.458	0.403	0.513
		N	692.640	510.525	984.384		p_2	0.342	0.296	0.391
							p_3	0.238	0.201	0.280
							N	579.040	538.502	633.683
CMP_LWR2	p(t)=c(t)	p_1	0.193	0.136	0.267	p(t)=c(t)	p_1	0.443	0.369	0.520
		p_2	0.174	0.121	0.244		p_2	0.335	0.272	0.404
		p_3	0.311	0.228	0.408		p_3	0.310	0.250	0.377
		N	263.876	216.691	341.273		N	277.548	253.131	314.890
CMP_UPR1	p(t)=c(t)	p_1	0.124	0.067	0.220	p(.),c(.)	p	0.602	0.514	0.684
		p_2	0.297	0.186	0.438		c	0.404	0.349	0.463
		p_3	0.335	0.212	0.485		N	195.869	188.884	212.847
		N	104.537	82.100	152.020					
GRB_LWR2	p(.)=c(.)	p	0.305	0.234	0.386	p(t)=c(t)	p_1	0.480	0.380	0.582
		N	141.038	119.879	179.498		p_2	0.314	0.236	0.404
							p_3	0.296	0.221	0.383
							N	162.427	145.103	192.740

Table 9. Camp Creek and Granite Boulder Creek fish captures during summer (June July) and fall (October November) of 2011. Numbers in parentheses were recaptured from previous sampling events.

Tag Site	Steelhead		Chinook		Bull Trout	
	Summer	Fall	Summer	Fall	Summer	Fall
CMP_LWR-1	206(8)	423(72)	19	62(2)	0	0
CMP_LWR-2	139(3)	208(46)	15	28	0	0
CMP_UPR-1	60(6)	181(20)	0	0	0	0
GRB_LWR-2	89(6)	122(26)		4	1	(1)

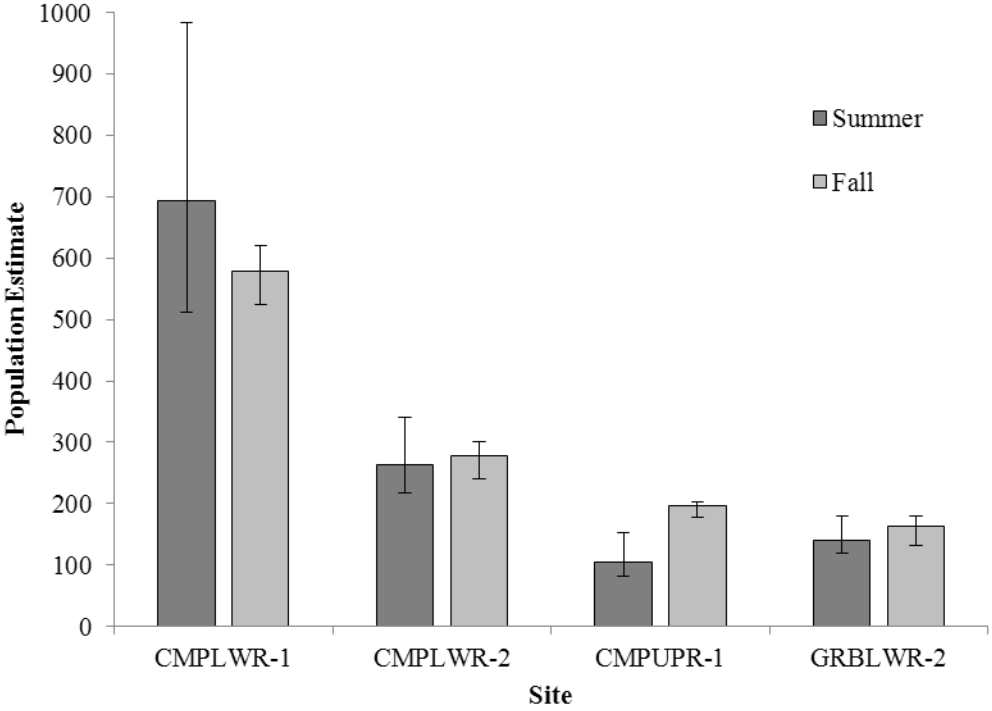

Figure 8. Abundance estimates (± 95% CI) for juvenile steelhead in Camp Creek (CMP prefix) and Granite Boulder Creek (GRB prefix) for summer (June-July) and Fall (October- November) sampling during 2011. See Figure 3 for site location.

Juvenile Chinook and Steelhead Open Population Modeling (POPAN)

Open population models used to estimate juvenile Chinook survival, probability of capture, and probability of entry showed varied results for each parameter at each site. Survival rates for juvenile Chinook varied from 92% between sampling intervals 2 and 3 at mid-control-1 to 24% between sampling intervals 2 and 3 at mid-control-2 in the MFJDR (Table 10). Survival rates increased temporally from the first to last interval at five sites, and were constant throughout the summer at the lower treatment site, mid-treatment-1, and Coyote Creek. Probability of entry decreased at six sites from the first to last interval, remained below 6.2% at Coyote Creek, and increased at the lower treatment site and lower Vinegar Creek throughout the summer for estimable parameters (Table 10). Not all parameters were estimable for each site.

The higher probability of entry between our first and second sampling interval was partially due to the small size of Chinook parr early in the season. During our first sampling interval 10.4% of juvenile Chinook captured were less than 60 mm FL and could not be PIT tagged (Table 11). During our second interval less than 1% of Chinook parr captured were less than 60 mm FL (Table 11). No Chinook parr were captured during our third and fourth intervals that were less than 60 mm FL.

Only four of the ten open population sites that we modeled for juvenile Chinook had fully estimable parameters. Of these four sites the abundance estimates for each sampling reach at each sampling interval ranged from 58 during the first interval at Mid-treatment 2 to 480 during the second interval at Mid-control-1 (Figure 9). Abundance estimates increased at all sites between the first and second interval and increased between all intervals at the upper treatment site. Abundance estimates decreased between the third and fourth interval at the other three sites. The greatest number of fish entered all four sampling reaches between the first and second intervals (Figure 9). The number of juvenile Chinook entering each sampling reach decreased between the second and third and third and fourth interval at all sites (Figure 9).

We recaptured 12 juvenile Chinook outside of the sites where they were first tagged. The highest frequency of tagged immigrant recaptures occurred at mid treatment 2 (RKM 92) where seven Chinook parr tagged outside of the reach were recaptured. Six of these fish were tagged at RKM 93 during tag dispersal operations and the other was tagged at mid control 1 (RKM 94). The emigration of the six fish from RKM 93 was likely due to active restoration work in the area where they were tagged. Only two fish were recaptured farther than one km away from their tagging location. The farthest known movement away from an original tagging location over the four intervals that we sampled was by a fish tagged on 13 July 2011 that moved downstream from RKM 94 (mid-control 1) to RKM 87 (mid treatment 1) where it was recaptured on 7 October 2011.

Table 10. POPAN models used and parameter estimates at individual sites monitored for juvenile 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. Upper and lower 95% confidence intervals are noted as UCI and LCI, respectively.

Model	Parameter	Estimate	LCI	UCI	Model	Parameter	Estimate	LCI	UCI
Lower Treatment					Mid Contol 2				
phi(.)	phi	0.795	0.441	0.950	phi(t)	phi$_1$	0.584	0.378	0.765
p(.)	p	0.335	0.146	0.597		phi$_2$	0.236	0.171	0.316
pent(Mlogit(t))	^{a}PENT$_1$	0.000	0.000	0.000		phi$_3$	0.748	0.582	0.864
	PENT$_2$	0.314	0.174	0.500	p(.)	p	0.490	0.338	0.644
	PENT$_3$	0.440	0.277	0.617	pent(Mlogit(t))	PENT$_1$	0.416	0.348	0.487
N(Log(.))	N	148.368	100.789	267.159		PENT$_2$	0.156	0.112	0.213
Lower Control						PENT$_3$	0.014	0.000	0.322
phi(t)	phi$_1$	0.599	0.388	0.779	N(Log(.))	N	729.639	614.243	923.252
	phi$_2$	0.865	0.351	0.987	Upper Treatment 1				
	phi$_3$	0.648	0.487	0.781	phi(t)	phi$_1$	0.290	0.172	0.446
p(.)	p	0.503	0.334	0.671		phi$_2$	0.704	0.541	0.828
pent(Mlogit(t))	PENT$_1$	0.469	0.319	0.626		phi$_3$	0.914	0.692	0.981
	PENT$_2$	0.131	0.030	0.421	p(.)	p	0.612	0.465	0.742
	PENT$_3$	0.043	0.005	0.279	pent(Mlogit(t))	PENT$_1$	0.383	0.298	0.476
N(Log(.))	N	200.176	176.046	242.475		PENT$_2$	0.185	0.112	0.290
Mid Treatment 1						PENT$_3$	0.140	0.076	0.242
phi(.)	phi	0.590	0.521	0.656	N(Log(.))	N	295.646	265.528	348.148
p(.)	p	0.269	0.206	0.344	Upper Control 1				
pent(Mlogit(t))	PENT$_1$	0.311	0.205	0.440	phi(t)	^{a}phi$_1$	0.000	0.000	0.000
	^{a}PENT$_2$	0.000	0.000	0.000		^{a}phi$_2$	1.000	0.000	1.000
	^{a}PENT$_3$	0.000	0.000	1.000		phi$_3$	0.909	0.016	1.000
N(Log(.))	N	689.014	570.888	857.901	p(.)	p	0.196	0.083	0.396
Mid Treatment 2					pent(Mlogit(t))	PENT$_1$	0.679	0.183	0.952
phi(t)	phi$_1$	0.329	0.199	0.491		PENT$_2$	0.054	0.000	0.974
	phi$_2$	0.874	0.727	0.948		PENT$_3$	0.033	0.000	1.000
	phi$_3$	0.672	0.588	0.746	N(Log(.))	N	195.563	134.271	320.237
p(.)	p	0.734	0.604	0.834	Lower Vinegar Cr.				
pent(Mlogit(t))	PENT$_1$	0.502	0.416	0.588	phi(t)	phi$_1$	0.280	0.009	0.943
	PENT$_2$	0.303	0.226	0.392		phi$_2$	0.377	0.047	0.880
	PENT$_3$	0.013	0.000	0.312		^{a}phi$_3$	1.000	1.000	1.000
N(Log(.))	N	320.560	302.748	352.319	p(.)	p	0.316	0.142	0.563
Mid Control 1					pent(Mlogit(t))	PENT$_1$	0.110	0.011	0.578
phi(t)	phi$_1$	0.358	0.296	0.425		PENT$_2$	0.607	0.385	0.793
	phi$_2$	0.915	0.818	0.962		^{a}PENT$_3$	0.000	0.000	1.000
	^{a}phi$_3$	1.000	0.000	1.000	N(Log(.))	N	66.512	44.113	134.056
p(.)	p	0.616	0.572	0.659	Coyote Creek				
pent(Mlogit(t))	PENT$_1$	0.307	0.261	0.357	phi(.)	Label	Estimate	LCI	UCI
	PENT$_2$	0.186	0.141	0.242		phi	0.649	0.483	0.785
	PENT$_3$	0.079	0.046	0.131	p(.)	p	0.405	0.254	0.576
N(Log(.))	N	911.861	872.867	961.726	pent(Mlogit(t))	PENT$_1$	0.043	0.000	0.956
						PENT$_2$	0.062	0.005	0.490
						^{a}PENT$_3$	0.000	0.000	1.000
					N(Log(.))	N	129.412	108.263	168.996

[a] These parameters were not be estimable for their respective time intervals.

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

	Interval 1	Interval 2	Interval 3	Interval 4
Proportion ≤ 60 mm FL	0.104	0.002	0	0

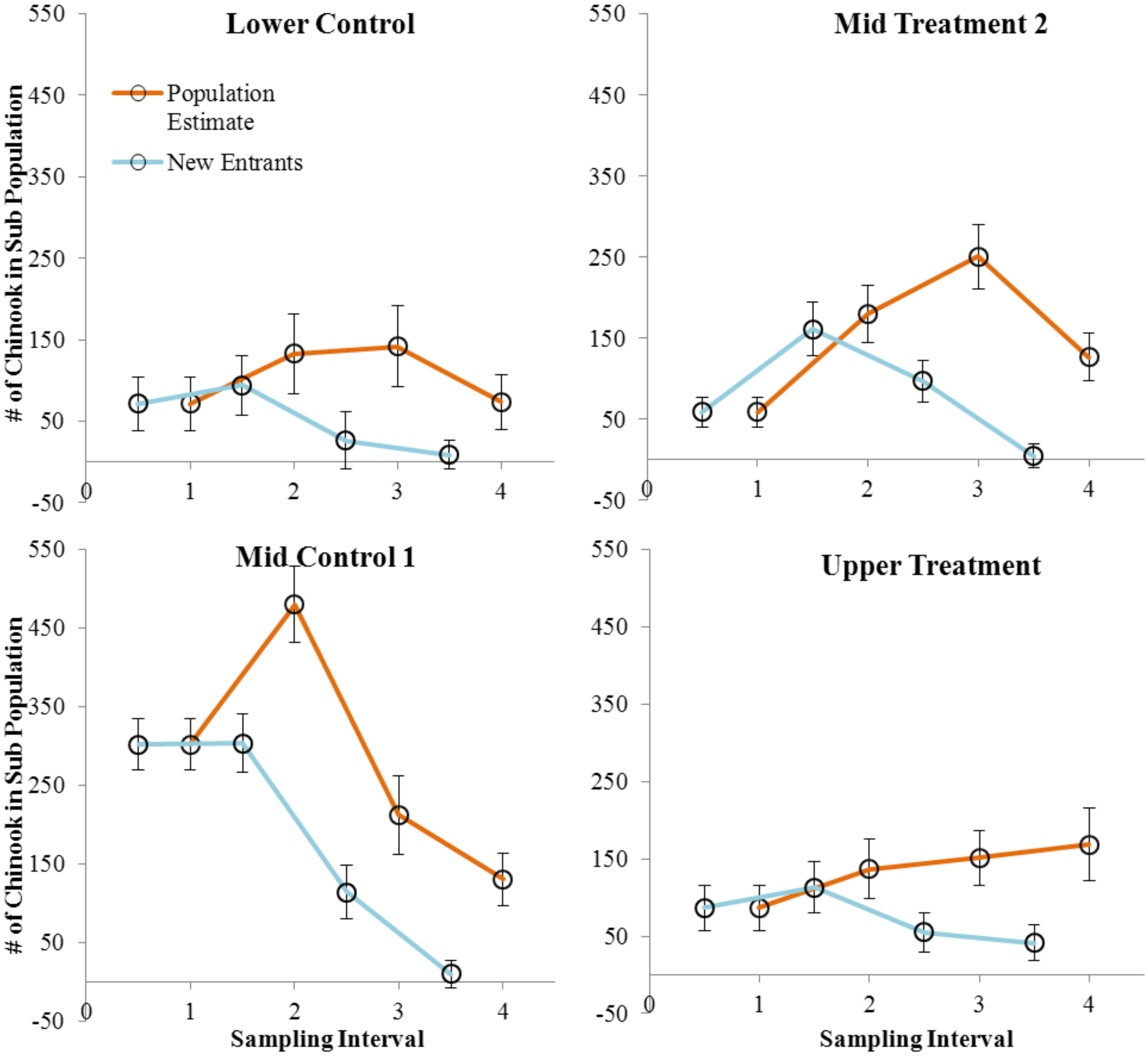

Figure 9. Abundance and Entry estimates at the four POPAN sites with fully estimable parameters for Chinook parr (± 95% CI). New entrants are defined as parr that entered the site between sampling intervals and survived to the next sampling interval. Abundance estimates are defined as the number of individuals present in the sampling reach during sampling.

Open population models used to estimate juvenile steelhead survival, probability of capture, probability of recapture, and abundance for tributary sites in the MFJDR IMW also showed varied results for each parameter at each site. Steelhead parr were only tagged during the first two intervals for the MFJDR sites, so no parameter estimates were completed for steelhead in the MFJDR. Proportional survival rates for juvenile steelhead ranged from 46% between sampling intervals 1 and 2 at the lower Vinegar Creek site to 96% between sampling intervals 2 and 3 at the upper Vinegar Creek site (Table 12). Our model results suggest survival rates increased throughout the summer in Vinegar Creek, and ranged from 54-94% throughout the summer in Coyote Creek (Table 12). Probability of capture ranged from 44% at Upper Vinegar Creek to 72% in Coyote Creek (Table 12). Our model results suggest probability of entry was low for steelhead in tributaries ranging from 6% between the first and second interval at Coyote Creek, to 51% at Upper Vinegar Creek between the third and fourth interval (Table 12). Probability of entry was high between the third and fourth sampling intervals at all three sites (Table 12). It appears that the increase in PENT between the third and fourth interval was caused by age zero steelhead growing to 60 mm which was our minimum PIT tag length. The percentage of new steelhead captured from 60 to 65 mm FL for those sites captured during our last sampling interval was 55% at Coyote Creek, 37% at Upper Vinegar Creek, and 28 % at Lower Vinegar Creek (Table 13). Only two of the 246 steelhead captured and tagged throughout the first three sampling intervals at Coyote and Vinegar Creek sites were between 60 and 65 mm FL. Our abundance estimates ranged from 59 at the Coyote Creek site to 286 at our Upper Vinegar Creek site (Table 12). Not all parameters were estimable for each site.

Only two of the three open population sites that we modeled for juvenile steelhead had fully estimable parameters. Of these two sites, the abundance estimates for each site during sampling intervals ranged from 25 during the last interval at Coyote Creek to 171 during the final interval at lower Vinegar Creek (Figure 10). Both populations showed the same pattern of entry with low entry between the first and second interval increasing to the last interval (Figure 10). This pattern of entry coupled with a high survival rate of 92% led to a gradual increase in abundance at Lower Vinegar Creek from the second to fourth interval (Figure 10; Table 12). In contrast this was not the case in Coyote Creek where the final population abundance estimate decreased in spite of an increase in entry prior to the last interval due to a lower survival rate of 54% (Figure 10; Table 12)

Table 12. POPAN models used and 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 LCIm, respectively.

Model	Parameter	Estimate	LCI	UCI	Model	Parameter	Estimate	LCI	UCI
Coyote Cr.					Lwr Vinegar Cr.				
Phi(t)p(.)pent(Mlogit(t)) N(Log(.))	Phi1	0.707	0.438	0.882	Phi(t)p(.)pent(Mlogit(t)) N(Log(.))	Phi1	0.461	0.237	0.701
	Phi2	0.939	0.144	0.999		Phi2	0.735	0.507	0.882
	Phi3	0.539	0.349	0.719		Phi3	0.920	0.400	0.995
	p	0.717	0.489	0.870		p	0.501	0.337	0.665
	PENT1	0.058	0.003	0.579		PENT1	0.137	0.065	0.267
	PENT2	0.090	0.023	0.294		PENT2	0.187	0.108	0.305
	PENT3	0.242	0.134	0.397		PENT3	0.336	0.239	0.450
	N	59.159	53.643	76.184		N	246.579	207.159	318.952
Upr Vinegar Cr.									
Phi(t)p(.)pent(Mlogit(t)) N(Log(.))	Phi1	0.692	0.490	0.839					
	Phi2	0.961	0.164	1.000					
	*Phi3	1.000	0.000	1.000					
	p	0.436	0.362	0.513					
	*PENT1	0.000	0.000	0.000					
	*PENT2	0.000	0.000	1.000					
	PENT3	0.512	0.425	0.597					
	N	286.232	249.321	340.995					

[a] These parameters were not be estimable for their respective time intervals and sites.

Table 13. Proportion of juvenile steelhead > 60 and ≤65 mm FL captured at three tributary POPAN sites during all four sampling intervals.

Site	Interval			
	1	2	3	4
Coyote Cr.	0	0	0	0.545
Lwr Vinegar Cr.	0	0	0	0.277
Upr Vinegar Cr.	0.032	0	0	0.366

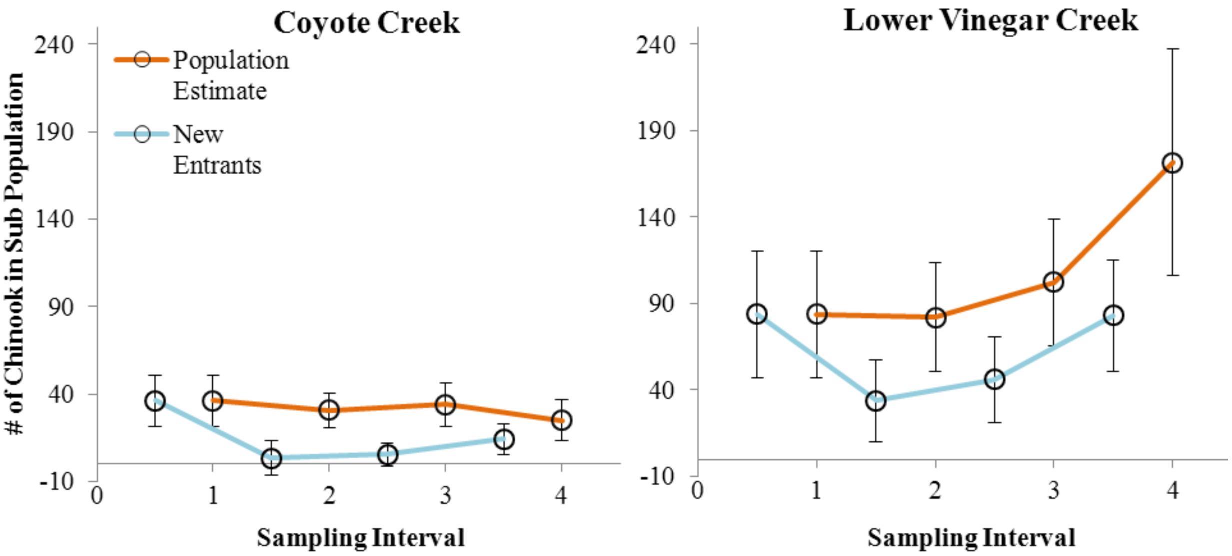

Figure 10. Abundance and Entry estimates at the two POPAN sites with fully estimable parameters for steelhead parr (± 95% CI). New entrants are defined as parr that entered the site between sampling intervals and survived to the next sampling interval. Abundance estimates are defined as the number of individuals present in the sampling reach during sampling.

Parr Length at Age

Juvenile steelhead scales collected in Camp and Granite Boulder Creek in 2010 and 2011 ranged from zero to four years of age for Granite Boulder Creek and zero to three years of age for Camp Creek. Only one fish was aged at four years in Camp Creek. Steelhead rearing in Camp Creek had slightly longer mean fork lengths for all age classes in 2010 and 2011 than steelhead rearing in Granite Boulder Creek this was more evident in older age classes (Figure 11).

Only one bull trout was aged in 2011. This fish was captured in Granite Boulder Creek in July was 165 mm FL and was aged at two years. Of the six juvenile Chinook over 100 mm FL captured in 2011 three were aged at one year and three were age zero fish.

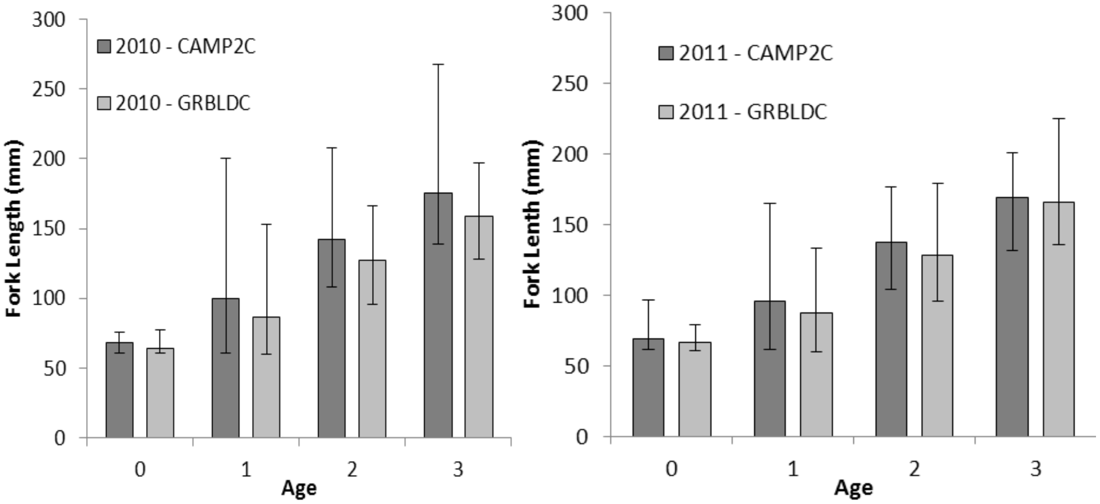

Figure 11. Mean length at age and range in length at age for juvenile steelhead collected in Camp Creek (CAMP2C) and Granite Boulder Creek (GRBLDC) in 2010 and 2011.

Chinook Parr Summer Rearing Distribution

We sampled fifteen tributary streams in the MFJDR IMW to assess summer rearing distribution of juvenile spring Chinook salmon in 2011. The observed summer distribution of juvenile Chinook salmon during 2011 (Figure 12) was similar in comparison to that observed during 2008, 2009, and 2010 in streams sampled all years (James et al. 2009, 2010, 2011). Surveys of Squaw Creek and Summit Creek identified presence of juvenile Chinook upstream of the Squaw and Summit Creek confluence in both tributaries (Figure 12). Distributions in Ruby and Clear Creeks extended beyond the previously identified habitat (Figure 12). In Davis and Deerhorn Creeks distribution appears to have decreased in 2011 (Figure 12). No Chinook were observed in Bear Creek and only one Chinook was observed in Deep Creek. We did not reach the end of the Chinook distribution in Bridge Creek but we did confirm the presence of juvenile Chinook upstream of Bates Pond near Austin Junction. In Lick Creek the distribution of Chinook ended approximately 400 meters downstream of the confluence with West Fork Lick Creek. No juvenile Chinook were observed in West Fork Lick Creek (Figure 12). Juvenile Chinook were quite abundant in Big Boulder Creek downstream from a two meter high water fall but no juvenile Chinook were observed upstream of this barrier in the adjacent 300 m we sampled.

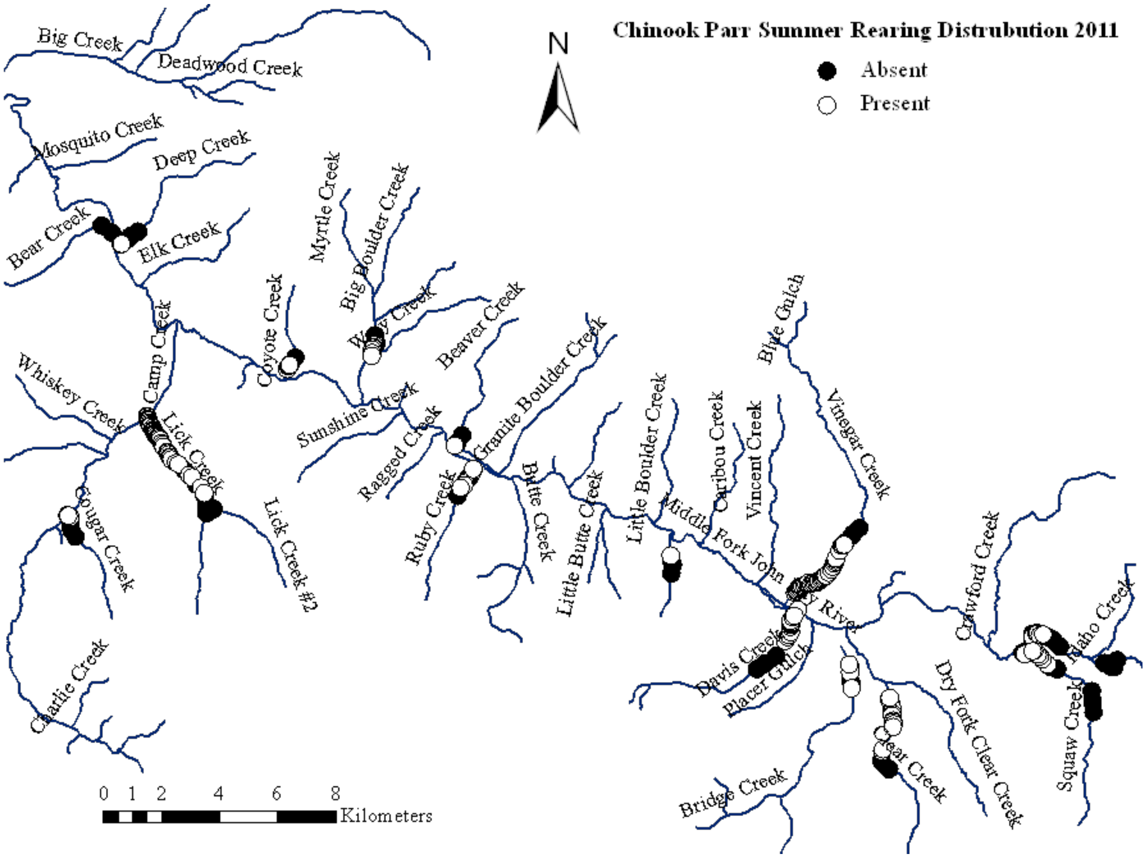

Figure 12. . Map of tributary pools surveyed for juvenile Chinook presence or absence in 2011. Open circles represent pools where juvenile Chinook were observed and closed circles represent pools where no juvenile Chinook were observed.

Bates Pond Juvenile Passage

At the upper Bridge Creek array, 114 juvenile steelhead tagged in 2010 upstream of

Bates Pond were detected from 31 August 2010 to 7 August 2011. Only two juvenile steelhead tagged upstream of Bates Pond in 2011were detected at the upper array as of 13 December 2011.

At the lower Bridge Creek antennae, we detected 40 juvenile steelhead tagged in 2010 in Bridge Creek (Table 14). Twenty-four of these fish were tagged upstream of Bates Bond and 16 were tagged downstream of the pond (Table 14). At the lower antennae, detection dates for juvenile steelhead tagged in 2010 occurred from 1 September 2010 to 27 June 2011.

Nine juvenile steelhead tagged in 2011 were detected at the lower antennae in 2011 (Table 14). Two of these steelhead were tagged downstream of Bates Pond in Bridge Creek, five were tagged upstream of Bates Pond in Bridge Creek, and two were tagged in the mainstem MFJDR during PIT tag dispersal. The steelhead parr tagged in the mainstem MFJDR were captured and released at river kilometers (RKM) 108 and 109 near the confluence of Bridge Creek and the MFJDR. These two fish were detected 27 July 2011 and 3 August 2011.

Two juvenile Chinook tagged upstream of Bates Pond were detected at the upper antennae array in the fall of 2010 (Table 15). Nine juvenile Chinook tagged in 2010, one tagged upstream and eight tagged downstream of Bates Pond, were detected at the lower antennae from 3-Sept-2010 through 16-March-2011 (Table 15). All three juvenile Chinook tagged in 2011 downstream of Bates Pond were detected at the lower Bridge Creek antennae in 2011 from 24 June 11 through 29 July 2011 (Table 15). Only one juvenile Chinook tagged in the MFJDR was detected at the lower antennae on 26 October 2011. This fish was tagged at RKM 109 near the mouth of Bridge Creek. No juvenile Chinook were detected in 2011 at the upper Bridge Creek antennae array.

Table 14. Number, year, and location of juvenile steelhead tagged in Bridge Creek and subsequent PIT tag detection locations at Bridge Creek antennae by year.

Year Tagged	Tagging Location	Number Tagged	Detection Location			
			Upper Antennae		Lower Antennae	
			2010	2011	2010	2011
2010	Upstream of Pond	256	91	23	3	21
	Downstream of Pond	85	0	0	14	2
2011	Upstream of Pond	30	n/a	2	n/a	5
	Downstream of Pond	45	n/a	0	n/a	2

Table 15. Number, year, and location of juvenile Chinook tagged in Bridge Creek and subsequent PIT tag detection locations at Bridge Creek antennae by year.

Year Tagged	Tagging Location	Number Tagged	Detection Location			
			Upper Antennae		Lower Antennae	
			2010	2011	2010	2011
2010	Upstream of Pond	3	2	0	0	1
	Downstream of Pond	50	0	0	6	2
2011	Upstream of Pond	0	n/a	0	n/a	0
	Downstream of Pond	3	n/a	0	n/a	3

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Summer Steelhead and Spring Chinook Smolt Monitoring

Juvenile PIT Tag Detection Histories

A relatively small percentage (5-27%) of fish PIT-tagged in the Middle Fork John Day River IMW from 2008-2011 were re-observed during subsequent capture or interrogation events (Tables16-20). The fewest capture events occur at the MFJDR RST near Ritter with a total of 137 captures (<2%) of all fish tagged as part of the IMW project.

Table 16. Total Detections of juvenile steelhead PIT-tagged in Camp Creek and subsequently detected at various interrogation/capture sites in the MFJDR and smolt migration corridor. Numbers in parentheses represent the number of total fish detected at each site that were never observed again.

Tag Year	Unique Tags	In-stream Recaptures			MF Array Detections			MF RST Recaptures			Out-of-basin Detections		
		2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
2008	1055	56(52)	4(4)	1(1)	40(31)	31(23)	5(5)	2(1)	5(5)	1(1)	35	19	3
2009	962	n/a	75(70)	2(2)	0	102(94)	26(20)	n/a	2(1)	2(1)	n/a	15	43
2010	1717	n/a	n/a	42(41)	n/a	n/a	119(108)	n/a	n/a	3(1)	n/a	n/a	55

Table 17. Detections of juvenile steelhead PIT-tagged in Granite Boulder Creek and subsequently detected at various interrogation/capture sites in the MFJDR and smolt migration corridor. Numbers in parentheses represent the number of total fish detected at each site that were never observed again.

Tag Year	Tags	In-stream Recaptures			MF Array Detections			MF RST Recaptures			Out-of-basin Detections		
		2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
2008	461	56(49)	17(17)	1(1)	3(3)	14(11)	2(1)	1 (0)	0	0	4	10	5
2009	359	n/a	33(33)	2(2)	0	14(12)	2(2)	n/a	0	0	n/a	3	6
2010	233	n/a	n/a	9(9)	n/a	n/a	1(1)	n/a	n/a	0	n/a	n/a	3

Table 18. Detections of juvenile Chinook PIT-tagged in Camp Creek and subsequently detected at various interrogation/capture sites in the MFJDR and smolt migration corridor. Numbers in parentheses represent the number of total fish detected at each site that were never observed again.

Tag Year	Tags	MF Array Detections			MF RST Recaptures			Out-of-basin Detections		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
2008	42	0	0	0	0	0	0	6	0	0
2009	292	0	71 (57)	0		6 (5)	0		20	0
2010	247			59(40)			11(7)			47

Table 19. Detections of juvenile Chinook PIT-tagged in Granite Boulder Creek and subsequently detected at various interrogation/capture sites in the MFJDR and smolt migration corridor. Numbers in parentheses represent the number of total fish detected at each site that were never observed again.

Tag Year	Tags	MF Array Detections			MF RST Recaptures			Out-of-basin Detections		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
2008	94	0	0	0	7 (6)	0	0	12	0	0
2009	254	0	44 (29)	0		8 (6)	0		20	0
2010	2			0			0			0

Table 20. Detections of juvenile Chinook PIT-tagged in the MFJDR and subsequently detected at various interrogation/capture sites in the Middle Fork John Day River and smolt migration corridor. Numbers in parentheses represent the number of total fish detected at each site that were never observed again.

Tag Year	Tags	MF Array Detections			MF RST Recaptures			Out-of-basin Detections		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
2008	950	0	0	0	39 (36)	0	0	115	0	0
2009	1285	0	234 (159)	0		36 (25)	0		97	0
2010	1671			176(130)			14(8)			116

SURPH Modeling

Survival rates for juvenile Chinook to the MF array varied from 27% for fish tagged in the summer to 58% for fish tagged in the fall indicating some level of mortality throughout the summer months for juvenile Chinook (Table 21). This model suggests that the highest mortality rate for Chinook parr occurs between tagging and migration to the MF array. The 2010 and 2011 SURPH models could not estimate a survival parameter from the RST to JDJ but models from MY 2008 and 2009 suggest survival rates to JDJ for those years range from 61% to 91%, respectively (James 2011 unpublished).

Table 21. SURPH model results assessing survival (S) and probability of detection (P) at four detection sites throughout the smolt migration corridor including the MF Array, Middle Fork rotary screw trap (RST), John Day Dam (JDJ), and Bonneville Dam (Bonn) for juvenile Chinook tagged in 2010 during summer and fall for the 2011 migration year. Numbers in parenthesis are standard error.

Tagging Season	S(MFArray)	S(RST)	S(JDJ)	P(MFArray)	P(RST)	P(JDD)	S*P(Bonn)
Summer	0.268 (0.02668)	0.704 (0.1635)	[a]1 (NaN)	0.398 (0.04189)	0.0459 (0.01509)	0.316 (0.06853)	0.0444 (0.0135)
Fall	0.584 (0.08743)	0.727 (0.1962)	[a]1 (NaN)	0.405 (0.06374)	0.109 (0.0397)	0.316 (0.06853)	0.0444 (0.0135)

[a] The survival parameter was not estimable to John Day Dam.

Summer Steelhead and Spring Chinook Smolt Abundance

The smolt abundance estimate from the Middle Fork rotary screw trap (RST) in the MFJDR for spring Chinook salmon was 21,322 and 18,301 for summer steelhead during the 2011 migration year (Table 22). For more information on the fish captured and tagged at this trap please see Dehart et al. (2012 in draft).

Table 22. Smolt abundance estimates (± 95% CI) for spring Chinook and summer steelhead from the MF RST 2011 migration year.

Species	Trapping Period	Captured	Tagged	Abundance	Lower	Upper
Chinook	9/28/10 - 6/3/11	1,364	1098	21,322	17,906	26,217
Steelhead	9/28/10 - 6/3/11	460	290	18,301	11,522	30,028

DISCUSSION

Even with a slightly lower redd estimate in 2011 than 2010 we had the highest escapement estimate in the MF IMW since it began in 2008. Difficult survey viewing conditions due to prolonged snow pack and elevated flows, along with several peak flow events during the steelhead spawning season resulted in a higher fish/redd expansion estimate during 2011. The 2011 fish/redd expansion estimate was the highest fish/redd estimate reported for the Deer Creek weir (M. Dobos, 2011 ODFW memorandum to J.R. Ruzycki). Our 2011 adult steelhead escapement estimate for the MF IMW was nearly five times greater than our 2008 estimate. The 2011 estimate was the first statistically significant increase in estimated escapement that we have recorded in the MF IMW, compared to the 2008 estimate. Large variability in redd counts from site to site contributes greatly to the substantial variance in our escapement estimates and the lack of detecting significant change in escapement from year to year. Given that the 95% CIs range approximately 40% of the estimate in any given year, even with a two fold increase in escapement we are not likely to detect a statistically significant difference in adult steelhead escapement estimates. This variance associated with steelhead redd counts is not true for Chinook counts where we conduct a census survey that has no sample variance. To help correct the lack of precision in our estimate we will continue to assess habitat suitability and accessibility for stream reaches in our spawning universe.

During our parr monitoring we were forced to shorten our mainstem MFJDR site reach length from 250 to 150 meters for all sites due to time constraints. Only the mid control 2 site was sampled at the 250 meter length and it was shortened for intervals three and four. This created a decrease in apparent survival between the second and third interval and abundance during the third interval at this site and should not be assumed to be accurate. Juvenile Chinook were not observed in great enough numbers or frequencies at the Deerhorn Creek or Upper Vinegar Creek sites to model and generate survival or abundance estimates for Chinook. The low probability of entry for juvenile Chinook at the Coyote Creek site through all intervals suggests that very few juvenile fish moved into this site after the first sampling interval. This is not surprising considering the high frequency of step pools and woody debris jams that appeared impassable at the lower summer flows. In contrast, the probability of entry was high during mid-summer in lower Vinegar Creek where access is not impeded during lower summer flows. The probability of entry suggested by the models at five of the eight MFJDR sites was highest before the second sampling interval with the exception of the lower treatment site where it appears 75% of juvenile Chinook in this reach arrived after the second interval in August and September. This may be due to the low density of redds in the vicinity the previous year (McCormick et al. 2011). The nearest documented Chinook redd to this site during the 2010 pawning season was located approximately 3.5 km upstream (McCormick et al. 2011).

Chinook parr distribution is likely a good indication of accessibility in many tributaries for juvenile fish. Juvenile Chinook production, and possibly survival, could be improved by increasing fish passage into tributary streams by removal of any un-natural stream barriers to juvenile fish. Chinook dispersal into tributaries may be more common in warmer, dryer years when parr seek out thermal refugia in cooler streams. Even small barriers could become less passible during dry periods and would likely make juvenile movement difficult. Although increasing Chinook passage may increase the amount of habitat available for juvenile Chinook, it could increase inter-specific competition for steelhead parr rearing in tributaries.

In-stream PIT detections and SURPH modeling will continue to be an important tool for assessing smolt survival. This tool may also be helpful in identifying differences in survival between sites and tagging intervals as fish are detected.

Downstream detections of PIT-tagged fish vary by interrogation site, with the lowest detection rates occurring at the RST; less than 2%. High water and ice formation consistently force the suspension of trapping operations at the Middle Fork RST, likely affecting the low capture probability of IMW tagged fish. Our SURPH model suggests that roughly 5-11% of tagged Chinook smolts migrating past the Middle Fork RST were captured in 2011. Since survival to smolt stage is an important metric in evaluating population response to restoration activity, it is imperative that accurate measurements of smolt production are conducted and greater efficiencies for trapping are assessed. We will continue to analyze our efficiency estimates to better represent the abundance of smolts emigrating from the IMW.

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