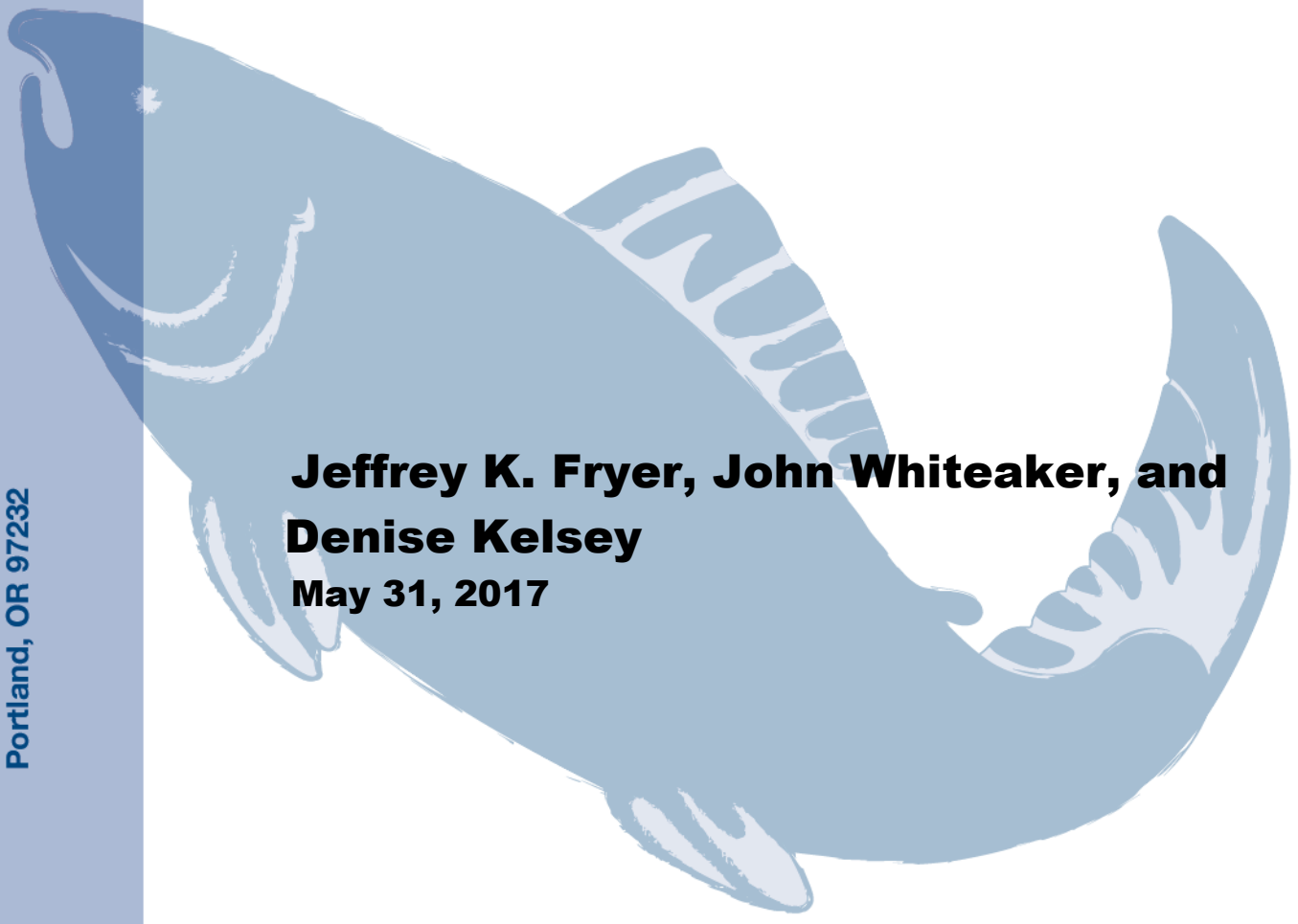
CRITFC
TECHNICAL REPORT 17-07

Upstream Migration Timing of Columbia Basin Chinook and Sockeye Salmon and Steelhead in 2015



Jeffrey K. Fryer, John Whiteaker, and Denise Kelsey

May 31, 2017

Columbia River Inter-Tribal Fish Commission
700 NE Multnomah, Suite 1200
Portland, OR 97232
503.238.0667
www.critfc.org

Upstream Migration Timing of Columbia Basin Chinook and Sockeye Salmon and Steelhead in 2015

Columbia River Inter-Tribal Fish Commission Technical Report for BPA Project 2008-518-00

Jeffrey K. Fryer
John Whiteaker
Denise Kelsey

May 31, 2017

ABSTRACT

In 2015, we sampled Sockeye and Chinook salmon as well as steelhead at the Bonneville Dam Adult Fish Facility (AFF). Fish were measured for length, scales were collected for analysis of age, and the fish were tagged with Passive Integrated Transponder (PIT) tags. These fish were tracked upstream as they passed through sites with PIT tag antennas, including fish ladders at dams, juvenile bypasses, hatcheries, weirs, as well as in-stream antennas. Total numbers of fish tracked upstream were 1294 spring Chinook, 616 summer Chinook, 1653 fall Chinook, 901 Sockeye salmon, and 898 steelhead. High temperatures adversely affected sampling in 2015, completely shutting down the AFF for three weeks plus parts of seven additional weeks. Between weeks 26 and 29, sampling restrictions resulted in only 93 summer Chinook sampled in a period when 67.4% of the run passed. No sampling during Week 33 meant we were unable to sample the peak week of steelhead passage when 14.5% of the run passed. For Sockeye, 22.2% of the run passed between July 2 and 23 when we were not able to sample due to restrictions. High water temperatures meant our sampling was less representative of the run at large than in past years, resulting in some changes in data analysis and cautions in interpreting results.

Chinook median migration rates between mainstem dams ranged between 20.6 and 53.6 km/day. Most spring Chinook Salmon that traveled upstream of McNary Dam were last detected in the Snake River, most summer Chinook were last detected in the Columbia River upstream of Priest Rapids Dam, and most fall Chinook were last detected upstream of McNary Dam, but downstream of Priest Rapids and Ice Harbor dams. With summer Chinook sampling so unrepresentative of the run, escapement estimates derived from PIT tag detections were only calculated for spring and fall Chinook. These estimates differed from those estimated by visual counts by -36.3% to +41.6% at mainstem dams.

Steelhead median migration rates between mainstem dams ranged from 15.7 km to 34.5 km/day. Steelhead classified as B-run (greater or equal to 78 cm fork length) were overwhelmingly last detected in the Snake River. Based on the data reported, the percentage of steelhead classified as B-run at Bonneville Dam reached its highest level on our last week of sampling at 33.7% of the run in Statistical Week 42. The number of B-run steelhead peaked in Week 38 at 3,586

steelhead. A total of 69 PIT steelhead tagged/sampled in 2015 were tracked in 2016 were detected moving downstream (mostly in juvenile bypasses) after spawning, detected in kelt recovery programs, or detected moving upstream in summer/fall 2016 or downstream in 2017, and were designated as kelt.

The estimated stock composition of Sockeye Salmon passing Bonneville Dam based on where PIT tagged Sockeye were last detected was 78.4% Okanogan, 21.1% Wenatchee, and 0.5% Snake River. The median migration between adjacent mainstem dams ranged between 19.6 km and 34.5 km per day.

Comparisons were made between weekly survival to The Dalles and McNary dams and 2014 and 2015 to assess the impact of high temperatures, although it is impossible to compare 5 out of 10 weeks between weeks 27 and 36 due to temperature restrictions preventing PIT tagging at the AFF in either of the two years. For Chinook, in weeks that could be compared, the mean decrease in survival to The Dalles Dam was 2.6 percentage points, for weeks that could be compared, but 17.0 percentage points to McNary Dam. For steelhead, there was a 6.2 percentage drop in survival to McNary Dam in 2015 compared to 2014, but a 2.2 percentage increase to The Dalles Dam. For Sockeye Salmon, there was a mean increase in survival to The Dalles Dam of 0.1 percentage point, but a 31.6 percentage point decrease to McNary dam.

ACKNOWLEDGMENTS

The following individuals assisted in this project: Christine Petersen and Peter Lofy of the Bonneville Power Authority, Ryan Branstetter, Henry Franzoni, David Graves, Doug Hatch, Jon Hess, Melissa Holland, Joe Nowinski, Buck Jones, Jayson FiveCrows, Agnes Strong, Crystal Chulik, Zach Penney, and Phil Roger of CRITFC; Ben Hausmann, Tammy Mackey, Jon Rerecich, and Kasey Welsh of the US Army Corps of Engineers, and Nicole Tancreto of the Pacific States Marine Fisheries Commission.

This report summarizes research funded by the Columbia Basin Fish Accords and the Pacific Salmon Commission.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Since 1985, the Columbia River Inter-Tribal Fish Commission (CRITFC) has, using Pacific Salmon Commission (PSC) funding, sampled Chinook and Sockeye salmon at Bonneville Dam to determine age, length-at-age, and, in the case of Sockeye Salmon stock identification (Fryer 2009). In 2004, CRITFC took over a similar long-running steelhead sampling program at Bonneville Dam from Oregon Department of Fish and Wildlife (Whiteaker and Fryer 2008). The development and maturation of two new technologies, Passive Integrated Transponder (PIT) tags and genetic stock identification (GSI), have provided an opportunity to greatly expand the information obtained from our stock monitoring program at Bonneville Dam. PIT tag antennas are now installed in fish ladders at most mainstem Columbia and Snake River dams, as well as at dams and weirs on many of the Columbia Basin tributaries. By PIT tagging fish that we sample at Bonneville Dam, we can track tagged fish upstream providing valuable information on migration timing and survival rates. PIT tags can provide much of the same information as radio tags, but at minimal expense. With the reduced cost, greater numbers of fish can be tagged, thus increasing the sample size and the small tag reduces the impact on the tagged fish. Unlike radio tags, data on the movement of PIT tagged fish through Columbia Basin receivers is readily available to all managers and researchers on a near real-time basis through the PIT Tag Information System (PTAGIS) at www.ptagis.org. The information obtained by PIT tags can be further expanded by identifying the origin of the fish using GSI. Using these two technologies it becomes possible, to determine migration timing, stray rates, and upstream survival on a stock-specific basis for Chinook and Sockeye salmon and steelhead.

The vast majority of PIT tagging in the Columbia Basin is conducted on juvenile salmonids, either at hatcheries, tributary smolt traps, or at dam juvenile bypasses. These efforts predominantly study the effects of the downstream juvenile migration, but rarely tag a sufficient number of juveniles to assess survival of returning adults as they pass Bonneville Dam and migrate to the spawning grounds. There are also many salmon stocks in the Columbia Basin which are not PIT tagged, thus it is difficult to answer questions on upstream migration timing, straying, and survival for those stocks. Because our project randomly samples adult salmon and steelhead passing the dam, this study tags salmonid stocks that have not previously been tagged and monitored.

METHODS

Sampling

Chinook and Sockeye salmon, as well as steelhead, were PIT tagged from April 15 through October 16, 2015, at the Bonneville Dam Adult Fish Facility (AFF), located adjacent to the Second Powerhouse at river km 235. This facility uses a weir with four pickets to divert fish ascending the Washington shore fish ladder into the AFF collection pool. An attraction flow is used to draw fish that enter the collection pool through a false weir where they then can be selected for sampling. Fish not selected, and fish that have recovered from sampling, migrate back to the Washington shore fish ladder above the pickets.

Our use of the AFF is restricted by protocols established by the Fish Passage Operation and Maintenance Coordination Team (http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2015/final/FPP15_AppG.pdf). These protocols have general restrictions on the number of salmonids we can simultaneously have in our anesthetic and recovery tanks and restrict picket lead operations at higher fish abundances. At temperatures above 21.1C, sampling is restricted to four days per week from 0600-1030 hours, the number of salmonids in the anesthetic tank is reduced and picket lead operations are changed to divert fewer fish into the AFF. Above 22C sampling is halted until temperatures drop to 21.9C.

Salmon and steelhead selected for sampling were diverted into an anesthetic tank where they were anesthetized, examined for tags, fin clips, wounds, and condition. They were measured for length, and tissue and six scales (four scales for Sockeye) collected for later genetic and age analysis (Whiteaker and Fryer 2008, Kelsey et. al 2011). Fish were scanned for PIT tags. If no tags were detected, standard techniques were used to inject PIT tags through a needle that penetrates the fish between the posterior tip of the pectoral fin and the anterior point of the pelvic girdle (CBFWA 1999). Tagged fish were then scanned for the PIT tag code, which was recorded if detected. If no tag was detected, no effort was made to re-tag the fish. Data on each PIT tagged fish was uploaded to www.ptagis.org.

As tagged salmon and steelhead continued their migration they were detected by PIT tag receivers located in the adult fish ladders at major Columbia Basin mainstem dams (Bonneville, The Dalles, McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells dams on the Columbia River; Ice Harbor, Lower

Monumental, Little Goose, and Lower Granite dams on the Snake River) as well as in numerous tributaries and hatcheries in the Columbia Basin (Appendix - Table A1 and Figure A1). PIT tag data is uploaded to www.ptagis.org, which is then accessible to users of the site.

Upstream Detection

At each site with PIT tag detection, PIT tagged salmon typically pass by a weir with one or more antennas. Salmon can be detected more than once as the pass over or through each weir. Each individual detection will subsequently be referred to as a "weir detection". The combination of all detections at the many weirs at a given site, regardless of the time between those detections, will subsequently be referred to as a "site detection". For example, the configuration of PIT tag antennas at Rock Island Dam is shown in Figure 1.

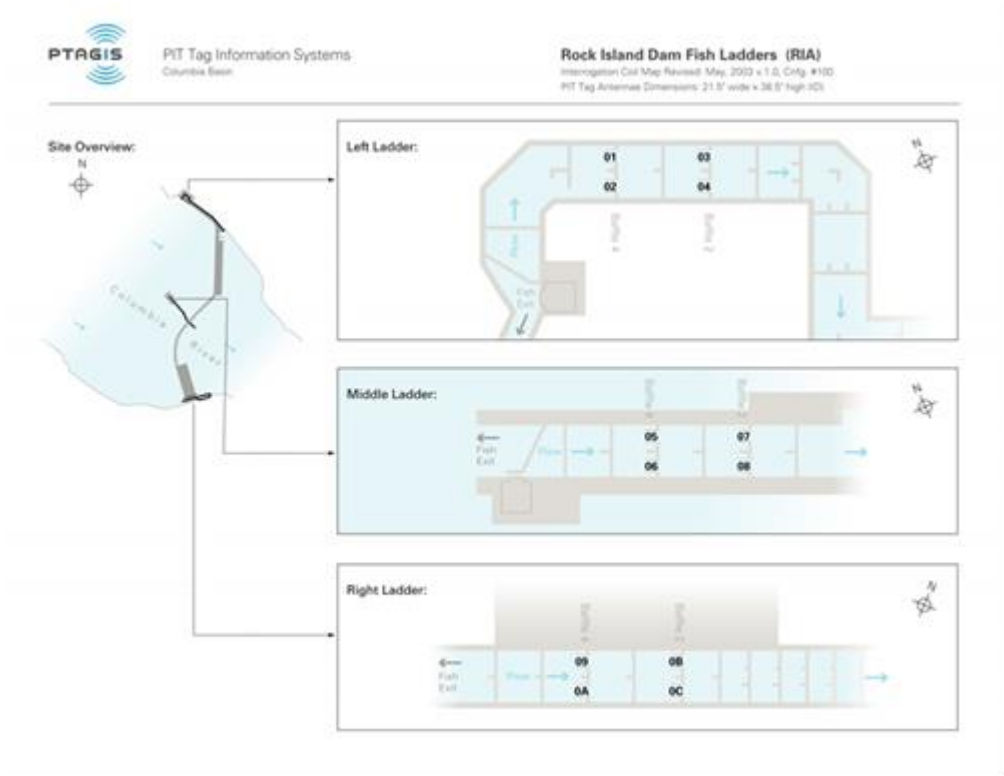


Figure 1. Example PIT tag detection configuration at Rock Island Dam showing two adjoining antennas at two weirs in each fish ladder. (Figure from www.ptagis.org.)

Salmon can pass this dam using any of three fish ladders. Each ladder has two weirs (referred to as baffles 2 and 4 at each ladder) with PIT tag detection and two antennas in each weir (numbered as 01 to 0C in hexadecimal format). If a fish ascended the left ladder and generated two detections at Baffle

2 and three at Baffle 4 (the word “baffle” and “weir” is interchangeable), this is five weir detections, but only one site detection (Rock Island Dam).

Site Detection Efficiencies

Any fish detected at an upstream dam should have been detected at lower dams (with the exception of Bonneville, McNary, Ice Harbor, and Lower Granite dams where it is possible that a fish could use the navigation locks to pass the dam). The percentage of PIT tagged fish missed at each dam with PIT tag detection arrays was calculated by looking at the fish detected upstream of the site in question and estimating the percentage not detected at that site. For example, the percentage missed at Rocky Reach Dam was calculated as:

$$P = \frac{R_m}{R_d}$$

where R_m was the number of fish missed at Rocky Reach Dam but detected upstream of Rocky Reach Dam and R_d was the number of fish detected upstream of Rocky Reach Dam.

PIT tag detection antennas in fish ladders are always placed in at least two locations in relatively close proximity. PIT tag interrogation maps (available at www.ptagis.org) indicate that these antennas are placed at vertical slots, weirs, or pools. To simplify the nomenclature, these locations will all subsequently be referred to as weirs.

Age Analysis

Visual assessment of scale patterns was used to determine age composition through techniques developed for the Bonneville Stock Sampling project *(*Whiteaker and Fryer 2008, Kelsey et al. 2011*).* We used the European method for fish age description (Koo 1962) where the number of winters a fish spent in freshwater (not including the winter of egg incubation) is described by an Arabic numeral followed by a period. The number following the period indicates the number of winters a fish spent in saltwater. Total age, therefore, is equal to one plus the sum of both numerals. If poor scale quality, particularly in the freshwater prevents age determination in all scales collected from a particular fish, no age is assigned. The exception is steelhead, where if saltwater age can be reliably determined, the age is designated as r.y where y is the saltwater age and “r” stands for regenerated.

The origin and age of Chinook and steelhead previously PIT tagged in

other projects and sampled in this project could be determined by querying PTAGIS for the tag code, thus providing a validation of age since release. Very few Sockeye Salmon are tagged as juveniles making it difficult to sample sufficient returning adults to validate ages for this species.

Escapement

Chinook and Sockeye salmon escapement at upstream detection sites were estimated as:

$$N = \sum_i \frac{B_i R_i}{T_i}$$

where N was the estimated escapement at a particular upstream site, *i* was the week at Bonneville Dam, B_i was the weekly count of fish passing Bonneville Dam in week *i*, T_i was the number of fish PIT tagged at Bonneville Dam in week *i,* and R_i was the number of PIT tag detections at the dam where escapement was being estimated of those fish tagged in week *i.* Estimated dam counts using PIT tag data were compared with dam counts made at fish ladder viewing windows or weir counts. No estimates were made for steelhead, due to the fact that many overwinter between dams on their upstream migration making it difficult to compare PIT tag estimates with dam counts.

Migration Rates and Passage Times

Run timing was estimated using the date and time of detection between detection sites. Migration rates were calculated between sites as the time between the last detection at the first site and the first detection at the upper site. The amount of time required to pass each dam was estimated as the difference between the first detection time at a dam and the last detection time at the same dam.

Upstream Age and Length-at-Age Composition Estimates

The age composition at upstream locations was calculated as:

$$T_j = \sum_k A_{j,k} * W_k$$

where T_j was the estimate for age group *j* at a particular location, $A_{j,k}$ was the percentage of fish for age group *j* in week *k* at Bonneville Dam (such that $\sum_j A_{j,k} = 1$) and W_k was the percentage of the run that passed Bonneville Dam in week *k.*

Fallback

Three methods were used to determine fallback, which is defined as a fish that ascends a fish ladder into the reservoir above the dam, then "falls back" to the downstream side of the dam either over the spillway, or through the navigation locks, juvenile bypass systems, or turbines. The first was if an adult salmon or steelhead was detected in the juvenile bypass system. However, on the Columbia River, only Bonneville, John Day, McNary, Rocky Reach dams have juvenile bypass system PIT detection capability while all four dams in the Snake River have juvenile detection. Furthermore, there is no detection at any dam for fish falling back over the spillway or through the navigation locks or turbines. Therefore, a second method of estimating fallback was to look at each dam for fish detected at an "upper" weir followed by detection at a "lower" weir separated by more than two hours. At McNary and Bonneville dams, the upper detection weir is at the fish counting window (which are believed to detect all passing PIT tagged fish), while the PIT tag detectors near the entrance to the fish ladder. At Priest Rapids, Rock Island, Rocky Reach, and Wells dams, there are only two weirs with PIT tag detectors in each fish ladder so these were designated as the upper and lower detection weirs, even if they are not at the top or bottom of the ladders. At McNary and Bonneville dams, detection histories of fish detected at multiple ladders were also reviewed (MC1 and MC2 for McNary and BO1 and BO4 for Bonneville (http://www.ptagis.org for maps of sites)). Finally, a third method of defining fallback was ascertained by fish that passed an upstream PIT tag detector at a given dam, then were next observed at a site downstream of the dam in question. These methodologies will underestimate fallback as they do not include fish that fall back over a dam and are not subsequently detected.

Adult steelhead downstream movements on or after March 31, 2015 were not considered fallbacks; rather they were considered kelts on their way downstream.

Night Passage

Fish counting at Columbia Basin dams is not consistent between dams. Salmonids passing Bonneville, McNary, Ice Harbor, and Lower Granite dams are counted live by observers stationed at fish ladder viewing windows from 0400 to 2000 PST (http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2012/index.html), while salmonids passing Priest Rapids, Rock Island, Rocky Reach, and Wells dams are all counted 24 hours per day from recorded video. Tributary dam passage is

estimated using 24 hour recorded video and/or counts at adult fish traps.

Night passage rates (where night is defined as 2000 to 0400 PST) were calculated based on the last time fish were detected in a fish ladder for all dams passed. This last time detected at a ladder was used as an approximation for passage time at the counting window, as the uppermost weir is closest to the fish counting window at nearly all ladders. (For maps of site configeration for mainstem dams see http://www.ptagis.org).

Steelhead B-Run Analyses

For management purposes Columbia Basin steelhead are commonly referred to as being either A- or B-run. B-run steelhead are defined as greater than or equal to 78 cm in length, while A-run steelhead are under 78 cm (Busby et al. 1996). B-run steelhead are generally older, spending three winters in saltwater compared to one or two winters for A-run steelhead, and generally pass Bonneville Dam after August 25, while A-run steelhead generally pass earlier (Busby et al. 1996). Upstream, run timing separation is not observed and the groups are separated based on size and age (Busby et al. 1996). B-run steelheads are thought to only be produced in the Clearwater, Middle Fork Salmon and South Fork Salmon rivers (Busby et al. 1996).

Analyses of B-run steelhead consisted of comparing the timing of the A- and B-runs at Bonneville Dam with the established August 25 criteria, comparing the length group of sampled steelhead with where at which they were last detected, and looking at the destination of B-run-sized steelhead by statistical week sampled at Bonneville Dam.

Steelhead (Kelt) Analyses

Steelhead differ from other salmonids studied in this project for they are capable of spawning multiple times. After spawning in late winter or early spring, some steelhead will migrate downstream to the ocean to feed; these fish are known as kelt. The fish that survive return in a subsequent spawning season. We considered all steelhead detected moving downstream (mostly in juvenile bypasses) on or after March 31, the year after tagging, to be kelt and tabulated where they were last detected.

Sockeye Stock Classification

Columbia Basin Sockeye Salmon consist of two major runs returning to the Okanogan and Wenatchee basins and one very small run returning to the

Snake River. In addition, there are efforts underway to reintroduce Sockeye to former habitat in the Deschutes and Yakima basins. Given the relatively small number of geographically separated stocks, Sockeye PIT tagged at Bonneville Dam can be classified by stock based on the point where they were last detected. Those individuals last observed at or upstream of Rocky Reach Dam were classified as Okanogan stock, those last observed at or upstream of Tumwater Dam were classified as Wenatchee stock, and those last observed at or upstream of Ice Harbor Dam were classified as Snake River stock. Sockeye Salmon last detected in the Deschutes, Entiat, or Yakima basins were considered as belonging to those stocks. Those last observed downstream of all these sites were classified as unknown and were also considered mortalities.

RESULTS-CHINOOK

Sample Size

A total of 1272 spring Chinook, 607 summer Chinook, and 1651 fall Chinook Salmon were PIT tagged in 2015 (Tables 1-3) between April 15 and October 16, 2015. Sampling restrictions due to water temperatures exceeding 21.1C reduced sampling days and hours during Statistical weeks 27, 30 and 31 of the summer Chinook run and weeks 32, and 34-38 of the fall Chinook run. Sampling was not allowed during weeks 28 and 29 of the summer Chinook Salmon run and Week 33 of the fall Chinook run. After adding previously tagged fish (which were sampled and therefore identified for the tracking study and included in our sample) and subtracting fish that were not detected after release (due to shed tags, mortalities, malfunctioning tags, or PIT tagged Chinook missing PIT tag antennas), the numbers of Chinook tracked upstream consisted of 1294 spring Chinook, 616 summer Chinook, and 1653 fall Chinook Salmon (Table 1-3).

Table 1. Number of PIT tagged spring Chinook Salmon at Bonneville Dam and then tracked, by date and statistical week, in 2015.

Sample Dates	Week	Sampled	Tagged	Previously Tagged	Not Detected After Release	Total Tracked	Days Sampling Restrictions in Effect		
							Reduced Sampling-Temperature	Reduced Sampling-Shad or Salmon Abundance	No Sampling-Temperature
4/15-4/17	16	52	51	1	0	52	0	0	0
4/20-24	17	158	152	5	0	157	0	0	0
4/27-30,5/1	18	268	265	1	0	266	0	2	0
5/4-8	19	216	213	3	0	216	0	0	0
5/11-5/14	20	192	188	4	1	191	0	0	0
5/18-22	21	268	262	6	1	267	0	0	0
5/26-5/28	22	146	141	4	0	145	0	0	0
Total		**1300**	**1272**	**24**	**2**	**1294**	**0**	**2**	**0**

Table 2. Number of PIT tagged summer Chinook Salmon tracked at Bonneville Dam by date and statistical week in 2015.

Dates	Week	Sampled	Tagged	Previously Tagged	Not Detected After Release	Total Tracked	Days Sampling Restrictions in Effect		
							Reduced Sampling-Temperature	Reduced Sampling-Shad or Salmon Abundance	No Sampling-Temperature
6/2-6/5	23	196	187	9	1	195	0	1	0
6/8-6/12	24	161	160	1	0	161	0	2	0
6/15-6/19	25	95	95	0	0	95	0	5	0
6/22-26	26	71	70	1	0	71	0	5	0
6/30,7/1-7/2	27	22	22	0	0	22	0	3	1
No Sampling	28	0	0	0	0	0	0	0	5
No Sampling	29	0	0	0	0	0	0	0	5
7/24	30	20	20	0	0	20	1	0	4
7/27-30	31	53	53	0	1	52	4	0	1
Total		**618**	**607**	**11**	**2**	**616**	**5**	**16**	**16**

Table 3. Number of PIT tagged fall Chinook Salmon tracked at Bonneville Dam by date and statistical week in 2015.

Dates	Week	Sampled	Tagged	Previously Tagged	Not Detected After Release	Total Tracked	Days Sampling Restrictions in Effect		
							Reduced Sampling-Temperature	Reduced Sampling-Shad or Salmon Abundance	No Sampling-Temperature
8/5-7	32	31	31	0	0	31	3	0	2
No Sampling	33	0	0	0	0	0	0	0	5
8/18-19	34	67	66	1	1	66	2	0	3
8/24-27	35	113	111	2	0	113	2	0	3
9/1-4	36	196	192	4	0	196	4	0	0
9/8-11	37	200	200	0	1	199	4	1	0
9/14-18	38	240	240	0	2	238	0	5	0
9/21-25	39	188	187	1	1	187	0	5	0
9/28-30,10/2-2	40	221	221	0	0	221	0	5	0
10/5-9	41	228	225	1	0	226	0	2	0
10/12-16	42	182	178	1	3	176	0	0	0
Total		**1666**	**1651**	**10**	**8**	**1653**	**15**	**18**	**13**

Distribution of Sample

Compared to the distribution of the Chinook run past Bonneville Dam as determined by visual counts, spring Chinook were under-sampled early in the run (Statistical weeks 16-18) and over-sampled late in the run (Figure 2). Summer Chinook were over-sampled early in the run (weeks 23-24) and greatly undersampled in weeks 26-29 due to temperature restrictions during the middle of the run (Figure 3). Fall Chinook were under-sampled during the middle of the run (Figure 4). During weeks 28 and 29 when sampling was not permitted due to temperatures exceeding 22.2C at Bonneville Dam, 23.0% of the summer Chinook run. Between when sampling was shut down on July 3 and resumed on July 23, 26.3% of the summer Chinook run passed. Between weeks 26 and 29, sampling restrictions or no sampling meant that only 93 summer Chinook were sampled during weeks when 67.4% of the summer Chinook run passed.

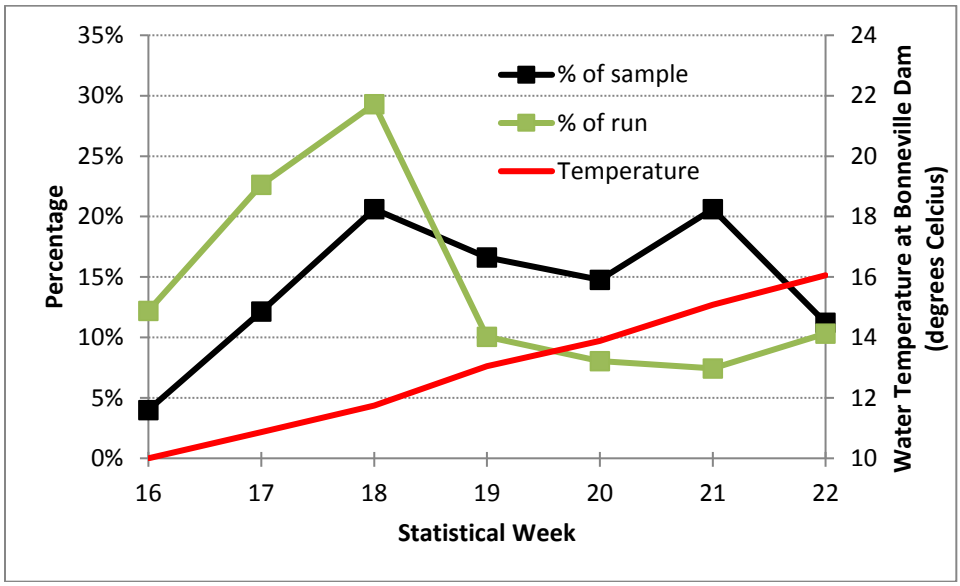


Figure 2. The weekly spring Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2015.

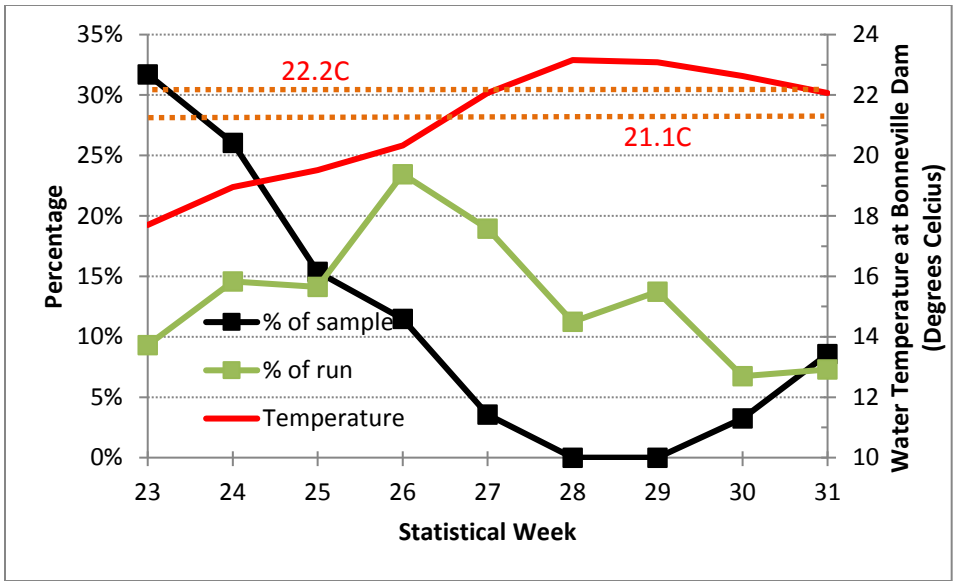


Figure 3. The weekly summer Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2015. Sampling was reduced at 21.1C and halted at 22.2C.

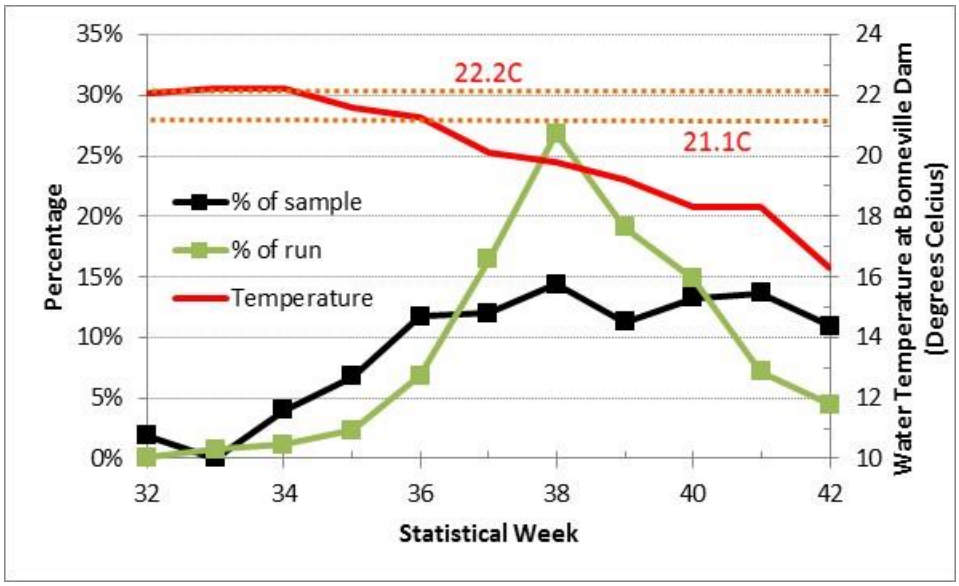


Figure 4. The weekly fall Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2015. Sampling was reduced at 21.1C and halted at 22.2C.

Detection Numbers

The tracking of 1294 spring Chinook generated 79074 weir detections, which were grouped into 8224 site detections at 96 sites. The 616 summer Chinook generated 32210 weir detections, grouped into 3811 site detections at 73 sites, and the 1653 fall Chinook generated 68722 weir detections grouped into 6690 site detections at 37 sites. Maps found in the Appendix (Figure A2-A13)

show the sites and the categorical ranges of detection numbers at the sites throughout the Columbia Basin. Note that the number of Chinook tracked in each run is determined by the migration timing at Bonneville, with the spring Chinook run ending May 31st, the summer Chinook running from June 1 through July 31st, and the fall Chinook run starting August 1st (FPC 2015).

Age Analysis

We are able to validate our scale aging techniques by using fish sampled at Bonneville that were previously tagged as juveniles for other projects or hatchery programs. We had ageable scale patterns from 6 spring Chinook, 14 summer Chinook, and 8 fall Chinook PIT tagged as juveniles that were sampled as returning adults by this project. Of these, 5 of 6 spring Chinook, all 14 summer Chinook, and 7 out of 8 fall Chinook were aged correctly. Only the total age was compared, as it is not possible to separate freshwater and saltwater age using PIT tag data.

In 2015, data were also available on total ages from genetic samples collected from each fish as part of this project. Scale pattern age estimates were in agreement with those estimated using genetics 98.9% of the time (Table 4).

Table 4. Comparison of total age estimates using genetics and scale pattern analysis for Chinook Salmon sampled at Bonneville Dam in 2015. Green shading indicates agreement between the two methods, orange indicates the age estimates differed.

Age Estimated Using Genetic Stock ID	Total Age Estimated Using Scale Patterns				% Concurrence
	Age 3	Age 4	Age 5	Unageable	
Age 3	112			12	100.0%
Age 4	3	497	3	107	98.8%
Age 5		1	7	0	87.5%
Total	**115**	**498**	**10**	**119**	**98.9%**

We attempt to exclude minijacks (defined as Chinook spending no winters in saltwater) from our sample by not diverting Chinook Salmon into the sampling tank that were estimated to be less than 36 cm in length, and immediately releasing without sampling any fish diverted that turned out to be less than this threshold. In general, these small Chinook Salmon are excluded due to lack of importance to fishery managers and the fact that sampling these fish would reduce our sample of larger Chinook, and other species, which are important to managers. In previous years, we have also excluded Chinook Salmon greater

than 36.0 cm in length but aged as Age 1.0 or 2.0 as minijacks from our analysis. In 2015, unlike most previous years, we did not have any Chinook Salmon aged as Age 1.0 or 2.0 that were over 36.0 cm fork length.

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Spring Chinook Salmon that traveled upstream of McNary Dam were predominantly last detected at or upstream of Ice Harbor Dam in the Snake River (Table 5, Figures 5 and 6), while summer Chinook were primarily bound for the Columbia River upstream of Priest Rapids Dam (Table 5, Figures 5 and 7). Fall Chinook were primarily last detected at areas between McNary and Ice Harbor/Priest Rapids dams (the location of Ringold and Priest Rapids hatcheries, which rear fall Chinook Salmon as well as the Hanford Reach spawning area (Table 5, Figures 5 and 8). The percentage of all Chinook that ultimately passed Ice Harbor Dam peaked during the spring Chinook migration, Chinook passing Priest Rapids Dam peaked during the summer Chinook migration, and the percentage last detected between McNary and Ice Harbor/Priest Rapids dams peaked during the fall Chinook migration (Figure 5). The percentage last detected downstream of McNary Dam had two peaks; the higher during the summer Chinook migration with the other during the fall Chinook migration.

Table 5. Percentage of spring, summer, and fall Chinook Salmon tracked from Bonneville Dam detected at upstream dams and the percentage lost due to tributary escapement, tag loss, harvest, spawning, or mortality between dams in 2015.

Dam	Spring Chinook	Summer Chinook (Before Sampling Shut Down)	Summer Chinook (After Sampling Shut Down)	Fall Chinook
Bonneville	100.0%	100.0%	100.0%	100.0%
The Dalles	78.9%	80.0%	93.0%	68.2%
McNary	65.0%	61.4%	76.8%	55.8%
Priest Rapids	11.7%	40.2%	65.6%	8.3%
Rock Island	11.4%	38.8%	65.6%	4.1%
Rocky Reach	6.1%	32.7%	59.8%	3.1%
Wells	5.9%	31.0%	54.0%	2.2%
Ice Harbor	46.7%	17.6%	6.8%	8.3%
Lower Monumental	45.2%	16.2%	6.8%	8.0%
Little Goose	44.1%	13.3%	6.8%	7.6%
Lower Granite	43.2%	13.1%	6.8%	7.4%

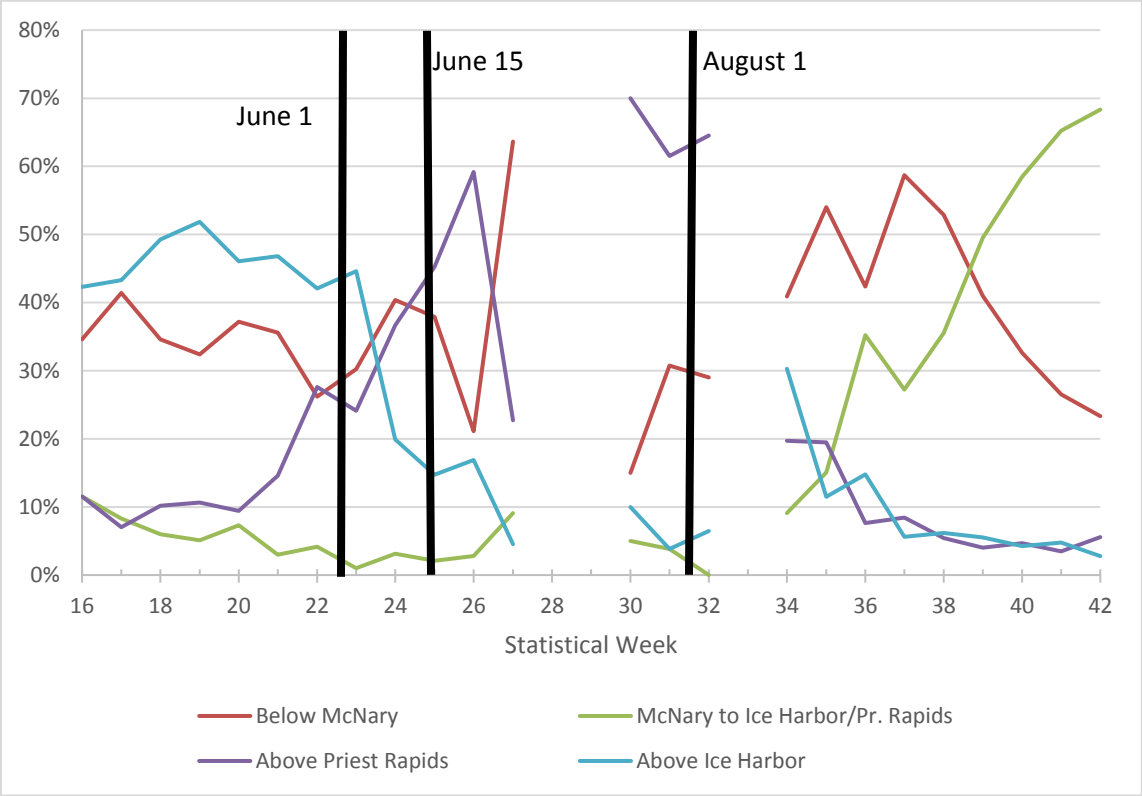


Figure 5. Distribution of final detection areas of the Columbia Basin by statistical week for Chinook Salmon PIT tagged at Bonneville Dam in 2015.

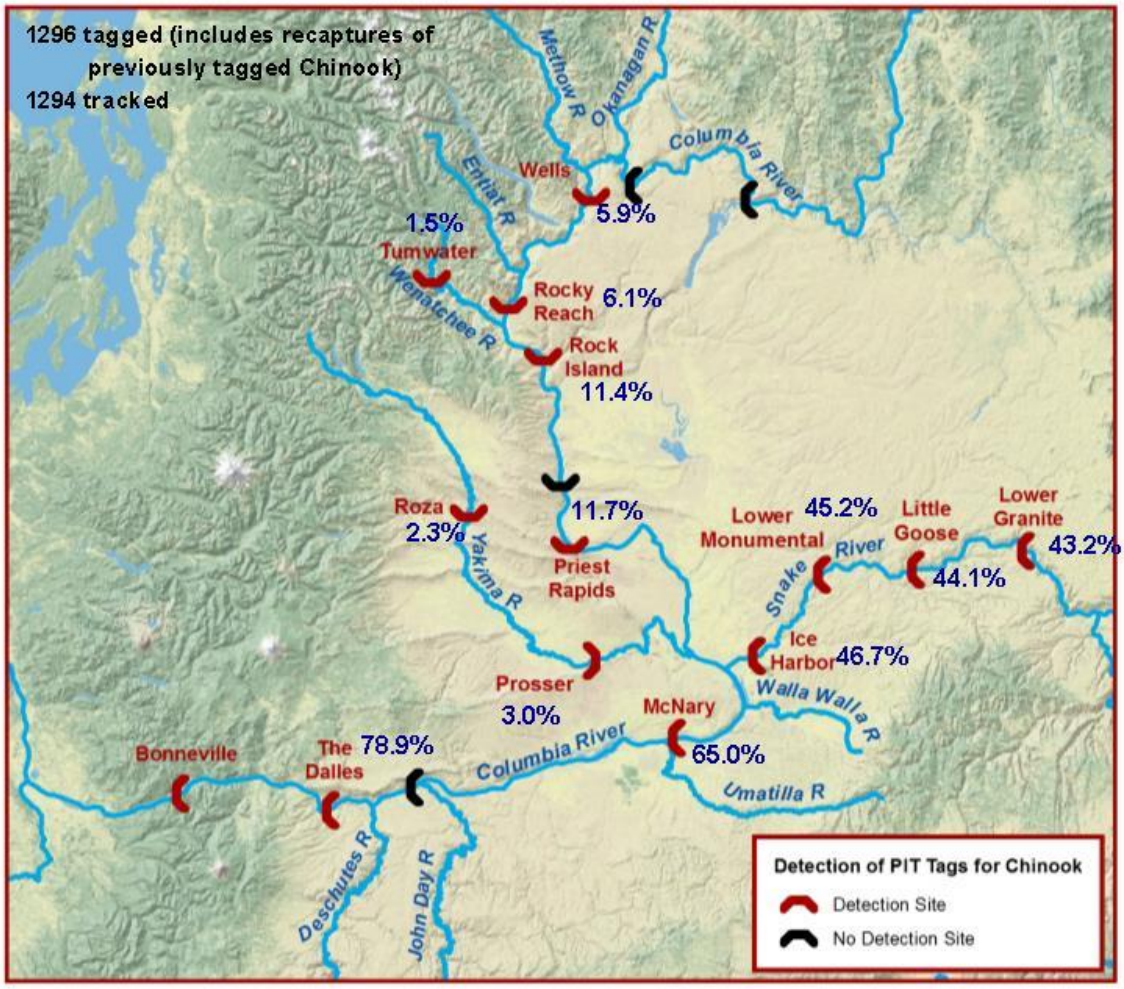


Figure 6. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of spring Chinook Salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2015.

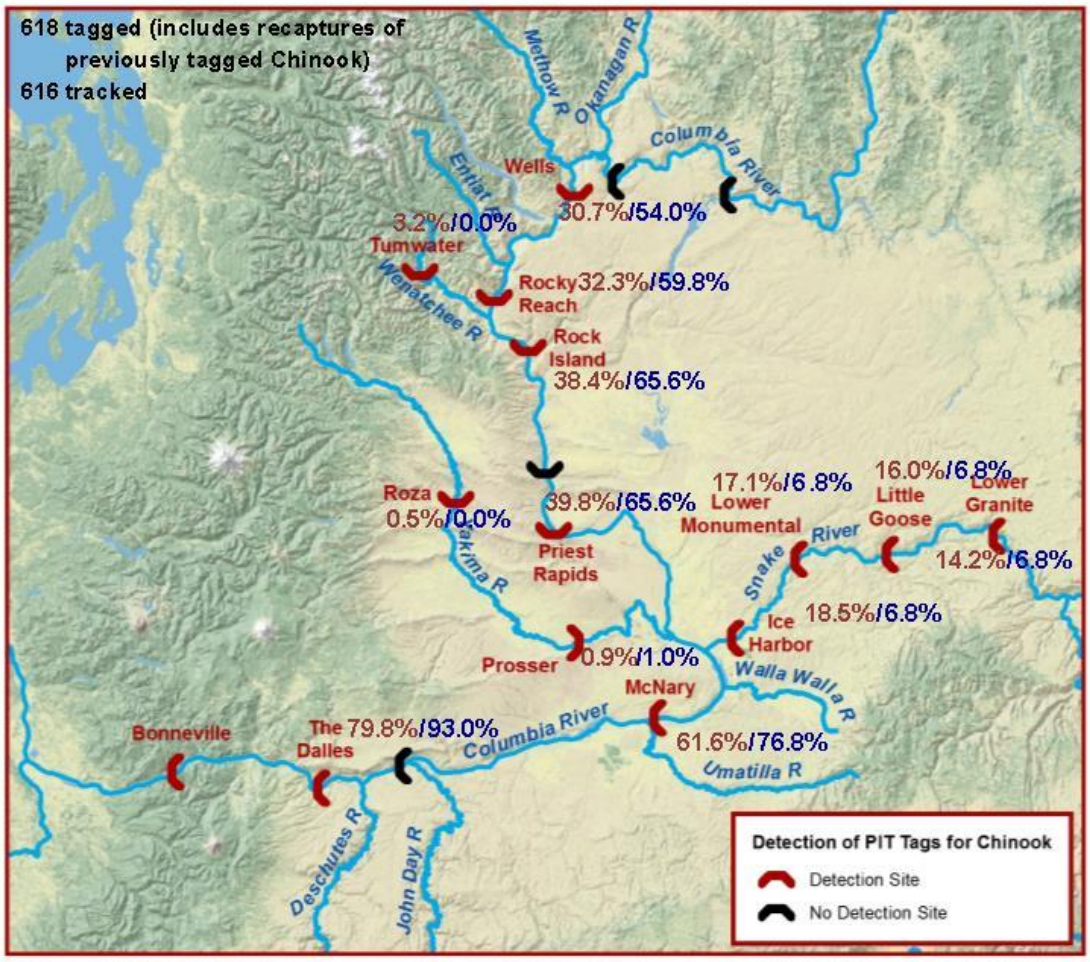


Figure 7. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of summer Chinook Salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2015 for weeks 23-27 (70.3% of run) followed by weeks 30-31 (10.7% of the run). No sampling occurred during weeks 28-29.

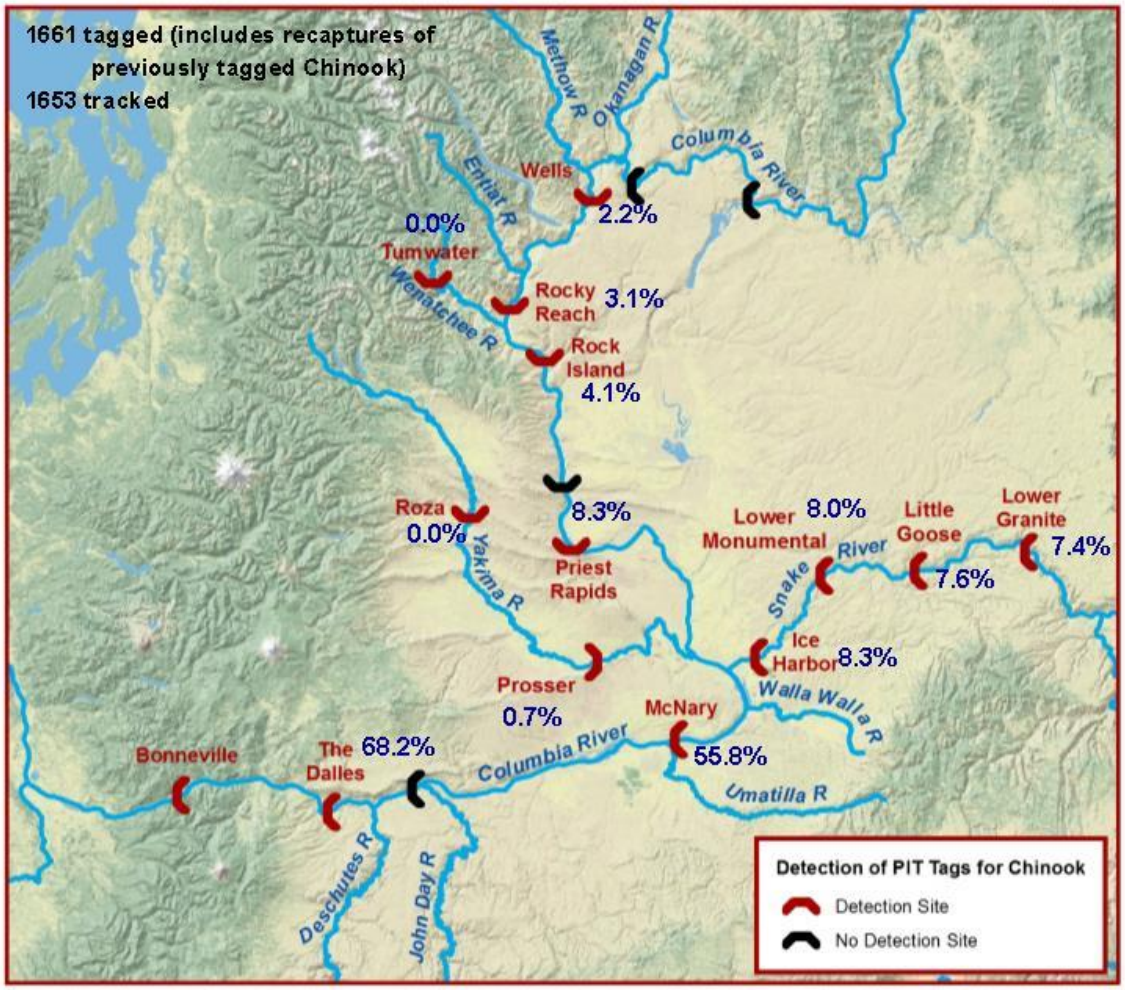


Figure 8. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fall Chinook Salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2015.

The mean percentage of PIT tagged Chinook Salmon documented passing a dam without detection, with the exception of Rock Island Dam, was 0.2% for spring Chinook, 1.1% for summer Chinook, and 0.1% for fall chinook (Table 6). At Rock Island Dam, the rate for missed tags ranged from 16.9% to 31.6%. High rates of missed PIT tagged fish at Rock Island Dam have also been observed in other years and are likely attributable to antenna size and electrical noise (Fryer et al. 2016). Summer Chinook Salmon were also missed at Little Goose Dam at a high rate in 2015 and this was attributable to electrical noise problems over the summer (http://www.ptagis.org/sites/interrogation-site-metadata?IntSiteCode=GOA). Bonneville, The Dalles, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams all have navigation locks where it is possible that PIT tagged salmon could pass upstream undetected. The rates of detection efficiency of individual weirs within ladders, at dams listed

in Table 6, are found in the Appendix (Table A1).

Table 6. Percentage of Chinook Salmon detected upstream that missed detection at mainstem dams in 2015.

Dam	Spring	Summer	Fall
Bonneville	0.0%	0.0%	0.0%
The Dalles	0.0%	0.0%	0.1%
McNary	0.1%	1.0%	0.1%
Priest Rapids	3.0%	2.1%	0.0%
Rock Island	31.6%	20.8%	16.9%
Rocky Reach	0.0%	0.0%	0.0%
Wells	0.0%	0.5%	0.0%
Ice Harbor	1.0%	0.7%	1.6%
Lower Monumental	0.3%	0.7%	0.0%
Little Goose	0.2%	14.1%	1.6%
Lower Granite	0.0%	0.8%	0.0%
Weighted Mean (by sample size) Excluding Rock Island	**0.2%**	**1.1%**	**0.1%**

Escapement estimates based on PIT tags were not calculated for the entire Chinook run in 2015, due to the percentage of the summer Chinook run missed. Escapement estimates for the spring Chinook run deviated from visual counts by up to 36.3% at Wells Dam, while fall Chinook estimates deviated by up to 41.6%, also at Wells Dam (Table 7).

Table 7. Spring and Fall Chinook Salmon escapement at Columbia Basin mainstem dams upstream of Bonneville Dam in 2015. Estimates are from both PIT tag recoveries and dam counts (FPC 2015) and the differences between the two estimates are displayed. Note that since no sampling could be conducted during weeks 28 and 29, summer Chinook are excluded. Although no sampling was conducted in Week 33, only 1% of the fall Chinook run passed during this week, so Fall Chinook are included.

	Spring Chinook Salmon			Fall Chinook Salmon		
Site	Viewing Window Count	PIT Tag Estimate	Percent Difference	Viewing Window Count	PIT Tag Estimate	Percent Difference
The Dalles	206423	183107	-11.3%	722582	706444	-2.2%
McNary	164918	150103	-9.0%	552588	577431	4.5%
Priest Rapids	29286	27227	-7.0%	95128	85673	-9.9%
Rock Island	32840	26411	-19.6%	43996	42106	-4.3%
Rocky Reach	15853	14203	-10.4%	37066	32600	-12.0%
Wells	21491	13681	-36.3%	16427	23268	41.6%
Ice Harbor	116462	108299	-7.0%	72986	86069	17.9%
Lower Monumental	120208	105484	-12.2%	70238	82588	17.6%
Little Goose	113677	102482	-9.8%	69036	79503	15.2%
Lower Granite	113252	100157	-11.6%	70827	76975	8.7%

Between 3.8% and 8.5% of spring Chinook (as determined by tagging

dates at Bonneville Dam) passing dams at or upstream of Priest Rapids Dam would have been counted as summer Chinook at those dams compared to 1.8% to 1.1% to dams at or upstream of Ice Harbor Dam (Table 8). Since a high proportion of the summer Chinook run was missed, or undersampled, it is not possible to estimate misclassification rates for summer Chinook sampled at Bonneville Dam.

Table 8. Percentage of Chinook sampled at Bonneville Dam as one race (as determined by run timing) that passed upstream dams as another race (as determined by run timing) in 2015.

Last Date Spring Run	First Date Fall Run	Race at Bonneville	Spring	Spring	Fall
		Race at Dam Listed Below	Summer	Fall	Summer
May 31	August 1	Bonneville			
June 3	August 4	The Dalles	0.0%	0.0%	0.0%
June 8	August 9	McNary	0.8%	0.0%	0.0%
June 13	August 14	Priest Rapids	7.5%	0.0%	3.6%
June 17	August 18	Rock Island	8.5%	0.0%	15.6%
June 19	August 20	Rocky Reach	5.9%	0.0%	19.7%
June 28	August 29	Wells	3.8%	0.0%	30.8%
June 11	August 12	Ice Harbor	1.8%	0.0%	0.0%
June 13	August 14	Lower Monumental	1.0%	0.0%	0.0%
June 15	August 16	Little Goose	0.9%	0.0%	0.8%
June 17	August 18	Lower Granite	1.1%	0.0%	0.0%

Dam escapement estimates for three sites, each with more than 30 detections, are found in Table 9 alongside estimates using visual counts. Chinook passing all three sites were primarily spring or summer (Figure 9).

Table 9. Estimated 2015 Chinook Salmon escapement, as estimated using PIT tag detections, to Tumwater, Prosser, and Roza dams.

Location and River	Number of Tag Detections	Escapement Estimate from Trap or Visual Counts	Estimated Escapement Using PIT Tags	Difference (%) Between Estimates
Tumwater Dam	45	7148	8157	14.1%
Prosser Dam	57	18268	16195	-11.3%
Roza Dam	33	6561	5655	-13.8%

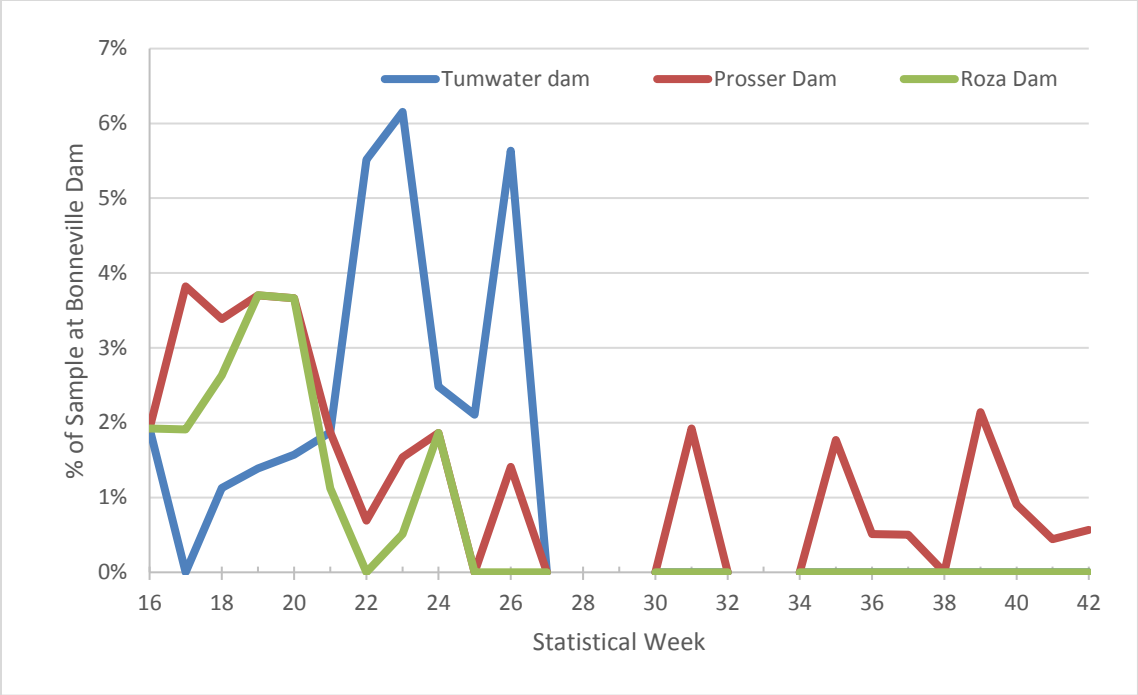


Figure 9. Percentage of Chinook Salmon by statistical week tagged at Bonneville Dam in 2015 destined for the Tumwater Dam (Wenatchee River), Prosser Dam (Yakima River) and Roza Dam (Yakima River) based on upstream PIT tag detections.

Migration Rates and Passage Time

Chinook migration rates between mainstem dams ranged between 20.6 and 53.6 km/day (Table 10). Migration rates to and between tributary sites were generally less than those in the mainstem Columbia and Snake rivers (Table 10).

Among the mainstem Columbia and Snake River dams, Chinook Salmon had the greatest median dam passage time (as determined by minutes between first detection time and last detection time at a dam) at Wells, Rocky Reach, Bonneville, McNary, and Lower Granite dams (Table 11). At these dams, there is a much greater distance between the furthest downstream and furthest upstream PIT tag detection antennas than at other dams; conversely, the distance between the PIT tag detection antennas at most other dams are placed at adjacent or nearby weirs. Passage times at Lower Granite, Bonneville, Priest Rapids, and Wells dams may also be inflated, because at all four sites, fish may take time to recover from sampling before moving upstream.

Table 10. Chinook Salmon travel rates between Columbia Basin dams estimated using PIT tag data in 2015.

		Median Migration Rate (km/day)		
Between Mainstem Dams	**Distance (km)**	**Spring Chinook**	**Summer Chinook**	**Fall Chinook**
Bonneville-The Dalles	74	42.0	45.5	33.7
The Dalles-McNary	157	53.6	46.0	41.7
Bonneville – McNary	231	49.2	45.5	38.5
McNary - Priest Rapids	167	40.9	47.0	20.6
Priest Rapids - Rock Island	89	27.7	38.1	28.7
Rock Island - Rocky Reach	33	29.0	31.8	31.6
Rocky Reach – Wells	65	31.8	35.4	37.8
Bonneville - Rock Island	487	37.5	41.5	31.8
Bonneville – Wells	585	34.4	39.9	36.8
McNary - Ice Harbor	67	51.4	46.0	37.4
Ice Harbor - Lower Granite	156	39.4	26.6	27.4
To and Between Tributary Sites				
Rock Island - Tumwater	73	5.9	7.4	--
McNary - Prosser	141	35.5	1.9	4.1
Prosser - Roza	133	24.2	15.7	--
Lower Granite - South Fork Salmon (SFG)	375	28.5	37.8	--

Table 11. Median passage time in minutes by run, from the time of first detection to time of last detection at a dam and the percentage of Chinook taking more than 12 hours between first and last detection in 2015.

	Median Passage Time (minutes)			Percentage of run with more than 12 hours between first and last detection at a dam		
Dam	**Spring Chinook**	**Summer Chinook**	**Fall Chinook**	**Spring Chinook**	**Summer Chinook**	**Fall Chinook**
Bonneville	6.9	7.1	13.6	1.7%	0.8%	4.2%
The Dalles	0.1	0.1	0.1	3.3%	2.6%	2.3%
McNary	90.9	69.9	82.8	10.6%	7.7%	6.4%
Priest Rapids	4.4	4.6	2.4	1.9%	1.3%	7.2%
Rock Island	0.2	0.5	0.2	0.0%	1.1%	3.1%
Rocky Reach	15.7	7.6	18.6	3.5%	1.5%	1.5%
Wells	111.7	97.7	95.15	19.0%	3.3%	0.0%
Ice Harbor	2.8	1.8	2.2	5.0%	4.6%	0.8%
Lower Monumental	0.2	0.6	0.2	2.5%	9.0%	5.6%
Little Goose	0.0	0.0	0	2.1%	4.2%	1.7%
Lower Granite	77.0	70.0	73.2	6.6%	7.9%	11.1%
Tumwater	7.8	11.6	NA	13.0%	9.1%	NA
Prosser	9.6	1.8	0.1	0.0%	0.0%	8.3%
Roza	1.4	139.2	NA	31.0%	25.0%	NA

Upstream Age and Length-at-Age Composition

Age 1.2 was the predominant age class for spring Chinook passing each mainstem dam in this study (Table 12, Figure 10). Among summer Chinook, Age

1.2 were predominant in both the Snake River and above Priest Rapids Dam (Table 12, Figure 11). Among fall Chinook, Age 0.3 was the predominant age above Columbia River dams, but Age 0.2 was the predominant age class above Snake River dams (Table 12, Figure 12). Mean length-at-age composition estimates at mainstem dam sites are shown in Tables 13-15.

Table 12. Age composition estimates (%) as determined from passing fish PIT tag detections at mainstem dams of fish aged using scale pattern analysis from scales collected at Bonneville Dam, for spring, summer, and fall Chinook Salmon in 2015.

		Brood Year and Age Class											
Run and Site	**Ageable**	**2013**	**2012**		**2011**			**2010**			**2009**		
Spring	**N**	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**2.1**	**0.4**	**1.3**	**2.2**	**0.5**	**1.4**	**2.3**
Bonneville	1005	0.0	0.1	7.2	0.3	87.4	0.0	0.9	4.2	0.0	0.0	0.0	0.0
The Dalles	850	0.0	0.0	8.2	0.4	86.7	0.0	1.1	3.6	0.0	0.0	0.0	0.0
McNary	691	0.0	0.0	8.5	0.4	85.7	0.0	1.2	4.2	0.0	0.0	0.0	0.0
Priest Rapids	130	0.0	0.0	7.5	1.1	82.2	0.0	3.7	5.5	0.0	0.0	0.0	0.0
Rock Island	122	0.0	0.0	7.9	1.0	81.7	0.0	3.6	5.8	0.0	0.0	0.0	0.0
Rocky Reach	67	0.0	0.0	9.2	0.9	80.2	0.0	3.4	6.3	0.0	0.0	0.0	0.0
Wells	63	0.0	0.0	9.5	0.9	80.0	0.0	3.4	6.2	0.0	0.0	0.0	0.0
Ice Harbor	508	0.0	0.0	8.5	0.0	88.3	0.0	0.0	3.1	0.0	0.0	0.0	0.0
Low. Mon.	489	0.0	0.0	8.7	0.0	88.1	0.0	0.0	3.2	0.0	0.0	0.0	0.0
Little Goose	474	0.0	0.0	8.7	0.0	88.1	0.0	0.0	3.2	0.0	0.0	0.0	0.0
Lower Granite	463	0.0	0.0	8.7	0.0	88.1	0.0	0.0	3.2	0.0	0.0	0.0	0.0
Summer	**N**	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**2.1**	**0.4**	**1.3**	**2.2**	**0.5**	**1.4**	**2.3**
Bonneville	523	0.5	5.2	17.9	5.9	41.8	0.0	8.6	18.5	0.0	0.0	1.5	0.1
The Dalles	433	0.5	5.3	19.1	6.9	39.6	0.0	7.7	18.7	0.0	0.0	2.1	0.2
McNary	352	0.6	6.6	20.1	7.7	39.6	0.0	8.3	14.5	0.0	0.0	2.4	0.2
Priest Rapids	216	0.7	8.9	15.8	9.7	29.7	0.0	12.0	18.8	0.0	0.0	4.1	0.4
Rock Island	209	0.7	9.0	15.4	9.4	30.4	0.0	12.4	18.2	0.0	0.0	4.1	0.4
Rocky Reach	169	0.2	10.3	16.7	10.5	29.6	0.0	11.6	15.1	0.0	0.0	5.5	0.5
Wells	159	0.3	11.0	17.4	10.2	29.9	0.0	12.3	12.9	0.0	0.0	5.5	0.5
Ice Harbor	126	0.0	0.0	28.2	5.4	57.9	0.0	0.0	8.5	0.0	0.0	0.0	0.0
Low. Mon.	121	0.0	0.0	27.7	5.7	57.6	0.0	0.0	9.0	0.0	0.0	0.0	0.0
Little Goose	115	0.0	0.0	30.8	5.7	56.3	0.0	0.0	7.2	0.0	0.0	0.0	0.0
Lower Granite	110	0.0	0.0	28.7	5.0	58.3	0.0	0.0	7.9	0.0	0.0	0.0	0.0
Fall	**N**	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**2.1**	**0.4**	**1.3**	**2.2**	**0.5**	**1.4**	**2.3**
Bonneville	1560	1.2	29.2	1.3	35.6	5.6	<0.1	25.6	1.2	0.0	0.2	0.1	0.0
The Dalles	1128	1.5	28.8	1.6	37.1	5.2	0.0	24.4	1.3	0.0	0.1	0.0	0.0
McNary	955	1.8	30.8	2.0	35.6	6.0	0.0	22.4	1.3	0.0	0.1	0.0	0.0
Priest Rapids	131	4.6	30.3	0.6	40.2	1.3	0.0	18.4	4.6	0.0	0.0	0.0	0.0
Rock Island	73	3.3	25.2	0.7	44.3	1.5	0.0	20.1	4.9	0.0	0.0	0.0	0.0
Rocky Reach	63	6.5	14.8	0.7	48.6	1.5	0.0	13.3	14.5	0.0	0.0	0.0	0.0
Wells	49	13.0	20.9	0.8	43.8	1.7	0.0	5.3	14.5	0.0	0.0	0.0	0.0
Ice Harbor	111	2.6	43.1	3.9	25.1	18.8	0.0	5.6	0.9	0.0	0.0	0.0	0.0
Low. Mon.	107	2.6	40.1	4.0	26.2	20.1	0.0	5.9	1.0	0.0	0.0	0.0	0.0
Little Goose	103	2.6	42.6	4.3	27.1	17.1	0.0	5.2	1.2	0.0	0.0	0.0	0.0
Lower Granite	101	2.6	44.4	2.5	28.9	15.3	0.0	5.2	1.2	0.0	0.0	0.0	0.0

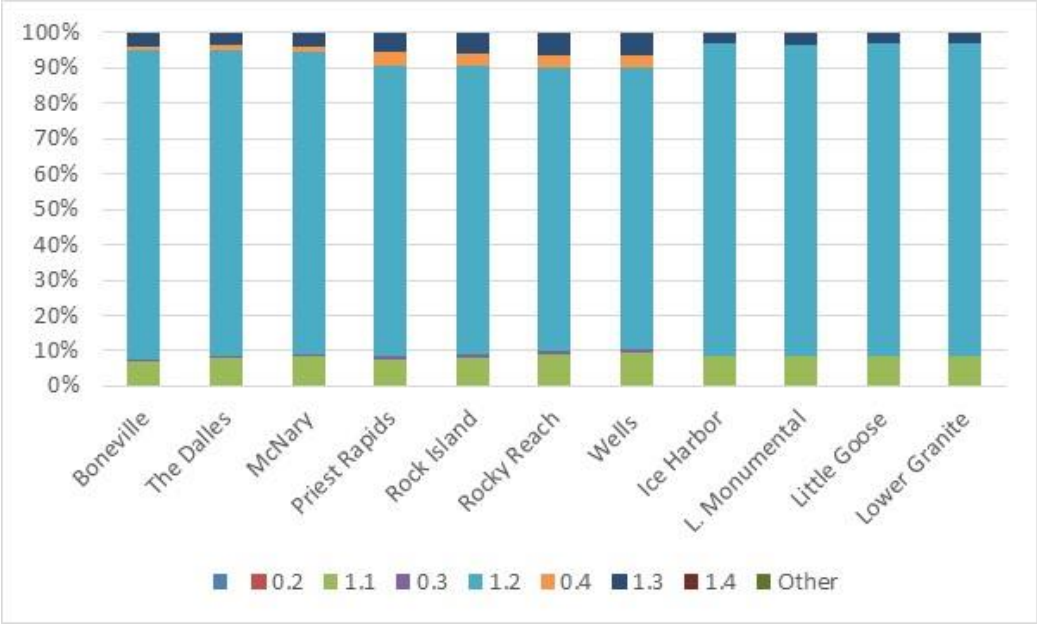


Figure 10. Spring Chinook age composition at Columbia and Snake River dams estimated using PIT tagged Chinook tracked by this project. Spring Chinook are defined as passing Bonneville Dam between April 1 and May 31, 2015.

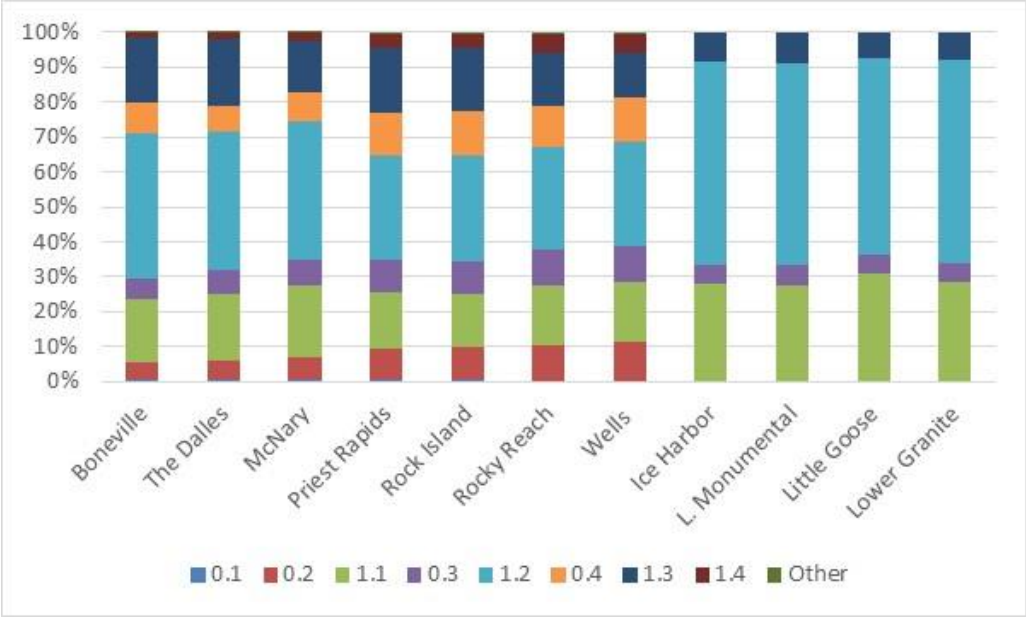


Figure 11. Summer Chinook age composition at Columbia and Snake River dams estimated using PIT tagged Chinook tracked by this project. Summer Chinook are defined as passing Bonneville Dam between June 1 and July 31, 2015. This excludes those summer Chinook passing Bonneville Dam during weeks 28 and 29, comprising 19.0% of the run, when no sampling was conducted due to high temperatures.

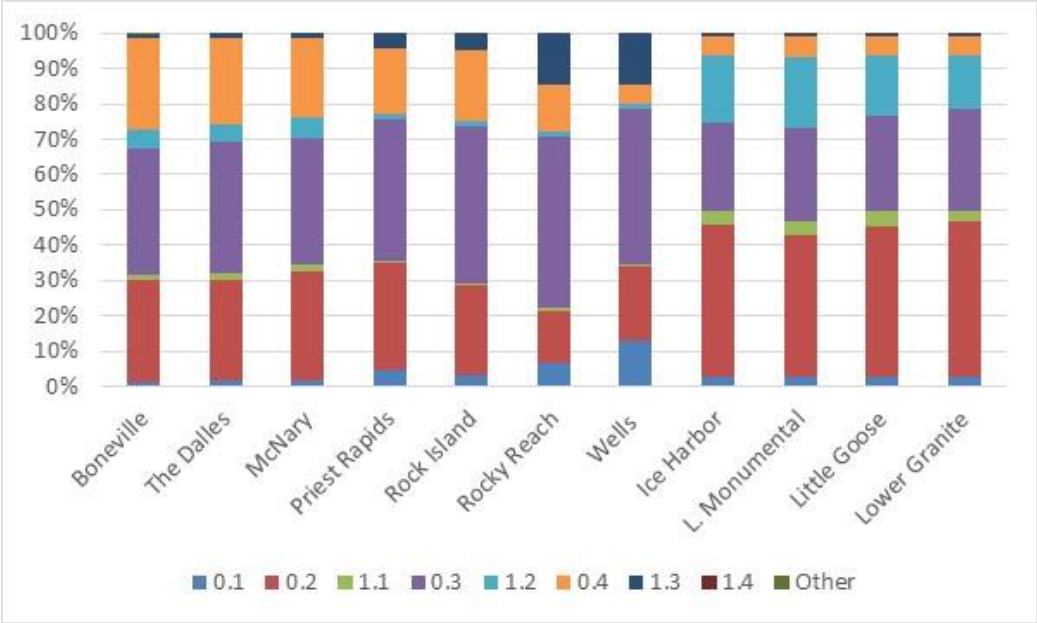


Figure 12. Fall Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project. Fall Chinook are defined as passing Bonneville Dam on or after August 1, 2015. This excludes those summer Chinook passing Bonneville Dam during Week 33, comprising 0.7% of the run, when no sampling was conducted due to high temperatures.

Table 13. Spring Chinook Salmon length-at-age composition, as estimated by PIT tag detections of fish aged using scale pattern analysis that passed Bonneville Dam on or before May 31, at Columbia and Snake River dams in 2015.

Dam	Statistic	Brood Year and Age Class						
		2013	2012		2011		2010	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3
Bonneville	μ		62.0	52.2	79.8	72.8	90.0	85.1
	s		-	3.8	4.7	5.0	3.9	5.7
	n		1	142	5	845	12	48
The Dalles	μ			52.1	79.8	72.5	90.0	84.7
	s			3.7	4.7	5.2	3.9	4.5
	n			137	5	696	12	35
McNary	μ			52.3	79.8	72.6	90.0	84.8
	s			3.6	4.7	5.4	3.9	4.6
	n			116	5	558	12	33
Priest Rapids	μ			52.1	81.6	72.8	90.0	85.2
	s			4.4	2.7	4.3	3.9	5.2
	n			23	4	91	12	15
Rock Island	μ			51.9	81.8	72.8	90.2	85.2
	s			4.4	3.2	4.4	3.9	5.2
	n			22	3	86	11	15
Rocky Reach	μ			51.2	83.0	71.2	90.4	85.1
	s			5.1	3.5	4.3	4.7	6.0
	n			14	2	44	7	10
Wells	μ			51.5	83.0	71.2	90.4	84.5
	s			5.1	3.5	4.4	4.7	6.1
	n			13	2	41	7	9
Ice Harbor	μ			52.4		72.8		84.7
	s			3.2		4.4		4.4
	n			85		423		16
Lower Monumental	μ			52.5		72.8		84.7
	s			3.2		4.4		4.4
	n			83		406		16
Little Goose	μ			52.5		72.8		84.7
	s			3.2		4.4		4.5
	n			81		393		15
Lower Granite	μ			52.4		72.8		84.7
	s			3.2		4.4		4.5
	n			79		384		15

Table 14. Summer Chinook Salmon length-at-age composition, as estimated by PIT tag detections of fish aged using scale pattern analysis that passed Bonneville Dam between June 1-July 31, at Columbia and Snake River dams in 2015.

Dam	Statistic	Brood Year and Age Class							
		2013	2012		2011		2010		2009
		0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Bonneville	μ	44.0	63.2	53.2	79.5	74.2	87.7	84.2	85.5
	s	3.3	5.0	9.1	6.1	7.1	6.0	5.0	3.4
	n	24	13	143	192	341	42	101	5
The Dalles	μ	44.0	62.9	53.7	79.7	73.8	88.2	83.9	85.5
	s	3.3	5.1	8.1	5.9	7.5	6.2	5.2	3.4
	n	24	12	132	162	276	34	84	5
McNary	μ	44.0	62.9	53.6	79.7	73.6	88.2	83.8	87.7
	s	3.4	5.4	8.2	6.0	7.7	6.2	5.3	1.4
	n	23	11	125	141	247	31	70	3
Priest Rapids	μ	43.7	62.9	52.5	79.8	72.1	88.4	84.2	87.7
	s	3.3	5.9	5.3	6.0	9.1	6.2	4.7	1.4
	n	20	9	39	129	140	30	66	3
Rock Island	μ	43.7	62.9	52.4	79.8	71.8	88.2	84.1	87.7
	s	3.3	5.9	5.2	6.1	9.1	6.3	4.3	1.4
	n	20	9	38	122	133	29	61	3
Rocky Reach	μ	43.8	64.6	52.2	79.5	71.2	86.5	83.6	87.7
	s	3.3	4.7	5.3	6.1	9.4	6.2	4.2	1.4
	n	19	7	31	99	115	16	47	3
Wells	μ	43.4	64.6	52.3	79.7	70.9	86.5	83.4	87.7
	s	3.5	4.7	4.6	6.0	9.7	6.2	4.4	1.4
	n	16	7	27	94	102	16	41	3
Ice Harbor	μ	45.8		54.1	78.1	75.8	84.0	79.8	
	s	4.3		9.5	3.8	4.7	--	0.4	
	n	3		81	10	101	1	2	
Lower Monumental	μ	45.8		54.1	78.1	75.7	84.0	79.8	
	s	4.3		9.5	3.8	4.7	--	0.4	
	n	3		81	10	100	1	2	
Little Goose	μ	48.3		54.1	78.1	75.7	84.0	79.8	
	s	1.1		9.5	3.8	4.7	--	0.4	
	n	2		81	10	100	1	2	
Lower Granite	μ	47.5		54.5	78.1	75.5	84.0	79.8	
	s	--		7.5	3.8	4.7	--	0.4	
	n	1		74	10	92	1	2	

Table 15. Fall Chinook Salmon length-at-age composition, as estimated by PIT tag detections of fish aged using scale pattern analysis that passed Bonneville after July 31, for fall Chinook Salmon at Columbia and Snake River dams in 2015.

Dam	Statistic	Brood Year and Age Class								
		2013	2012		2011		2010		2009	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Bonneville	μ	46.3	63.1	55.9	76.1	72.5	82.9	80.0	80.6	79.5
	s	4.2	7.0	4.7	6.2	5.6	5.7	4.3	5.0	6.4
	n	78	186	26	816	33	122	12	4	2
The Dalles	μ	46.3	62.3	56.5	75.7	72.0	82.7	81.5	81.3	75.0
	s	4.1	7.2	4.5	6.0	5.9	5.9	3.6	1.1	--
	n	64	146	21	576	20	83	9	2	1
McNary	μ	46.4	62.2	56.4	75.5	72.7	82.6	80.4	81.3	75.0
	s	4.3	7.5	4.6	6.2	5.5	6.4	2.2	1.1	--
	n	55	134	20	466	15	61	6	2	1
Priest Rapids	μ	45.0	59.8	53.6	76.0	71.0	86.0			
	s	3.3	4.2	3.3	5.9	–	4.4			
	n	19	24	10	58	1	6			
Rock Island	μ	44.7	58.8	53.6	74.7		86.0			
	s	3.7	1.9	3.3	6.1		2.1			
	n	15	8	10	15		2			
Rocky Reach	μ	44.9	59.4	53.2	73.8		86.0			
	s	3.8	1.2	3.3	6.8		2.1			
	n	14	7	9	9		2			
Wells	μ	44.4	59.5	53.2	70.8		87.5			
	s	3.3	1.5	3.3	5.8		–			
	n	13	5	9	6		1			
Ice Harbor	μ	44.9	63.1	58.3	74.5	70.4	85.5			
	s	5.4	4.6	3.4	5.9	6.0	3.8			
	n	6	24	6	25	7	3			
Lower Monumental	μ	44.9	62.8	58.3	75.4	70.4	85.5			
	s	5.4	4.5	3.4	5.8	6.0	3.8			
	n	6	23	6	21	7	3			
Little Goose	μ	44.9	62.8	58.3	75.4	70.4	85.5			
	s	5.4	4.5	3.4	5.8	6.0	3.8			
	n	6	23	6	21	7	3			
Lower Granite	μ	43.0	63.0	57.8	75.3	70.9	85.5			
	s	3.0	4.5	3.5	5.9	4.1	3.8			
	n	5	22	5	20	5	3			

Fallback

Estimated fallback rates, based on Chinook Salmon reascending fish ladders or being detected downstream after ascending a fish ladder, ranged from 0.0% to 13.8% (Table 16). These rates likely underestimate the true fallback rates as they do not include any fish that ascended a dam, fell back, and then were not subsequently detected.

Table 16. Estimated minimum Chinook Salmon fallback rates by race at Bonneville Dam at Columbia Basin dams in 2015 as estimated by PIT tags[a].

Dam	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	2.6%	2.1%	1.5%
The Dalles	4.6%	3.2%	3.6%
McNary	7.4%	1.7%	1.8%
Priest Rapids	3.1%	2.9%	0.7%
Rock Island	0.9%	0.5%	0.0%
Rocky Reach	8.2%	4.1%	3.0%
Wells	8.9%	6.0%	1.9%
Ice Harbor	7.0%	5.3%	2.3%
L. Monumental	3.4%	13.8%	1.6%
Little Goose	3.8%	9.2%	5.0%
Lower Granite	3.9%	2.4%	12.8%
Mean	**4.5%**	**4.4%**	**3.6%**

A total of 297 Chinook generated 509 fallback events (Table 17). A large number of Chinook had more than one fallback event at a single dam or several dams (2 to 10 dams fallen back over). Fall Chinook at Priest Rapids Dam had the highest fallback rate with 33 fall Chinook generating 46 fallback events out of 237 fall Chinook detected passing the site. One spring Chinook, 3DD.00773AF1A7, fell back a total of 10 times over multiple dams. This fish was tagged on April 16, 2015; detected passing McNary Dam on April 22, then detected passing the Bonneville Dam Oregon ladder on May 2 and passed Little Goose Dam on May 10, 2015. It was then detected passing the Bonneville Dam Washington Shore counting station on May 26 and was last detected passing McNary Dam on May 30, 2015.

Unlike 2014, when 28 fall Chinook passed Priest Rapids dam before being detected downstream at the Priest Rapids Hatchery channel PIT tag array, in 2015 we observed only one fall Chinook dropping back over Priest Rapids Dam

[a] Fallback rates do not include Chinook Salmon which fell back over a dam and were not subsequently detected.

before reascending.

Table 17. Number of Chinook salmon tagged by this project estimated to have fallen back over dams compared to the number of fallback dams per fish in 2015.

Number of Dams Fallen Back Over	Total Number of Chinook
1	182
2	76
3	15
4	6
5	10
6	4
7	2
8	1
10	1
Total	**297**

Night Passage

Night passage (2000-0400 Pacific Standard Time) of tagged Chinook Salmon was under 10% at all dams except for at Prosser and Roza tributary dams (Table 18). The Bonneville Dam estimate of night passage is likely biased low, due to the fact that tagging occurred during morning and early afternoon hours and that the median Bonneville Dam passage time is less than two hours, tagged Chinook would be expected to pass during daytime hours.

Table 18. Estimated Chinook Salmon night passage (2000-0400) in 2015 at Columbia Basin dams as estimated by PIT tag detections.

Site	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	0.0%	0.3%	0.1%
The Dalles	1.5%	2.2%	0.7%
McNary	1.7%	2.5%	0.1%
Priest Rapids	0.6%	0.8%	2.2%
Rock Island	5.7%	2.1%	9.4%
Rocky Reach	7.1%	2.6%	3.0%
Wells	5.1%	2.7%	5.8%
Ice Harbor	0.2%	1.3%	1.6%
Lower Monumental	1.0%	3.4%	0.0%
Little Goose	2.8%	7.6%	0.8%
Lower Granite	2.3%	5.5%	1.7%
Prosser	18.9%	25.0%	16.7%
Roza	34.5%	50.0%	NA
Tumwater	4.3%	9.1%	NA

RESULTS-STEELHEAD

Sample Size

A total of 875 steelhead were PIT tagged in 2015 (Table 19). After adding previously tagged fish (which were sampled and therefore identified for the tracking study and included in our sample) and subtracting fish that were not detected after release (possibly a result of tag shed, tag malfunction, mortality, or the fish moving downstream after tagging), the number of steelhead tracked upstream totaled 898 (Table 19).

Table 19. Number of steelhead PIT tagged at Bonneville Dam and tracked past Bonneville by date and statistical week in 2015.

Dates	Week	Sampled	PIT Tagged	Previously Tagged	Not Detected After Release	Total Tracked	Days Sampling Restrictions in Effect		
							Reduced Sampling-Temperature	Reduced Sampling-Shad or Salmon Abundance	No Sampling Due to Temperature
4/15-4/17	16	7	5	1	0	6	0	0	0
4/20-24	17	6	6	0	0	6	0	0	0
4/27-30,5/1	18	3	3	0	0	3	0	2	0
5/4-8	19	7	7	0	0	7	0	0	0
5/11-5/14	20	7	7	0	0	7	0	0	0
5/18-22	21	7	5	2	0	7	0	0	0
5/26-5/28	22	6	6	0	0	6	0	0	0
6/2-6/5	23	11	7	4	1	10	0	1	0
6/8-6/12	24	2	2	0	0	2	0	2	0
6/15-6/19	25	6	5	1	0	6	0	5	0
6/22-26	26	3	3	0	0	3	0	5	0
6/30,7/1-7/2	27	3	3	0	0	3	0	3	1
No Sampling	28	--	--	--	--	--	0	0	5
No Sampling	29	--	--	--	--	--	0	0	5
7/24	30	22	20	2	0	22	1	0	4
7/27-30	31	170	167	3	0	170	4	0	1
8/5-7	32	95	94	1	0	95	3	0	2
No Sampling	33	--	--	--	--	--	0	0	5
8/18-19	34	54	51	3	0	54	2	0	3
8/24-27	35	100	97	3	0	100	2	0	3
9/1-4	36	61	60	1	0	61	4	0	0
9/8-11	37	11	11	0	0	11	4	1	0
9/14-18	38	58	58	0	0	58	0	5	0
9/21-25	39	42	41	1	0	42	0	5	0
9/28-30,10/2-2	40	92	92	0	0	92	0	5	0
10/5-9	41	78	75	2	0	77	0	2	0
10/12-16	42	53	50	0	0	50	0	0	0
Total		**904**	**875**	**24**	**1**	**898**	**20**	**36**	**29**

Distribution of Sample

In 2015 temperature restrictions imposed at the Adult Fish Facility restricted sampling between weeks 24 and 37 and shut down sampling entirely during weeks 28, 29, and 33 (Table 19). The weeks between 24 and 37 were weeks when 80.7% of the steelhead run passed. The shut down for Week 33 meant that we were unable to sample the peak week of steelhead passage in 2015 when 14.5% of the run passed (Figure 13). During the Week 28-29 shutdown, 5.6% of the run passed.

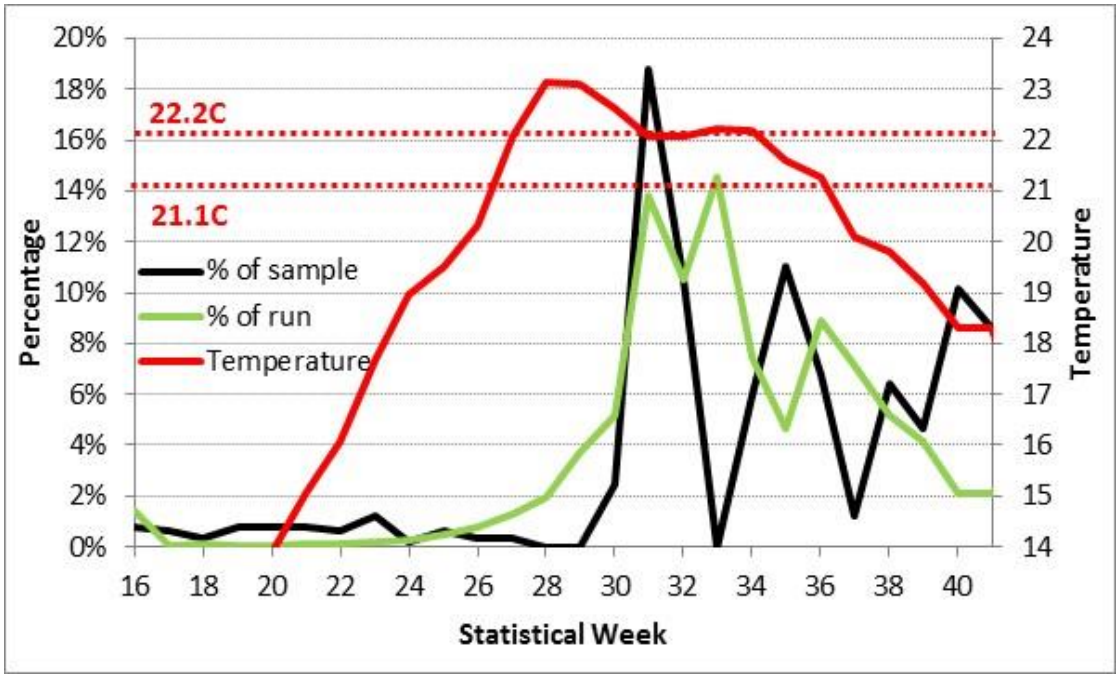


Figure 13. The weekly steelhead sample and run as a percentage of the total sample and run size at Bonneville Dam in 2015. Sampling was reduced at 21.1C and halted at 22.2C.

Detection Numbers

The 898 steelhead tracked in 2015 generated 64550 weir detections and 5921 site detections at 122 sites. Maps (Figure A14-A19) found in the Appendix show the categorical ranges of detection numbers at the sites throughout the Columbia Basin.

Age Analysis

We were able to validate our scale aging techniques by using fish sampled at Bonneville that were previously tagged as juveniles for other projects or hatchery programs. Our age estimates for all 24 previously tagged steelhead with readable scales concurred with the information from juvenile PIT tagging.

Only the total age could be compared for it was not possible to separately validate freshwater and ocean age.

In 2015 ocean age estimates were available from analysis of genetics samples collected by this study. Ages estimated using the scale patterns agreed with estimates using GSI for 483 out of 500 steelhead samples (Table 20). All GSI ages were from hatchery-origin steelhead.

Table 20. Comparison of age estimates using genetics and scale pattern analysis for Chinook Salmon sampled at Bonneville Dam in 2015. Green shading indicates agreement between the two methods, orange indicates the age estimates differed.

Ocean Age Using Genetic Stock ID	Ocean Age Estimated Using Scale Patterns			% Concurrence
	1	2	3	
1	273	5		98.2%
2	10	206		95.4%
3		2	4	66.7%
Total	**283**	**213**	**4**	**96.6%**

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Data on tag detections was last downloaded from www.ptagis.org on January 20, 2017. Upstream migration during 2015 is divided into five periods representing the three periods when sampling was allowed at Bonneville Dam (weeks 16-27, 30-31, and 34-42) and the two periods when trap restrictions presented sampling (Weeks 28-29 and 33), Table 21. An estimated 11.6% of the steelhead run passing Bonneville Dam during weeks 16-27 was last detected upstream of Ice Harbor Dam compared to 44.0% during weeks 30-32 and 64.8% for weeks 34-42. The estimate for all weeks sampled was 53.8% (Figure 15); however, this does not include weeks 28-29 and 33 when 20.1% of the steelhead run passed Bonneville Dam and was not sampled. In contrast, 10.7% of the week 16-27 steelhead passed Priest Rapids Dam compared to 2.6% for those passing between weeks 34-42, (Table 21, Figure 14). The proportion of steelhead bound for the Snake River generally increased as the run progressed, while those last detected downstream of McNary Dam generally decreased. (Figures 14). Estimated weekly abundance of portions of the steelhead run bound for the Snake River, above Priest Rapids, McNary to Ice Harbor/Priest Rapids, and below McNary are shown in Figure 16.

Table 21. Percentage of steelhead run passing upstream dams prior to, and after, temperature restrictions closed the Bonneville Adult Fish Facility in 2015. Estimates are weighted by weekly run size passing Bonneville Dam.

	Weeks 16-27	Weeks 28-29	Weeks 30-32	Week 33	Weeks 34-42	All Weeks Sampled (16-27, 30-32, 34-42)
% of Run	**5.0%**	**5.6%**	**29.5%**	**14.5%**	**45.4%**	**79.9%**
The Dalles	46.3%	NA	79.6%	NA	87.6%	82.1%
McNary	27.8%	NA	63.4%	NA	72.2%	66.2%
Priest Rapids	10.7%	NA	9.4%	NA	2.6%	5.6%
Rock Island	2.0%	NA	9.0%	NA	2.6%	4.9%
Rocky Reach	1.7%	NA	7.2%	NA	2.5%	4.2%
Wells	1.7%	NA	7.0%	NA	2.5%	4.1%
Ice Harbor	11.6%	NA	44.0%	NA	64.8%	53.8%
Lower Monumental	11.6%	NA	42.9%	NA	63.4%	52.7%
Little Goose	9.6%	NA	40.7%	NA	61.2%	50.4%
Lower Granite	9.2%	NA	39.4%	NA	59.0%	48.7%
Tumwater	0.3%	NA	0.8%	NA	0.1%	0.4%
Prosser	5.3%	NA	1.6%	NA	0.3%	1.1%
Roza	5.3%	NA	0.6%	NA	0.1%	0.6%

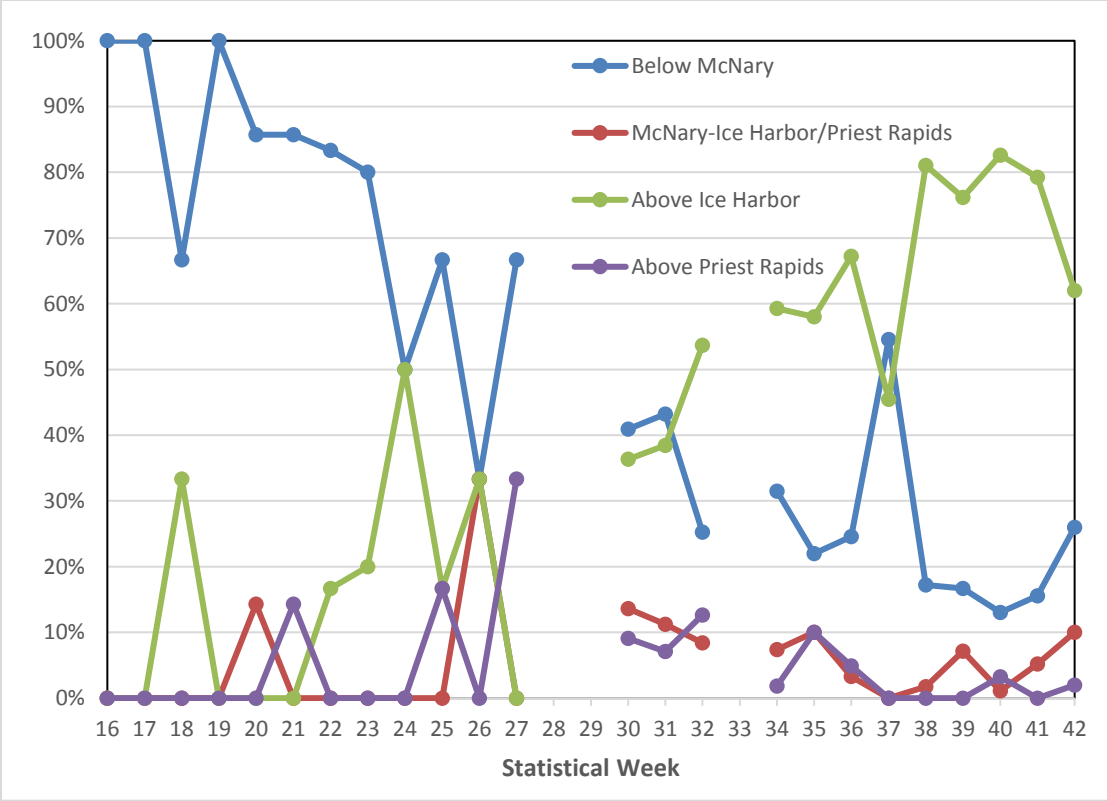


Figure 14. Distribution of final upstream detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2015 estimated as a percentage of the weekly run.

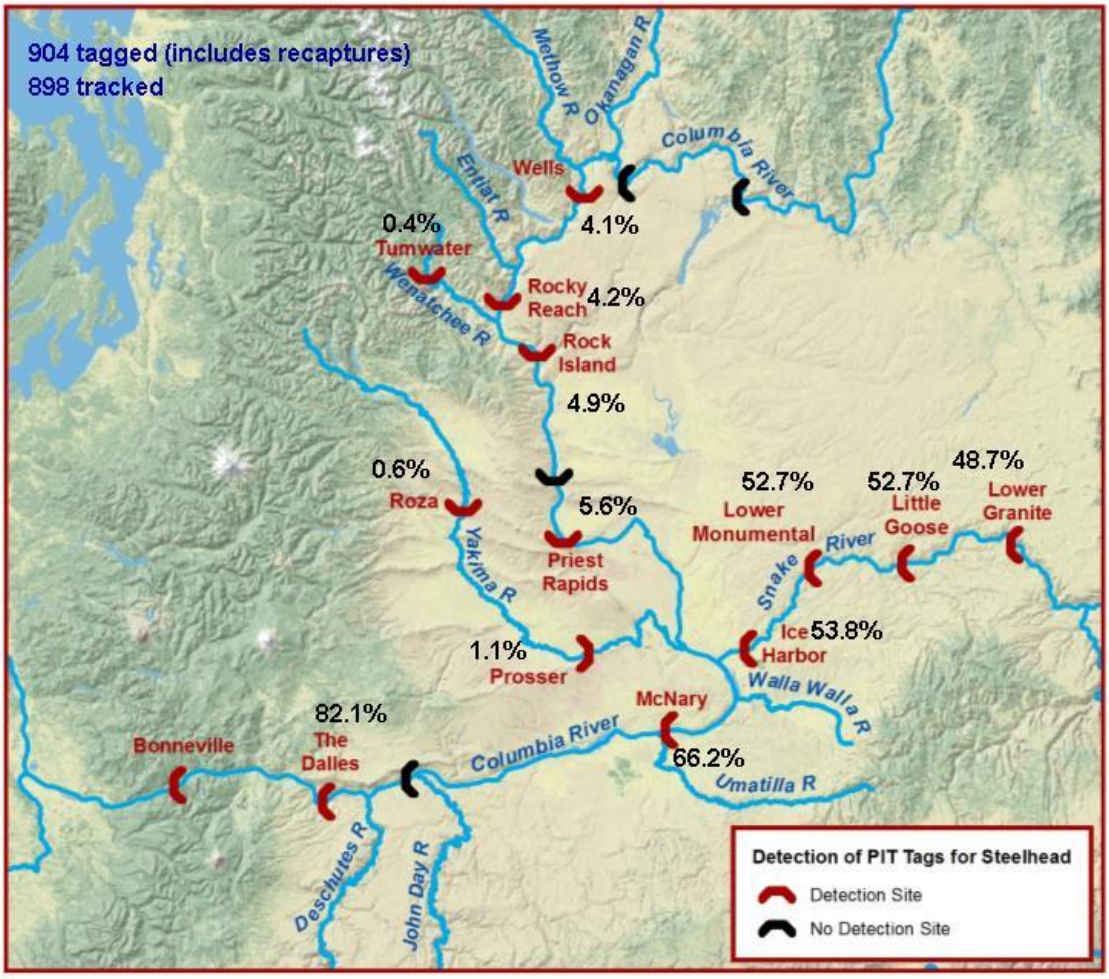


Figure 15. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of steelhead PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2015. These estimates do not include Weeks 28-29 and 31 when 21.1% of the steelhead run passed Bonneville Dam as no sampling was allowed.

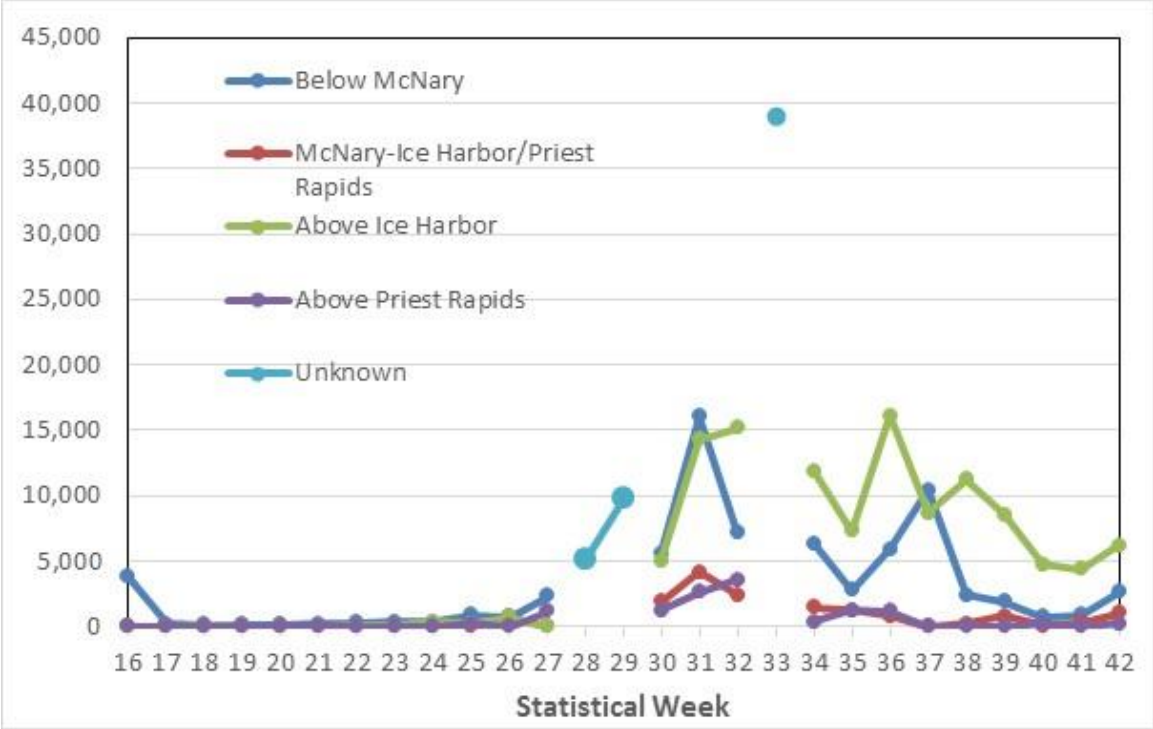


Figure 16. Distribution of final detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2015 estimated in numbers of fish passing Bonneville Dam by week.

In 2013, a PIT tag site was installed just upstream of the mouth of the Deschutes River (DRM). A total of 102 of the 898 steelhead tracked in 2015 by this study were detected at this site. Of these 102 steelhead, the most upstream detection of 47 were in the Snake River, 2 steelhead above Priest Rapids Dam, 13 between McNary and Priest Rapids, 31 in Deschutes Basin (with 21 not being detected past DRM), and 9 elsewhere between Bonneville and McNary dams (Figure 17). Ten steelhead tagged by this project were recaptured upstream of DRM at Sherar's Falls; of these four were detected at DRM. One of these four (3DD.00775D596A) was last detected at Lower Monumental Dam on December 21, 2015.

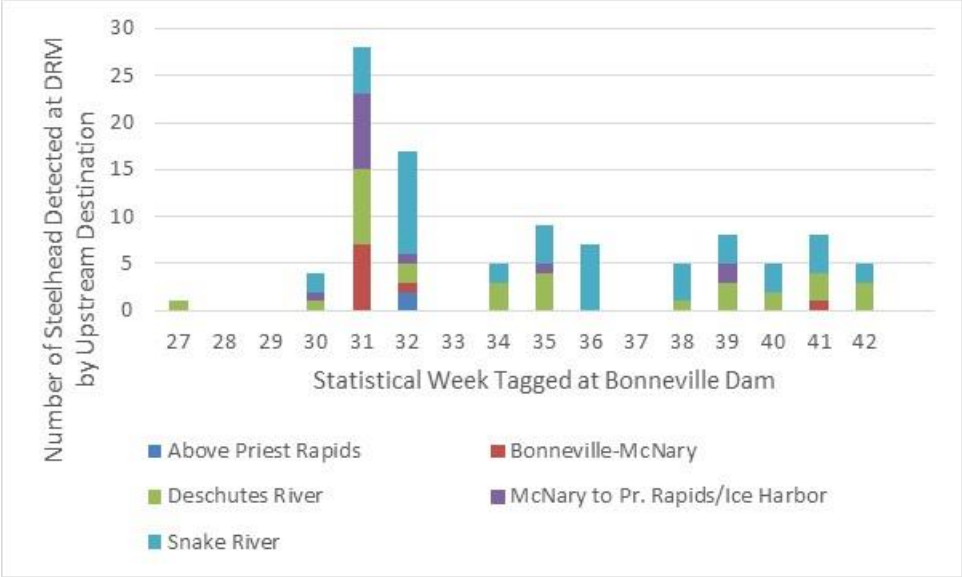


Figure 17. Distribution of final detection site by statistical week for steelhead PIT tagged at Bonneville Dam which were detected at the Deschutes River Mouth antenna (DRM) in 2015.

As with Chinook Salmon, the percentage of PIT tagged steelhead passing a dam without detection was generally under 1% (Table 22). Rock Island Dam, which has known detection issues due to antenna size and electrical noise (Fryer et al. 2014), stands out from the other dams with 9.1% of steelhead not detected.

Table 22. Percentages of steelhead passing a dam undetected that were subsequently detected upstream in 2015.

Dam	2015
Bonneville	2.5%
The Dalles	1.2%
McNary	0.6%
Priest Rapids	0.0%
Rock Island	9.1%
Rocky Reach	0.0%
Wells	0.0%
Ice Harbor	0.6%
Lower Monumental	0.2%
Little Goose	0.9%
Lower Granite	0.0%
Mean (weighted by number passing each dam)	**1.1%**

Migration Rates and Passage Time

The fastest median migration rate between mainstem dams, as measured in kilometers per day, was between The Dalles and McNary dams (34.5 km/day), while the slowest was 15.7 km/day between Bonneville and Lower Granite dams (Table 23).

Table 23. Steelhead migration rate between Columbia Basin dams as estimated by PIT tag detections in 2015.

Steelhead		
Dam Pair	**Distance (km)**	**Median Migration Rate (km/day)**
Bonneville-The Dalles	74	24.0
The Dalles-McNary	157	34.5
Bonneville - McNary	231	21.7
McNary - Priest Rapids	167	32.7
Priest Rapids - Rock Island	89	25.1
Rock Island - Rocky Reach	33	19.6
Rocky Reach - Wells	65	33.8
Rock Island - Tumwater	73	3.1
Bonneville – Rock Island	487	17.8
Bonneville - Wells	585	19.5
McNary - Ice Harbor	67	27.7
Ice Harbor - Lower Granite	156	21.9
Bonneville-Lower Granite	461	15.7

Wells, Lower Granite, and McNary dams had the greatest median passage time among mainstem Columbia Basin dams (Table 24). Passage times at Wells, Lower Granite, Priest Rapids, Tumwater and Bonneville dams may be inflated because of fish trapping programs. Short median passage times are a reflection of a very short distance between lower-most and upper-most PIT tag antennas at a given site.

Table 24. Steelhead median passage times from time of first detection at a dam to time of last detection and the percentage of steelhead taking more than 12 hours between first detection and last detection in 2015.

Dam	Median Passage Time (minutes)	Percentage with more than 12 hours between first detection and last detection at a dam
Bonneville	9.8	4.8%
The Dalles	0.1	9.0%
McNary	78.4	6.5%
Priest Rapids	4.0	0.0%
Rock Island	0.2	0.0%
Rocky Reach	5.7	7.7%
Wells	103.8	18.9%
Ice Harbor	3.8	4.7%
Lower Monumental	1.9	5.4%
Little Goose	0.0	2.9%
Lower Granite	87.9	10.2%
Tumwater	9.2	0.0%

Upstream Age and Length-at-Age Composition

Age 1.1 steelhead had the highest abundance among all age classes at Bonneville Dam in 2015 (Table 25, Figure 18) and at all other dams, reaching over 50% of steelhead passing Rocky Reach and Wells dams. Length-at-age composition data are found in Table 26.

Table 25. Age composition estimates for steelhead at upstream Columbia and Snake River dams (%) in 2015. These were estimated from scale patterns of steelhead sampled at Bonneville Dam[b]. The "r" in age r.X means that the freshwater zone of the scale was regenerated, and therefore, the age is not possible to determine.

		2012	2011		2010			2009		Unknown				Repeat Spawners
Site	n	1.1	1.2	2.1	1.3	2.2	3.1	2.3	4.2	r	r.1	r.2	r.3	
Bonneville	895	25.1%	20.4%	10.1%	1.2%	14.5%	0.1%	0.2%	0.1%	1.3%	10.8%	15.3%	0.4%	0.2%
The Dalles	739	28.1%	18.3%	10.3%	1.4%	15.3%	0.1%	0.3%	0.1%	1.5%	11.2%	12.9%	0.4%	0.1%
McNary	621	27.7%	19.2%	9.2%	1.4%	15.5%	0.2%	0.3%	0.2%	1.6%	11.3%	13.0%	0.3%	0.2%
Priest Rapids	46	41.3%	4.3%	17.4%	0.0%	13.0%	0.0%	0.0%	0.0%	0.0%	15.2%	8.7%	0.0%	0.0%
Rock Island	44	43.2%	4.5%	18.2%	0.0%	13.6%	0.0%	0.0%	0.0%	0.0%	11.4%	9.1%	0.0%	0.0%
Rocky Reach	37	51.4%	5.4%	13.5%	0.0%	13.5%	0.0%	0.0%	0.0%	0.0%	10.8%	5.4%	0.0%	0.0%
Wells	36	52.8%	5.6%	13.9%	0.0%	13.9%	0.0%	0.0%	0.0%	0.0%	11.1%	2.8%	0.0%	0.0%
Ice Harbor	515	28.3%	21.4%	6.2%	1.7%	14.4%	0.2%	0.4%	0.2%	1.6%	11.3%	13.8%	0.4%	0.2%
Lower Monumental	505	28.5%	21.4%	6.3%	1.8%	14.3%	0.2%	0.4%	0.2%	1.4%	11.3%	13.7%	0.4%	0.2%
Little Goose	482	29.0%	21.2%	6.0%	1.9%	13.7%	0.2%	0.4%	0.2%	1.2%	11.4%	14.1%	0.4%	0.2%
Lower Granite	471	29.3%	21.0%	6.2%	1.7%	13.6%	0.2%	0.4%	0.2%	1.3%	11.3%	14.2%	0.4%	0.2%

[b] Unlike in previous years, age composition estimates are not weighted by week due to the unrepresentative nature of the sample in 2015 caused by Adult Fish Facility trap restrictions.

Table 26. Steelhead length-at-age composition, as estimated by PIT tag detections of fish aged from scales at Bonneville Dam in 2015.

		Brood Year and Age Class										
Dam	Stat	2012	2011			2010		2009	2008	Unknown		
		1.1	1.2	2.1	1.3	2.2	3.1	2.3	4.2	r.1	r.2	r.3
Bonneville	μ	58.6	72.0	58.4	85.1	70.6	58.0	81.0	73.5	58.0	69.0	83.3
	s	3.3	7.1	3.6	4.2	5.6	--	2.1	--	3.4	8.6	5.5
	N	225	183	90	11	130	1	2	1	97	137	4
The Dalles	μ	58.7	72.9	58.3	85.5	70.7	58.0	81.0	73.5	57.9	70.3	84.5
	s	3.4	7.2	3.8	4.3	5.7	--	2.1	--	3.1	6.7	6.1
	N	208	135	76	10	113	1	2	1	83	95	3
McNary	μ	58.7	72.8	58.7	85.6	71.1	58.0	81.0	73.5	58.0	70.9	87.8
	s	3.3	7.3	4.0	4.5	5.7	--	2.1	--	3.1	6.7	3.2
	n	172	119	57	9	96	1	2	1	70	81	2
Priest Rapids	μ	58.3	66.8	57.3		69.0				57.8	70.6	
	s	2.3	3.9	3.3		3.9				3.2	4.5	
	n	19	2	8		6				7	4	
Rock Island	μ	58.3	66.8	57.3		69.0				59.2	70.6	
	s	2.3	3.9	3.3		3.9				2.0	4.5	
	n	19	2	8		6				5	4	
Rocky Reach	μ	58.3	66.8	58.0		68.6				58.9	70.8	
	s	2.3	3.9	4.1		4.3				2.1	4.6	
	n	19	2	5		5				4	2	
Wells	μ	58.3	66.8	58.0		68.6				58.9	67.5	
	s	2.3	3.9	4.1		4.3				2.1	--	
	n	19	2	5		5				4	1	
Ice Harbor	μ	58.7	73.2	59.7	85.6	72.0	58.0	81.0	73.5	58.2	71.3	87.8
	s	3.4	7.1	4.7	4.5	5.9	--	2.1	--	3.2	6.9	3.2
	n	146	110	32	9	74	1	2	1	58	71	2
Lower Granite	μ	58.7	73.1	59.7	85.6	72.1	58.0	81.0	73.5	58.2	71.4	87.8
	s	3.4	7.1	4.7	4.5	5.9	--	2.1	--	3.2	7.0	3.2
	n	144	108	32	9	72	1	2	1	57	69	2

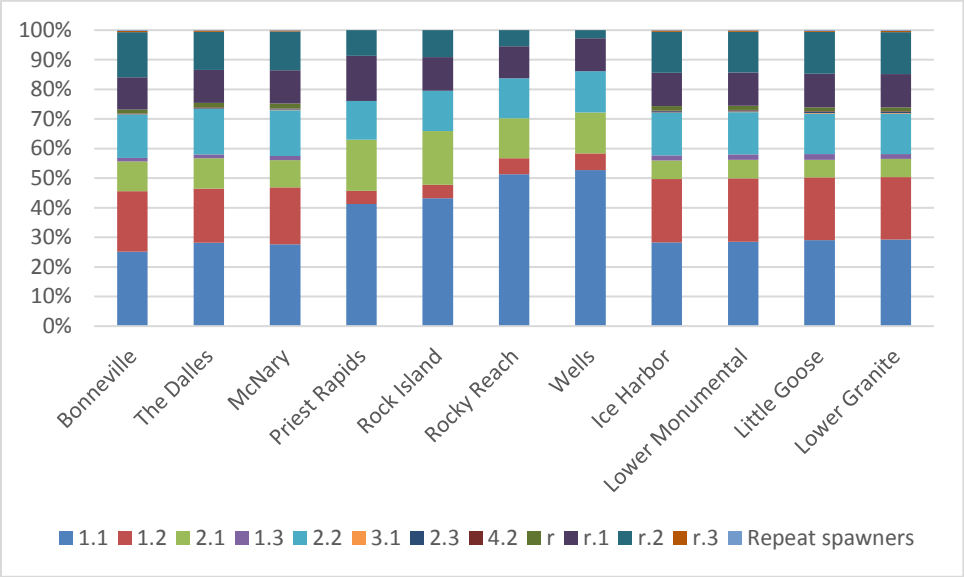


Figure 18. Steelhead age composition at Columbia and Snake River dams estimated from upstream detections of steelhead aged using scales at Bonneville Dam in 2015. The "r" in age r.X means that the freshwater zone of the scale was regenerated and the age therefore not possible to determine.

Fallback

Estimated minimum fallback rates based on steelhead either reascending fish ladders or steelhead subsequently detected downstream, ranged from 3.4% at Ice Harbor and Little Goose dams to 12.1% at The Dalles Dam (Table 27). These rates likely underestimate the true fallback rates as they do not include any fish that ascended a dam, fell back, and then were not subsequently detected.

Table 27. Estimated minimum steelhead fallback at Columbia Basin dams in 2015 as estimated by PIT tag[c] detections.

Dam	Percent Fallback
Bonneville	9.1%
The Dalles	12.1%
McNary	5.2%
Priest Rapids	8.9%
Rock Island	2.5%
Rocky Reach	10.8%
Wells	5.3%
Ice Harbor	3.4%
Lower Monumental	3.5%
Little Goose	3.4%
Lower Granite	4.5%

[c] Fallback rates do not include steelhead which fell back over a dam and were not subsequently detected.

Night Passage

Night passage (2000-0400 Pacific Standard Time) by tagged steelhead ranged from 1.3% at Bonneville Dam to 9.8% at Lower Monumental Dam (Table 28). Given the median Bonneville Dam passage time of 9.8 minutes (Table 24), and the fact that sampling was generally conducted between 0800 and 1400, steelhead would be expected to pass during daytime hours.

Table 28. Estimated steelhead night passage (2000-0400 PST) at Columbia Basin dams in 2015.

Site	Percentage Night Passage
Bonneville	1.3%
The Dalles	3.1%
McNary	4.8%
Priest Rapids	2.0%
Rock Island	9.8%
Rocky Reach	2.6%
Wells	8.1%
Ice Harbor	7.2%
Lower Monumental	8.5%
Little Goose	6.1%
Lower Granite	8.5%

B-Run Analyses

A total of 100 B-run steelhead were sampled (where B-run is defined as steelhead greater than or equal to 78.0 cm fork length). Among the weeks sampled, the percentage of steelhead sampled and tagged that were classified as B-run peaked in Statistical Week 40 at 33.7% of the run with Week 22 at 33.3% of the run (Figure 19) but Week 22 was based on only 6 steelhead sampled. The estimated B-Run escapement at Bonneville Dam (estimated by multiplying the weekly run size using counting window data by the percentage B-run in that week estimated by this project) peaked in Week 38 at 3,586 fish while the A-run steelhead peaked in Week 31 at 36,937 fish. An estimated 6.0% of the run passing between weeks 16 and 27 was estimated as B-run compared to 0.3% of the run passing between weeks 30-32 and 11.7% for those passing between weeks 34 and 42. Among steelhead detected above McNary Dam and in tributaries between Bonneville and McNary dams (thereby eliminating most of the steelhead that may have been captured in the Zone 6 fishery in the mainstem Columbia between those dams), steelhead with fork lengths 78.0 cm and greater were almost entirely destined for the Snake River (Figure 20). Among the 882 steelhead sampled at Bonneville Dam where ocean age could be estimated, B-run steelhead were comprised entirely of two- and three-ocean steelhead, while

A-run steelhead were comprised entirely of one- and two-ocean steelhead (Table 29). The mean length of sampled A-Run steelhead was 63.2 cm compared to 81.8 cm for B-Run steelhead.

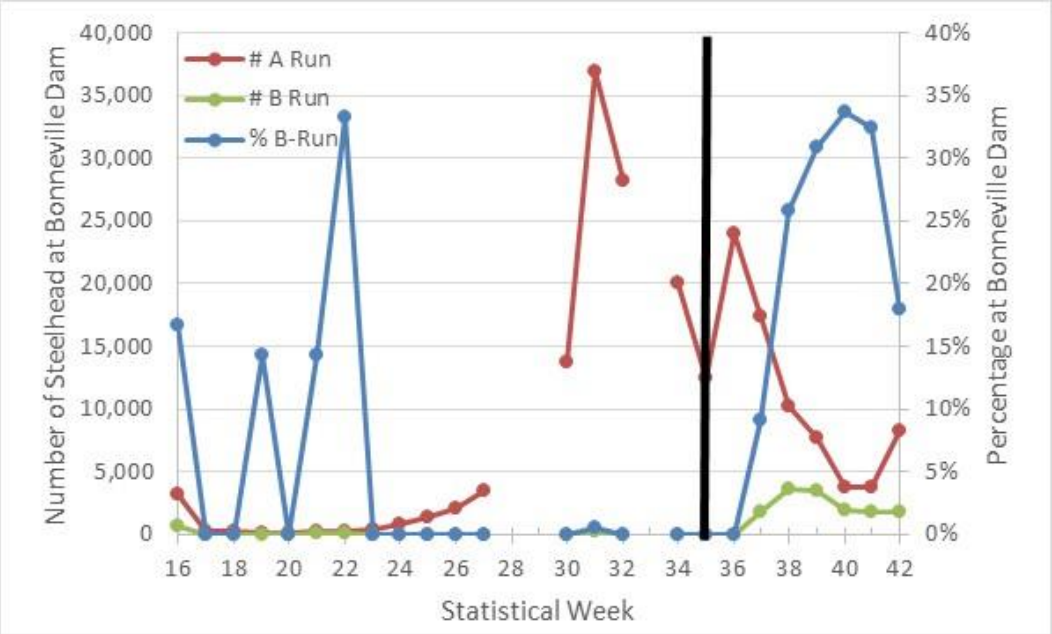


Figure 19. Percentage of B-run steelhead and estimated A- and B-run escapement at Bonneville Dam by statistical week in 2015. August 25 is noted as it is considered the date that separates A- and B-run steelhead.

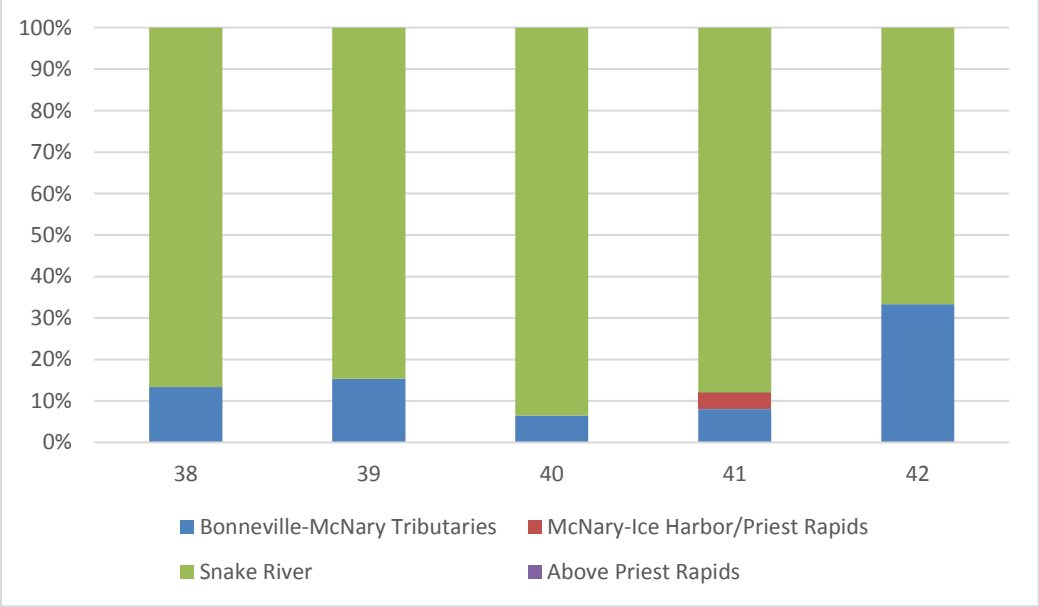


Figure 20. Final detection site for B-run steelhead (≥78 cm fork length) by Statistical Week they were sampled at Bonneville Dam in 2015. Weeks with fewer than five B-run steelhead sampled are omitted. No B-run steelhead passed upstream of Priest Rapids Dam in 2015.

Table 29. Ocean age composition of A- and B-Run steelhead sampled at Bonneville Dam in 2015.

Run	N	One-Ocean (x.1)	Two-Ocean (x.2)	Three Ocean (x.3)
A-Run	785	40.3%	47.4%	0.0%
B-Run	97	0.0%	82.5%	17.5%
All Steelhead	**882**	**35.8%**	**51.2%**	**1.9%**

Kelt Analyses

A total of 63 steelhead PIT tagged and tracked in 2015 were either detected going downstream in the Columbia Basin after March 31, 2016, presumably in an attempt to return to the ocean after spawning (kelts), or detected moving back upstream later in 2016 or 2017 as repeat spawners. An additional six steelhead were recognized in the CRITFC Kelt Project as either spawned-out and moving back downriver (collected for study – Hatch et. al. *Multiple Years*) or from their behavior (Table 30 and Table A2).— Excluding weeks 21 and 25 when only a single steelhead was identified as a kelt, both the highest percentage of steelhead passing Bonneville and the greatest number of kelt were estimated to be in weeks 30-32 and 34 (Figure 21).

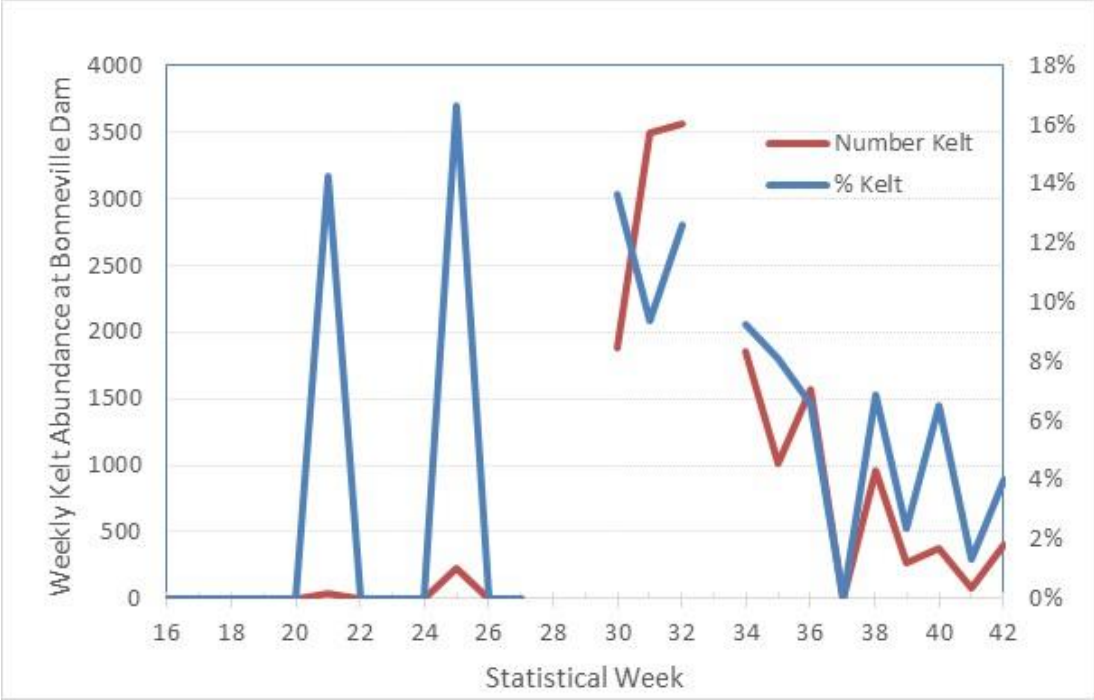


Figure 21. Percentage and number of kelt passing Bonneville Dam by Statistical Week as estimated by this project in 2015.

Table 30. Some biological and detection information on the steelhead moving in the Columbia Basin system in 2015 that were determined to be kelts (CRITFC Kelt Project), or repeat spawners and potential kelts (because of their behavior). Please see Tables A2-5 for more details on the detected behavior of the steelhead.

					Most Upstream Site		Last Site Detected				
PIT Tag	Date Tagged	Fin Clip	Age	Fork Length	Basin and Site	Date	Basin and Site	Date	Comment	Detected Migrating Downstream in Spring 2015	Detected Migrating Upstream in Fall 2016
3DD.00773AF801	5/21/15		2.2	71	Wenatchee (UWE)	10/9/15	Columbia (BCC)	5/2/16		X	
3DD.00775D152D	7/28/15	AD	r.1	60	Snake (GRA)	10/12/15	Columbia (BCC)	4/15/16		X	
3DD.00775D15B3	8/25/15		2.2	63	Walla Walla (BBT)	4/9/16	Columbia (JDJ)	4/18/16		X	
3DD.00775D179E	6/18/15		1.2	70.5	Columbia (BO4)	6/18/15	Columbia (BCC)	5/4/16		X	
3DD.00775D1F41	8/24/15		2.2	69.5	Columbia (MC2)	9/15/15	Columbia (BCC)	4/13/16		X	
3DD.00775D23F1	8/19/15		2.1	62.5	Snake (LMA)	3/30/2016	Walla Walla (BGM)	4/21/2016		X	
3DD.00775D2CA6	8/5/15		2.1	59	Snake (GRA)	10/24/15	Columbia (B2J)	5/8/16		X	
3DD.00775D2E4C	7/27/15		1.1	56.5	Yakima (SUN)	3/20/16	Columbia (BCC)	5/19/16		X	
3DD.00775D4A20	9/28/15		r.1	65.5	Snake (GRA)	10/13/15	Columbia (BCC)	5/1/16		X	
3DD.00775D4AFE	8/7/15		2.1	57.5	Walla Walla (NBA)	3/2/16	Walla Walla (MDR)	4/7/17		X	X
3DD.00775D5D32	7/27/15		2.1	55.5	Columbia (RIA)	8/18/15	Columbia (BCC)	5/15/16		X	
3DD.00775D6695	8/6/15		r.2	62.5	Salmon (JOC)	4/18/16	Columbia (BCC)	5/1/16		X	
3DD.00775DA0D9	8/19/2015		2.1	53.5	John Day (JD1)	12/10/15	Columbia (BO1)	4/12/16		X	
3DD.00775DA161	10/9/2015	AD	1.1	57.5	Snake (GRA)	4/25/16	Snake (GRA)	5/16/16	In Kelt program		
3DD.00775DA9C3	9/15/15	AD	1.1	60.5	Snake (LMA)	10/22/15	Walla Walla (PRV)	3/30/16		X	
3DD.00775DABFB	8/26/15		2.2	70.5	Yakima (PRO_	10/23/15	Columbia (BCC)	4/28/16		X	
3DD.00775DB230	9/1/15		2.2	73.5	Snake (GRA)	9/22/15	Columbia (BCC)	4/30/16		X	
3DD.00775DB27B	8/6/15		2.1	56	Wenatchee (PEU)	5/13/16	Columbia (BCC)	5/27/16		X	
3DD.00775DB747	8/26/15		1.1	54.5	Walla Walla (PRV)	4/18/16	Walla Walla (PRV)	4/18/16	Last detected moving downstream	X	
3DD.00775DB9CD	8/19/15		2.2	68	Columbia (TD1)	10/29/15	Columbia (BCC)	4/8/16		X	
3DD.00775DC164	8/5/15		r.2	64	McNary (MC1)	10/5/15	Columbia (B2J)	4/24/16		X	
3DD.00775DC2FE	7/24/15		2.1	53.5	Walla Walla (BBT)	2/18/16	Columbia (B2J)	5/9/16		X	
3DD.00775DC4D2	10/13/15	AD	r.1	57.5	Snake (GRA)	11/11/15	Snake (GOJ)	5/13/16		X	
3DD.00775DCC83	8/7/15	AD	r.2	64	Umatilla (FDD)	10/13/15	Columbia (B2J)	4/9/16		X	
3DD.00775DCD79	9/30/2015		2.2	80	Snake (FISHC)	6/13/16	Snake (FISHC)	6/13/16	Considered kelt by Kelt Program		

3DD.00775DCD7D	8/6/15		2.1	56	Yakima (TOP)	4/16/16	Columbia (JDJ)	4/30/16		X	
3DD.00775DCEA7	8/27/15				Yakima (ROZ)	4/1/16	Yakima (ROZ)	4/1/16	Considered kelt by Kelt Program		
3DD.00775DCEC7	9/4/15		r.2	70.5	Snake (GRA)	9/22/15	Columbia (BCC)	6/10/16		X	
3DD.00775DCF46	7/30/15		2.1	54	Snake (JOC)	4/3/16	Columbia (JDJ)	4/24/16		X	
3DD.00775DDA42	10/12/15		r.2	61.5	Fifteenmile (15D)	3/26/16	Columbia (BCC)	4/13/16		X	
3DD.00775DDDEE	7/27/15		2.2	68	Yakima (ROZ)	3/6/16	Columbia (BCC)	4/22/16		X	
3DD.00775DDF81	9/15/15	AD	1.2	66.5	Snake (SC1)	10/24/15	Snake (SC1)	4/16/2016		X	
3DD.00775DE800	8/25/15		2.2	76	Snake (GRA)	10/24/15	Snake (GRA)	10/2/2016			X
3DD.00775DE986	7/24/15		2.2	63.5	Fifteenmile (158)	4/6/16	Columbia (BCC)	4/10/16		X	
3DD.00775DF732	9/29/15		r.2	70	Rock Creek (RCL)	2/10/16	Columbia (JDJ)	4/5/16		X	
3DD.00775DF88A	8/18/15		2.2	62	Snake (GRA)	11/14/15	Snake (ICH)	5/14/16		X	
3DD.00775DFB87	8/6/2015		r.1	58.5	Snake (GRA)	5/8/16	Snake (GRA)	5/8/16			
3DD.00775E01D8	9/3/15	AD	r.1	58	Snake (GRA)	10/4/15	Columbia (BCC)	4/28/16		X	
3DD.00775E0764	7/30/15		2.2	67	Snake (GRA)	10/16/2015	Snake (GOA)	3/25/2016			X
3DD.00775E0825	8/25/2015	AD	1.1	58	Snake (STL)	4/18/2016	Snake (GRA)	5/16/2016	Considered kelt by Kelt Program		
3DD.00775E0E43	7/27/15	AD RV	1.1	56	Snake (GRA)	10/13/15	Snake (GRA)	9/20/16		X	X
3DD.00775E1236	7/27/15		2.2	64	Methow (LMR)	3/31/16	Columbia (RRJ)	5/19/16		X	
3DD.00775E1EE2	8/5/15	AD	1.1	57	Salmon (USE)	3/8/16	Columbia (BCC)	4/30/16		X	
3DD.00775E203B	9/17/15		r.2	66	Snake (GRA)	10/6/15	Snake (GOJ)	4/13/16		X	
3DD.00775E218B	7/29/15		2.2	67	Yakima (PRO)	10/24/15	Yakima (SUN)	10/16/2016		X	
3DD.00775E21E4	9/15/15	AD	1.1	58	Snake (GRA)	10/6/15	Snake (GRJ)	3/21/16		X	
3DD.00775E252C	9/28/15		2.1	58	John Day (SJ1)	3/9/16	Columbia (B2J)	4/18/16		X	
3DD.00775E2B26	8/6/15		2.1	56.5	Deschutes (SHK)	5/8/16	Columbia (BCC)	5/18/16		X	
3DD.00775E2B63	9/29/15		2.2	73	Salmon (VC2)	4/10/16	Columbia (BCC)	5/3/16		X	
3DD.00775E2D00	9/28/15	AD	1.2	73	Columbia (TD1)	11/1/15	Columbia (BCC)	3/23/16		X	
3DD.00775E2D47	9/22/15	AD	1.1	58	Snake (GOA)	10/25/15	Columbia (MCJ)	4/5/16		X	
3DD.00775E2F58	7/29/15	AD	1.1	54	Snake (GRA)	9/19/15	Columbia (BCC)	6/13/16		X	
3DD.00775E3438	7/29/15		2.1	57	Umatilla (TMF)	4/23/16	Umatilla (TMF)	4/23/16	In TMF juvenile bypass	X	
3DD.00775E34E5	8/26/15	AD	1.1	60.5	Snake (GRA)	10/2/15	Columbia (BCC)	5/19/16		X	

3DD.00775E3585	7/24/15		r.1	58	Columbia (MC1)	10/3/15	Columbia (JDJ)	4/14/16		X	
3DD.00775E5B9E	8/7/15		2.2	66.5	Snake (GRA)	9/11/15	Snake (GOJ)	4/25/16		X	
3DD.00775E681F	8/27/15	AD	1.1	57	Snake (BHC)	4/7/2016	Snake (LGR)	5/11/2016	In kelt program		
3DD.00775E6832	9/1/15	AD	1.1	59.5	Snake (ICH)	3/28/16	Snake (ICH)	3/28/16		X	
3DD.00775E683E	10/8/15		1.1	63	Columbia (JDJ)	3/23/2016	Columbia (TDA)	3/30/2016		X	
3DD.00775E69B3	8/5/15		2.2	66.5	Tucannon (LTR)	3/6/16	Walla Walla (PRV)	5/6/16	Last detected moving downstream	X	
3DD.00775E7477	7/28/15	AD	1.1	56	Snake (GRA)	9/21/15	Snake (GOJ)	4/10/16		X	
3DD.00775E7541	8/19/15		2.2	64	Asotin (AFC)	4/8/16	Snake (GOJ)	4/16/16		X	
3DD.00775E8493	10/1/15	AD	1.1	60.5	Columbia (WEA)	4/14/16	Columbia (RRJ)	5/1/16		X	
3DD.00775E849C	7/28/15		2.1	51.5	Deschutes (TR2)	2/6/16	Columbia (BCC)	4/4/16		X	
3DD.00775E8522	7/27/15		un	58.5	Snake (GRA)	9/30/15	Columbia (BO1)	5/3/16		X	
3DD.00775E9E95	7/29/15		2.1	53.5	Umatilla (MWC)	5/2/16	Umatilla (TMF)	5/2/16	In TMF juvenile bypass	X	
3DD.00775EADCA	8/26/15		2.2	66.5	Rock Creek (RCL)	2/10/16	Columbia (JDJ)	4/4/16		X	
3DD.00775EC6E2	8/18/15		2.2	70	Snake (GRA)	9/8/2015	Columbia (BCC)	6/7/2016		X	
3DD.00775ECFF6	7/28/15		2.1	58.5	Columbia (MC1)	10/4/15	Columbia (BCC)	4/14/16		X	

In addition, since a multitude of detection sites are now available, we looked at fish moving before April 1st to determine if any steelhead were exhibiting kelt behavior, that might be missed by our standard March 31st cutoff date. We found six fish, tagged in 2015, that were detected moving out of the system in juvenile bypasses at mainstem dams, most after visiting upper areas of tributaries in the Winter of 2015/2016 (Figure 21, Table 30 and Table A3). These additional fish expand the count to 69 fish tagged in 2015 determined to be kelts.

Many kelts that are detected moving out of the system are detected in the juvenile bypasses (last detection location) of the major dams such as Bonneville, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Rocky Reach. Another major exit location for kelts is Bonneville Dam's Corner Collector, which had 25 steelhead use it in 2015 (Tables 31 and A2). Of the 63 identified kelts, 40 of them were tracked into the Columbia River tributaries; many had multiple hits in the tributaries as they made their way to the spawning grounds (Table A1 and Figure A1 - map of all detection locations). Four steelhead appeared to be repeat spawners as they were last seen at Bonneville Dam in the spring of 2015 heading downstream, and then not for many months, until they traveled back up past Bonneville for the next migration to the spawning grounds.

Among those steelhead where ocean age could be estimated, the age composition of steelhead kelts and non-kelts was similar (Table 32.) The mean length of sampled kelts was 62.2 cm compared to 65.4 cm for non-kelts.

We have also updated information of several kelts/repeat spawners from past annual reports with data from 2016/2017 movements (Tables A4 and A5). Some steelhead already identified as kelts or repeat spawners in the reports have new information added, others are newly added because they were detected a year or two later moving upriver again to spawn. Usually, up to three past years of tagged steelhead have appeared in the detection system, however, for steelhead tagged in 2012 there was no additional detection in the system in 2016/2017.

Table 31. PIT tagged steelhead sampled at Bonneville Dam subsequently designated as kelt by being last detected moving downstream after March 31 the year after sampling or being last detected moving upstream the year after sampling for sampling years 2009-2015. Data is categorized by last detection site.

Last site	2015	2014	2013	2012	2011	2010	2009
Bonneville Corner Collector	25	38	30	25	10	23	61
Bonneville Juvenile Bypass	5	3	6	5	1	4	7
Bonneville Dam Bradford Island Ladders heading downstream	2	1	3	2	0	0	0
Estuary Trawl	0	0	2	2	0	0	1
Ice Harbor Juvenile Bypass	1	0	0	0	1	6	0
Ice Harbor Ladders heading downstream	0	0	1	0	NA	NA	NA
John Day Juvenile Bypass	6	2	8	6	3	11	3
Little Goose Juvenile Bypass	5	2	9	5	11	13	6
Lower Granite Juvenile Bypass	0	3	4	3	4	10	3
Lower Monumental Juvenile Bypass	0	2	7	1	12	9	4
Lower Washington Shore McNary Dam ladder downstream.	0	1	0	0	0	2	1
McNary Dam Juvenile Bypass	1	1	4	4	3	2	4
Rocky Reach Juvenile Bypass	2	10	1	0	4	6	7
Migrating downstream in tributaries	6	NA	4	3	0	0	0
Repeat spawners, passed Bonneville Dam migrating upstream	4	5	12	1	NA	NA	NA
Trapped by CRITFC Kelt Program							
Snake Basin	5	4	11	NA	NA	NA	NA
Yakima Basin	1	6	6	1	NA	NA	NA
Total	**63**	**77**	**108**	**58**	**49**	**86**	**97**
Percent of steelhead tracked designated as kelt.	**5.3%**	**4.5%**	**7.2%**	**4.0%**	**3.1%**	**5.2%**	**4.8%**
Additional steelhead detected migrating upstream in subsequent migration year	**NA**	**8**	**16**	**11**	**5**	**9**	**NA**
Minimum Number of Kelt	**63**	**85**	**124**	**69**	**54**	**95**	**97**

Table 32. Ocean age composition of kelt and non-kelt sampled at Bonneville Dam in 2015.

Designated as Kelt	N	One-Ocean (x.1)	Two-Ocean (x.2)	Three Ocean (x.3)
Yes	68	54.4%	45.6%	0.0%
No	814	46.2%	51.7%	2.1%
All Steelhead	**882**	**46.8%**	**51.2%**	**1.9%**

RESULTS-SOCKEYE[d]

Sample Size

In 2015 a total of 917 Sockeye Salmon were sampled for this project at the Bonneville Dam Adult Fish Facility between May 27 and August 6 (Table 33). Of these, one was not tagged, and one fish died prior to release. One Sockeye was previously tagged and added to the remaining 915 Sockeye tagged and released resulting in a total sample size of 916 tagged Sockeye Salmon and 901 tracked upstream.

Table 33. Number of Sockeye Salmon sampled and PIT tagged at Bonneville Dam and tracked upstream by date and statistical week in 2015.

Sampling Dates	Statistical Week	Mean Temp (C)	Sampled (N)	Tagged	Mortalities	Previously Tagged	Detected After Tagging and Tracked	Days Temperature Restrictions	
								Reduced Sampling	No Sampling
5/27-28,6/2-6/5	22-23	16.8	30	30	0	0	29	0	0
6/8-6/12	24	18.7	125	125	0	0	125	0	0
6/15-6/19	25	19.6	298	298	0	1	295	0	0
6/22-6/26	26	20.7	251	251	1	0	248	0	0
6/30,7/1-2	27	22.3	175	174	0	0	169	3	2
7/6-7/10	28	22.5	0	0	0	0	0	0	5
7/13-7/19	29	22.5	0	0	0	0	0	0	5
7/24	30	21.8	15	15	0	0	15	1	4
7/27-8/6	31-32	21.8	24	24	0	0	22	7	3
Total			**917**	**916**	**1**	**1**	**901**	**11**	**19**

Distribution of Sample

Unprecedented early summer water temperatures resulted in the triggering of restrictions on our use of the Adult Fish Facility as outlined in Appendix G of the 2015 U.S. Army Corps of Engineers Fish Passage Plan (http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2015/final/FPP15_AppG.pdf). These restrictions resulted in a reduction in sampling hours between June 30 and July 2 (Table 33) when water temperatures were between 21.1 and 22.2C. Temperatures continued to climb above 22.2C, resulting in no sampling between

[d] The information presented in this section of the report is a summary of Fryer et al. 2017.

July 3 and July 23 (Table 33), a period in which 22.2% of the run passed. Upon resumption of sampling, hours were restricted for the rest of the Sockeye migration due to high temperatures.

Detection Numbers

The tracking of 901 Sockeye generated 29864 weir detections, which were grouped into 5182 site detections at 35 sites. Of the 916 Sockeye included in this study, 15 were not detected after release. These fish may have shed their tags, had defective tags, or died. It is also possible that these Sockeye Salmon passed downstream without being detected as Sockeye Salmon often pass over the top of weirs in the fish ladder rather than through the underwater slots where PIT tag antennas are located in the lower portions of Bonneville Dam fish ladders. It is unlikely that Sockeye Salmon pass upstream through fishways undetected as, at Bonneville Dam, they must pass through four PIT tag antennas on the Washington shore ladder or three antennas on the Oregon shore ladder near the fish counting window that detect very close to 100% of passing PIT tagged fish. However, at Bonneville Dam (as well as The Dalles, McNary, Ice Harbor, and Lower Granite dams) fish can pass upstream through the navigation locks. All other dams with PIT tag detection have antennas in fish ladders that Sockeye Salmon must pass, through data from 2006-2015 indicate that PIT tagged Sockeye Salmon are missed at fish ladder sites (Table 34). No Sockeye PIT tagged by this project in 2015 were detected above Ice Harbor Dam making it impossible to estimate detection rates at Snake River dams.

Table 34. Number and percentage of PIT tagged fish not detected at dam detection sites as estimated from upstream detections in 2015 compared to 2006-2014.

Dam	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
Bonneville	1.6%	0.7%	0.4%	1.8%	0.5%	0.7%	0.6%	0.4%	2.1%	0.2%
The Dalles	0.6%	0.3%	1.6%	--	--	--	--	--	--	--
McNary	1.1%	3.8%	2.1%	12.1%	1.6%	3.8%	5.0%	10.1%	6.5%	3.1%
Priest Rapids	0.4%	0.2%	0.0%	0.4%	0.2%	0.6%	0.3%	0.3%	0.8%	0.0%
Rock Island	10.2%	41.5%	4.4%	5.4%	4.4%	6.2%	2.6%	6.9%	6.8%	1.3%
Rocky Reach	0.0%	0.3%	0.0%	1.4%	0.7%	0.5%	0.0%	0.2%	0.7%	12.3%
Wells	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	--	--	--	--
Ice Harbor	0.0%	12.5%	NA	0.0%	--	0.0%	20.0%	0.0%	--	--
Lower Monumental	0.0%									
Little Goose	0.0%									
Lower Granite	--	0.0%	--	--	--	--	--	--	--	--
Tumwater	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	--	--	--

Rock Island Dam has stood out in both 2014 and 2015 for the high rate of PIT tagged Sockeye Salmon missing detection (Table 34). New antennas were installed during the winter of 2014-15, but detection was still poor. We did inform Biomark, who installed the antennas, of this, adjustments were made, and detection did improve later in the run (Fryer et al. 2017).

Age Analysis

The predominant age group, of the 93.8% of the run that was sampled, was Age 1.2, followed by Age 1.3 (Table 35).

Table 35. Weekly and total age composition of Sockeye Salmon at Bonneville Dam as estimated from scale patterns in 2015. (Weighted by Statistical week, ignoring Sockeye passing during weeks 28-29)

Statistical Week	Percentage of Run	N Ageable	Age Class				
			1.1	1.2	2.1	1.3	2.2
22-23	0.6%	30	0.0%	96.7%	0.0%	3.3%	0.0%
24	4.3%	123	0.0%	92.7%	0.0%	7.3%	0.0%
25	16.5%	291	0.7%	94.8%	0.0%	4.1%	0.3%
26	35.6%	250	0.0%	94.8%	0.2%	4.4%	0.4%
27	24.1%	168	0.0%	91.7%	0.0%	7.7%	0.6%
28	11.5%	0	NA	NA	NA	NA	NA
29	4.6%	0	NA	NA	NA	NA	NA
30	1.9%	14	0.0%	92.9%	0.0%	7.1%	0.0%
31-32	0.9%	20	0.0%	90.0%	0.0%	10.0%	0.0%
Composite Weeks 22-27 30-32	**83.9%**	**896**	**0.1%**	**93.8%**	**0.1%**	**5.6%**	**0.4%**

Upstream Recoveries, Mortality, and Escapement

Unprecedented Columbia River temperatures (Figure 22) adversely affected the Sockeye Salmon migration in 2015. The mean Bonneville Dam forebay temperature in June, 2015 was 3.4C above the 10-year average and temperatures elsewhere in the basin were also at unprecedented high levels. Survival, as estimated using PIT tags, to all upstream Columbia Basin dams was the lowest since CRITFC began PIT tagging Sockeye at Bonneville Dam in 2006 (Table 36). The increase in upstream migration mortality over the mean rate for previous years ranged from 97.7% between Bonneville and The Dalles to 358.8% between The Dalles and McNary dams (Table 37).

Estimated escapement based on upstream PIT tag detections were consistently less than the number of Sockeye counted at mainstem dams (Table

38, Figure 23). The sole exception was at Ice Harbor Dam where only three Sockeye Salmon from this study were detected.

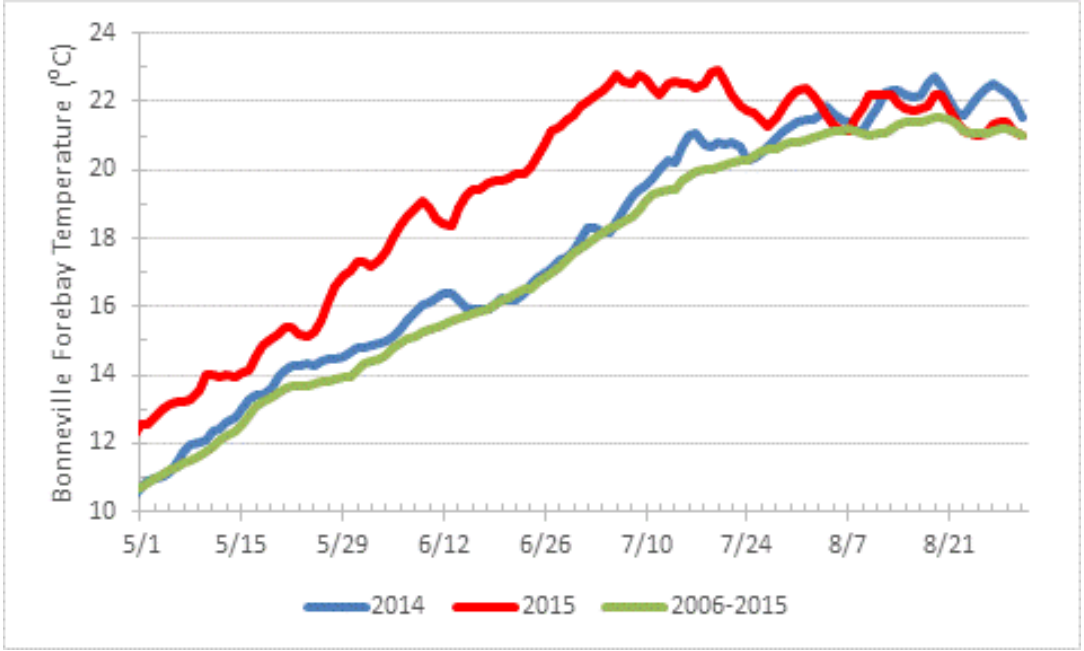


Figure 22. 2015 daily Bonneville Dam forebay water temperature with 2014 and 2006-2015 temperatures for comparison.

Table 36. Survival of Sockeye PIT tagged at Bonneville Dam to The Dalles, McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells dams 2006-2015. (Since no Sockeye were tagged during weeks 28 and 29, data from Sockeye tagged as juveniles was used for those weeks as described later in this report.)

Dam	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	Mean 2006 to 2014
The Dalles	82.8	93.1	89.5	--	--	--	--	--	--	--	91.3
McNary	54.0	88.3	83.6	82.4	76.1	81.5	85.7	89.4	84.0	88.4	84.4
Priest Rapids	44.9	84.5	78.6	77.3	71.9	78.4	82.1	86.3	77.4	84.8	80.1
Rock Island	40.6	79.5	74.2	75.0	68.9	76.3	80.2	85.8	73.4	81.1	77.2
Rocky Reach	31.6	65.3	52.4	62.1	55.3	63.7	67.1	73.7	62.2	58.8	62.3
Wells	29.4	64.2	50.5	60.8	53.9	62.6	65.2	71.1	60.9	53.8	60.3
Tumwater	8.3	13.6	20.9	12.9	14.2	13.3	12.2	9.4	NA	NA	13.8
Bonn Pool Temperature 6/15-7/14	21.3	17.9	18.2	16.4	15.8	16.6	17.9	17.0	18.2	18.3	17.8

Table 37. Rate of loss of Sockeye tagged at Bonneville Dam between mainstem Columbia Basin dams in 2015 compared to 2006-2014 rates as determined from data in Table 36. (Since no Sockeye were tagged during weeks 28 and 29, data from Sockeye tagged as juveniles was used for those weeks as described later in this report. The Dalles Dam PIT tag data is only available since 2013.)

Dam Pairs	2015 Loss	2013-2014 Mean Loss	2006-2014 Mean Loss	Increase in 2015 Mortality Over Base Mean Rate
Bonneville-The Dalles	17.2%	8.7%	NA	97.7%
The Dalles-McNary	34.8%	7.6%	NA	358.8%
Bonneville-McNary	46.0%	--	15.6%	194.5%
McNary-Priest Rapids	16.9%	--	5.0%	235.9%
Priest Rapids-Rock Island	9.6%	--	3.7%	156.8%

Table 38. Percentage of PIT tagged Sockeye Salmon detected at upstream dams subsequent to tagging at upstream dams, estimated escapement from both PIT tags and visual means, and the difference between the PIT tag and visual escapement estimate in 2015. (Since no Sockeye were tagged during weeks 28 and 29, data from Sockeye tagged as juveniles was used for those weeks as described elsewhere in this report.)

Dam	Estimated Percentage Reaching Dam	Estimated Escapement Using Bonneville PIT Tagged Sockeye	Visual Dam Count	Difference Between Bonneville PIT Tag and Visual Estimate
Bonneville	--	--	510077	--
The Dalles	82.8%	423032	429797	-1.6%
McNary	54.0%	275889	279744	-1.4%
Priest Rapids[e]	44.9%	229078	301272	-24.0%
Rock Island	40.6%	207174	264678	-21.7%
Rocky Reach	31.6%	161493	216389	-25.4%
Wells	29.4%	150147	187055	-19.7%
Zosel	4.9%	24988	36360	-25.1%
Tumwater	8.3%	42586	59939	-17.4%
Ice Harbor	0.3%	1308	1052	24.3%

[e] Thirty tagged Sockeye were last detected at the Priest Rapids adult fish trap, and presumably among the 10,000 Sockeye collected for a Cle Elum Lake Sockeye reintroduction program, are not included. Trapped fish are trapped downstream of the fish ladder so would not be expected to be included in Priest Dam visual counts.

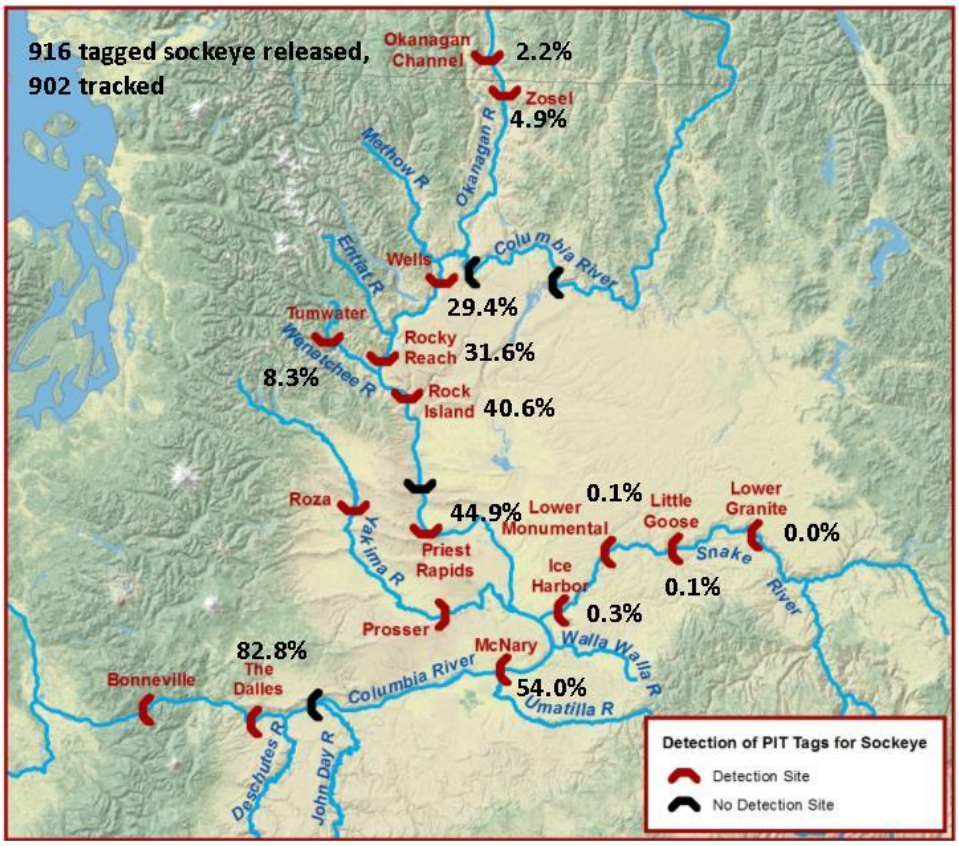


Figure 23. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of Sockeye PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2015. (Since no Sockeye were tagged during weeks 28 and 29, data from Sockeye tagged as juveniles was used for those weeks as described in Fryer et al. 2017.)

Computing weekly upstream survival for Bonneville Dam-tagged Sockeye Salmon during Statistical weeks 28 and 29 was not possible because no Sockeye were tagged during those weeks. As a substitute, the survival of all adult Sockeye PIT tagged as juveniles at Rock Island Dam and in the Wenatchee and Okanagan basins which passed Bonneville Dam during these weeks was used (shown in orange shading in Table 39). Using this data, as in most years of this study, survival from Bonneville to The Dalles, McNary, Priest Rapids, and Rock Island dams showed a significant linear decrease with week sampled and tagged at Bonneville Dam (Table 39, Figure 24) as did survival to Rock Island Dam of the three groups of returning juvenile Sockeye Salmon tagged originating from Wenatchee and Okanagan Sockeye. The percentage of Age 1.3 Sockeye surviving to Rock Island Dam (50.0%) was greater than that for Age 1.2 (42.7%) Sockeye Salmon.

Table 39. Sockeye Salmon survival through selected reaches by statistical week as estimated by PIT tag detections in 2015 and the p-value for a linear regression between weekly reach survival and statistical week. Since no tagging was permitted at Bonneville Dam for weeks 28 and 29, data from returning adult Sockeye tagged as juveniles was used (noted with orange shading).

Statistical Week at Bonneville Dam	Bonneville-The Dalles	Bonneville-McNary	Bonneville-Priest Rapids[f]	Bonneville-Rock Island
23	100.0%	96.6%	93.1%	93.1%
24	95.2%	92.8%	89.6%	88.8%
25	90.8%	82.7%	77.9%	70.4%
26	91.1%	75.0%	64.9%	58.1%
27	72.8%	23.1%	11.8%	9.5%
28	64.5%	16.1%	9.7%	9.7%
29	75.0%	12.5%	6.3%	6.3%
30	86.7%	40.0%	0.0%	0.0%
31	72.7%	40.9%	27.3%	27.3%
Composite	**82.8%**	**54.0%**	**44.9%**	**40.6%**
p-value	**0.028**	**0.012**	**0.003**	**0.003**

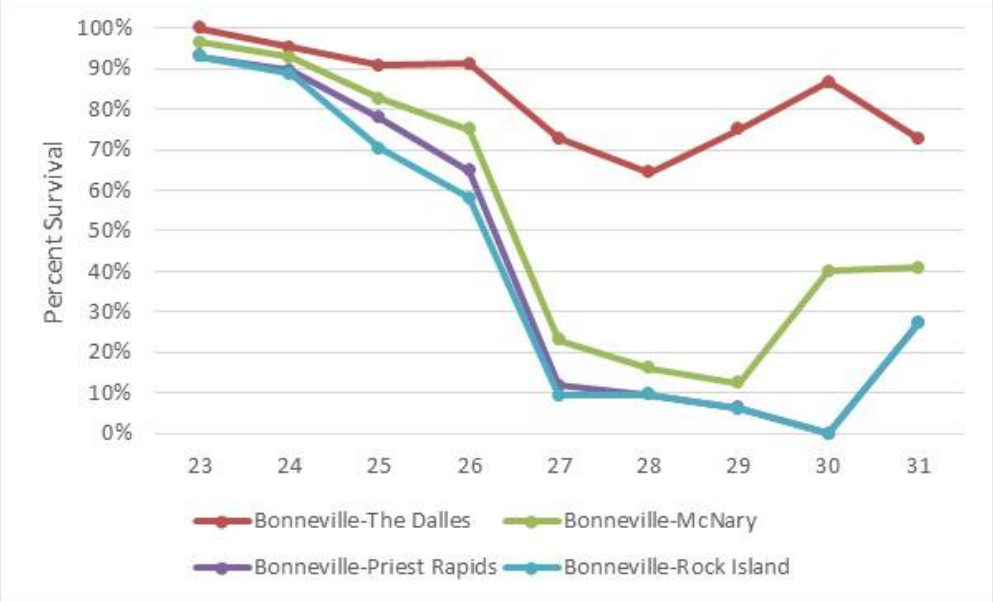


Figure 24. Survival of Sockeye Salmon PIT tagged at Bonneville Dam to The Dalles, McNary, Priest Rapids, and Rock Island dams by statistical week in 2015. Since no tagging was permitted at Bonneville Dam for weeks 28 and 29, data from returning adult sockeye tagged as juveniles was used (Fryer et al. 2017).

[f] Includes Sockeye Salmon only detected in the Priest Rapids Dam trap that likely were collected for the Cle Elum Sockeye reintroduction project.

Stock Composition

An overall Sockeye stock composition estimate is not possible for 2015 as two entire weeks (weeks 28-29 comprising 22.2% of the run) and portions of two others (weeks 27 and 30, an additional 17.6% of the run) were missed due to Bonneville trap restrictions (Table 40). In Statistical Week 30, only 15 Sockeye were sampled and none of these fish made it upstream of McNary Dam and were, therefore, not possible to classify by stock based on PIT tag detections. For the portion of the run that was sampled, 78.4% of the run was estimated as Okanagan stock, 21.1% Wenatchee stock, and 0.5% Snake stock. No Sockeye tagged at Bonneville Dam were detected migrating upstream in the Yakima River.

Thirty-four Sockeye Salmon last detected in the Wenatchee River were previously detected at Rocky Reach Dam with 18 of these also detected at Wells Dam. There was only one Sockeye detected at Tumwater Dam that was subsequently detected anywhere downstream of Tumwater Dam. This Sockeye, with PIT tag 3DD.00775E08D4, was tagged at Bonneville on June 18, 2015, passed Wells Dam on July 3, but dropped downstream to pass LWE on July 8, Tumwater on July 18, and the Upper Wenatchee array on July 18 before being last detected at the ICL array on Icicle Creek downstream of Tumwater Dam on July 31 and August 1, 2015. This was the only fallback observed at Tumwater Dam.

Among the three Sockeye detected at Ice Harbor Dam, two were last detected at Little Goose Dam with the third last detected at Ice Harbor Dam.

A total of 21 Sockeye Salmon PIT tagged at Bonneville Dam were adipose clipped with 2 each left maxillary clipped, and 1 with both a right maxillary and adipose clip (Table 41). Of these Sockeye, eight were last detected in the Wenatchee Basin, one in the Okanagan Basin, two at Priest Rapids Dam, one in the Snake Basin, nine downstream of McNary Dam.

Table 40. Weekly and composite Sockeye Salmon stock composition at Bonneville Dam as estimated by PIT tags in 2015 and a comparison to stock composition estimates estimated using visual dam counts. Note no sampling was conducted Statistical Weeks 28 and 29 and too few Sockeye were sampled Statistical Week 30 to estimate stock composition in week 30.

Statistical Week and Dates	Run Size from Bonneville Dam visual counts	PIT tags deployed at Bonneville	% Okanagan	% Wenatchee	% Snake
23 (May 16-June 6)	2810	30	88.9%	11.1%	0.0%
24 (June 9-13)	21918	125	64.8%	35.2%	0.0%
25 (June 16-20)	84383	298	72.1%	26.9%	1.0%
26 (June 23-27)	181971	251	67.6%	31.7%	0.7%
27 (June 30-July 3)	123153	174	100.0%	0.0%	0.0%
28 (July 7-11)	58543	0	NA	NA	NA
29 (July 14-18)	23496	0	NA	NA	NA
30 (July 21-25)	9927	15	NA	NA	NA
31-32 (July 28-Aug 1)	4506	23	100.0%	0.0%	0.0%
Composite (weeks 23-27 and 31-32)	**418741**	**916**	**78.4%**	**21.1%**	**0.5%**
Week 28-30	**91965**	**NA**	**NA**	**NA**	**NA**
Visual Fish Counts at dams (using difference between Rock Island and Rocky Reach counts to estimate proportion Wenatchee escapement; Rocky Reach to estimate Okanagan escapement)			81.7%	18.3%	
Visual Fish Counts at dams (Tumwater count to estimate the Wenatchee; Rocky Reach to estimate Okanagan)			80.8%	19.2%	

Table 41. Last detection site of clipped Sockeye Salmon tagged at Bonneville Dam in 2015.

Last Detection Site	Left Maxillary Clip	Right Maxillary Clip Plus Adipose Clip	Adipose Clip	All Clips
Bonneville Dam	0	0	2	2
The Dalles Dam	0	0	6	6
Deschutes River Mouth (DRM)	0	0	1	1
Priest Rapids Dam	1	0	1	2
Upper Wenatchee (UWE)	0	1	2	3
Wenatchee spawning grounds (WTL)	0	0	5	5
Wells Dam	0	0	2	2
Lower Methow River (LMR)	0	0	1	1
OKC	1	0	0	1
Little Goose Dam	0	0	1	1
Total	**2**	**1**	**21**	**24**

Migration Rates and Passage Time

Adult Sockeye Salmon travel quickly upstream with a median migration rates between mainstem dams ranging between 29.6 and 53.2 km/day for Sockeye tagged at Bonneville Dam (Table 42). Returning adults tagged as smolts generally have comparable migration rates, with their median migration rate from Bonneville to Rock Island Dam being 0.5 km per day greater than Sockeye tagged as adults (Table 42).

Sockeye Salmon tagged at Bonneville Dam later in the migration travel upstream faster than those tagged earlier in the migration (Table 43). Unlike most previous years when later migrating Sockeye generally migrated between mainstem dams faster than earlier migrating Sockeye, there were no significant (α=0.05) linear relationships between statistical week passing Bonneville Dam and migration time from Bonneville Dam to upstream dams (Table 43). The median difference in travel time from Bonneville Dam to all upstream mainstem dams was 1.7 days or less between the two major stocks, and 1.5 days or less between the three main age groups (Table 43).

Table 42. Median Sockeye Salmon migration rates and travel time between dams as estimated by PIT tag detections in 2015.

		Tagged at Bonneville Dam		Adults Tagged as Juveniles	
Dam Pair	Distance (km)	Median Travel Time (days)	Median Migration Rate (km/day)	Median Travel Time (days)	Median Migration Rate (km/day)
Bonneville-The Dalles	74	1.5	47.1	1.4	51.4
The Dalles-McNary	162	3.0	53.2	3.2	50.1
McNary-Priest Rapids	167	3.4	50.1	3.2	52.0
Priest Rapids-Rock Island	89	3.0	30.2	3.0	30.8
Rock Island-Rocky Reach	33	1.1	29.6	1.0	30.9
Rocky Reach-Wells	65	1.6	41.6	3.0	34.0
Rock Island-Tumwater	73	15.2	4.6	4.0	17.4
Bonneville-McNary	231	4.7	49.5	4.7	49.4
Bonneville-Priest Rapids	329	8.0	41.1	7.9	50.9
Bonneville-Rock Island	487	11.5	42.3	10.9	45.0
Bonneville-Tumwater	560	27.1	20.7	28.3	19.8
Bonneville-Wells	585	13.9	42.6	13.3	42.6

Table 43. Adult Sockeye Salmon travel median time in days between dam pairs by Statistical Week tagged at Bonneville Dam, the p-value for a linear regression between travel time and Statistical Week, and mean travel time by stock as estimated using PIT tags in 2015.

Statistical Week at Bonneville Dam	BON-TDA	BON-MCN	BON-PRA	BON-RIA	BON-TUM	BON-RRH	BON-WEL	BON-ZSL	WEL-ZSL	RIA-TUF
22	1.9	4.7	8.4	NA	NA	12.7	14.9	22.8	7.8	NA
23	1.7	4.7	9.2	12.5	25.3	14.1	16.5	20.9	6.5	NA
24	1.6	4.7	8.1	12.0	18.8	12.7	14.2	49.0	35.4	7.4
25	1.2	4.4	7.8	10.9	29.9	11.8	13.6	45.6	33.8	18.9
26	1.5	4.8	8.1	11.0	24.9	11.7	13.0	37.3	23.0	14.0
27	1.7	5.1	9.2	12.9	NA	15.1	17.2	30.3	13.3	NA
28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	1.2	4.2	NA	NA	NA	NA	NA	NA	NA	NA
31	1.8	5.5	9.1	12.6	NA	13.8	15.9	31.4	14.5	NA
p-value	**0.512**	**0.469**	**0.443**	**0.660**	**0.719**	**0.543**	**0.656**	**0.778**	**0.942**	**0.612**
Stock										
Okanagan	1.5	4.7	7.9	10.9	NA	12.0	13.9	41.9	28.0	NA
Wenatchee	1.5	4.7	8.1	12.1	27.1	13.7	14.0	NA	NA	15.0
Unknown[g]	1.5	4.4	7.9	11.7	NA	11.8	13.2	NA	NA	NA
Age										
1.1	1.6	4.6	8.0	10.1	NA	12.1	13.5	NA	NA	NA
1.2	1.5	4.7	8.0	11.6	27.0	12.1	13.9	41.7	27.8	15.4
1.3	1.4	4.7	8.0	10.9	29.0	12.5	13.1	71.3	58.2	19.1

[g] Unknown Sockeye Salmon stock are those that passed Bonneville, but were not detected at Tumwater, Rocky Reach, Wells, Ice Harbor, or Lower Granite dams.

The median passage time at a dam (defined as the difference between the first and last detection at a dam) for Sockeye tagged at Bonneville Dam and those tagged as smolts was generally under six minutes (Table 44). Exceptions were Ice Harbor and Lower Monumental, where only three fish passed, and Bonneville Dam with an extensive array of antennas that include the lower ladders resulting in earlier detection than most other dams and thus a more complete record of passage times in the ladders. Median passage time for Sockeye tagged as juveniles was generally similar to those tagged as part of this project; however, the percentage of juveniles-tagged adults taking more than 12 hours to pass was greater than that for adult Sockeye tagged by this study at 9 out of 12 dams (Table 44).

Table 44. Sockeye Salmon median passage time from time of first detection at a dam to last detection at a dam and the percentage of Sockeye Salmon taking greater than 12 hours between first detection and last detection in 2015.

	Adults Tagged at Bonneville Dam		Previously Tagged as Juveniles	
Dam	Median Passage (Minutes)	%>12 Hours	Median Passage (Minutes)	%>12 Hours
Bonneville	10.2	0.3%	16.0	6.9%%
The Dalles	0.1	0.9%	0.2	16.2%
McNary	0.2	3.4%	0.2	4.3%
Priest Rapids	5.9	2.4%	5.8	3.1%
Rock Island	0.8	0.9%	1.4	1.1%
Rocky Reach	5.6	1.8%	6.4	3.4%
Wells	4.8	3.5%	7.2	11.4%
Zosel	2.3	10.3%	1.5	20.0%
Tumwater	5.2	1.9%	5.0	0.0%
Ice Harbor	9.0	0.0%	4.2	11.7%
Lower Monumental	796.8	50.0%	3.1	26.0%
Little Goose	0.0	0.0%	0.0	9.4%
Lower Granite	—	—	3.4	14.8%

Fallback

Fallback rates for adults tagged at Bonneville Dam ranged from 0.7% at Bonneville Dam to 19.6% at Zosel Dam for sites with 10 or more detections (Table 45). Fallback rates of Sockeye tagged as juveniles were generally higher than those tagged as adults, reaching a high of 34.5% at The Dalles Dam. Fallback rates for all four Snake River dams were 9.1% or more for Sockeye tagged as juveniles. Of the 86 Sockeye tagged by this project in 2015 which were estimated to fall back over at least one dam, 27 had multiple fallbacks (Table 46). Among Sockeye tagged as juveniles, the mean number of fallbacks

events per Sockeye Salmon for Snake River Sockeye was 0.67 compared to 0.08 to 0.30 for the other juvenile groups and 0.16 for Sockeye in our Bonneville study.

Table 45. Estimated fallback rates for Sockeye Salmon at dams in 2015[h].

Dam	Adults Tagged at Bonneville	Tagged as Juveniles
Bonneville	0.7%	14.3%
The Dalles	1.4%	34.3%
McNary	1.3%	2.0%
Priest Rapids	2.3%	1.8%
Rock Island	1.0%	1.5%
Rocky Reach	9.8%	30.4%
Wells	5.9%	21.1%
Tumwater	0.9%	0.0%
Zosel	19.6%	13.3%
Ice Harbor	0.0%*	11.1%
Lower Monumental	50.0%*	24.0%
Little Goose	0.0%*	9.1%
Lower Granite	NA	18.5%

Table 46. Number of fallback events by tag group for returning Sockeye tagged as juveniles and Sockeye included in our Bonneville adult tagging study in 2015.

	Sockeye Tagged as Juveniles by Tagging Location				Adults Tagged at Bonneville
Fallback Events	**Okanagan**	**Rock Island**	**Snake**	**Wenatchee**	
1	5	7	74	21	57
2	2	5	39	10	20
3	0	2	31	4	7
4	0	1	16	0	0
5	0	0	7	0	0
6	0	0	9	0	1
7	0	0	3	0	0
8	0	0	1	0	0
10	0	0	1	0	1
11	0	0	1	0	0
Number of Sockeye falling back at least once	**7**	**15**	**182**	**35**	86
% of Sockeye with at least one fallback event	6.7%	11.4%	27.1%	20.1%	9.7%
Total fallback events	9	27	448	53	134
Number of Sockeye in study	104	132	671	174	915
Fallbacks events per Sockeye	0.09	0.20	0.67	0.30	0.16

[h] Does not include Sockeye Salmon that fell back over a dam and were not subsequently detected.

Night Passage

Okanagan Sockeye Salmon stock tagged at Bonneville Dam passed PIT tag antennas at night (2000-0400 hours) at a higher rate than Wenatchee Sockeye Salmon stock at 7 out of 11 sites where Sockeye from both stocks were detected (Table 47). Okanagan stock Sockeye Salmon had among the highest night passage rates at Zosel Dam (93.1% compared to 46.7% for Sockeye tagged as juveniles). The Bonneville Dam Washington shore (site BO4) estimate of night passage is likely biased low because tagging occurred between about 0800 and 1300 hours, and with a median passage time of 10.2 minutes from tagging to final detection at Bonneville Dam (Table 44), fish would be expected to pass the counting window prior to 2000 hours

Table 47. Estimated Sockeye Salmon night passage (2000-0400) by stock at mainstem Columbia River dams in 2015.

Dam		Adults Tagged at Bonneville Dam				Sockeye Tagged as Juveniles
	All Adults	Okanagan	Wenatchee	Snake	Unknown	
Bonneville-OR shore	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%
Bonneville-WA shore	0.8%	0.6%	1.1%	10.0%	0.0%	2.5%
The Dalles-OR shore	10.4%	10.7%	11.3%	0.0%	0.0%	5.2%
The Dalles, WA shore	8.7%	9.7%	6.8%	0.0%	10.0%	7.2%
McNary-OR shore	7.8%	10.0%	3.1%	0.0%	13.3%	3.6%
McNary-WA shore	6.8%	8.3%	0.0%	0.0%	33.3%	4.9%
Priest Rapids	3.1%	4.0%	1.2%	NA	0.0%	0.9%
Rock Island	2.8%	4.2%	0.0%	NA	0.0%	5.5%
Rocky Reach	6.8%	6.7%	6.3%	NA	50.0%	6.8%
Wells	12.1%	11.5%	16.7%	NA	50.0%	13.8%
Tumwater	4.7%	NA	4.7%	NA	NA	5.0%
Zosel	93.1%	93.1%	NA	NA	NA	46.7%

DISCUSSION

This study sampled 5405 and PIT tagged 5321 salmonids at Bonneville Dam in 2015 and then tracked (5362 – includes previously tagged fish) these fish upstream to estimate parameters such as upstream escapement, age composition, length composition, and migration rates at and between mainstem dams and other tributary interrogation sites. The year 2015 marked the 10th year we have been PIT tagging Sockeye Salmon, the 9th year we have tagged Chinook Salmon and the 7th year we have tagged steelhead at Bonneville Dam. Over this time, the number of PIT tag detection sites has continually increased, allowing us to learn more about the movement of tagged salmonids throughout the Columbia Basin.

For both Chinook Salmon and steelhead, there are management concerns regarding the timing of run components. One question of interest to fish managers is the definition of a summer Chinook Salmon. Traditionally, spring Chinook Salmon were defined as those migrating past Bonneville Dam through May 31, with summer Chinook Salmon passing from June 1 through July 31, and fall Chinook Salmon defined as passing on or after August 1. Dates of defining a Chinook run at upstream dams were lagged to take into account migration times from Bonneville Dam to the dam in question. However, in 2005, for management purposes the spring-summer differentiation at Bonneville Dam was moved from June 1 to June 16 (though visual counts are typically reported using the old cutoff). Managers moved this date because radio tagging studies suggested that many of the Chinook Salmon migrating in early June are from the Snake River (many spring/summer Chinook in the Snake River Basin are listed as endangered under ESA), while Chinook migrating in late June are mid-Columbia summers. Tag detection data from this project showed that in 2015 the percentage of Chinook Salmon at Bonneville Dam which ultimately passed Ice Harbor Dam peaked at 51.9% of the run for the week starting May 3 and declined to the point where the percentage ranged between 14.7% and 19.9% for the weeks of June 7 to June 21. This percentage dropped further to 4.5% the week of June 28; however, salmon sampled this week (and likely in prior weeks) likely had decreased survival to natal basins due to high temperatures that shut down sampling at Bonneville Dam in the middle of this week. The portion of the run surviving to Priest Rapids Dam over the same period increased from 10.6% to 59.2% the week of June 21 and ranged between 61.5% and 70.0% for the weeks

of July 19 through August 2. In years 2010-2013, the run at Bonneville Dam transitioned over the month of June from being primarily Snake River spring/summer to being primarily mid-Columbia summer Chinook, in 2015, as in 2014 this transition started earlier in May than in past years.

As at Bonneville Dam, Chinook runs (spring, summer, and fall) passing dams upstream of Bonneville Dam are differentiated based on the date they pass, and these dates per dam are based on fixed migration rates assumed by managers. For instance, spring Chinook transition to summer Chinook on June 1 at Bonneville Dam, June 11 at Ice Harbor Dam and June 13 at Priest Rapids Dam. This means that the same Chinook traveling slower than expected could be classified differently at different dams. For example, a "spring" Chinook passing Bonneville Dam on May 31 would be a "summer" Chinook passing Priest Rapids Dam on June 13. Using PIT tag data, this study found that 7.5% of spring, 7.1% of the summer, and 5.3% of the fall Chinook at Bonneville Dam were classified differently at Priest Rapids Dam (Table 8). Misclassified Bonneville spring Chinook were all classified as summers, misclassified summers were classified mostly as springs, and misclassified fall Chinook were all classified as summer Chinook at Priest Rapids Dam. This study found that 1.8% of spring, 24.3% of summer, and no fall Chinook at Bonneville Dam were classified differently at Ice Harbor Dam. Chinook classified at Bonneville Dam as spring Chinook were classified differently most commonly as summer Chinook at Ice Harbor Dam, while Chinook classified as summer Chinook at Bonneville Dam were most commonly misclassified as spring Chinook at Ice Harbor Dam and all misclassified fall Chinook were classified as summer Chinook. These results should be treated with some caution due to the adverse impact of temperature restrictions on summer Chinook sample size during the entire month of July.

Escapement estimates using PIT tag data for mainstem dam passage varied from the traditional methods (i.e. visual counts) and ranged from -36.3% to -7.0% for spring Chinook and +41.6% to -12.0% for fall Chinook. No estimates were made for summer Chinook or the entire Chinook run due to lack of sampling for three weeks and the low numbers sampled in other weeks due to temperature restrictions. For the same reasons, PIT tag derived estimates of Sockeye Salmon escapement were not calculated.

The number of fish tagged in 2015 was lowest since 2010 and second lowest since this Accords project began in 2009 (Table 48). The proportion of

the run tracked for all three species was the lowest since the project began. The low sample sizes were due to high temperatures shutting down sampling for 3 weeks, including the peak week of steelhead passage, and restricting sampling in 11 weeks.

Table 48. Total number of Chinook and Sockeye salmon and steelhead PIT tags tracked by year (includes recaptures of previously PIT tagged fish).

	Total Tracked				Percent of Run Tracked			
Year	Chinook	Steelhead	Sockeye	Total	Chinook	Steelhead	Sockeye	Total
2009	2968	2485	838	6,91	0.42%	0.41%	0.47%	0.42%
2010	2579	1741	913	5233	0.29%	0.42%	0.24%	0.31%
2011	3253	1377	763	5393	0.38%	0.37%	0.41%	0.38%
2012	3438	1451	1601	6496	0.50%	0.62%	0.31%	0.45%
2013	3406	1276	772	5454	0.26%	0.55%	0.42%	0.32%
2014	3869	1717	1400	6986	0.27%	0.63%	0.27%	0.33%
2015	3563	898	901	5362	0.25%	0.33%	0.18%	0.24%

Year 2015 was marked by unusually high temperatures (Figure 22). For several weeks in late July, the plight of Columbia Basin Sockeye Salmon was widely covered in the media[i] and videos such as that produced by the U.S. Geological Survey[j] showed Sockeye badly infected with *Saprolegniasis* or Cotton Wool Disease (e-mail from Dr. Kyle Garver, DFO to Dr. Kim Hyatt, DFO dated August 14, 2015). There was also concern expressed regarding the impact of high temperatures on Chinook and steelhead migration, but there were no images of dead and dying fish to attract media attention.

In an effort to broadly assess the potential impact of high temperatures on the migration of Chinook, steelhead and Sockeye, we compared weekly survival of fish sampled and tagged at Bonneville Dam and tracked to The Dalles and McNary dams over the period of late May through early September for 2014 and 2015. During this period, the mean weekly temperature at Bonneville Dam exceeded 21.1C from Week 27 through 36, in 2015, and weeks 31 through 35 in 2014. Due to these elevated temperatures, sampling was not permitted during the entirety of weeks 28, 29, and 33 in 2015 and weeks 34 and 35 in 2014.

[i] http://wabc-afs.org/w/wp-content/uploads/2016/05/01.-Jeff-Fryer.pdf
[j] https://www.youtube.com/watch?v=g7N7aKQEvj4

For Chinook, there were only 5 weeks (27, 30, 31, 32, 36) over the 10 weeks between weeks 27 and 36 when 2015 temperatures exceeded 21.1C (Table 49) in which sampling occurred in both 2014 and 2015. In 4 of these 5 weeks, survival was higher in 2015 than 2014 from Bonneville to both The Dalles and McNary dams (Table 49, Figure 25 and 26). However, the one week when 2015 survival was lower (Week 27) was the first week temperatures exceeded 21.1C and temperatures continued to increase. During Week 27, survival to The Dalles was 18 percentage points lower in 2015 than 2014, and survival to McNary Dam was 44.6 points lower. Chinook passing Bonneville Dam in 2015 also had lower survival in weeks 24 and 25, but not 26, during the period when temperatures were rapidly rising on their way towards the peak of 23.2C in week 28. Over the five weeks where temperatures were above 21.1C in 2015 and comparisons could be made, the mean decrease in survival in 2015 versus 2014 was only 2.6 percentage points to The Dalles Dam but 17.0 percentage points to McNary Dam.

Table 49. Comparison of the weekly survival for Chinook Salmon from Bonneville to The Dalles and McNary dams estimated by this project in 2014 and 2015 with the percentage point difference and Bonneville Dam weekly water temperatures. Weeks where sampling was not allowed due to high water temperatures at Bonneville Dam are shown as NA; yellow shading indicated a mean weekly water temperature at or above 21.1C, orange shading indicates a mean weekly water temperature at or above 22.2C.

Week	Bonneville Dam Water Temperature		Survival to The Dalles Dam (%)			Survival to McNary Dam (%)		
	2015	2014	2015	2014	Percentage Point Difference	2015	2014	Percentage Point Difference
23	17.7	15.1	82.7	80.6	2.1	69.4	71.1	-1.7
24	19.0	16.2	77.6	85.5	-7.9	59.0	76.6	-17.6
25	19.5	16.0	76.8	92.5	-15.7	60.0	87.9	-27.9
26	20.3	16.8	91.5	86.0	5.5	78.9	82.0	-3.1
27	22.1	18.0	68.2	86.2	-18	36.4	81.0	-44.6
28	23.2	19.3	NA	89.8	NA	NA	84.7	NA
29	23.1	20.7	NA	84.1	NA	NA	72.7	NA
30	22.6	20.6	100.0	76.7	23.3	85.0	67.4	17.6
31	22.1	21.2	84.9	81.4	3.5	67.9	67.8	0.1
32	22.1	21.5	87.1	76.5	10.6	71.0	58.8	12.1
33	22.2	22.1	NA	91.7	NA	NA	75.0	NA
34	22.2	22.2	68.2	NA	NA	59.1	NA	NA
35	21.6	22.2	66.4	NA	NA	46.0	NA	NA
36	21.3	21.0	69.4	60.8	8.6	57.7	50.9	6.8
37	20.1	20.2	59.3	45.3	14.0	44.2	31.3	13.0
Mean above 21.1C in 2015					**-2.6**		**78.6**	**-17.0**

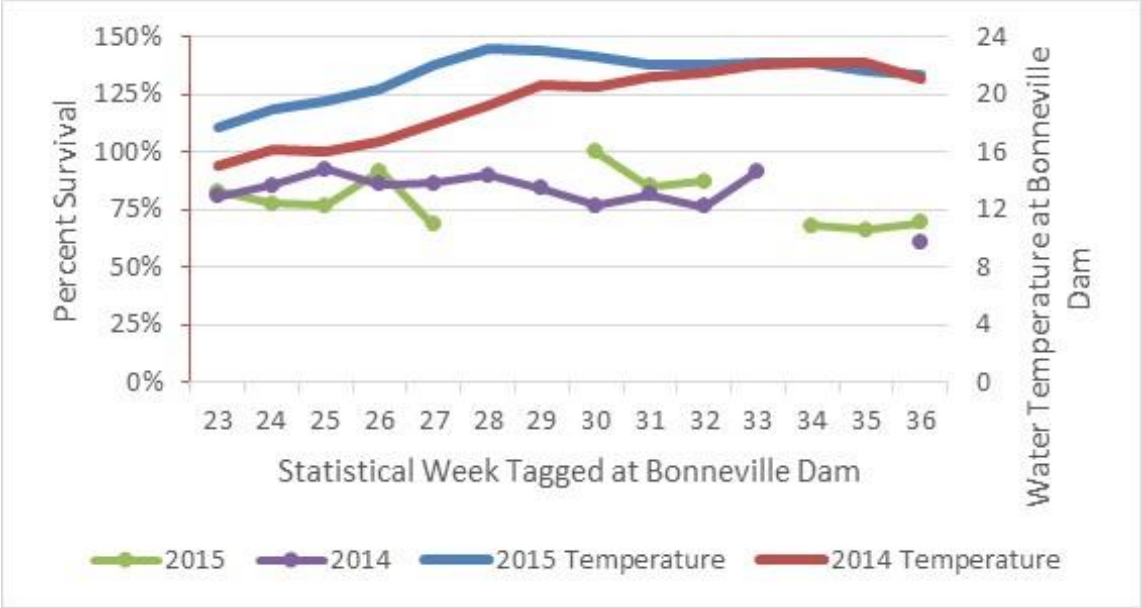


Figure 26. Weekly survival of Chinook Salmon from Bonneville to The Dalles Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

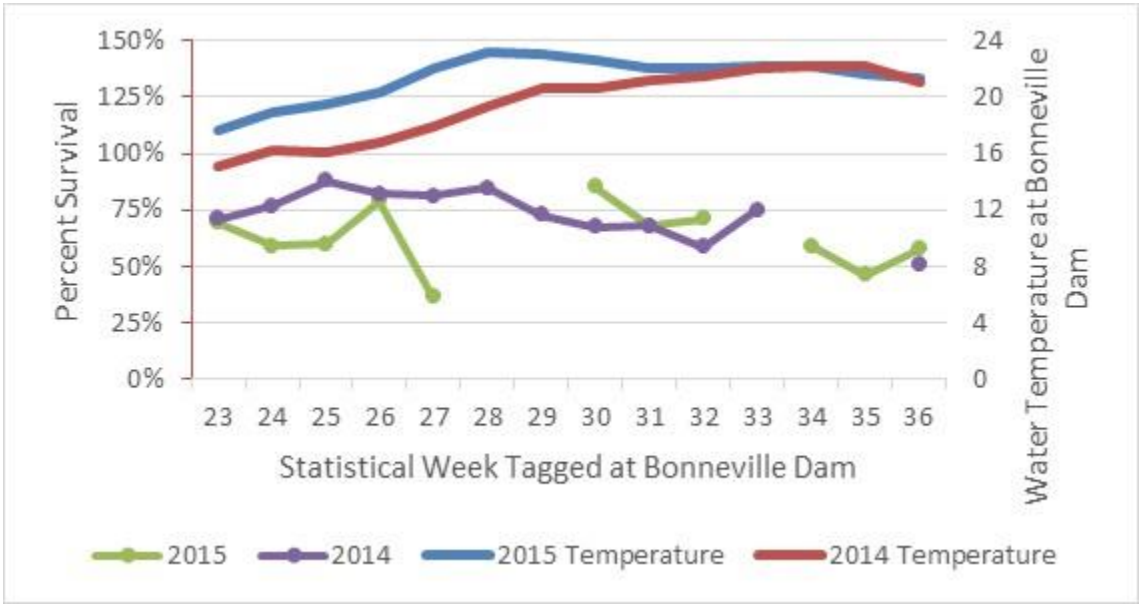


Figure 25. Weekly survival of Chinook Salmon from Bonneville to McNary Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

For Steelhead, there were only 25 steelhead tagged between weeks 23 and 27 in 2015, so these weeks were excluded from the analysis. Of the four weeks where the mean weekly temperature was over 21.1C in 2015, in 3 of them there was lower survival in 2015 than 2014 to both The Dalles and McNary dams. The mean percentage point drop in survival from 2014 to 2015 was 6.2 points to The Dalles, but an increase in survival of 0.1 point to McNary Dam. (Table 50, Figures 27 and 28). The only notable difference in survival between weeks 28 and 37 was the decreased survival in Statistical Week 37 with a 15.5 percentage point drop to The Dalles and 53.8 point drop to McNary Dam. However, this Week 37 estimate was based on only 11 steelhead in 2015 and 17 in 2014.

Table 50. Comparison of the weekly survival estimated by this project for steelhead from Bonneville to The Dalles and McNary dams 2015 and 2016 with the percentage point difference and Bonneville Dam weekly water temperatures. Weeks where sampling was not allowed due to high water temperatures at Bonneville Dam are shown as NA; yellow shading indicated a mean weekly water temperature at or above 21.1C, orange shading indicates a mean weekly water temperature at or above 22.2C.

	Bonneville Dam Water Temperature		Survival to The Dalles Dam (%)			Survival to McNary Dam (%)		
Week	2015	2014	2015	2014	Percentage Point Difference	2015	2014	Percentage Point Difference
28	23.2	19.3	NA	85.5	NA	NA	66.7	NA
29	23.1	20.7	NA	73.8	NA	NA	56.0	NA
30	22.6	20.6	68.2	78.6	-10.4	59.1	64.3	-5.2
31	22.1	21.2	76.5	80.2	-3.7	57.1	62.7	-5.6
32	22.1	21.5	83.2	81.0	2.2	75.8	62.5	13.3
33	22.2	22.1	NA	72.6	NA	NA	61.1	NA
34	22.2	22.2	90.6	NA	NA	69.8	NA	NA
35	21.6	22.2	89.0	NA	NA	76.0	NA	NA
36	21.3	21.0	86.9	90.7	-3.8	72.1	74.1	-2.0
37	20.1	20.2	72.7	88.2	-15.5	34.4	88.2	-53.8
Mean above 21.1C in 2015					**-6.2**			**2.2**

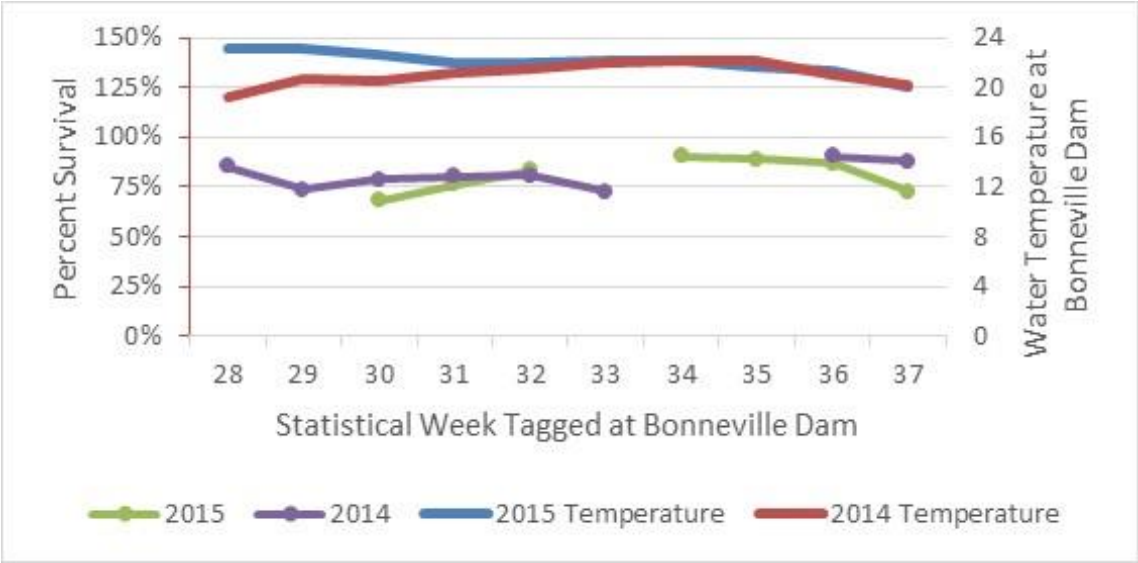


Figure 27. Weekly survival of steelhead from Bonneville to The Dalles Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

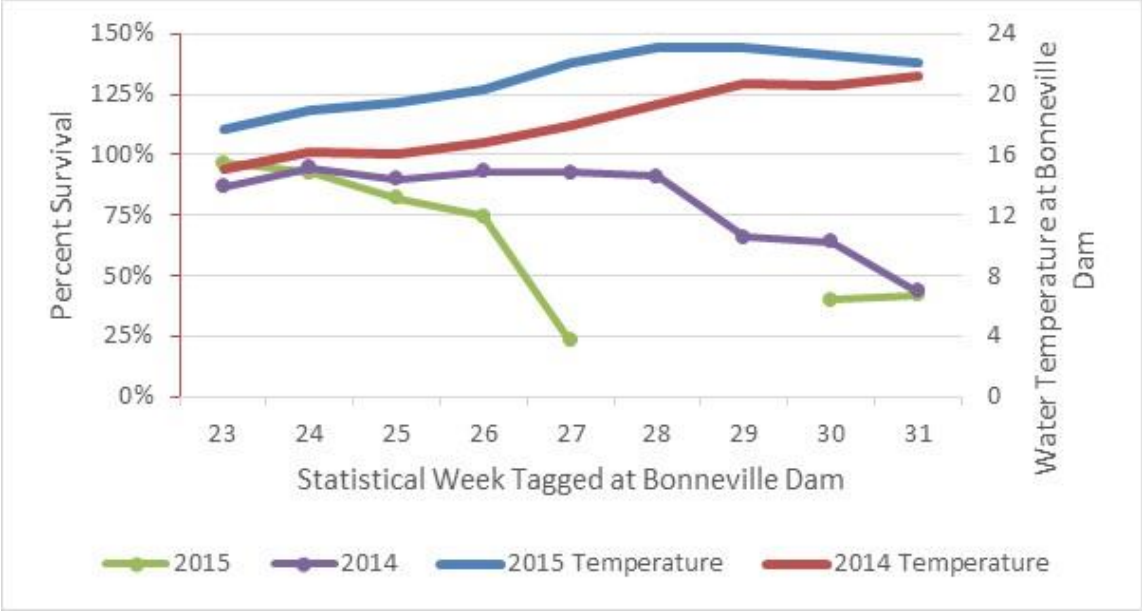


Figure 28. Weekly survival of steelhead from Bonneville to McNary Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

The Sockeye Salmon run passes prior to August, thus comparisons between 2014 and 2015 survival were only possible through Week 31. As with Chinook and steelhead, the greatest decrease in weekly survival in 2015 compared to 2014 was in Week 27 at 23.5 percentage points to The Dalles and 69.6 percentage points to McNary Dam (Table 51, Figures 29 and 30). No sampling was permitted in weeks 28 and 29, but in Week 30, 2015 Sockeye survived at a higher rate to The Dalles by 5.8 percentage points, but worse to McNary Dam by 23.8 percentage points. These estimates are based on a small sample size of only 15 Sockeye in 2015 compared to 59 in 2014. Over the three weeks with temperatures above 21.1C, where comparisons were possible, the difference between 2015 and 2014 mean weekly survival to The Dalles was only 0.1 percentage points, but to McNary 2015 survival averaged 31.6 points less. However, in 2015 the Week 27 run comprised 24.1% of the run compared to 2.8% of the run for weeks 30 and 31; in 2014 the Week 27 run comprised 30.8% of the entire 2014 run compared to 1.9% for weeks 30 and 31. Also, survival in the weeks leading up to week 27 was lower in 2015 than in 2014, especially to McNary Dam as the Sockeye run, likely due to the higher temperatures 2015 Sockeye faced on their upstream migration.

Table 51. Comparison of the weekly survival for Sockeye Salmon from Bonneville to The Dalles and McNary dams estimated by this project in 2015 and 2016 with the percentage point difference and Bonneville Dam weekly water temperatures. Weeks where sampling was not allowed due to high water temperatures at Bonneville Dam are shown as NA; yellow shading indicated a mean weekly water temperature at or above 21.1C, orange shading indicates a mean weekly water temperature at or above 22.2C.

	Bonneville Dam Water Temperature		Survival to The Dalles Dam (%)			Survival to McNary Dam (%)		
Week	2015	2014	2015	2014	Percentage Point Difference	2015	2014	Percentage Point Difference
23	17.7	15.1	100.0	100.0	0.0	96.6	86.7	9.9
24	19.0	16.2	95.2	95.7	-0.5	92.8	94.7	-1.9
25	19.5	16.0	89.8	92.9	-3.1	82.0	90.0	-8.1
26	20.3	16.8	90.3	96.9	-6.6	74.6	92.9	-18.3
27	22.1	18.0	72.6	96.1	-23.5	23.2	92.8	-69.6
28	23.2	19.3	NA	96.3	NA	NA	91.2	NA
29	23.1	20.7	NA	77.1	NA	NA	66.1	NA
30	22.6	20.6	86.7	80.9	5.8	40.0	63.8	-23.8
31	22.1	21.2	78.9	60.9	18.1	42.1	43.5	-1.4
Mean above 21.1C in 2015					**0.1**			**-31.6**

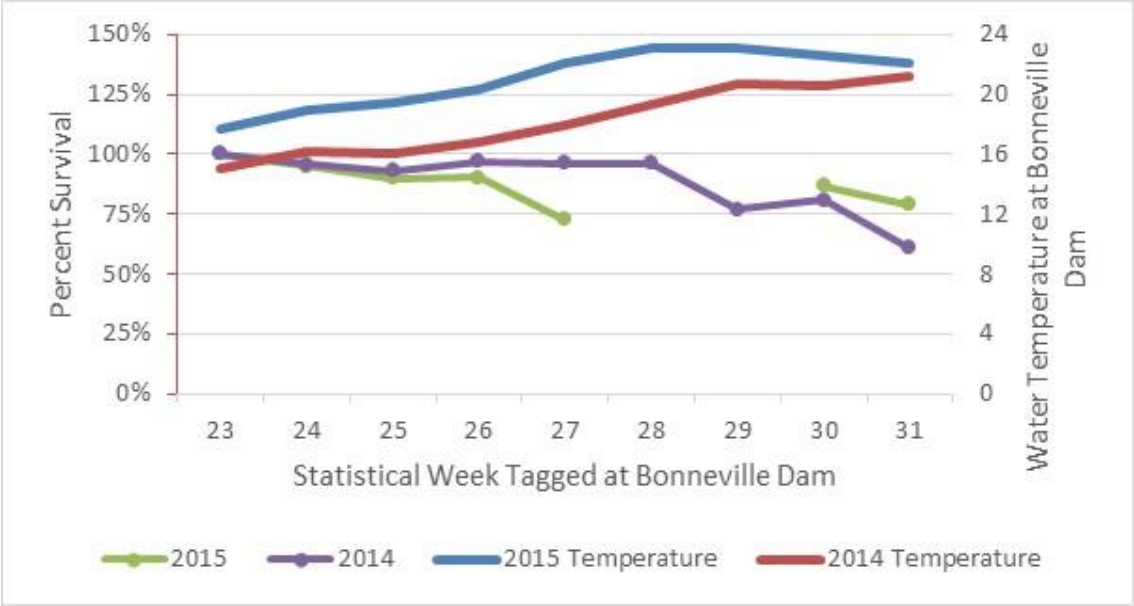


Figure 29. Weekly survival of Sockeye Salmon from Bonneville to The Dalles Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

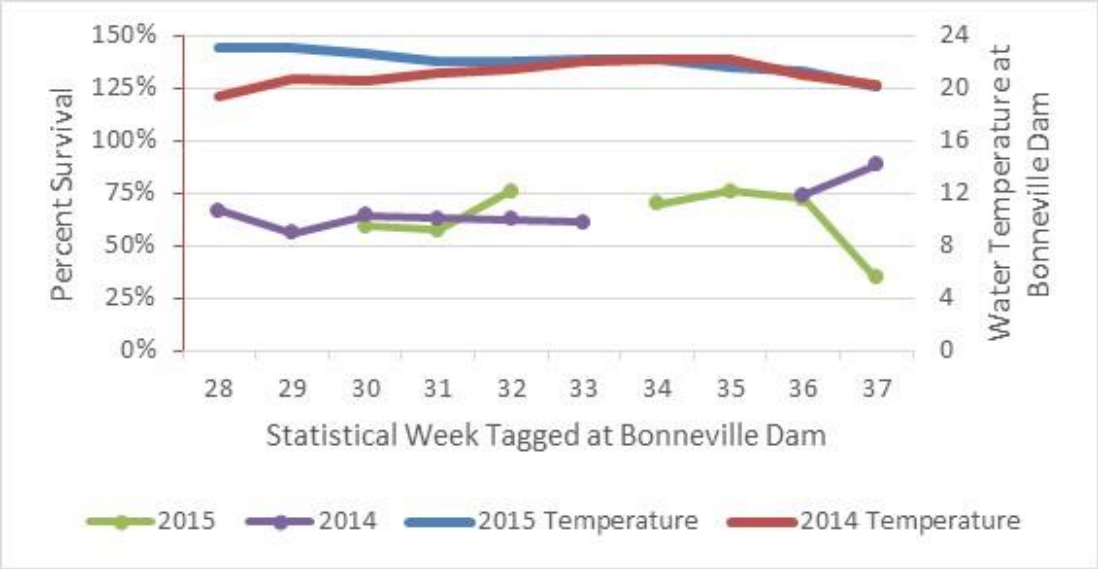


Figure 30. Weekly survival of Sockeye Salmon from Bonneville to McNary Dam estimated by this project in 2014 and 2015 with weekly mean water temperature at Bonneville Dam.

In comparisons between 2014 and 2015, among the three species sampled, Chinook and Sockeye salmon and steelhead, Sockeye were hardest hit by the high temperatures with increased mortality to McNary Dam, especially in Week 27 when temperatures were already at 22.1C at Bonneville Dam and heading up. Chinook also showed some increased mortality, especially in Week 27. Steelhead, on the other hand, showed little change in survival between 2014 and 2015 except in Week 31 when sample sizes were low.

REFERENCES

Busby, P.J. T. C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, R. W. Waknitz, and I.V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27. http://www.nwfsc.noaa.gov/publications/techmemos/tm27.

CBFWA (Columbia Basin Fish and Wildlife Authority PIT Tag Steering Committee). 1999. PIT tag marking procedures manual. CBFWA. Portland. 26 pp.

FPC (Fish Passage Center). 2015. Adult fish counts online at www.fpc.org.

Fryer, J.K. 2008. Use of PIT tags to determine upstream migratory timing and survival of Columbia Basin Sockeye Salmon in 2007. Columbia River Inter-Tribal Fish Commission Technical Report 08-02.

Fryer, J.K. 2009. Use of PIT tags to determine upstream migratory timing and survival of Columbia Basin Sockeye Salmon in 2008. Columbia River Inter-Tribal Fish Commission Technical Report 09-03.

Fryer, J.K., H. Wright, S. Folks, R. Bussanich, K. Hyatt, and J. Miller. 2016. Studies into Factors Limiting the Abundance of Okanogan and Wenatchee Sockeye Salmon in 2015. U.S. Dept. of Energy Bonneville Power Administration Report Project #2008-503-00.

Fryer, J.K., H. Wright, S. Folks, R. Bussanich, K. Hyatt, and J. Miller. 2017. Studies into Factors Limiting the Abundance of Okanogan and Wenatchee Sockeye Salmon in 2015. U.S. Dept. of Energy Bonneville Power Administration Report Project #2008-503-00.

Hatch, D. et.al*. Multiple Years. Annual Reports on the Kelt Reconditioning and Reproductive Success*. Columbia River Inter-Tribal Fish Commission Technical Report. http://www.critfc.org/fish-and-watersheds/fishery-science/scientific-reports/

Kelsey D., J. Mainord, J. Whiteaker, and J.K. Fryer. 2011. Age and length composition of Columbia Basin Chinook and Sockeye salmon and steelhead at Bonneville Dam in 2009. Columbia River Inter-Tribal Fish Commission Technical Report.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48 *in* T.S.Y. Koo (editor). Studies of Alaska Red Salmon. University of Washington Press, Seattle, Washington.

Whiteaker J., and J.K. Fryer. 2008. Age and length composition of Columbia Basin Chinook and Sockeye salmon and steelhead at Bonneville Dam in 2007. Columbia River Inter-Tribal Fish Commission Technical Report.

APPENDIX

Table A1. List of PTAGIS interrogation sites (three letter code, name, and description) to use with maps that follow. Out of 316 active sites, 152 sites detected the fish tagged in 2015.

Site Code	Site Name	Site Description
158	Fifteenmile Ck at Eightmile Cr	At the confluence of Eightmile and Fifteenmile Creeks. Site is on private land.
15D	Fifteenmile Ck at Dry Ck	At the confluence of Dry and Fifteenmile Creeks. Site is on private land.
ACB	Asotin Cr at Cloverland Bridge	Mainstem of Asotin Creek above the George Creek confluence, underneath the Cloverland Bridge, 4.6 km upstream from the mouth of Asotin Creek.
ACM	Asotin Creek near mouth	Near the mouth of Asotin Creek 50 m upstream of the Highway 129 bridge spanning the mainstem of Asotin Creek in two serial sets of two antennas.
AFC	Asotin Creek ISA at North/South fk junction	Instream detectors on Asotin Creek at the junction of the North and South forks.
B2J	Bonneville PH2 Juvenile	Bonneville Dam PH2 Juvenile Bypass and Sampling Facility.
BBT	Touchet River at Bolles Bridge	The Bolles Bridge site is located about 200 feet above the State HWY 124 bridge on the Touchet River, near Bolles Road, at River Kilometer 65.2.
BCC	BON PH2 Corner Collector	Bonneville Dam 2nd Powerhouse Corner Collector Outfall Channel.
BGM	Burlingame Dam and Canal	Burlingame Diversion Dam is located on the lower Walla Walla River.
BHC	Bohannon Creek Lemhi R Basin	The array is located in Bohannon Creek, 40 m upstream of the confluence with the Lemhi River.
BO1	Bonneville Bradford Is Ladder	Bradford Island Adult Fishway at Bonneville Dam.
BO2	Bonneville Cascades Is Ladder	Cascades Island Adult Fishway at Bonneville Dam.
BO3	Bonneville WA Shore Ladder/AFF	Washington Shore Adult Fishway and AFF at Bonneville Dam; replaces B2A and BWL.
BO4	Bonneville WA Ladder Slots	Washington Shore Fishway Vertical Slots at Bonneville Dam.
BR0	Bridge Creek Gauge	Located near the USGS flow gauge site on Bridge Creek.
BR1	Bridge Creek Kiosk	Located at the John Day Fossil Beds National Monument on Bridge Creek.
BSC	Big Sheep Creek ISA at km 6	In-stream detection system located in Big Sheep Creek at river km 6 (N 45.50649, W -116.85067).
CAL	Carson NFH Adult Return Ladder	Hatchery adult spring Chinook return ladder from the Wind River to Carson NFH.
CCW	Catherine Creek Ladder/Weir	Instream detection array located in the adult return fish ladder at the Catherine Creek weir.
CHL	Lower Chiwawa River	Chiwawa River rkm 1, located between the Chiwawa smolt trap and the Chiwawa Acclimation Ponds.
CHU	Upper Chiwawa River	Chiwawa River rkm 12, located above the Forest Road 62 bridge and below Alder Creek.
CHW	Chiwaukum Creek	Located at rkm 0.4 on Chiwaukum Creek, a tributary of Wenatchee River, near Tumwater Campground.
CLC	Clear Creek near Kooskia NFH	Instream detection array located in lower Clear Creek, a tributary to the Clearwater River, just downstream of Kooskia National Fish Hatchery.
CMP	Camp Creek - Imnaha	Located on Camp Creek in the Imnaha River Basin, 2.0 rkm from the mouth of the creek.
CRW	Chewuch River above Winthrop	Chewuch River at river km 1, above Winthrop, WA.
DBH	Buck Hollow Ck Deschutes Trib	Instream detection array in Buck Hollow Creek, a tributary to the Decshutes River.
DRM	Deschutes River mouth	Mouth of the Deschutes River in the west channel at Moody Island (rkm 0.46).
DWL	Dworshak NFH adult trap	Located at the terminus of the Dworshak National Hatchery adult fish ladder in the North Fork Clearwater River.
EHL	Entiat NFH Adult Ladder	This adult interrogation site is located in the Entiat National Fish Hatchery adult ladder.
ENA	Upper Entiat River at rkm 17.1	The site is located approximately 400 meters above the mouth of the Mad River near the township of Ardenvoir at river kilometer 17.1.
ENF	Upper Entiat River at rkm 40.6	The site is located approximately 600 meters below the beginning of Forest Service Property within the upper portion of the Entiat River at rkm 40.6.
ENL	Lower Entiat River	Entiat River rkm 2, located immediately upstream of Entiat, WA.
ENM	Middle Entiat River	Entiat River rkm 26, below the McKenzie Diversion Dam.
ENS	Upper Entiat River at rkm 35.7	The site is located approximately 4.3 km above Stormy Creek at river kilometer 35.7 and near the entrance of the
ESS	EFSF Salmon River at Parks Cr	East Fk South Fk Salmon River (rkm 21) near Parks Creek.
FDD	Feed Diversion Dam	Feed Diversion Dam, at Umatilla River rkm 47.
GOA	Little Goose Fish Ladder	Adult Fishway at Little Goose Dam.
GOJ	Little Goose Dam Juvenile	Little Goose Dam Juvenile Fish Bypass/Transportation Facility.
GRA	Lower Granite Dam Adult	Lower Granite Dam Adult Fishway and Fish Trap.
GRJ	Lower Granite Dam Juvenile	Lower Granite Dam Juvenile Fish Bypass/Transportation Facility.
HRM	Hood River Mouth	Located at the mouth of the Hood River against the west side jetty just inside the bar where the Hood River
HST	Touchet River at Harvey Shaw	Located at rkm 50 on the Touchet River.
HYC	Hayden Creek Instream Array	Lower section of Hayden Creek, in the Lemhi River Basin.
ICH	Ice Harbor Dam (Combined)	Ice Harbor Dam Adult Fishways (both) and Full Flow Bypass.
ICL	Lower Icicle Instream Array	Located at rkm 0.4 on Icicle Creek (Wenatchee River Basin), near Leavenworth, WA.
ICM	Middle Icicle Instream Array	Located at rkm 7 on Icicle Creek.
IML	Imnaha River Weir Adult Ladder	Located in the adult return fish ladder at the Imnaha River weir. Site is on public land.
IR1	Lower Imnaha River ISA at km 7	Lower Imnaha River at river km 7 (N 45.761162, W -116.750658).
IR2	Lower Imnaha River ISA at km 10	Lower Imnaha River at river km 10 (N 45.742839 W -116.764563).
IR3	Upper Imnaha River ISA at km 41	Upper Imnaha River at river km 41 (N 45.49004 W 116.80393).
JD1	John Day River, McDonald Ferry	John Day River in-stream detection, near McDonald Ferry at RM 20.

Table A1. Continued.

Site Code	Site Name	Site Description
JDJ	John Day Dam Juvenile	John Day Dam Juvenile Fish Bypass and Sampling Facility.
JDM	Upper John Day Array	Located on the Upper Mainstem John Day River approximately 7 miles upstream of Dayville, Oregon.
JOC	Joseph Creek ISA at km 3	Joseph Creek, Grande Ronde basin at river km 3 (N 46.030016, W -117.016042).
JOH	Johnson Creek	Johnson Creek enters the Okanogan River at RKM 65.3, in the town of Riverside, WA. The site is located approximately 0.25 KM upstream from the confluence of the Okanogan River.
KHS	Big Bear Creek at Kendrick High School	Located near the mouth of Big Bear Creek (in the Potlatch River Basin) adjacent to the high school in the town of Kendricks, ID.
KRS	SF Salmon River at Krassel Cr	Krassel Creek at rkm 65 on the South Fork Salmon River.
LAP	Lapwai Creek, near its mouth	In-stream detection system consisting of three arrays located in Lapwai Creek.
LC1	Lower Lolo Creek at rkm 21	Lolo Creek, a tributary to the Clearwater River located at river km 522.224.087.021 (N 46.294434 W -115.976119).
LC2	Upper Lolo Creek at rkm 25	Lolo Creek, a tributary to the Clearwater River located at river km 522.224.087.025 (N 46.290562 W -115.934153.
LFF	Lyle Falls Fishway	The Lyle Falls Fishway in Klickitat River.
LLC	Loup Loup Creek Instream Array	Loup Loup Creek trib of the Okanogan River at RKM 27.2, within the city of Malott, WA. The LLC site is located 0.42 km from the confluence with the Okanogan River.
LLR	Lower Lemhi River	Lower Lemhi River in Salmon, ID.
LMA	Lower Monumental Adult Ladders	This interrogation site is in both ladders at Lower Monumental Dam.
LMJ	Lower Monumental Dam Juvenile	Lower Monumental Dam Juvenile Fish Bypass/Transportation Facility.
LMR	Lower Methow River at Pateros	Lower Methow River near the WDFW 'Miller Hole' access site on the lower Methow River immediately upstream of Pateros, WA.
LNF	Leavenworth NFH Adult Ladder	Located in the Leavenworth National Fish Hatcheries adult ladder and holding pond.
LOR	Lost River at rkm 0.81	A permanent instream PIT tag detection system located at rkm 0.81 on the Lost River (Methow River Basin), located near the Lost River Airport.
LRW	Lemhi River Weir	Lemhi River above the mouth of Hayden Creek and below the IDFG weir.
LTR	Lower Tucannon River	Near the mouth of the Tucannon River. The upstream array group was located at an abandoned railroad bridge abutment upstream of Hwy 261 on the Tucannon River downstream from Starbuck. The CO in-stream array was relocated below the Hwy 261 bridge on Sept. 29, 2010.
LWE	Lower Wenatchee River	Wenatchee River rkm 2.
LWL	Ltl. White Salmon NFH returns	Adult fish ladder allowing passage from the Little White Salmon River into the adult holding ponds at Little White Salmon NFH.
MC1	McNary Oregon Shore Ladder	Oregon Shore Adult Fishway at McNary Dam.
MC2	McNary Washington Shore Ladder	Washington Shore Adult Fishway at McNary Dam.
MCD	Mill Creek Diversion Project	Fish bypass and passage facilities at the (Bennington) Diversion Dam and the first Division Works in the Mill Creek Diversion Project in the Walla Walla Basin.
MCJ	McNary Dam Juvenile	McNary Dam Juvenile Fish Bypass/Transportation Facility.
MDR	McDonald Road Bridge	Middle Walla Walla River at McDonald Road Bridge.
MJ1	Middle Fork John Day Array	The Middle Fork John Day Array is near the current confluence with Mosquito Creek on Malheur National Forest Service Land.
MRC	Methow River at Carlton	Located in the mainstem Methow River near the town of Carlton at rkm 45.
MRT	Methow River at Twisp	Methow River at river km 67, above the Twisp River.
MRW	Methow River at Winthrop	Methow River. During 2009 and early 2010, the array was located at river km 81, above Winthrop, WA near Winthrop National Fish Hatchery. In Sept. 2010 it was moved upstream to its new location below Wolf Creek on the mainstem Methow River, at river km 85.
MSH	Methow Fish Hatchery Outfall	On the outlet of the Washington Department of Fish and Wildlife (WDFW) Methow Hatchery located on the Methow River at Rk 82.3 from the confluence with the Columbia River.
MTD	Mill Creek at The Dalles	Located approximately 2.5 km upstream of the mouth of Mill Creek and the confluence with the Columbia River. Site is on private land.
MTR	Middle Tucannon River	The Middle Tucannon River site is located about 250 feet above the River Ranch Ln bridge on the Tucannon River, at River Kilometer 19.5.
MVF	Moving Falls Fish Ladder	Located in the fish ladder at a site known as Moving Falls on the West Fork of the Hood River.
MWC	Maxwell Canal	Maxwell Canal is located at rkm 24 on the Umatilla River.
NAL	Lower Nason Creek	Nason Creek rkm 1, located within Lake Wenatchee State Park.
NAU	Upper Nason Creek	Nason Creek rkm 19 (Wenatchee River Basin).
NBA	Nursery Bridge Adult	Nursery Bridge Dam Fishways (both), Walla Walla River at Milton-Freewater, OR.
NFS	North Fork Salmon River	Located on the North Fork Salmon River approximately 0.5 km above the confluence with the Salmon River.
NMC	Ninemile Creek Instream Array	Ninemile enters the east side of Lake Osoyoos at Okanogan River rkm 129.5, north of the town of Oroville, WA. The site is 0.78 km upstream from the confluence with Lake Osoyoos.
NSB	North Santiam at Upper Bennett Dam	Located on the North Santiam River, a tributary to the Wilammette River. The array is in the fish ladder at Upper Bennet Dam near the town of Stayton.
OKC	Okanagan Channel at VDS-3	The OKC site is located in the Okanagan (Canadian spelling) Channel at 310th Avenue/Road 18 upstream from Osoyoos Lake.
OKL	Lower Okanogan Instream Array	Site at RKM 24.9 on the mainstem Okanogan River, upstream of Chiliwist area in Okanogan County.
OMK	Omak Creek Instream Array	Omak Creek enters the Okanogan River at RKM 51.5, approximately 1 km upstream from the city of Omak, WA. The OMK site is located on Omak Creek, 0.24 km from the confluence with the Okanogan River.
PES	Peshastin Creek	Instream interrogation system at rkm 3 on the Peshastin River (Wenatchee River Basin), located just below the bridge at Smithson's property.
PEU	Upper Peshastin Creek	Located at rkm 17 on Peshastin Creek.
PRA	Priest Rapids Adult	Priest Rapids Dam Adult Fishways (both).
PRH	Priest Rapids Hatchery Outfall	Priest Rapids Hatchery outfall channel. The site is located just upstream of the typical point of inundation in the channel.
PRO	Prosser Diversion Dam Combined	Adult Fishways (all three) and Juvenile Bypass/Sampling Facility at Prosser Dam.

Table A1. Continued.

Site Code	Site Name	Site Description
PRV	Walla Walla R at Pierce RV Prk	Lower Walla Walla River at Pierce Green Valley RV Park.
RCL	Rock Creek (WA) at rkm 5	Rock Creek (WA) at rkm 5 near the Yakama Nation Longhouse.
RIA	Rock Island Adult	Rock Island Dam Adult Fishways (all three).
ROZ	Roza Diversion Dam (Combined)	Roza Dam Smolt Bypass.
RPJ	Rapid River Hatchery Pond	Rapid River Hatchery (IDFG) outfall.
RRF	Rocky Reach Fishway	Rocky Reach Dam Adult Fishway.
RRJ	Rocky Reach Dam Juvenile	Juvenile Fish Bypass Surface Collector.
SA1	Salmon Creek Instream Array	Salmon Creek, 2.9 km upstream of the confluence with the Okanogan River.
SC1	Lower SF Clearwater R at rkm 1	Lower South Fork Clearwater River at river km 0.9 (N 46.13685 W -115.98091).
SC2	Lower SF Clearwater R at rkm 2	Lower South Fork Clearwater River at river km 2 (N 46.12749 W -115.97730).
SCL	Spring Creek NFH Adult Ladder	Fish ladder allowing passage from the Columbia River into the adult holding ponds at Spring Creek NFH.
SCP	Spring Creek Acclimation Pond	Juvenile releases from and adults returning to Winthrop National Fish Hatchery.
SFG	SF Salmon at Guard Station Br.	Located at rkm 30 near the lower South Fork Salmon River Guard Station on the South Fork Salmon River.
SHK	Shitike Creek PIT Array	he array is located across the tailout of a pool created by a bridge (known as the Scale Bridge) that is used by logging truck to deliver lumber to the Warm Springs Mill.
SJ1	SF John Day (Mid)	Located on the South Fork John Day River south of Dayville on the PW Schneider Wildlife Management Area (ODFW).
STL	Sawtooth Hatchery Adult Trap	Ladder of the Sawtooth Hatchery adult fish trap.
STR	SF Salmon Satellite Facility	Ladder of the South Fork Salmon River adult fish trap.
SUN	Sunnyside Instream Array	Located 600 M below Sunnyside Dam on the Yakima River.
SWC	Swale Creek Array	Located in Swale Creek, a tributary to the Klickitat River, Klickitat County, Washington. The site is approximately 100 m upstream from the confluence with the Klickitat River.
SWT	Sweetwater Cr. near its mouth	Approximately 0.1 kilometers upstream from the mouth of Sweetwater Creek.
TAY	Big Creek at Taylor Ranch	Centered around the bridge at Taylor Ranch, Big Creek, ID.
TD1	The Dalles East Fish Ladder	East Fish Ladder at The Dalles Dam.
TD2	The Dalles North Fish Ladder	North Fish Ladder at The Dalles Dam.
TFH	Tucannon Fish Hatchery	The Tucannon Fish Hatchery site is located about 200 feet above the Tucannon Fish Hatchery Adult Trap and Water Intake System on the Tucannon River, at River Kilometer 59.4.
TMF	Three Mile Falls Dam Combined	Adult Fishway and Juvenile Bypass/subsampling facility at Three Mile Falls Dam.
TNK	Tunk Creek Instream Array	Tunk Creek enters the Okanogan River at rkm 72.4. The site is approximately 0.2 KM upstream from the confluence of the Okanogan River.
TON	Tonasket Creek	Tonasket Creek enters the Okanogan River in Lake Osoyoos at rkm 129.4, in the town of Oroville, WA. The site is approximately 0.40 KM upstream from the confluence of Lake Osoyoos.
TOP	Lower Toppenish Creek	On Toppenish Creek located approximately 1700 meters upstream from the confluence of Toppenish Creek with the Yakima River at rkm 130, based on 2011 aerial photography.
TR1	Lower Trout Cr - Deschutes	Lower Trout Creek is located at RKM 0.7 upstream from the confluence with the Deschutes River on privately owned land.
TR2	Trout/Antelope Cr - Deschutes	Trout and Antelope Creek array is located at RKM 20.7 upstream from the confluence with the Deschutes River on privately owned land.
TUF	Tumwater Dam Adult Fishway	Adult Fishway at Tumwater Dam.
TWR	Lwr Twisp Rvr near MSRF Ponds	Lower Twisp River adjacent to the Methow Salmon Recovery Foundation Ponds.
TWX	Estuary Towed Array (Exp.)	The TWX experimental trawl detector is typically deployed in the Columbia River estuary, at and above Jones Beach (rkm 75).
UGR	Upper Grande Ronde at rkm 155	Grand Ronde River located at river km 522.271.155 (45. 593338, -117.903124).
USE	Upper Salmon River at rkm 437	Located in the Salmon River at river km 522.303.437 (N45.028939 W-113.915892).
USI	Upper Salmon River at rkm 460	Located in the mainstem Salmon River at river km 522.303.460 (N44.890380 W-113.962575).
UTR	Upper Tucannon River	The Upper Tucannon River site is located about 200 yards above Don Howards House on the Tucannon River, at River Kilometer 53.2.
UWE	Upper Wenatchee River	Located at rkm 81.2 on the Wenatchee River, near Plain, WA.
VC1	Valley Creek, Upstream Site	Located on Valley Creek at Stanley, ID., in the Upper Salmon River.
VC2	Valley Creek, Downstream Site	Located on Valley Creek below Stanley, ID., in the Upper Salmon River.
WEA	Wells Dam, DCPUD Adult Ladders	Wells Dam Adult Fishways (both).
WEB	Webb Creek	Located approximately 1.0 kilometers upstream from the mouth of Webb Creek.
WFF	Willamette Falls Fishway	Willamette Falls Adult Fishway
WR1	Wallowa River at river km 14	Instream array located in the Wallowa River, Oregon rkm 522.271.131.014 (N 45.633769 ° W -117.73369°).
WRU	Upper Wind River (WA) rkm 30	At rkm 30 of the Wind River, WA. The site is at the FR3065 bridge over the Wind River.
WSH	Warm Springs Hatchery	Adult Fishway at Warm Springs NFH.
WSR	Warm Springs River PIT Array	The Warm Springs River PIT tag array is installed end-to-end across the entire river channel.
WTL	White River, Wenatchee Basin	A permanent instream PIT tag interrogation site at RKM 2.88 on the White River.
YFK	Yankee Fork Salmon River	The site is located 3.14 river kilometers upstream from the confluence with the Salmon River at an elevation of 1855m.
YHC	Yellowhawk Creek	Yellowhawk Creek in-stream detection site, between Mill Creek and Walla Walla R.
ZEN	Secesh River at Zena Cr Ranch	Near the Zena Creek Ranch.
ZSL	Zosel Dam Adult Fishways	Zosel Dam is located at Okanogan River km 132, approximately 3 km downstream from the outlet of Lake Osoyoos

Table A2. Season by season activities of steelhead tagged in 2015 and later labeled as kelts or repeat spawners when they began migrating downstream and upstream (after March 31st) in spring, summer, or fall of 2016 or 2017, presumably to and from the ocean.

Tag Year	Tag Number	First Detection After Tagging 2015 in Spring/Summer/Fall	Fall 2015	Winter 2015/16	Spring 2016	Summer 2016	Fall 2016	Winter 2016/17	Spring 2017	Comments
2015	3DD.00775ECFF6	The Dalles East Ladder - July 30th	Lower Walla Walla River - October 10th John Day River - October 12th		Bonneville Dam Corner Collector - April 14th					
2015	3DD.00775EC6E2	The Dalles North Ladder - August 20th	Lower Granite - September 8th			Bonneville Dam Corner Collector - June 7th				
2015	3DD.00775D5D32	The Dalles East Ladder - July 29th	Prosser Dam (Yakima) - November 10th	Middle Yakima - February 12th	Bonneville Dam Corner Collector - May 15th					
2015	3DD.00775E849C	The Dalles North Ladder - July 30th		Lower Trout Creek (Deschutes) - January 20th Trout/Antelope Cr (Deschutes) - January 20th to February 6th	Bonneville Dam Corner Collector - April 4th					
2015	3DD.00775E2F58	The Dalles East Ladder - August 6th	Lower Granite - September 9th			Lower Granite Dam Juvenile Bypass - June 4th McNary Juvenile Bypass - June 10th Bonneville Dam Corner Collector - June 13th				
2015	3DD.00773AF801	The Dalles East Ladder - May 24th	Upper Wenatchee River - October 9th		Bonneville Dam Corner Collector - May 2nd					
2015	3DD.00775E34E5	The Dalles North Ladder - September 6th	Lower Granite - October 2nd		Little Goose Juvenile Bypass - May 10th Bonneville Dam Corner Collector - May 19th					
2015	3DD.00775D152D	The Dalles East Ladder - July 31st	Lower Granite - October 12th		Bonneville Dam Corner Collector - April 15th					
2015	3DD.00775D1F41	The Dalles East Ladder - September 15th		Lower John Day River - December 12th	Bonneville Dam Corner Collector - April 13th					
2015	3DD.00775E2B63	The Dalles East Ladder - October 5th	Lower Granite - November 1st		Upper Salmon River - March 12th Valley Creek (Salmon) - April 4th to 10th McNary Juvenile Bypass - April 28th Bonneville Dam Corner Collector - May 3rd					
2015	3DD.00775D4A20	The Dalles East Ladder - September 30th	Lower Granite - October 13th		Bonneville Dam Corner Collector - May 1st					
2015	3DD.00775E1EE2	The Dalles East Ladder - September 1st	Lower Granite - September 27th		Upper Salmon - March 8th McNary Juvenile Bypass - April 26th Bonneville Dam Corner Collector - April 30th					
2015	3DD.00775E2B26	The Dalles North Ladder - August 14th			Shitike Creek (Deschutes) - March 6th to May 8th Bonneville Dam Corner Collector - May 18th					
2015	3DD.00775DABFB	The Dalles East Ladder - August 31st	Prosser Dam (Yakima) - October 23rd		Bonneville Dam Corner Collector - April 28th					
2015	3DD.00775D6695	The Dalles North Ladder - August 8th	Lower Granite - October 4th		Joseph Creek (Grand Ronde) - March 2nd to April 18th Lower Monumental Juvenile Bypass - April 24th Bonneville Dam Corner Collector - May 21st					
2015	3DD.00775DB9CD	The Dalles East Ladder - October 20th			Bonneville Dam Corner Collector - April 8th					
2015	3DD.00775D179E				Bonneville Dam Corner Collector - May 4th					Fish was tagged on June 16th, not detected again until spring of 2016.
2015	3DD.00775DCEC7	The Dalles East Ladder - September 8th	Lower Granite - September 22nd			Bonneville Dam Corner Collector - June 10th				
2015	3DD.00775DDA42				Lower 15mile Creek - March 7th Middle 15mile Creek - March 12th to 26th Lower 15mile Creek - April 9th Bonneville Dam Corner Collector - April 13th					Fish was tagged on October 12th, not detected again until spring of 2016 entering 15mile Creek.
2015	3DD.00775E218B	The Dalles East Ladder - October 2nd	Prosser Dam (Yakima) - November 1st	Middle Yakima - February 14th to 24th	Middle Yakima - March 3rd to 5th McNary Juvenile Bypass - April 25th Bonneville Dam Corner Collector - April 29th	The Dalles East Ladder - August 21st	Prosser Dam (Yakima) - October 16th			May have spent time in the ocean before returning.
2015	3DD.00775DDEE	The Dalles East Ladder - July 29th	Prosser Dam (Yakima) - October 5th	Roza Dam (Yakima) - February 26th	Prosser Dam (Yakima) - March 7th Bonneville Dam Corner Collector - April 22nd					
2015	3DD.00775E01D8	The Dalles East Ladder - September 20th	Lower Granite - October 4th		Lower Monumental Juvenile Bypass - April 21st Bonneville Dam Corner Collector - April 28th					
2015	3DD.00775DE986	The Dalles East Ladder - November 4th			Eightmile Creek (Fifteenmile) - March 17th to April 6th Bonneville Dam Corner Collector - April 10th					
2015	3DD.00775D2E4C	The Dalles East Ladder - August 27th	Prosser Dam (Yakima) - October 8th		Middle Yakima March 20th Bonneville Dam Corner Collector - May 19th					
2015	3DD.00775DB230	The Dalles East Ladder - September 6th	Lower Granite - September 22nd		McNary Juvenile Bypass - April 23rd Bonneville Dam Corner Collector - April 30th					
2015	3DD.00775DB27B	The Dalles East Ladder - August 10th	Lower Wenatchee - September 30th		Upper Peshastin Creek (Wenatchee) - April 28th to May 13th Bonneville Dam Corner Collector - May 27th					
2015	3DD.00775E8522	The Dalles North Ladder - July 29th	Lower Granite - September - 30th		Bonneville Bradford Is. Ladder - May 3rd					
2015	3DD.00775DA0D9	The Dalles East Ladder - August 23rd	McNary - November 25th	John Day River - December 10th	Bonneville Bradford Is. Ladder - April 12th					
2015	3DD.00775DC164	The Dalles East Ladder - October 1st	McNary - October 5th McNary Juvenile Bypass- November 29th		Bonneville Juvenile Bypass - April 24th					
2015	3DD.00775DCC83	The Dalles East Ladder - August 9th	Feed Diversion Dam (Umatilla) - October 13th		Bonneville Juvenile Bypass- April 9th					
2015	3DD.00775DC2FE	The Dalles North Ladder - August 31st	McNary - September 4th	Touchet River - January 22nd to February 18th	Bonneville Juvenile Bypass - May 9th					
2015	3DD.00775D2CA6	The Dalles East Ladder - August 9th	Lower Granite - October 24th		Lower Granite - April 25th Bonneville Juvenile Bypass - May 8th					
2015	3DD.00775E252C	The Dalles East Ladder - October 12th	McNary - October 8th		SF John Day -March 5th to 9th Bonneville Juvenile Bypass - April 18th					
2015	3DD.00775EADCA	The Dalles East Ladder - September 14th		Rock Creek - December 8th to February 10th	John Day Dam Juvenile Bypass - April 4th					
2015	3DD.00775DCD7D	The Dalles East Ladder - August 8th	Prosser Dam (Yakima) - Octomber 29th		Lower Toppenish Creek (Yakima) - April 16th John Day Dam Juvenile Bypass - April 30th					
2015	3DD.00775DF732	The Dalles East Ladder - October 3rd		Rock Creek - January 16h to February 10th	John Day Dam Juvenile Bypass - April 5th					
2015	3DD.00775E3585	The Dalles East Ladder - September 28th	McNary Juvenile Bypass - November 23rd	John Day River - December 9th	John Day Dam Juvenile Bypass - April 14th					
2015	3DD.00775DCF46	The Dalles East Ladder - August 2nd	Lower Granite - October 31st	Joseph Creek (Grand Ronde) - February 18th	Joseph Creek (Grand Ronde) - April 3rd John Day Dam Juvenile Bypass - April 24th					
2015	3DD.00775D15B3	The Dalles North Ladder - August 27th	Ice Harbor - September 4th		Ice Harbor - March 23rd Lower Walla Walla - March 24th Touchet River - April 2nd to 9th John Day Dam Juvenile Bypass - April 14th					
2015	3DD.00775E2D47	The Dalles East Ladder - September 25th	Lower Monumental - November 2nd	Lower Walla Walla - February 17th	Lower Walla Walla - March 6th Mill and Yellowhawk creeks - March 25th to 28th Lower Walla Walla - April 2nd McNary Juvenile Bypass - April 5th					
2015	3DD.00775E0E43	The Dalles North Ladder - October 3rd	Lower Granite - October 13th		Lower Monumental Juvenile Bypass - April 14th	Bonneville Bradford Is. Ladder - July 2nd	Lower Granite - September 20th			May have spent time in the ocean before returning.
2015	3DD.00775DE800	The Dalles East Ladder - September 4th	Lower Granite - September 21st		Lower Monumental Juvenile Bypass - April 9th	Bonneville WA Ladder - August 2nd	Lower Granite - October 2nd			May have spent time in the ocean before returning.

Table A2 (Continued).

Tag Year	Tag Number	First Detection After Tagging 2015 in Spring/Summer/Fall	Fall 2015	Winter 2015/16	Spring 2016	Summer 2016	Fall 2016	Winter 2016/17	Spring 2017	Comments
2015	3DD.00775E203B	The Dalles East Ladder - September 21st	Lower Granite - October 6th		Little Goose Juvenile Bypass - April 13th					
2015	3DD.00775DC4D2	The Dalles East Ladder - October 15th	Lower Granite - November 11th		Little Goose Juvenile Bypass - May 13th					
2015	3DD.00775E5B9E	The Dalles East Ladder - August 9th	Lower Monumental - August 22nd	Lower Granite - September 11th	Little Goose Juvenile Bypass - April 25th					
2015	3DD.00775E7477	The Dalles East Ladder - July 31st	Lower Granite - September 21st		Little Goose Juvenile Bypass - April 10th					
2015	3DD.00775E7541	The Dalles North Ladder - August 24th	Lower Granite - September 4th	Lower Asotin Creek - February 20th	NF/SF Asotin Creek - March 30th to April 8th Lower Asotin Creek - April 10th Little Goose Juvenile Bypass - April 16th					
2015	3DD.00775DF88A	The Dalles North Ladder - August 22nd	Lower Granite - November 14th		Ice Harbor - May 14th					
2015	3DD.00775E8493	The Dalles East Ladder - October 3rd	Wells - October 25th		Wells - April 14th Rocky Reach Juvenile Bypass - May 1st					
2015	3DD.00775E1236	The Dalles East Ladder - August 2nd	Lower Methow - November 2nd	Wells - December 27th	Wells - March 30th Lower Methow - March 31st Rocky Reach Juvenile Bypass - May 19th					
2015	3DD.00775E681F	The Dalles North Ladder - August 31st	Lower Granite - October 8th		Lower Lemhi River (Salmon) - April 7th Lower Granite - May 11th					Steelhead was recaptured and released at Lower Granite Dam for the CRITFC Kelt Project - considered a kelt.
2015	3DD.00775E0825	The Dalles East Ladder - August 27th	Upper Salmon River - October 19th		Sawtooth Hatchery (Salmon) - April 13th to 18th Lower Granite - May 16th					Steelhead was recaptured and released at Lower Granite Dam for the CRITFC Kelt Project - considered a kelt.
2015	3DD.00775DFB87	The Dalles East Ladder - August 11th	Lower Granite - October 16th		Lower Granite - May 8th					Steelhead was recaptured and released at Lower Granite Dam for the CRITFC Kelt Project - considered a kelt.
2015	3DD.00775DA161	The Dalles East Ladder - October 11th	Lower Granite - October 25th		Lower Granite - April 25th					Steelhead was recaptured and released at Lower Granite Dam for the CRITFC Kelt Project - considered a kelt.
2015	3DD.00775E9E95	The Dalles East Ladder - November 1st	McNary - November 6th		Three Mile Dam (Umatilla) - May 2nd					This fish was tagged at Bonneville in July the 29th.
2015	3DD.00775E3438	The Dalles East Ladder - October 14th		Three Mile Dam (Umatilla) - December	Three Mile Dam (Umatilla) - April 23rd					This fish was tagged at Bonneville in July the 29th.
2015	3DD.00775DCEA7	The Dalles East Ladder - August 29th	Prosser Dam (Yakima) - October 22nd		Roza Dam (Yakima) - April 1st					Steelhead sampled in CRITFC Kelt Project - considered a kelt by the project.
2015	3DD.00775DCD79	The Dalles East Ladder - October 10th	Lower Monumental - November 1st		Lower Granite - April 3rd	Fish Creek (Clearwater) - June 13th				Steelhead sampled in CRITFC Kelt Project - considered a kelt by the project.
2015	3DD.00775DDF81	The Dalles East Ladder - September 18th	Lower Granite - October 4th	Lower SF Clearwater - February 12th	Lower SF Clearwater - April 16th					
2015	3DD.00775DB747	The Dalles East Ladder - October 9th	Ice Harbor - October 20th		Middle Walla Walla - March 28th Lower Walla Walla - April 18th					
2015	3DD.00775E69B3	The Dalles North Ladder - August 7th	Lower Monumental - October 11th	Lower Tucannon - February 16th	Ice Harbor - March 24th Lower Walla Walla River - March 25th Middle Walla Walla River - April 5th to May 5th Lower Walla Walla River - May 6th					
2015	3DD.00775D23F1	The Dalles East Ladder - August 26th	Lower Monumental - October 29th		Lower Monumental - March 30th Lower Walla Walla River - April 5th Middle Walla Walla River - April 6th to 9th Lower Walla Walla River - April 21st					
2015	3DD.00775D4AFE	The Dalles East Ladder - September 7th	McNary - September 12th	Middle Walla Walla River - February 17th	Middle Walla Walla River - March 2nd	Bonneville Washington Ladder - August 20th	McNary - September 23rd	Lower Walla Walla River - January 25th Middle Walla Walla River - February 27th	Middle Walla Walla River - April 7th	Repeat Spawner

Key - - - Upstream | Downstream | Spawning

Table A3. Season by season activities of steelhead tagged in 2015 and later labeled as kelts or repeat spawners when they began migrating downstream and upstream (before April 1st) in spring, summer, or fall of 2016, presumably to and from the ocean.

Tag Year	Tag Number	First Detection After Tagging 2015 in Spring/Summer/Fall	Fall 2015	Winter 2015/16	Spring 2016	Comments
2015	3DD.00775E2D00	The Dalles East Ladder - November 1st			Bonneville Dam Corner Collector - March 23rd	
2015	3DD.00775DA9C3	The Dalles East Ladder - September 17th	Lower Monumental - October 22nd		Lower Walla Walla - March 3rd Middle Walla Walla - March 14th to 18th Lower Walla Walla - March 30th	
2015	3DD.00775E0764	The Dalles East Ladder - August 6th	Lower Granite - October 16th		Little Goose - MArch 2th	
2015	3DD.00775E21E4	The Dalles East Ladder - September 18th	Lower Granite - October 6th		Lower Granite Juvenile Bypass - March 21st	
2015	3DD.00775E683E	The Dalles East Ladder - October 10th	The Dalles East Ladder - November 4th		John Day Juvenile Bypass - March 23rd The Dalles North Ladder - March 30th	
2015	3DD.00775E6832	The Dalles East Ladder - September 4th	Ice Harbor - October 9th		Ice Harbor - March 28th	

Key - - - Upstream | Downstream | Spawning

Table A4. Season by season activities of steelhead tagged in 2014 and later labeled as kelts or repeat spawners when they began migrating downstream and upstream presumably to and from the ocean. Any new steelhead or steelhead with additional information from the 2014 report table is included here as behavioral detections became available in 2016/2017.

Tag Year	Tag Number	First Detection After Tagging 2014 in Spring/Summer/Fall	Summer 2014	Fall 2014	Winter 2014/15	Spring 2015	Summer 2015	Fall 2015	Winter 2015/16	Spring 2016	Summer 2016	Fall 2016	Comments
2014	384.3B23ADA9E6	The Dalles East Ladder - June 20th	Lower Monumental - June 28th			Bonneville Dam Corner Collector - March 20th					Bonneville Bradford Is. - June 2nd Lower Monumental - June 12th	Little Goose - October 7th Middle Tucannon River - November 8th	Steelhead that traveled out of the system before March 31st and would not normally have been counted.
2014	384.3B23AF8A1D	Wind River - July 31st					Bonneville Cascade Is. Ladder - July 13th				Bonneville Bradford Is. - August 4th	Bonneville Washington Shore Ladder - September 16th	
2014	384.3B23AF1DE4	Bonneville Washington Shore Ladder - April 16th	Bonneville Juvenile Bypass - June 4th							Bonneville Washington Shore Ladder - April 8th			New steelhead added.
2014	3DD.00773AB71C	The Dalles North Ladder - - July 27th		Prosser Dam (Yakima) - November 1st	Lower Toppenish Creek (Yakima) - January 10th	Simcoe Creek (Yakima) - March 31st Lower Toppenish Creek (Yakima) - April 6th Prosser Dam (Yakima) - April 13th		Prosser Dam (Yakima) - November 5th	Lower Toppenish Creek (Yakima) - January 10th				Steelhead collected in CRITFC Kelt Project at Prosser Dam for reconditioning. Released from project November 5th, 2015. Updated info.
2014	3DD.00773AE101	The Dalles East Ladder - October 24th				Bonneville Dam Corner Collector - April 20th		Deschutes River - September 10th		Bonneville Dam Corner Collector - March 25th			
2014	3D9.1C2E03A59F	The Dalles North Ladder - June 15th		Ice Harbor - September 13th			Bonneville Bradford Is. Ladder - July 27th	Walla Walla River - September 6th	Touchet River - January 28th				
2014	3DD.00773AFAC5	The Dalles East Ladder - July 11th	McNary - November 28th		Prosser Dam (Yakima) - December 10th Lower Status Creek - January 25th	Lower Status Creek - March 1st Bonneville Dam Corner Collector - April 12th	Bonneville Washington Ladder - August 13th	Prosser Dam (Yakima) - November 11th	Lower Status Creek - January 26th	Bonneville Dam Corner Collector - April 8th			May have spent time in the ocean before returning.
2014	3DD.00773B93F4	The Dalles East Ladder - September 21st		John Day River (McDonald Ferry) - November 28th			Bonneville Washington Ladder - August 13th	The Dalles East Ladder - October 4th John Day River (McDonald Ferry) - October 19th					New steelhead added.

Key - - - Upstream | Downstream | Spawning

Table A5. Season by season activities of steelhead tagged in 2013 and later labeled as kelts or repeat spawners when they began migrating downstream and upstream presumably to and from the ocean. Any new steelhead or steelhead with additional information from the 2013 report table is included here as behavioral detections became available in 2016/2017.

Tag Year	Tag Number	First Detection After Tagging 2013 in Spring/Summer/Fall	Fall 2013	Winter 2013/14	Spring 2014	Summer 2014 to Spring 2015	Summer 2015	Fall 2015	Winter 2015/16	Spring 2016	Comments
2013	3D9.1C2E034EB9	The Dalles North Ladder - July 25th	McNary - October 3rd		Middle John Day River - April 8th		Bonneville Washington Shore Ladder - August 4th Deschutes River Mouth - August 6th	John Day River (McDonald Ferry) - November 15th		Middle Fork John Day - March 4th	

Key - - - Upstream | Downstream | Spawning

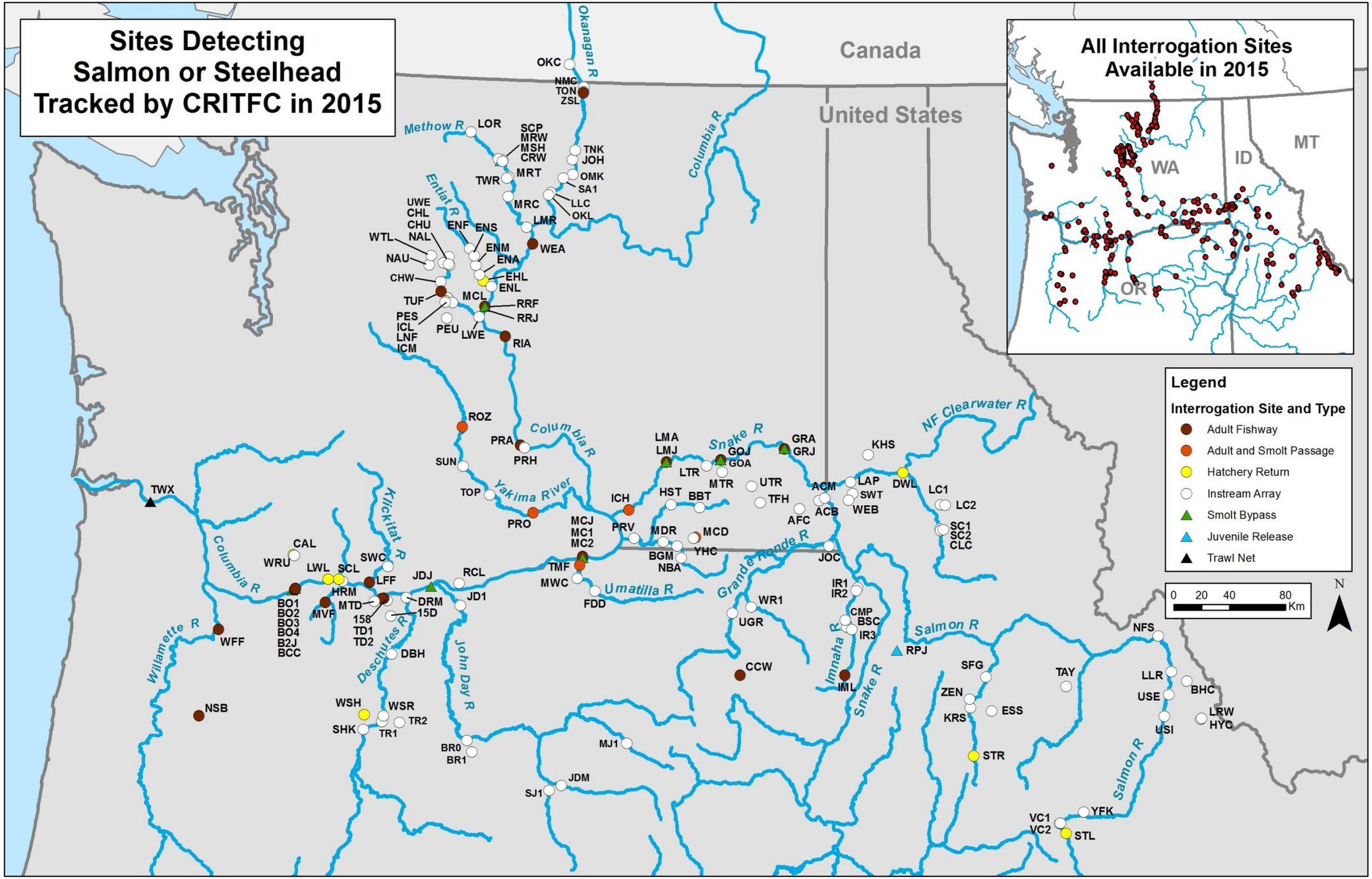


Figure A1. Map of Columbia River interrogation sites that detected Chinook and Sockeye salmon, and steelhead in 2015. Table A1 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

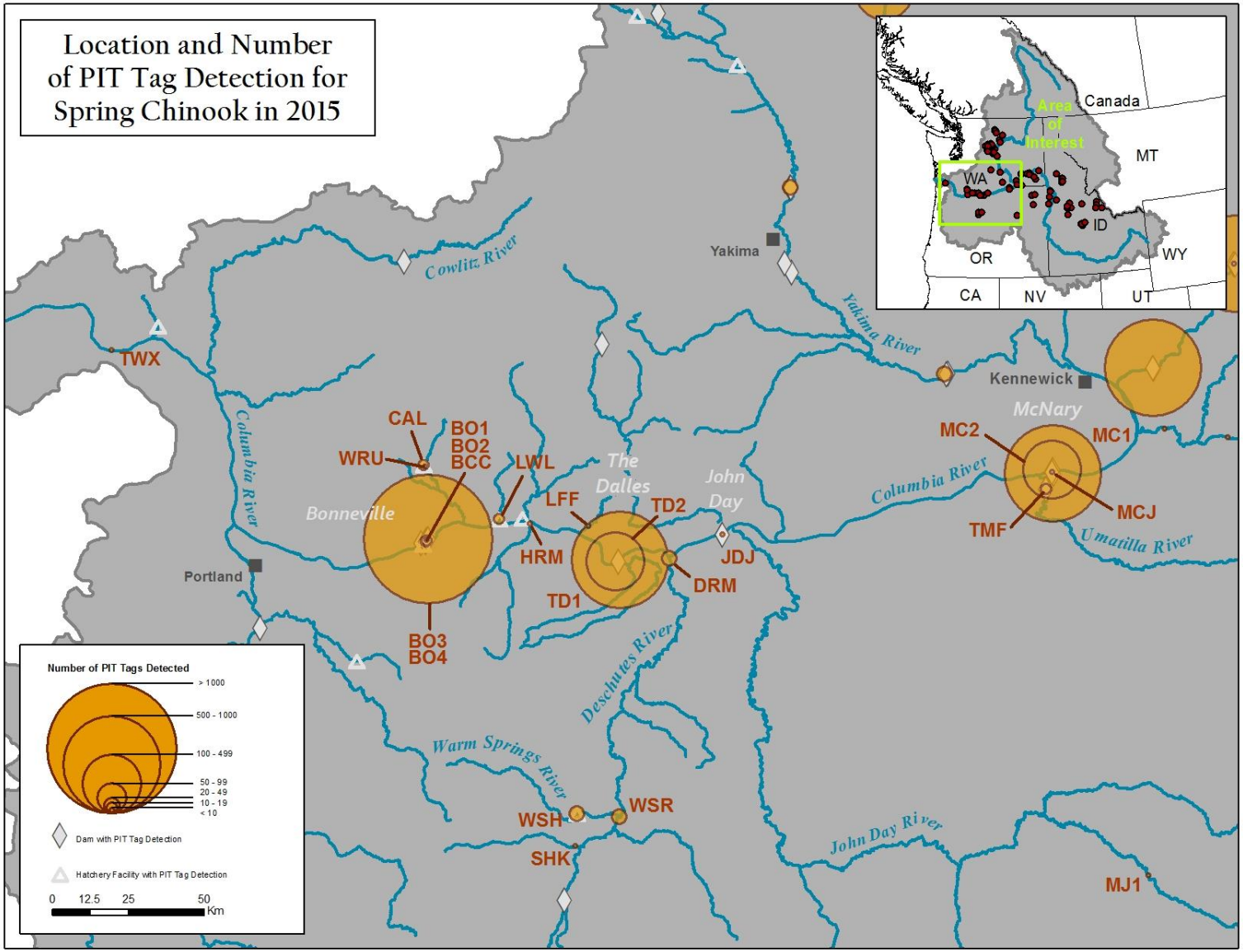


Figure A2. Map of Lower Columbia River detection sites (below Snake River) and number of spring Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

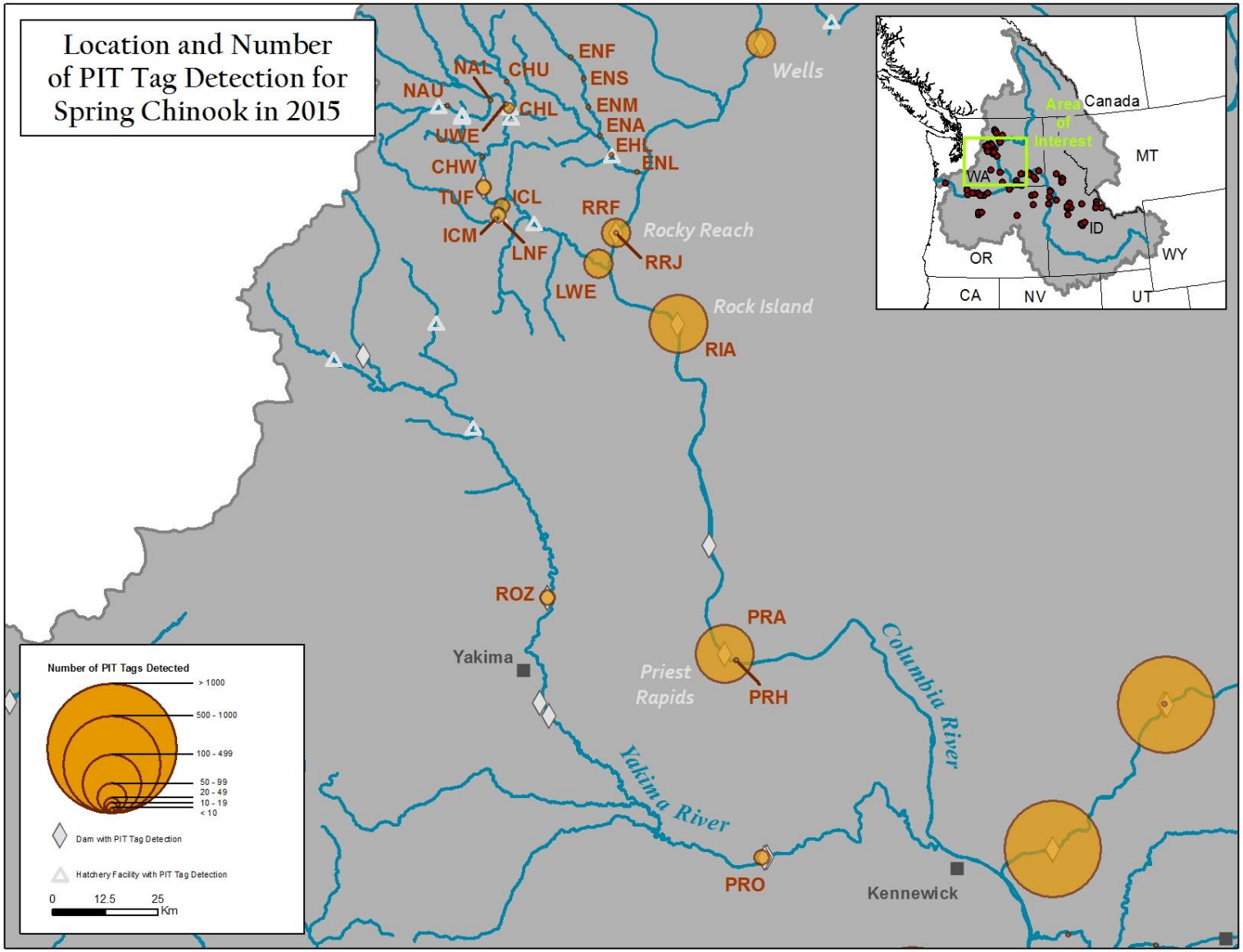


Figure A3. Map of Upper Columbia River (between the Snake River and Wells Dam) detection sites and number of spring Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

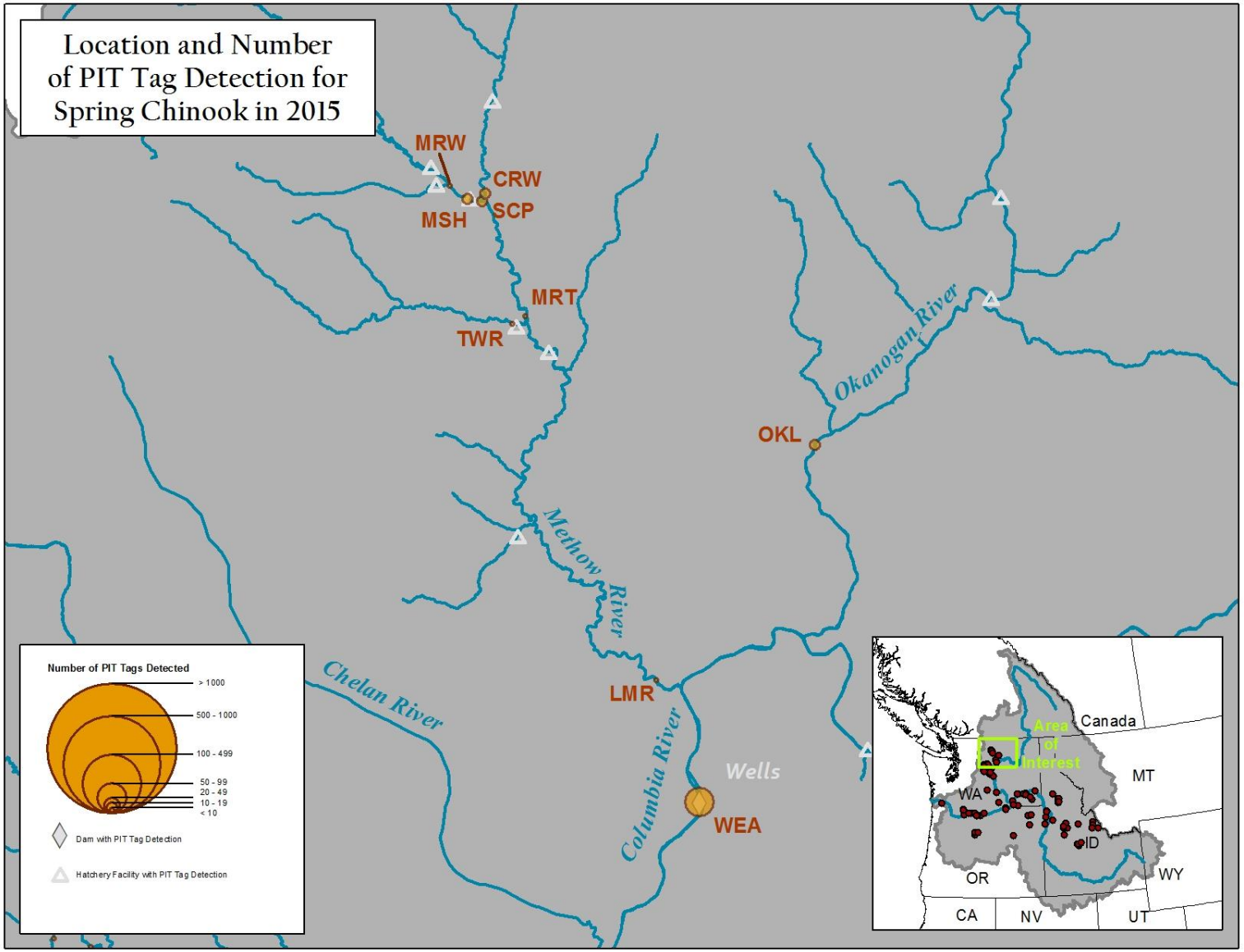


Figure A4. Map of Upper Columbia River (Wells Dam and above) detection sites and number of spring Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

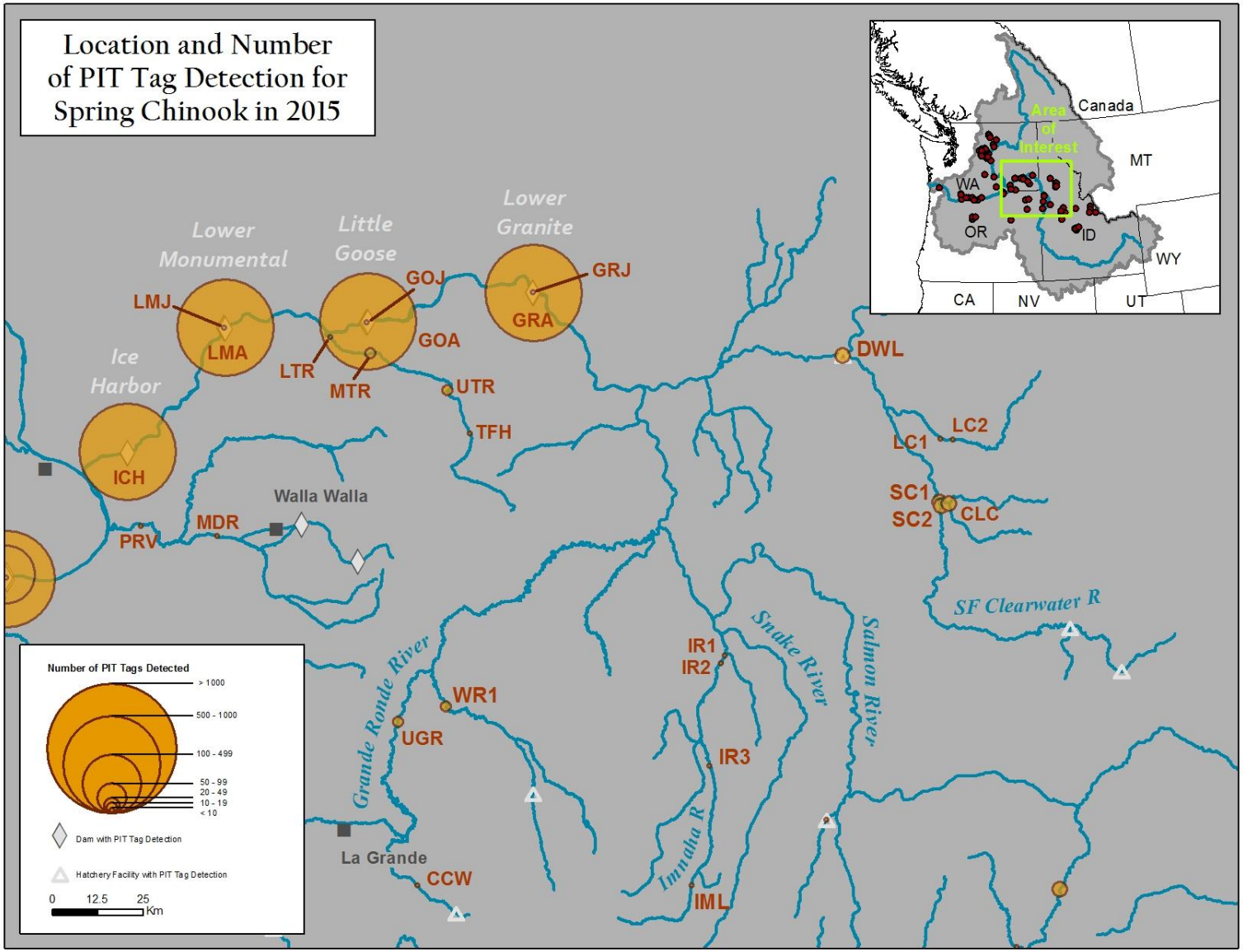


Figure A5. Map of Lower Snake River detection sites (Salmon River not included) and number of spring Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

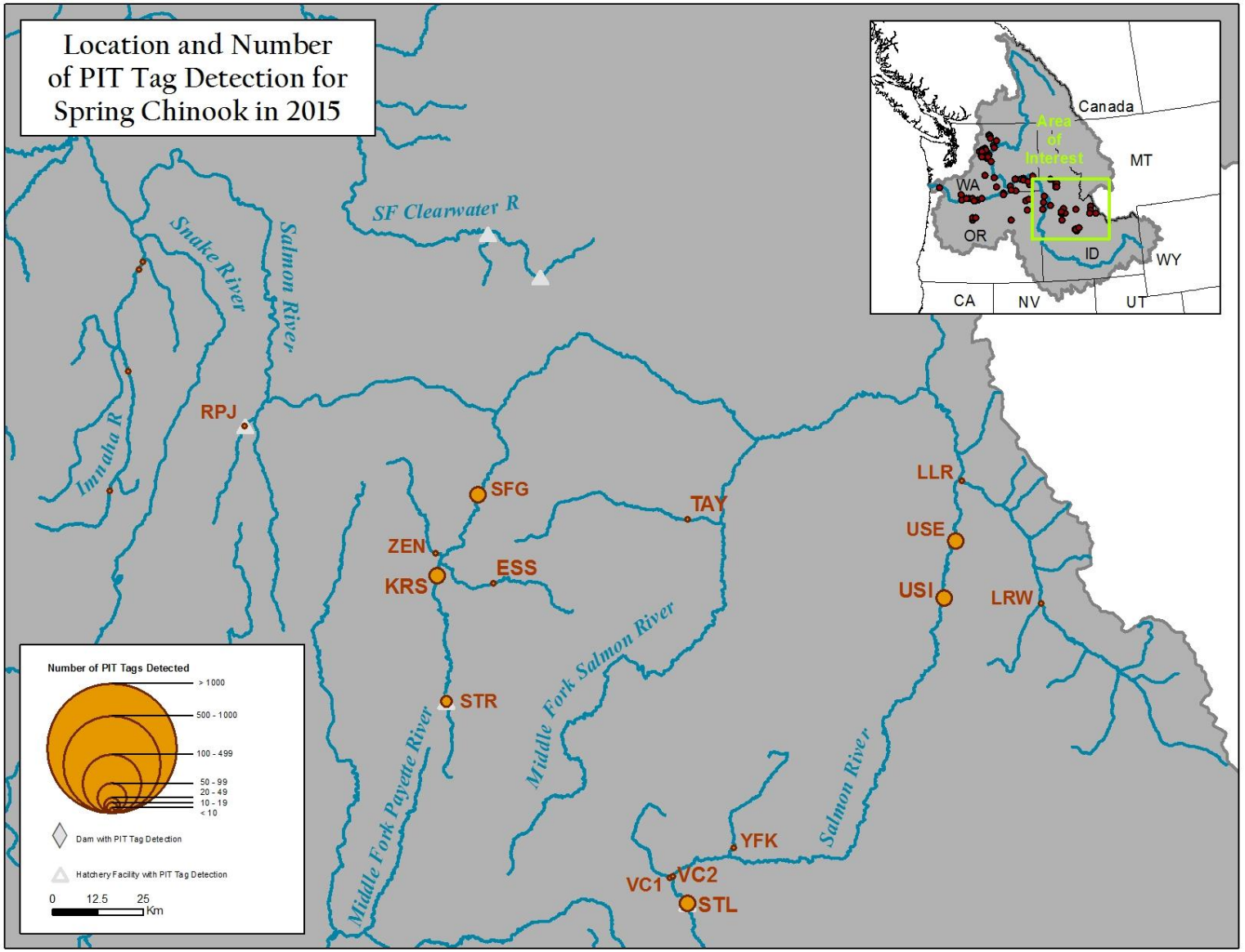


Figure A6. Map of Salmon River detection sites and number of spring Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

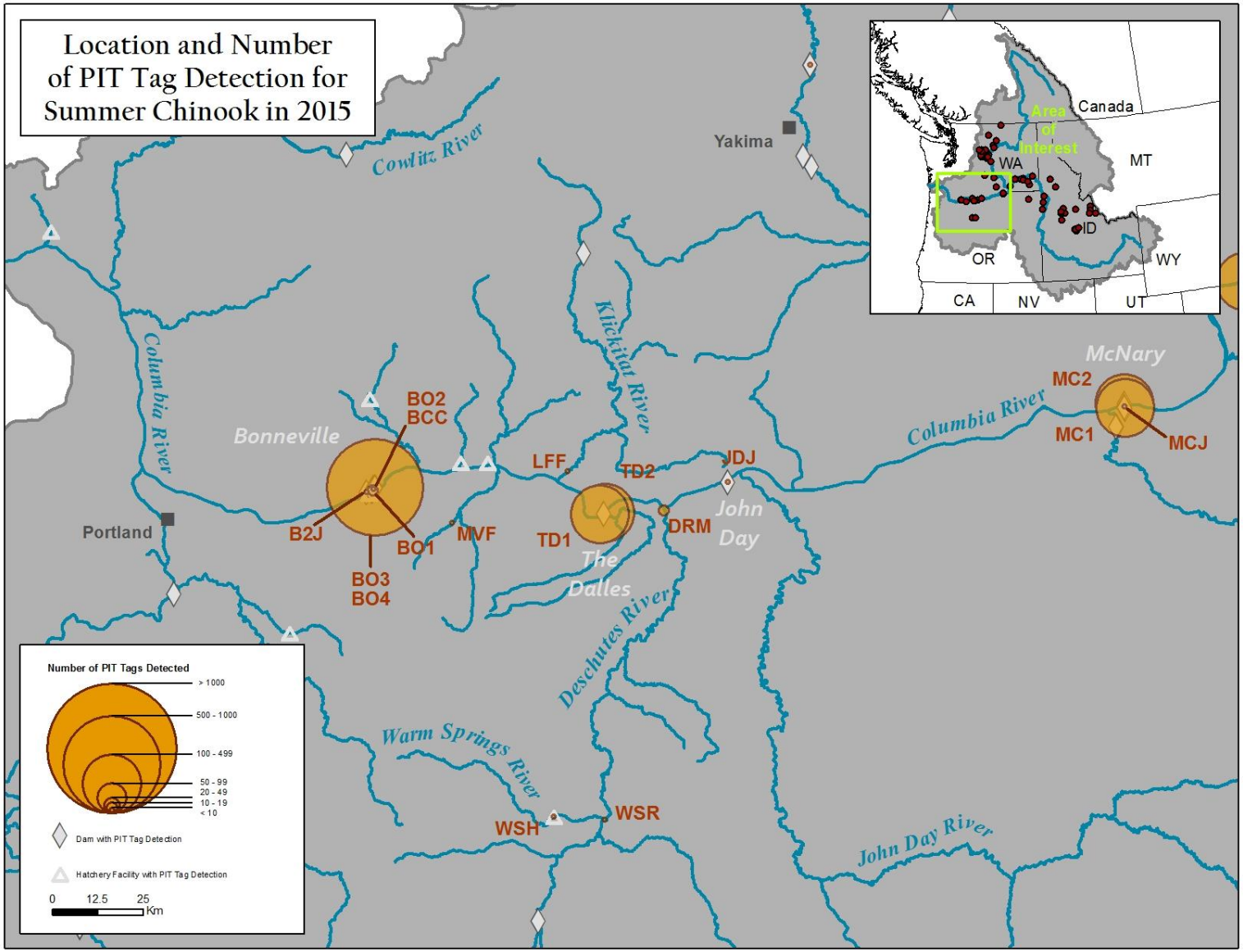


Figure A7. Map of Lower Columbia River detection sites (below Snake River) and number of summer Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

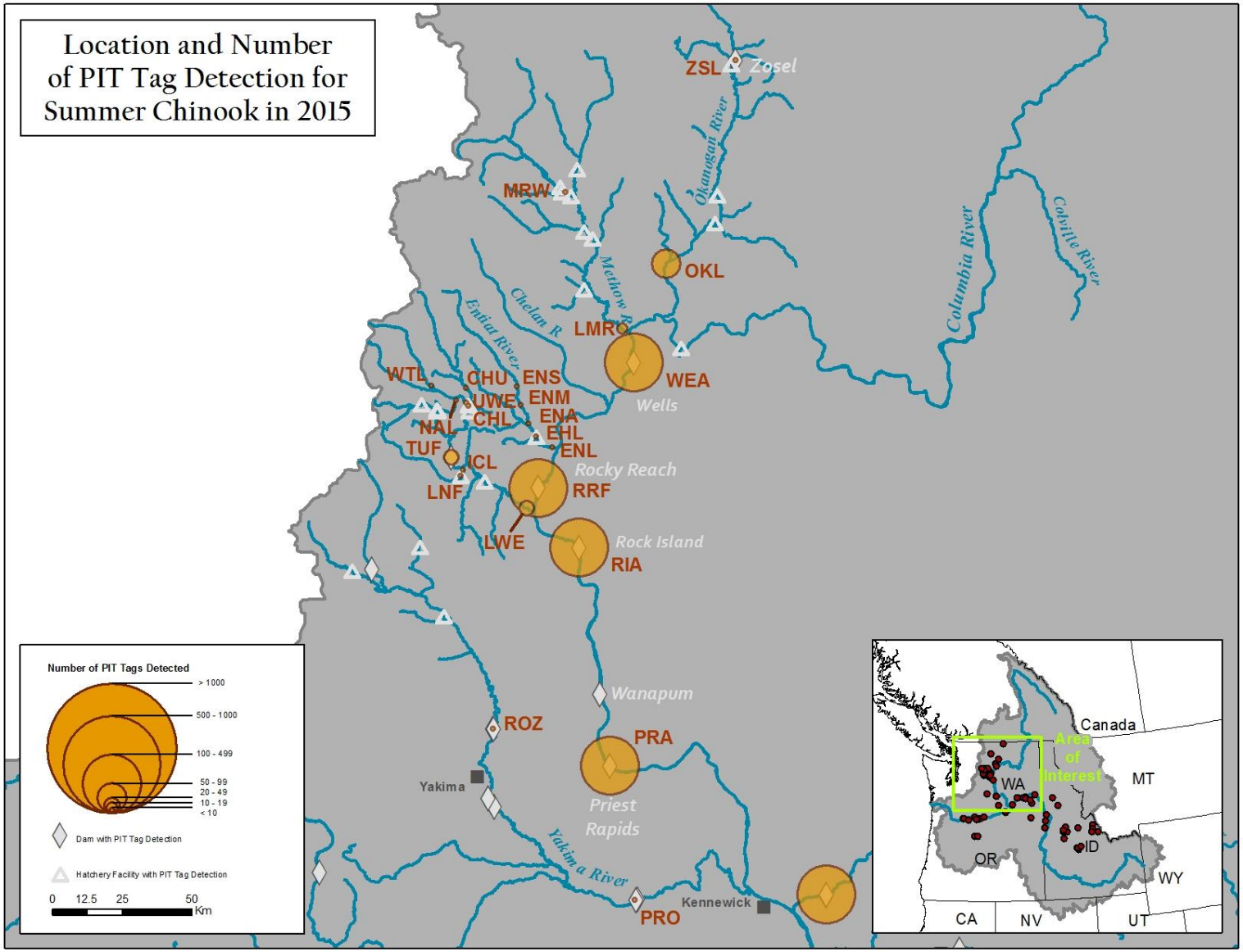


Figure A8. Map of Upper Columbia River (above the Snake River) detection sites and number of summer Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

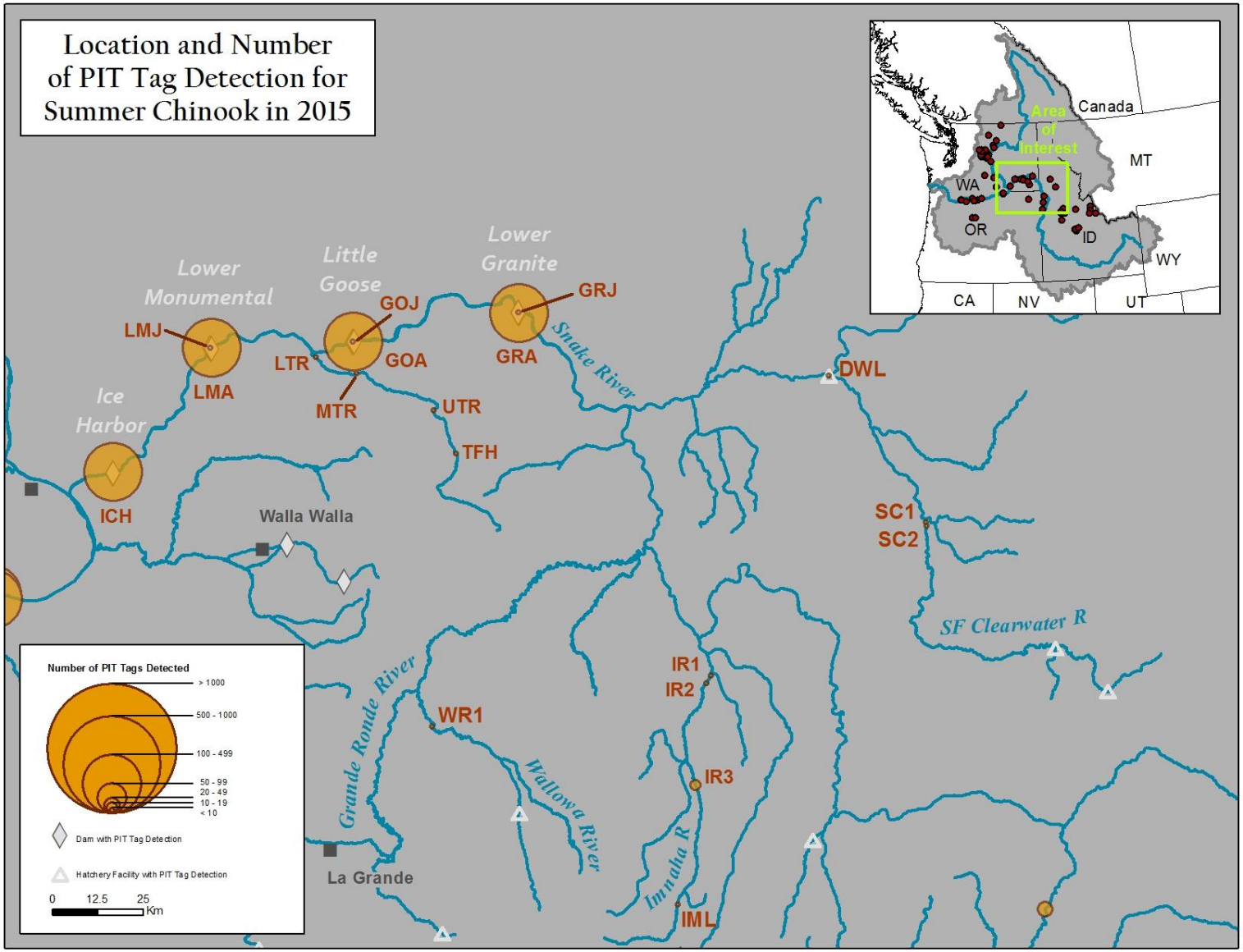


Figure A9. Map of Lower Snake River detection sites (Salmon River not included) and number of summer Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

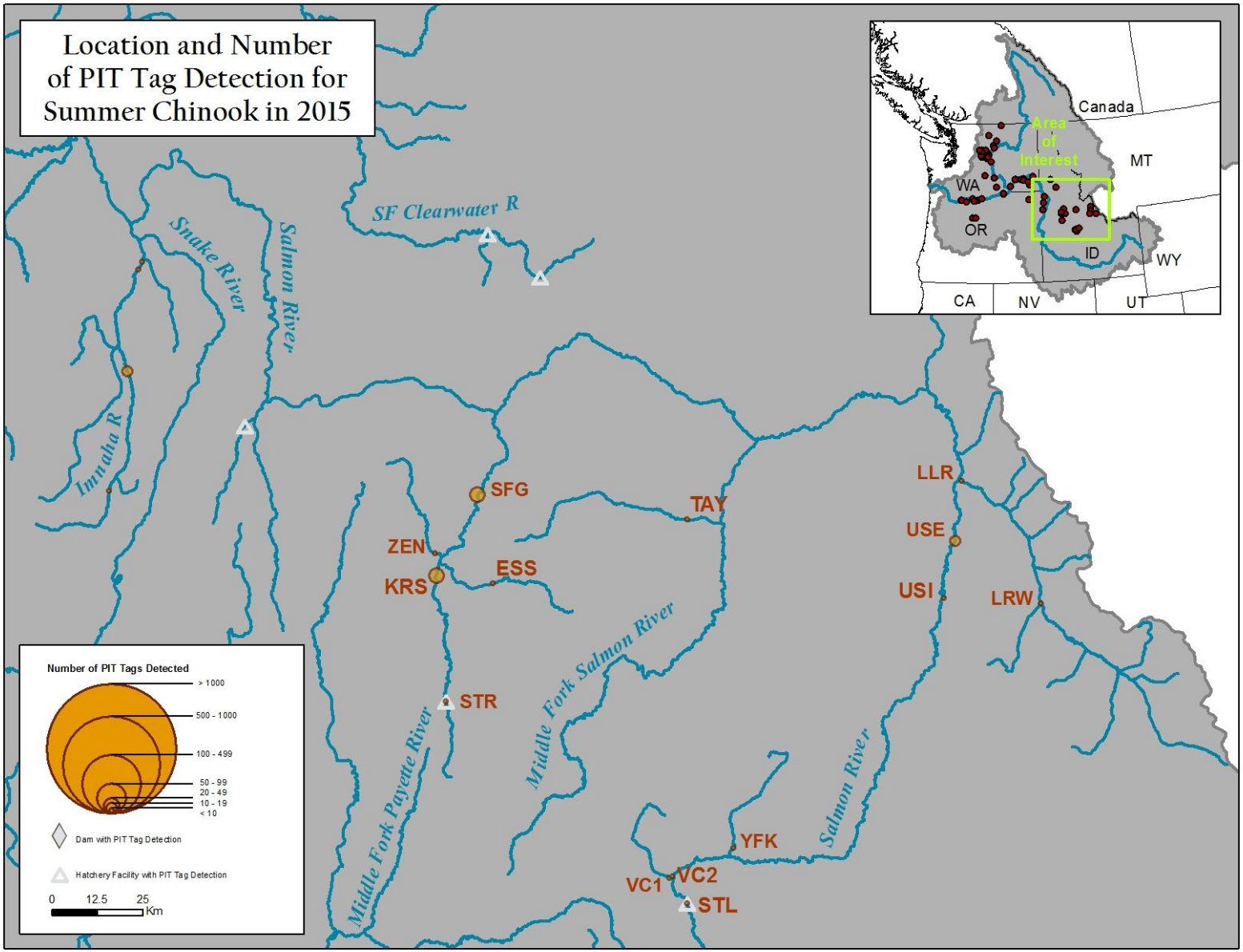


Figure A10. Map of Salmon River detection sites and number of summer Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

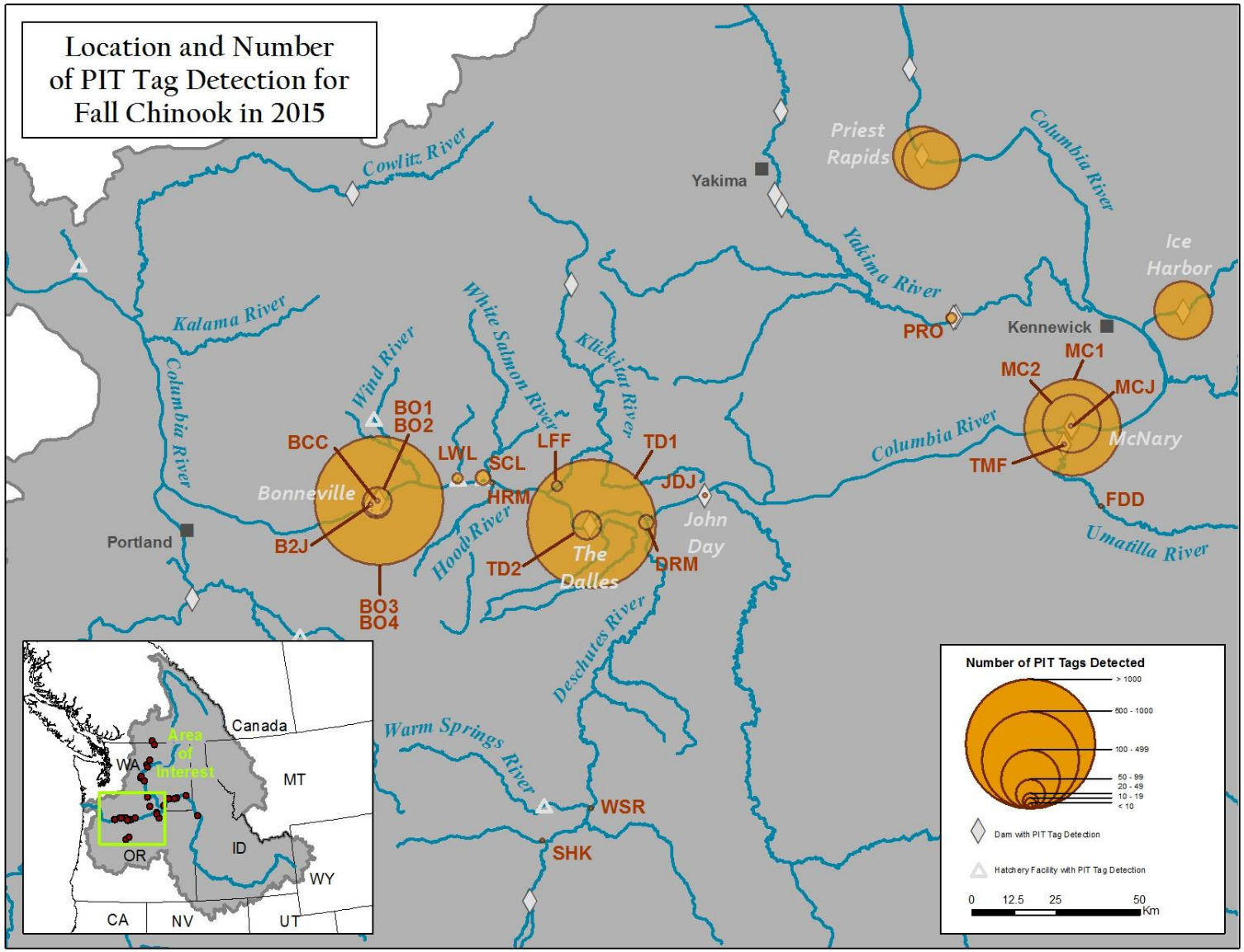


Figure A11. Map of Lower Columbia River detection sites (below Snake River) and number of fall Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

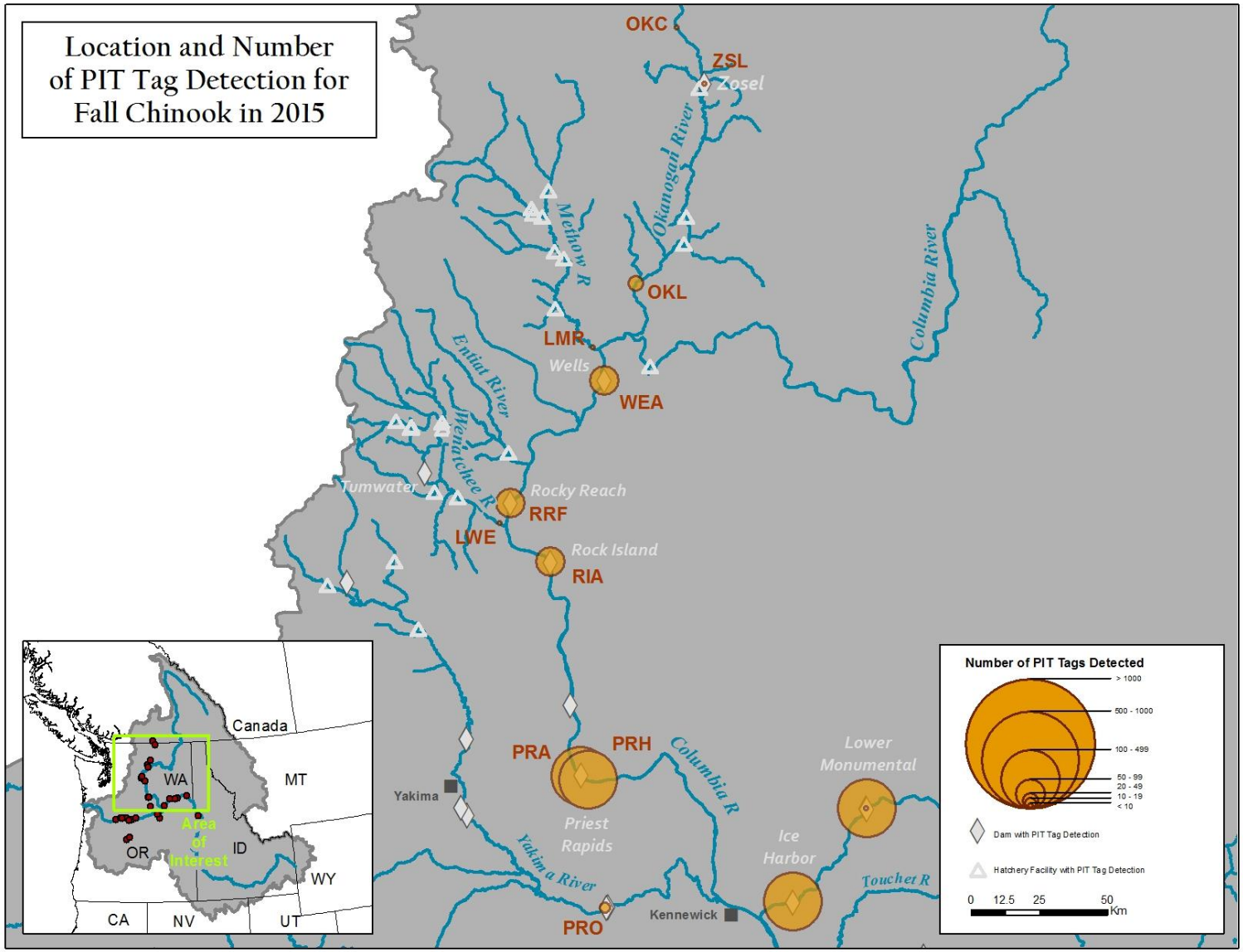


Figure A12. Map of Upper Columbia River detection sites (above Snake River) and number of fall Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

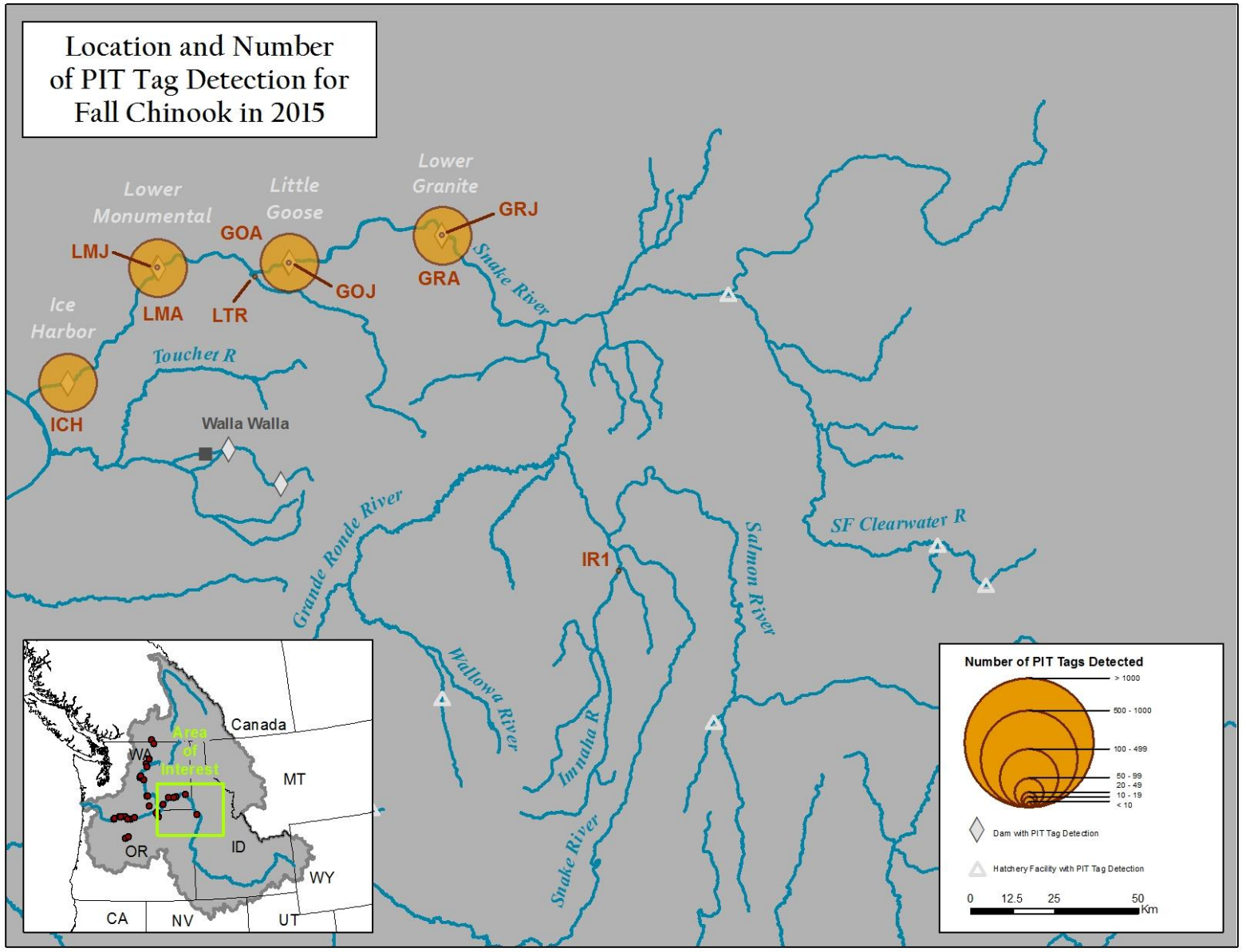


Figure A13. Map of Lower Snake River detection sites and number of fall Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

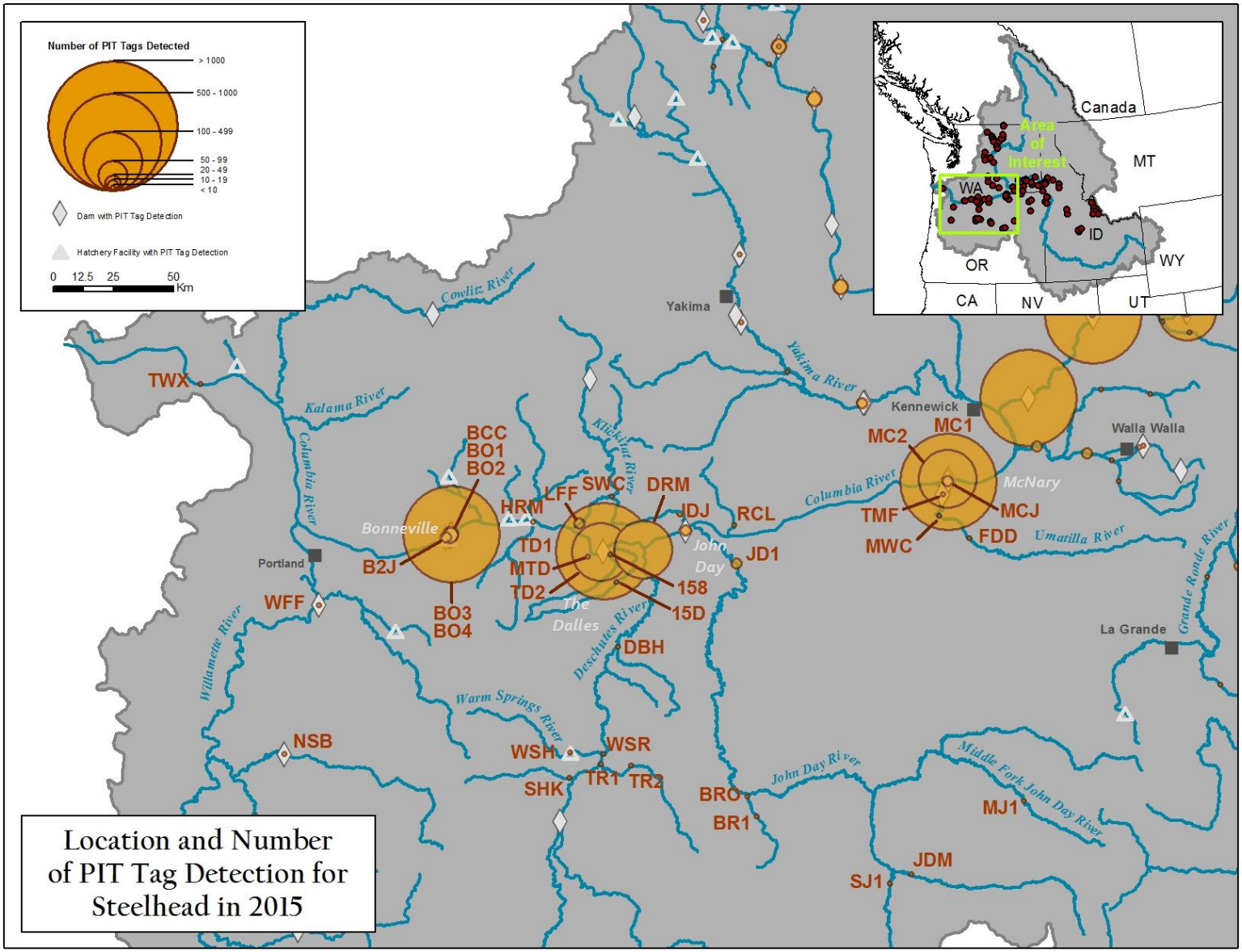


Figure A14. Map of Lower Columbia River detection sites (below Snake River) and number of steelhead detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map.

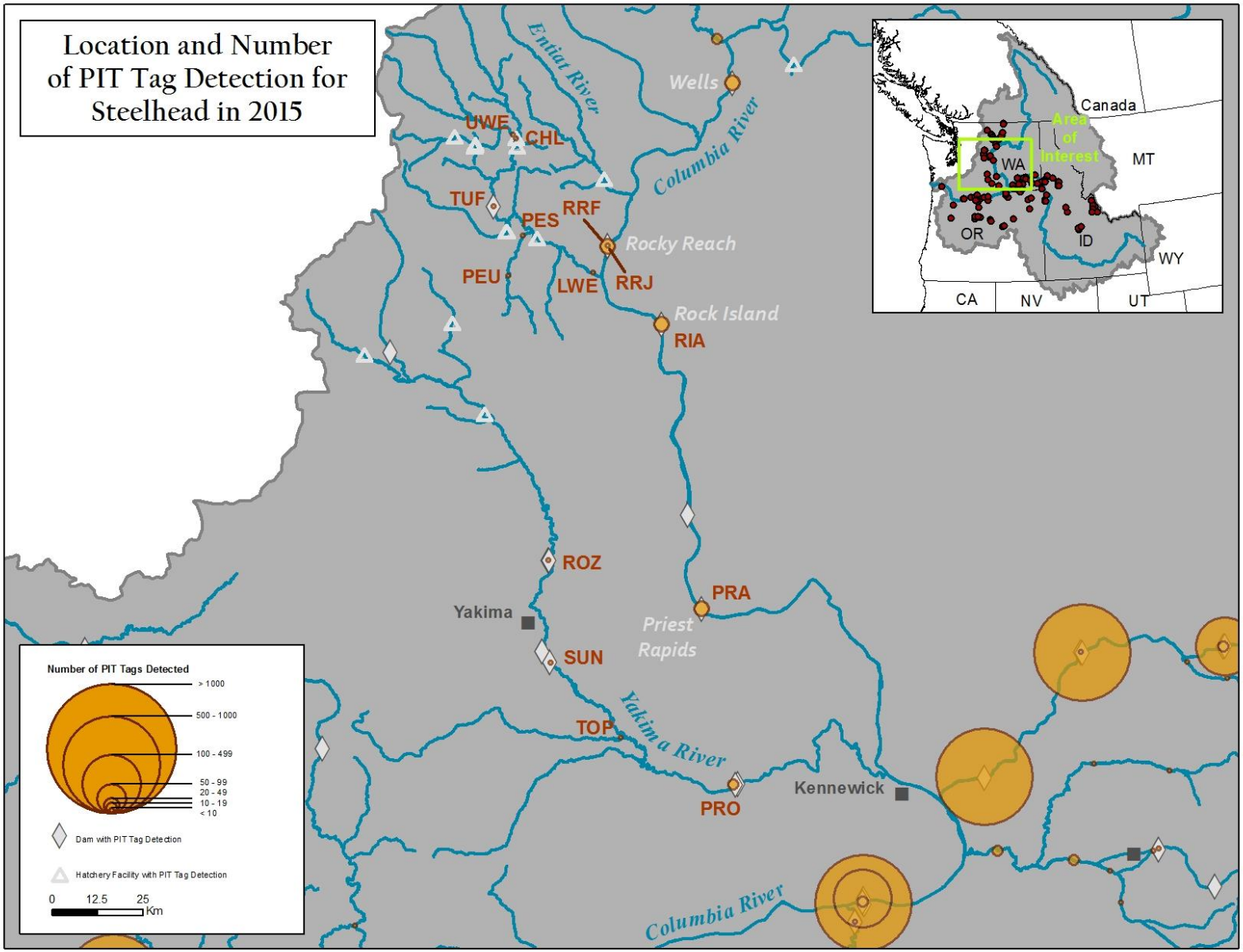


Figure A15. Map of Upper Columbia River (between the Snake River and Wells Dam) detection sites and number of steelhead detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map.

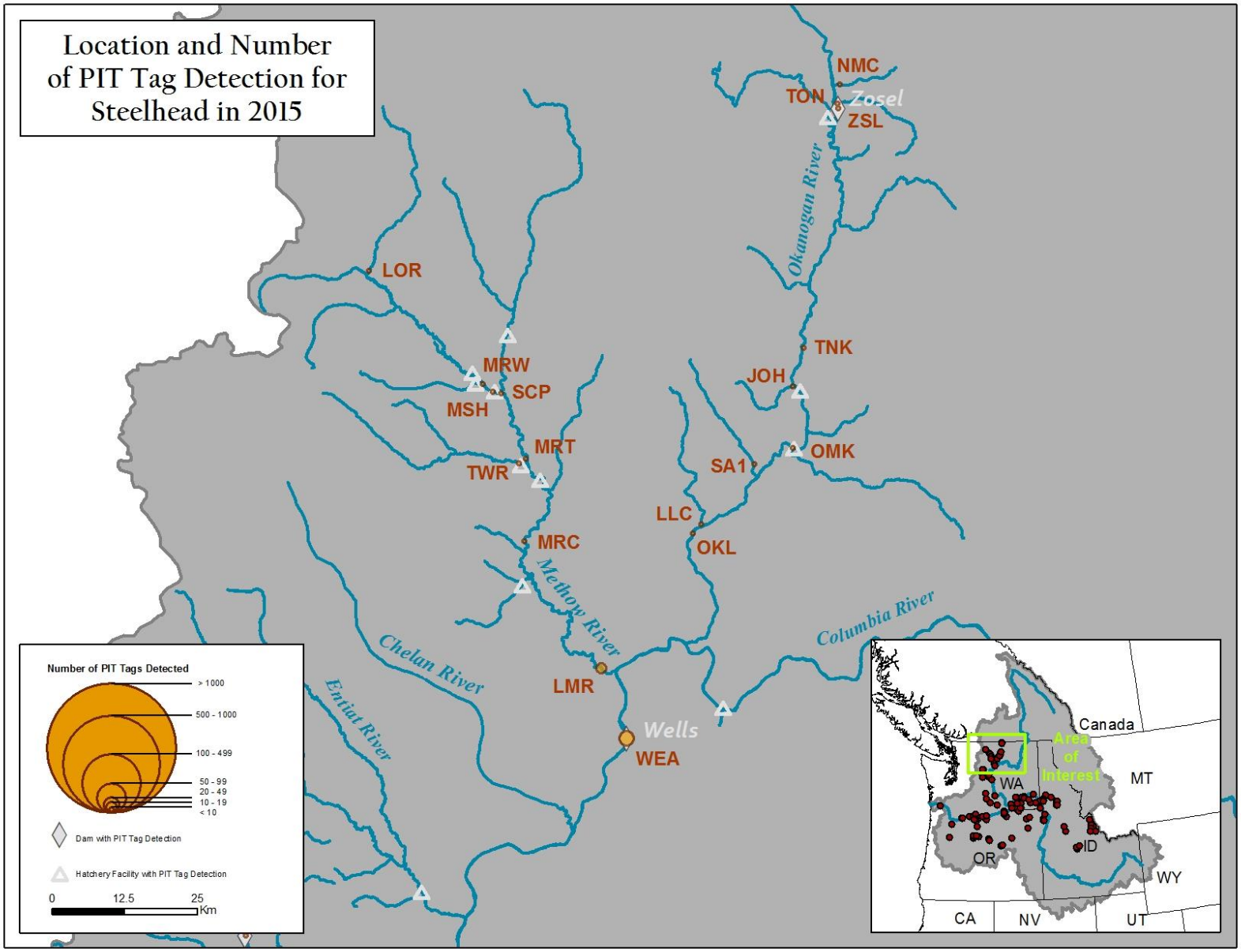


Figure A16. Map of Upper Columbia River (Wells Dam and above) detection sites and number of steelhead detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map.

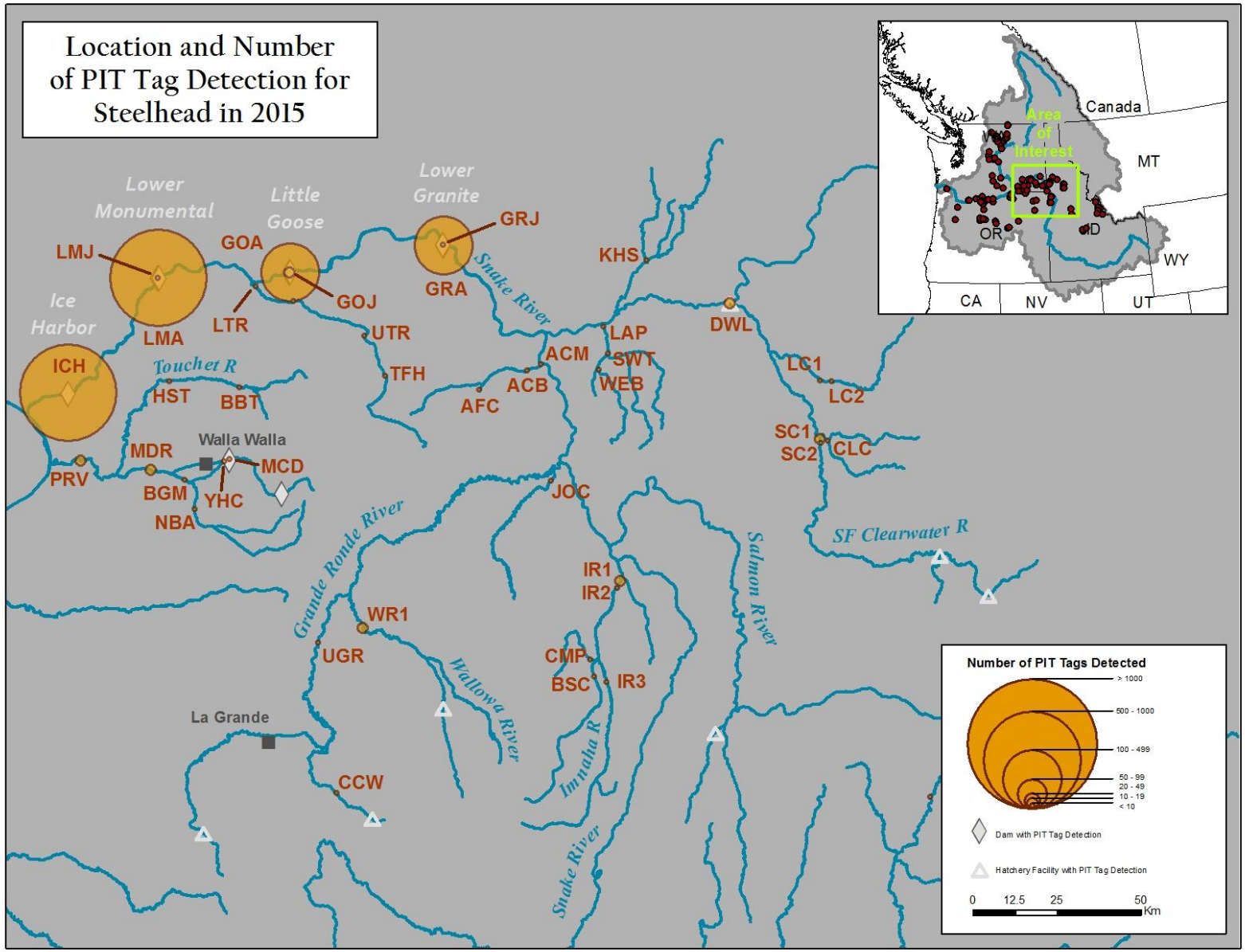


Figure A17. Map of Lower Snake River detection sites (Salmon River not included) and number of steelhead detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map.

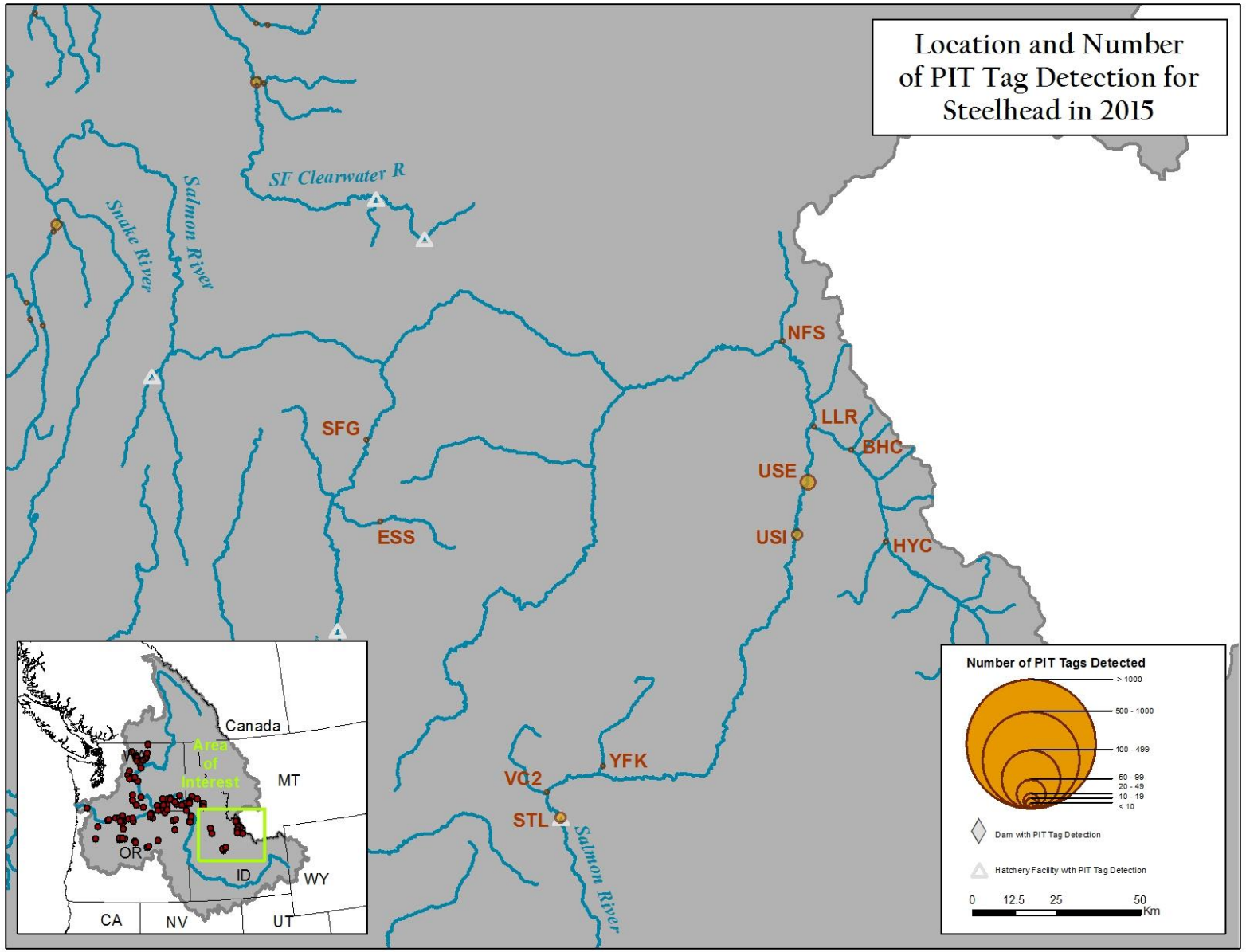


Figure A18. Map of Salmon River detection sites and number of steelhead detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map.

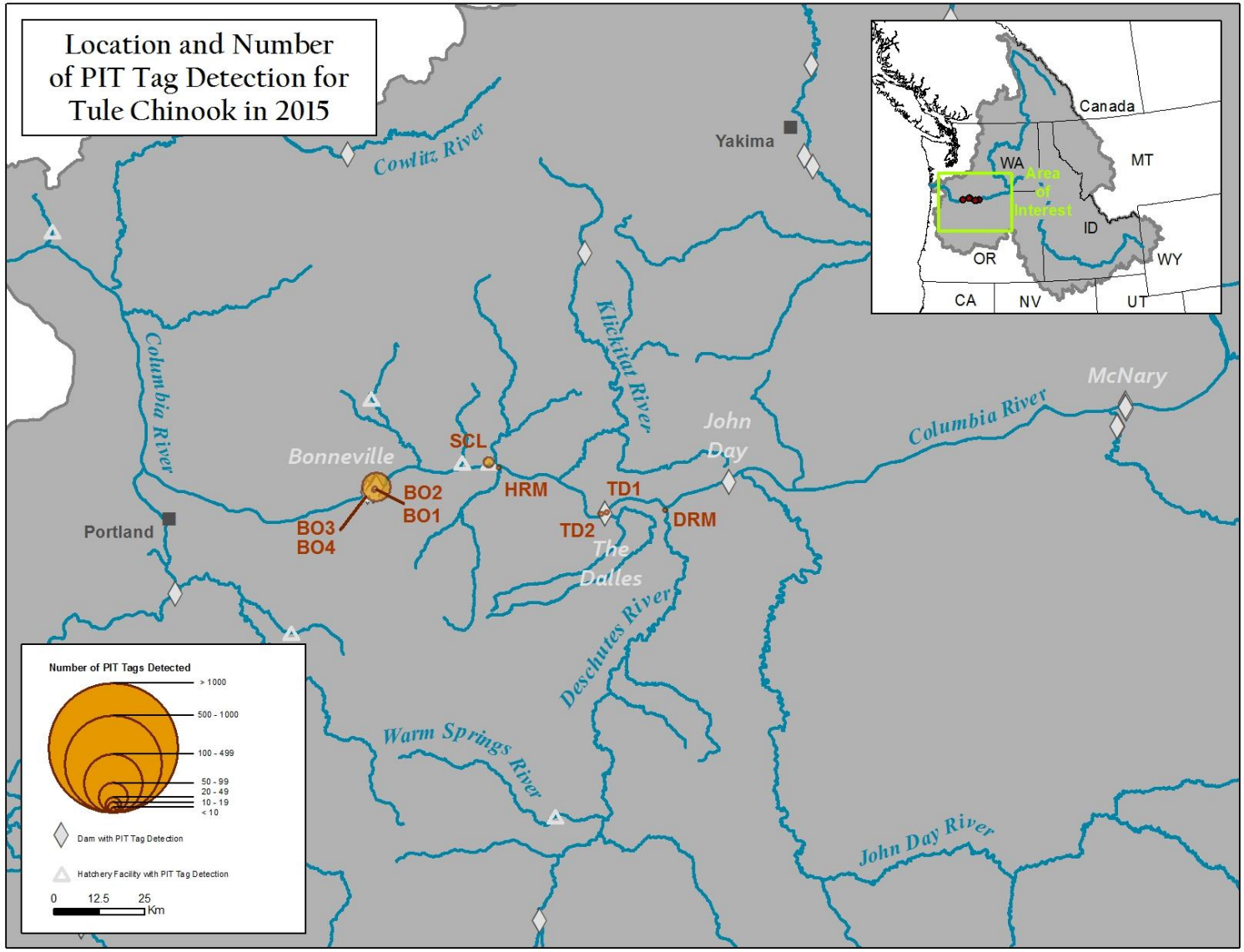


Figure A19. Map of Lower Columbia River detection sites (below Snake River) and number of Tule Chinook salmon detected. Table A1 in the Appendix lists the PTAGIS sites' full name and the three-letter codes on this map. Tule Chinook is defined as fish passing Bonneville Dam in the fall and maturation (showing spawning colors).