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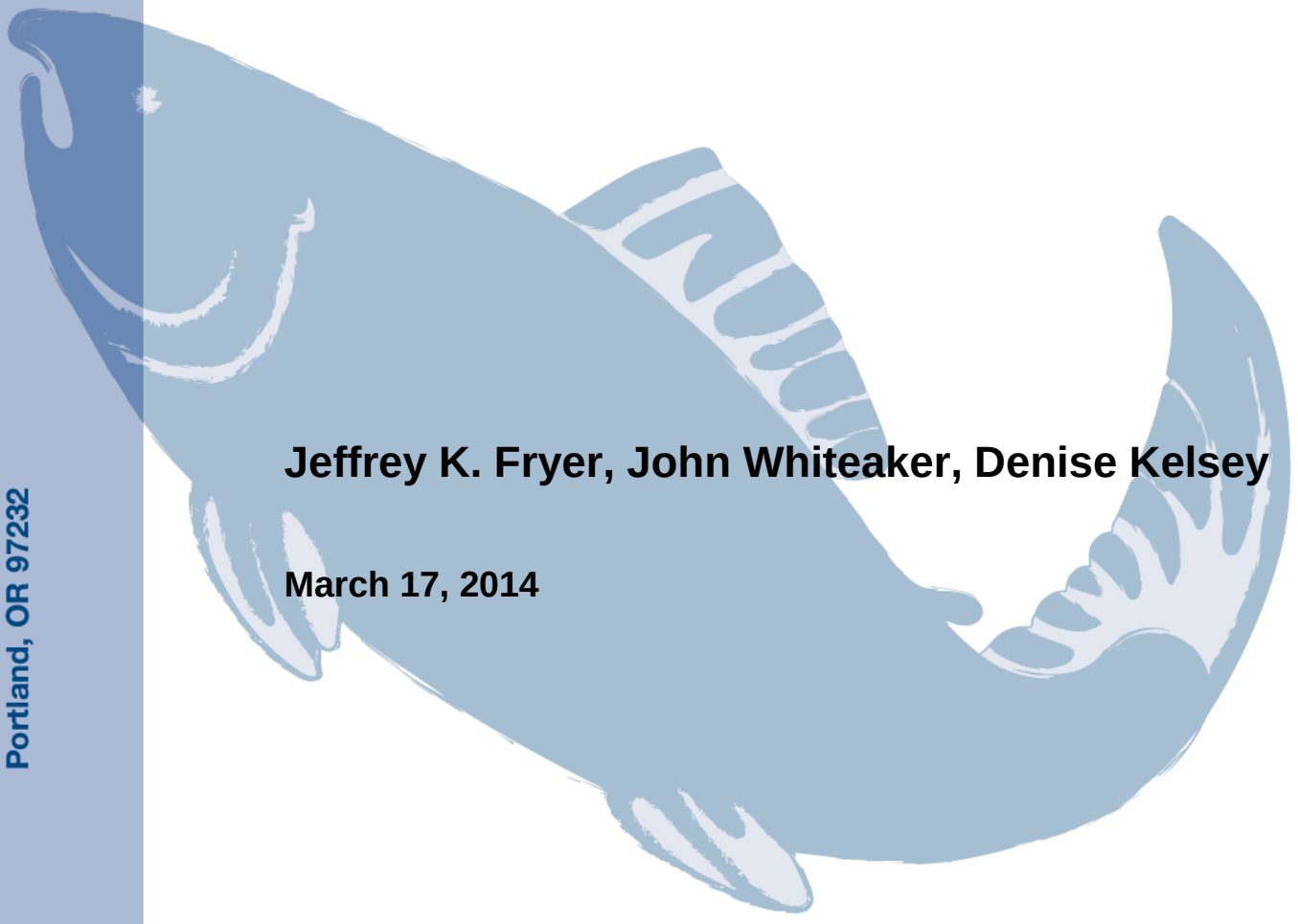
TECHNICAL REPORT 14-02

Upstream Migration Timing of Columbia Basin Chinook and Sockeye Salmon and Steelhead in 2012



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March 17, 2014

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

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ABSTRACT

In 2012 we sampled sockeye and Chinook salmon as well as steelhead at the Bonneville Dam Adult Fish Facility. Fish were measured for length and scales collected for later analysis for 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 939 spring Chinook, 390 summer Chinook, 1457 fall Chinook, 1451 steelhead, and 1601 sockeye salmon.

Chinook migration rates between mainstem dams ranged between 22.1 and 39.3 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 the majority of fall Chinook passed upstream of McNary Dam. Escapement estimates for the entire Chinook run derived from PIT tag detections result in estimates differing from those estimated by visual counts by -18.1% to +7.4% at mainstem dams.

Steelhead median rates between mainstem dams ranged from 15.8 km to 28.2 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 peaked on our last week of sampling in early October at 52.5% of the total steelhead run, with the estimated weekly number of B-run steelhead peaking in that same week at just over 4,200 fish. A total of 58 PIT tagged steelhead tracked in 2012 were detected moving downstream (mostly in juvenile bypasses) after March 31, 2013 presumably in an attempt to return to the ocean after spawning.

The estimated stock composition of sockeye salmon passing Bonneville Dam was 82.4% Okanogan, 17.6% Wenatchee, and 0.0% Snake. Upstream survival of sockeye salmon was highest early and late in the run.

The mean migration rate between Bonneville and Rock Island Dam was 31.0 km per day. Sockeye passing Bonneville Dam later in the migration traveled upstream faster than those earlier in the migration.

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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 23 through October 12, 2012, 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.

Salmon and steelhead selected for sampling 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.

In 2012 a new 9 mm PIT tag (Biomark model HPT9) was tested for effectiveness compared to the standard 12.5 mm tag (Biomark model HPT12). These tags measured 9.0 mm in length and 2.04 mm in diameter compared to the SST dimensions of 12.45 mm by 2.01 mm. Our sampling protocol called for every every fifth steelhead, Chinook, and sockeye salmon to be tagged with 9 mm tags with the remaining fish being tagged with 12.5 mm tags.

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, McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells dams on the Columbia River; Ice Harbor, and Lower Granite dams on the Snake River) as well as in numerous tributaries and hatcheries in the Columbia Basin (Appendix Table A5 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.

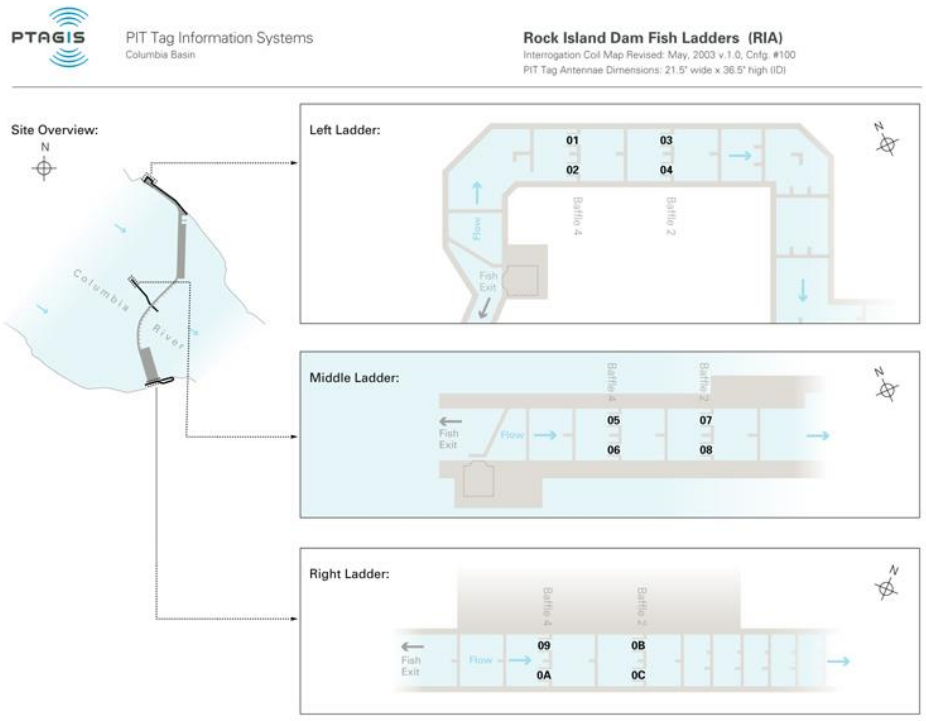

Figure 1. Example PIT tag detection configuration at Rock Island Dam showing two adjoining antennas at two weirs in each fish ladder. (Figure from www.ptagis.org.)

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.

If a fish is detected at one detection weir in a given fish ladder, it should also be detected at the rest of the weirs with PIT tag detection in that same ladder. This allows a probability of detection at the individual weirs in a ladder to be calculated by comparing it with other weirs in that same ladder. Detection probabilities were calculated as:

$$Pi = 1 - \prod_i (1 - \frac{N_i}{T})$$

where N_i is the number of fish detected at a given weir and T is the total number of fish detected by any weir at that ladder. This data was tabulated and is presented in the Appendix, Tables A1 – A3.

Comparison of Tag Types

A statistical test comparing the proportions of independent samples (Snedecor and Cochrane, 1980) was used to evaluate whether similar proportions of Chinook, steelhead, and sockeye salmon tagged with the two tag types (9 mm and 12 mm) were observed at mainstem dams and weirs with PIT tag detection.

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 detected at juvenile facilities on or after March 31, 2013 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 steelhead 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 and return in another year to spawn again; these fish are known as kelt. 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 that is listed under the Endangered Species Act. 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, those last observed at or upstream of Ice Harbor Dam were classified as Snake

River stock, and those last observed downstream of all these sites were classified as unknown and were also considered mortalities. Sockeye (as well as other species tagged) never detected after release were subtracted from the number of fish tracked for subsequent analysis.

RESULTS-CHINOOK

Sample Size

A total of 1128 spring Chinook, 453 summer Chinook, and 1791 fall Chinook salmon were PIT tagged in 2012 (Tables 1-3). Sampling was also halted between August 12 and 17 (portions of Statistical weeks 33 and 34) and reduced September 12 (Week 38) due to water temperatures at the trap exceeding 22.2C. 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 Chinook missing PIT tag antennas after tagging), the numbers of Chinook tracked upstream consisted of 1154 spring Chinook, 462 summer Chinook, and 1822 fall Chinook salmon (Table 1-3).

Table 1. Number of PIT tagged spring Chinook salmon tracked at Bonneville Dam by date and statistical week in 2012.

			Tagged		Recaptures of Previously Tagged Fish	Tracked Upstream of Bonneville	
Sampling Dates	Statistical Week	Sampled (n)	9 mm	12.5 mm	12.5 mm	9 mm	12.5 mm
4/23-4/27	17	120	22	93	4	22	97
4/30-5/4	18	221	42	176	3	42	179
5/7-5/11	19	350	65	274	9	65	283
5/14-18	20	235	44	184	6	44	189
5/21-25	21	127	22	100	5	22	103
5/28-5/31	22	109	20	86	2	20	88
Total		**1162**	**215**	**913**	**29**	**215**	**939**

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 during the peak weeks of the run (Statistical weeks 19-20) and over-sampled late in the run (Figure 2). Summer Chinook were over-sampled early in the run while under-sampled during the middle of the run (Figure 3). Fall Chinook were under-sampled during the middle of the run and over-sampled at the end of the run (Figure 4).

Table 2. Number of PIT tagged summer Chinook salmon tracked at Bonneville Dam by date and statistical week in 2012.

			Tagged		Recaptures of Previously Tagged Fish	Tracked Upstream of Bonneville	
Sampling Dates	Statistical Week	Sampled (n)	9 mm	12.5 mm	12.5 mm	9 mm	12.5 mm
6/1	22	21	4	17	0	4	17
6/4-6/8	23	112	19	89	4	19	93
6/11-6/15	24	87	16	69	0	16	69
6/18-6/22	25	56	9	46	1	9	47
6/25-6/29	26	35	5	30	0	5	30
7/2-7/6	27	46	5	39	2	5	41
7/9-7/13	28	59	9	47	2	9	49
7/16-20	29	21	2	18	1	2	19
7/23-25	30	16	2	14	0	2	14
7/31-7/31	31	13	1	12	0	1	11
Total		**466**	**72**	**381**	**10**	**72**	**390**

Table 3. Number of PIT tagged fall Chinook salmon tracked at Bonneville Dam by date and statistical week in 2012.

			Tagged		Recaptures of Previously Tagged Fish	Tracked Upstream of Bonneville	
Sampling Dates	Statistical Week	Sampled (n)	9 mm	12.5 mm	12.5 mm	9 mm	12.5 mm
8/1-8/3	31	8	1	7	0	1	7
8/6-8/8	32	11	0	11	0	0	10
8/17	33	12	2	9	0	2	9
8/20-8/24	34	141	25	110	5	25	115
8/27-8/31	35	239	45	191	1	45	190
9/4-9/7	36	268	51	209	7	51	216
9/10-9/14	37	317	62	248	5	60	251
9/17-9/21	38	370	67	283	10	66	291
9/24-9/27	39	229	37	173	4	37	175
10/1-10/5	40	164	61	95	8	61	102
10/8-10/12	41	111	17	87	6	17	91
Total		**1870**	**368**	**1423**	**46**	**365**	**1457**

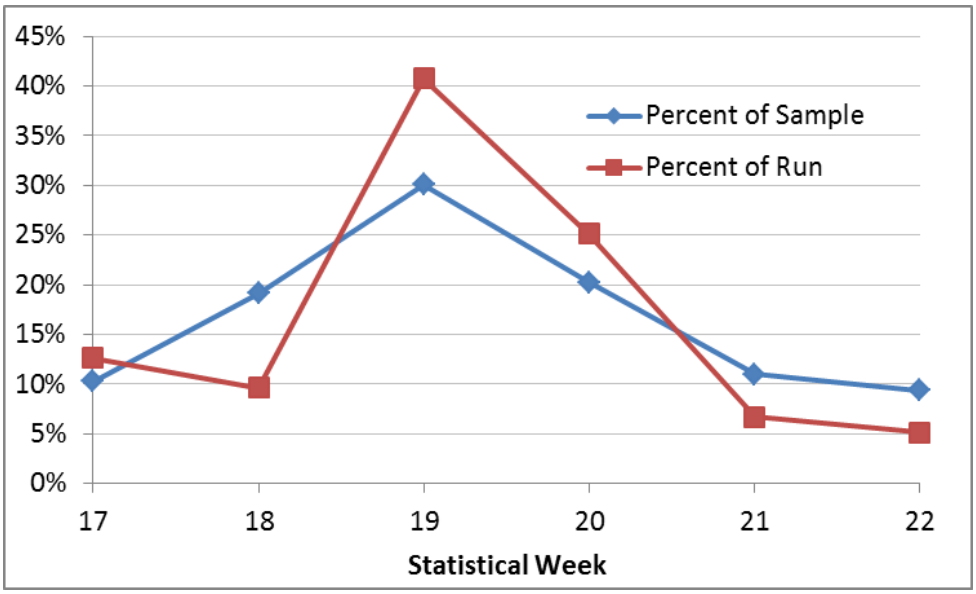

Figure 2. The weekly spring Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2012.

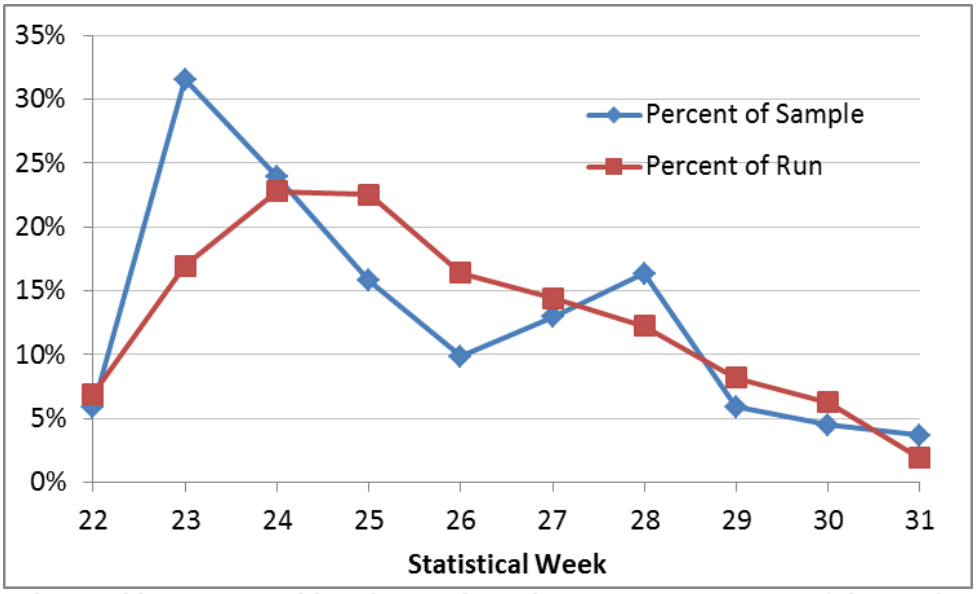

Figure 3. The weekly summer Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2012.

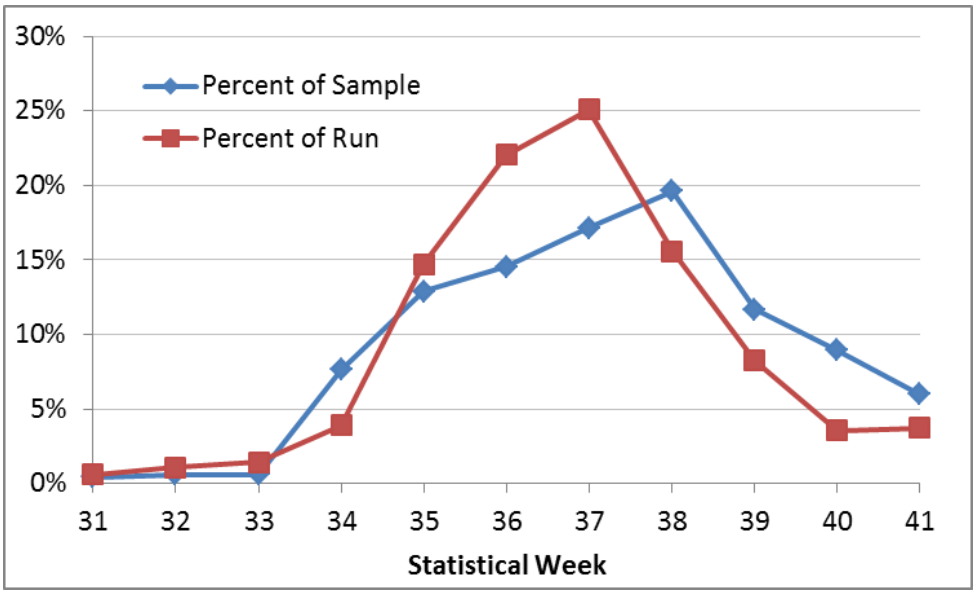

Figure 4. The weekly fall Chinook sample and run as a percentage of the total sample and run size at Bonneville Dam in 2012.

Detection Numbers

The tracking of 1154 spring Chinook generated 48628 weir detections, which were grouped into 4796 site detections at 84 sites. The 462 summer Chinook generated 27134 weir detections, grouped into 2554 site detections at 55 sites, and the 1822 fall Chinook generated 42945 weir detections grouped into 4852 site detections at 45 sites. Maps found in the Appendix (Figure A1-A16) 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 2012).

Comparison of 9 and 12.5 mm tags

At 14 out of 19 sites with more than 40 detections of Chinook PIT tagged by this study (Table 4), the percentage of tagged Chinook detected with 9 mm tags was less than expected percentage of 18.7% (the percentage of Chinook in our sample that were tagged with 9 mm tags). At only two sites (Little White Salmon Hatchery and the Bonneville Dam Cascades Island Fishway) was this significant. At the former, the percentage of 9 mm detected was significantly less than expected, but at the Bonneville Dam site, the percentage was greater. At both sites, sample size was relatively small. Combining all in-stream arrays and weirs also resulted in a statistically significant difference ($p=0.009$) with 9 mm tagged fish being under-detected. Combining all sites resulted in 17.9% of all

detections being 9 mm tags, but this was not a statistically significant difference from the expected 18.7%. Due to the sparseness of data from most weir and in-river array sites, this report will deal primarily with detection sites at dams. Unless otherwise indicated, data from both tag types was pooled for subsequent analyses presented in this report.

Table 4. Total number of tagged Chinook detected (40 detection minimum) by site, the percentage which were 9 mm tags and the p-value for a comparison with the percentage of 9 mm tags deployed (19.2% in 2012). Significant p-values (α=0.05 for a two tailed test) are highlighted.

Site	PTAGIS Site Code	Total Tags Detected at Site (9 and 12.5 mm)	% 9 mm Tags of Total Tags Detected	P-value for a test comparing the % of 9 mm tags detected from an expected value of 18.7%
Bonneville Dam WA Shore Vertical Slots	BO4	3380	18.6%	0.464
Bonneville Dam WA Shore Fishway & AFF	BO3	3314	18.9%	0.443
McNary Dam Oregon Shore Fishway	MC1	1572	19.0%	0.422
Ice Harbor Dam Fishways and Juvenile Bypass	ICH	857	16.5%	0.062
Lower Granite Dam Adult Fishway and Trap	GRA	782	16.1%	0.044
McNary Dam Washington Shore Fishway	MC2	632	16.0%	0.051
Priest Rapids Dam Adult Fishways	PRA	530	18.5%	0.449
Rock Island Dam Adult Fishways	RIA	390	16.4%	0.132
Rocky Reach Fishway	RRF	293	15.4%	0.077
Priest Rapids Hatchery	PRH	249	20.1%	0.298
Wells Dam Adult Fishways	WEA	236	16.5%	0.200
Prosser Dam Fishways and screened Diversion	PRO	101	14.9%	0.162
Bonneville Dam Bradford Island Fishway	BO1	80	17.5%	0.391
Roza Dam Juvenile Diversion	ROZ	48	22.9%	0.230
Lower Wenatchee River	LWE	43	14.0%	0.212
Little White Salmon National Fish Hatchery	LWL	43	4.7%	0.009
Bonneville Dam Cascades Island Fishway	BO2	42	31.0%	0.022
Lyle Falls Fishway	LFF	42	16.7%	0.367
Tumwater Dam Adult Fishway	TUF	41	14.6%	0.252
All weirs and in-stream arrays		775	15.1%	0.009
All Sites		13421	17.9%	0.141

Age Analysis

We are able to validate our scale aging techniques by using fish sampled at Bonneville for this project that were previously tagged as juveniles for other projects or hatchery programs. We had ageable scale patterns from 24 spring Chinook, 11 summer Chinook, and 16 fall Chinook and all were correctly aged using scale patterns. Only the total age was compared, for it is not possible to separately validate freshwater and ocean age.

In 2012, data were also available on total ages from genetics samples collected as part of this project. Scale pattern age estimates were correct 98.0% of the time when compared with estimates generated by genetics (Table 5).

Table 5. Comparison of total age estimates using genetics and scale pattern analysis for Chinook salmon sampled at Bonneville Dam in 2012. 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				% Correct
	Age 3	Age 4	Age 5	Unageable	
Age 3	20	2		2	94.7%
Age 4	3	368	3	47	98.4%
Total					**98.0%**

We attempted 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. However, two Chinook salmon greater than 36 cm in length were sampled and aged as Age 1.0 and therefore classified as minijacks. Although these fish were PIT tagged, they were excluded from analyses subsequently presented in this study except to indicate their last known location. One of these minijacks, with a length of 38.5 cm was tagged on May 22 and last detected at Roza Dam on July 5, while the other, with a length of 40.0 cm, was tagged on July 20 and last detected at Rocky Reach Dam on August 8.

We also sampled and PIT tagged a total of 40 tule Chinook salmon for another project[a]. Of these fish, 21 were last observed passing upstream through the Bonneville Dam Washington Shore ladder, 16 at Spring Creek National Fish Hatchery, and 1 each at the Bonneville Dam Oregon Shore ladder, McNary Dam Oregon Shore ladder, and the instream array at the Hood River Mouth.

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Spring Chinook salmon that traveled upstream of McNary Dam were predominantly bound for the Snake River upstream of Ice Harbor Dam (Table 6, Figures 5 and 6), while summer Chinook were primarily bound for the Columbia River upstream of Priest Rapids Dam (Table 6, Figures 5 and 7). Fall Chinook were primarily headed for areas between McNary and Ice Harbor/Priest Rapids dams which are where the Hanford Reach and Priest Rapids Hatchery are located (Table 6, Figures 5 and 8). Over the first half of the entire Chinook run, the percentage of Chinook salmon passing Priest Rapids Dam steadily increased, while the percentage of those last detected below McNary Dam decreased (Figure 5). The percentage of all Chinook that ultimately passed Ice Harbor Dam peaked during the Spring Chinook migration, with another peak early in the fall Chinook migration. The majority of the fall Chinook run, after Statistical Week 38, was last detected in-between McNary and Priest Rapids/Ice Harbor dams which is the spawning grounds for the Hanford Reach fall Chinook, as well as the location of Ringold and Priest Rapids hatcheries, which rear fall Chinook salmon.

[a] Tule Chinook are a lower river run of Chinook that return from the ocean ready to spawn, with a dark coloration, hooked snouts, and well developed breeding teeth. Upriver bright Chinook, which this project has focused on, retain their bright sides and firm flesh as they migrate upstream and are favored by commercial and sort fishers.

Table 6. 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 2012.

	Spring Chinook		Summer Chinook		Fall Chinook	
Dam	% Reaching Dam	Decrease from Downstream Dam	% Reaching Dam	Decrease from Downstream Dam	% Reaching Dam	Decrease from Downstream Dam
Bonneville	100.0%	--	100.0%	--	100.0%	--
McNary	59.5%	40.5%	79.3%	20.7%	61.4%	38.6%
Priest Rapids	8.6%	85.5%	58.4%	26.3%	10.5%	83.0%
Rock Island	8.5%	1.8%	56.6%	3.1%	3.3%	68.9%
Rocky Reach	3.4%	60.3%	47.9%	15.4%	2.3%	30.0%
Wells	3.3%	1.4%	40.9%	14.6%	0.9%	61.5%
Ice Harbor	40.8%	31.3%	18.6%	76.6%	18.1%	70.5%
Lower Granite	38.1%	6.7%	17.8%	4.3%	15.1%	16.6%

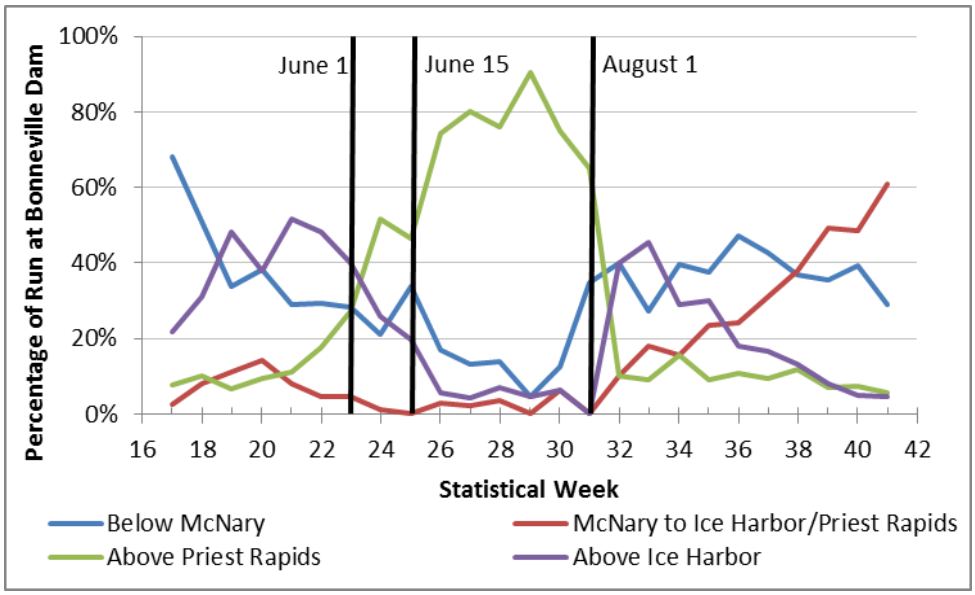

Figure 5. Distribution of final detection areas of the Columbia Basin by statistical week for Chinook salmon PIT tagged at Bonneville Dam in 2012.

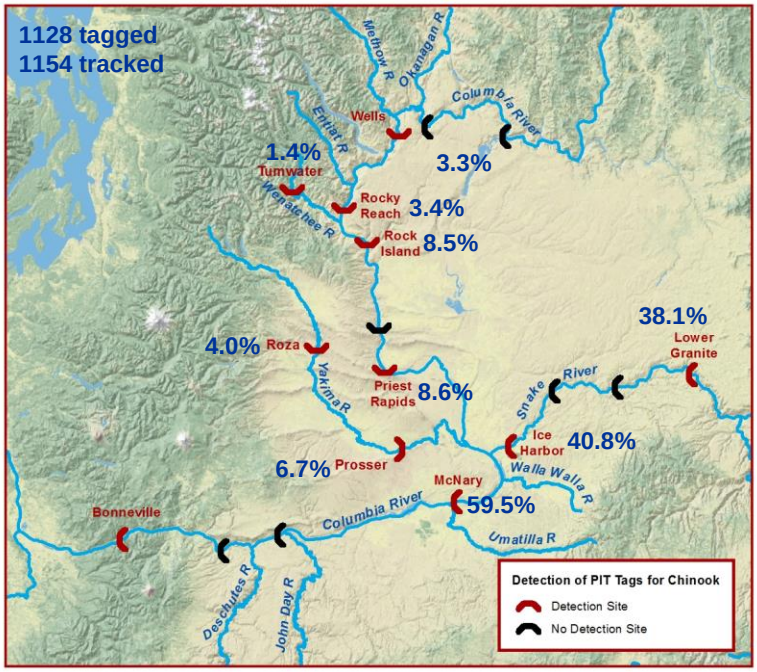

Figure 6. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of spring Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2012.

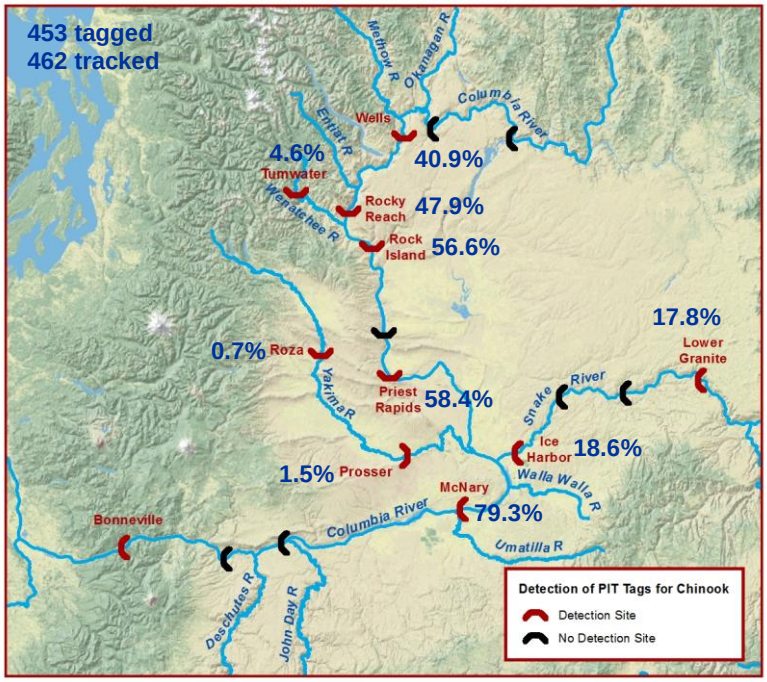

Figure 7. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of summer Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2012.

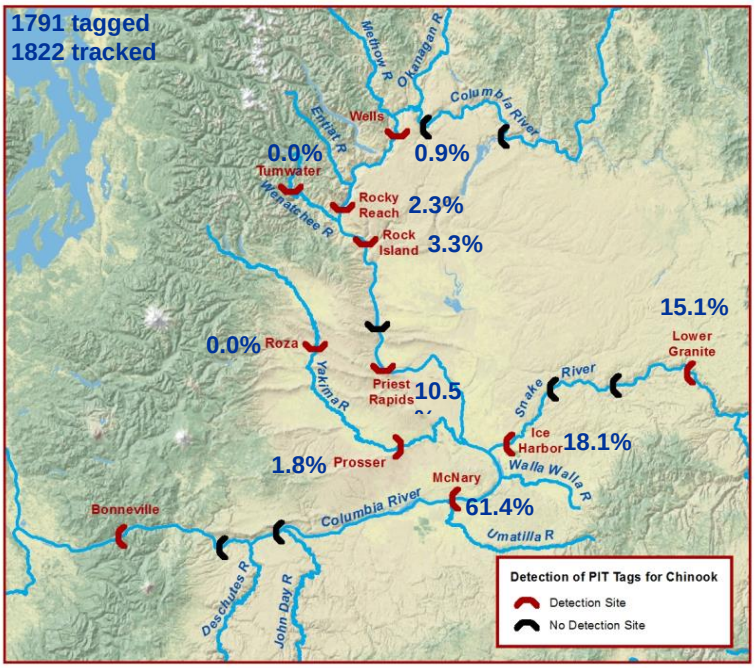

Figure 8. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fall Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2012.

The percentage of 12.5 mm PIT tagged Chinook salmon, over the entire run; passing a dam without detection was less than 3% for all dams except Rock Island Dam (Table 7) and spring Chinook passing Priest Rapids Dam. Rock Island Dam is also known to have problems with detection due to the antenna size and electrical noise (Fryer et al. 2011). Over all sites listed in Table 7,

Table 7. Percentage of Chinook salmon detected upstream that missed detection at given dams in 2012.

	Spring Chinook		Summer Chinook		Fall Chinook		All Chinook	
Dam	**9 mm**	**12.5 mm**	**9 mm**	**12.5 mm**	**9 mm**	**12.5 mm**	**9 mm**	**12.5 mm**
Bonneville	1.6%	1.1%	1.7%	1.3%	3.2%	1.0%	2.4%	1.1%
McNary	0.0%	0.4%	0.0%	0.0%	0.0%	0.7%	0.0%	0.4%
Priest Rapids	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.3%
Rock Island	12.5%	1.9%	5.7%	2.1%	50.0%	21.6%	13.7%	4.7%
Rocky Reach	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wells	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ice Harbor	0.0%	1.1%	0.0%	0.0%	2.9%	0.5%	0.8%	0.8%
Lower Granite	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weighted mean (by sample size)	**0.8%**	**0.8%**	**1.2%**	**0.7%**	**3.4%**	**1.3%**	**2.0%**	**1.2%**

summer and fall Chinook tagged with 9 mm tags were more likely to be missed than those tagged with 12.5 mm tags, while for spring Chinook the weighted percentage was the same for the two tag types. Rates of detection efficiency of individual weirs within ladders at dams listed in Table 6 are found in the Appendix (Table A1).

Escapement estimates for the entire Chinook run derived from PIT tag detections result in estimates that are generally within 20% of visual counts (Table 8). The greatest differences are with fall Chinook where PIT tag estimates for dams at and upstream of Priest Rapids were 17.0 to 32.1% under visual counts, while PIT tag estimates at Snake River dams were greater than visual counts. PIT tag estimates were also much less than visual counts for spring Chinook at Priest Rapids, Rock Island, and Rocky Reach dams. Some of this difference is likely explained by spring Chinook at Bonneville being counted as summer Chinook at upstream dams. Between 18.1% and 27.8% of "spring Chinook" (as determined at tagging at Bonneville Dam) passing Priest Rapids and upstream dams actually would have been counted as summer Chinook at those dams (Table 9). Conversely, over 10% of summer Chinook reaching Ice Harbor and Lower Granite dams would have been counted as spring Chinook at those dams.

Table 8. Chinook salmon escapement in 2012, by run, at Columbia Basin mainstem dams upstream of Bonneville Dam. Estimates are from both PIT tag recoveries and dam counts and the differences between the two estimates are displayed.

	Spring Chinook Salmon			Summer Chinook Salmon		
Site	Viewing Window Count	PIT Tag Estimate	Percent Difference	Viewing Window Count	PIT Tag Estimate	Percent Difference
McNary	107,550	98,531	-8.4%	69,532	74,452	7.1%
Priest Rapids	20,510	14,267	-30.4%	52,661	54,826	4.1%
Rock Island	20,681	14,012	-32.2%	55,527	53,119	-4.3%
Rocky Reach	7,100	5,556	-21.7%	48,303	44,995	-6.8%
Wells	6,011	5,477	-8.9%	41,859	38,435	-8.2%
Ice Harbor	74,862	67,651	-9.6%	15,663	17,457	11.5%
Lower Granite	69,891	63,091	-9.7%	14,880	16,702	12.2%
	Fall Chinook Salmon			**All Chinook Salmon**		
McNary	228,120	260,264	14.1%	405,202	433,247	6.9%
Priest Rapids	65,316	44,348	-32.1%	138,487	113,442	-18.1%
Rock Island	16,642	13,807	-17.0%	92,850	80,938	-12.8%
Rocky Reach	13,074	9,915	-24.2%	68,477	60,467	-11.7%
Wells	4,976	3,726	-25.1%	52,846	47,638	-9.9%
Ice Harbor	60,100	76,729	27.7%	150,625	161,838	7.4%
Lower Granite	56,678	63,989	12.9%	141,449	143,782	1.6%

Table 9. 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 2012.

Last Date Spring Run	First Date Fall Run	Race at Bonneville	Spring	Spring	Summer	Summer	Fall
		Race at Dam Listed Below	Summer	Fall	Spring	Fall	Summer
May 31	August 1	Bonneville					
June 8	August 9	McNary	2.7%	0.0%	3.0%	0.0%	0.4%
June 13	August 14	Priest Rapids	18.1%	0.0%	0.0%	1.2%	1.6%
June 17	August 18	Rock Island	19.2%	0.0%	0.4%	1.3%	2.1%
June 19	August 20	Rocky Reach	25.0%	0.0%	0.5%	2.5%	2.2%
June 28	August 29	Wells	23.3%	0.0%	0.0%	1.1%	27.8%
June 11	August 12	Ice Harbor	1.7%	0.0%	10.2%	0.0%	0.0%
June 17	August 18	Lower Granite	2.1%	0.2%	17.0%	2.1%	0.0%

Tributary escapement estimates for 5 sites, each with more than 50 detections, are found in Table 10 alongside estimates using visual or trap counts at 3 of the sites. Chinook destined for all five tributary sites were primarily spring or summer Chinook (Figure 9).

Table 10. Estimated 2012 Chinook salmon escapement, as estimated using PIT tag detections, to Tumwater, Prosser, and Roza dam, Lyle Falls and the Imnaha River.

Location and River	Number of Tag Detections	Escapement Estimate from Trap or Visual Counts	Estimated Escapement Using PIT Tags	Difference (%) Between Estimates
Tumwater Dam, Wenatchee River	41	8,038**	6,609	-17.8%
Prosser Dam, Yakima River	103	14,780	19,691	33.2%
Roza Dam, Yakima River	47	6839	7,330	7.2%
Imnaha PIT Tag Antennas	38	NA	6,023	NA
Lyle Falls	42	NA	9,183	NA

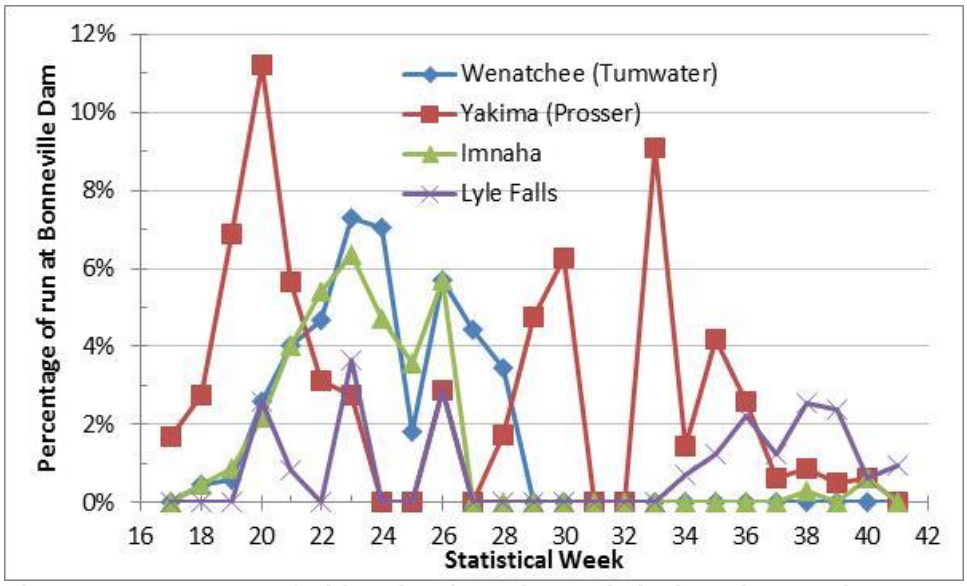

Figure 9. Percentage of Chinook salmon by statistical week tagged at Bonneville Dam in 2012 destined for the Yakima, Wenatchee, Klickitat (at Lyle Falls) and Imnaha subbasins based on upstream PIT tag detections at Prosser, Tumwater , and Lyle Falls fishways, and the Imnaha weir.

Migration Rates and Passage Time

Chinook migration rates between mainstem dams ranged between 22.1 and 39.3 km/day (Table 11). Migration rates to and between tributary sites were generally less than those in the Columbia and Snake rivers (Table 11).

Table 11. Chinook salmon travel rates between Columbia Basin dams estimated using PIT tag data in 2012.

		Median Migration Rate (km/day)		
Between Mainstem Dams	**Distance (km)**	**Spring Chinook**	**Summer Chinook**	**Fall Chinook**
Bonneville – McNary	231	34.6	35.2	39.3
McNary - Priest Rapids	167	31.0	29.6	23.2
Priest Rapids - Rock Island	89	26.8	29.2	22.1
Rock Island - Rocky Reach	33	29.2	28.2	22.8
Rocky Reach – Wells	65	32.0	30.2	27.9
Bonneville - Rock Island	487	28.5	28.8	25.1
Bonneville – Wells	585	26.9	26.6	28.0
McNary - Ice Harbor	67	38.5	36.7	38.0
Ice Harbor - Lower Granite	156	36.5	31.9	32.4
To and Between Tributary Sites				
Rock Island - Tumwater	73	2.3	3.3	NA
McNary - Prosser	141	29.2	27.9	12.2
Prosser - Roza	133	9.4	10.5	NA
Lower Granite - South Fork Salmon (SFG)	375	19.6	31.4	NA

Among the mainstem Columbia and Snake River dams, Chinook salmon have the greatest median dam passage time (as determined by minutes between first detection time and last detection time at a dam) at Bonneville, McNary, and Lower Granite dams (Table 12). However, at both Bonneville and McNary dams there is a much greater distance between the furthest downstream and furthest upstream PIT tag detection antennas than at all other dams; conversely, the distance between the PIT tag detection antennas at Priest Rapids, Rock Island, Rocky Reach, and Wells dams is very short as antennas were placed at adjacent weirs. Passage times at both Lower Granite and Bonneville dams may also be inflated, because at both sites, fish may take time to recover from sampling before moving upstream again (many fish are trapped and sampled at Lower Granite Dam for other projects, while this project samples fish at Bonneville Dam). Spring Chinook salmon passing Roza and Tumwater dams had the highest percentage taking more than 12 hours to pass at 23.3% and 22.2% respectively, while 39.1% of summer Chinook took more than 12 hours to pass Tumwater Dam. More than 10% of fall Chook took more than 12 hours to pass Priest Rapids, Rock Island, Rocky Reach, Wells, and Lower Granite dams. Fallback/reascension is a contributing factor as this rate ranged from 11.1-58.9% at all of these dams except Lower Granite.

Table 12. 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 2012.

	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	71.1	83.6	84.6	5.6%	5.4%	9.3%
McNary	102.1	98.8	89.5	7.1%	7.5%	6.7%
Priest Rapids	4.6	5.4	4.7	3.2%	2.0%	17.8%
Rock Island	9.1	36.8	234.5	6.7%	14.8%	39.6%
Rocky Reach	11.3	9.3	11.2	6.8%	5.9%	13.3%
Wells	2.5	0.6	0.6	18.6%	17.8%	11.1%
Ice Harbor	3.7	2.4	2.0	4.1%	5.1%	3.7%
Lower Granite	76.5	72.1	81.2	12.8%	11.7%	15.1%
Tumwater	8.7	10.0	--	22.2%	39.1%	--
Prosser	9.6	12.3	11.5	5.8%	0.0%	7.4%
Roza	1.4	1.5	--	23.3%	0.0%	--

Upstream Age and Length-at-Age Composition

Age 1.2 was the predominant age class for both spring and summer Chinook passing at all dams with PIT tag detection (Table 13, Figures 10 and 11). Age 0.2 was the most abundant age class for fall Chinook passing all dams

except Wells Dam where Age 0.1 was most abundant (Table 13, Figure 12). Mean length-at-age composition estimates at mainstem dam sites are given in Tables 14-16.

Table 13. Age composition estimates (%) as estimated by 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 2012.

		Brood Year and Age Class							
Run, Site, Number		**2009**	**2008**		**2007**		**2006**		**2005**
Spring	**N**	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**0.4**	**1.3**	**1.4**
Bonneville	949	0.1%	0.8%	4.1%	0.4%	85.7%	8.6%	0.1%	0.1%
McNary	590	0.2%	1.1%	5.1%	0.6%	83.0%	9.6%	0.2%	0.2%
Priest Rapids	90	0.0%	0.4%	8.3%	0.9%	82.6%	6.9%	0.9%	0.0%
Rock Island	89	0.0%	0.4%	8.3%	1.0%	82.4%	6.9%	1.0%	0.0%
Rocky Reach	37	0.0%	1.0%	16.2%	1.1%	78.5%	3.2%	0.0%	0.0%
Wells	36	0.0%	1.2%	16.4%	1.1%	77.9%	3.4%	0.0%	0.0%
Ice Harbor	403	0.3%	1.5%	4.0%	0.3%	84.8%	9.1%	0.0%	0.0%
Lower Granite	378	0.3%	1.6%	4.2%	0.3%	84.5%	9.1%	0.0%	0.0%
Summer									
Bonneville	408	1.7%	7.5%	13.7%	10.4%	51.8%	10.3%	4.6%	0.0%
McNary	324	2.0%	8.2%	12.9%	11.4%	49.9%	10.9%	4.6%	0.0%
Priest Rapids	229	2.3%	8.6%	13.0%	13.3%	43.2%	13.6%	6.0%	0.0%
Rock Island	223	2.1%	8.5%	11.8%	13.6%	44.9%	13.0%	6.1%	0.0%
Rocky Reach	188	0.9%	9.5%	9.8%	13.1%	50.4%	10.3%	5.9%	0.0%
Wells	161	0.8%	10.0%	9.9%	13.1%	48.8%	10.9%	6.5%	0.0%
Ice Harbor	84	0.0%	5.0%	17.6%	0.5%	71.7%	5.2%	0.0%	0.0%
Lower Granite	81	0.0%	5.0%	19.4%	0.5%	69.1%	6.0%	0.0%	0.0%
Fall									
Bonneville	1692	21.7%	40.9%	5.0%	17.8%	3.6%	1.2%	9.7%	0.0%
McNary	1049	25.3%	43.3%	6.7%	12.6%	3.6%	1.1%	7.4%	0.0%
Priest Rapids	180	39.2%	41.7%	1.3%	11.8%	1.0%	0.0%	5.0%	0.0%
Rock Island	59	37.6%	48.9%	2.3%	6.5%	0.3%	0.0%	4.5%	0.0%
Rocky Reach	44	33.0%	48.3%	3.0%	2.4%	0.4%	0.0%	12.9%	0.0%
Wells	17	58.1%	37.7%	1.9%	0.4%	0.9%	0.0%	0.9%	0.0%
Ice Harbor	273	25.8%	43.9%	18.0%	2.4%	7.9%	1.4%	0.6%	0.0%
Lower Granite	229	29.2%	45.8%	14.6%	2.9%	6.0%	0.8%	0.7%	0.0%

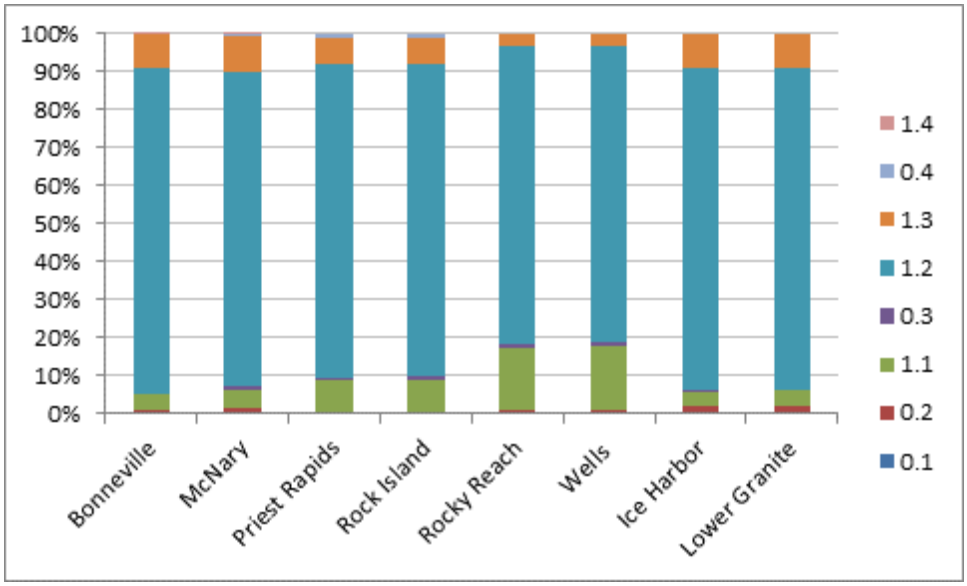

Figure 10. Spring Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project. Spring Chinook are defined as passing Bonneville Dam between April 1 and May 31, 2012.

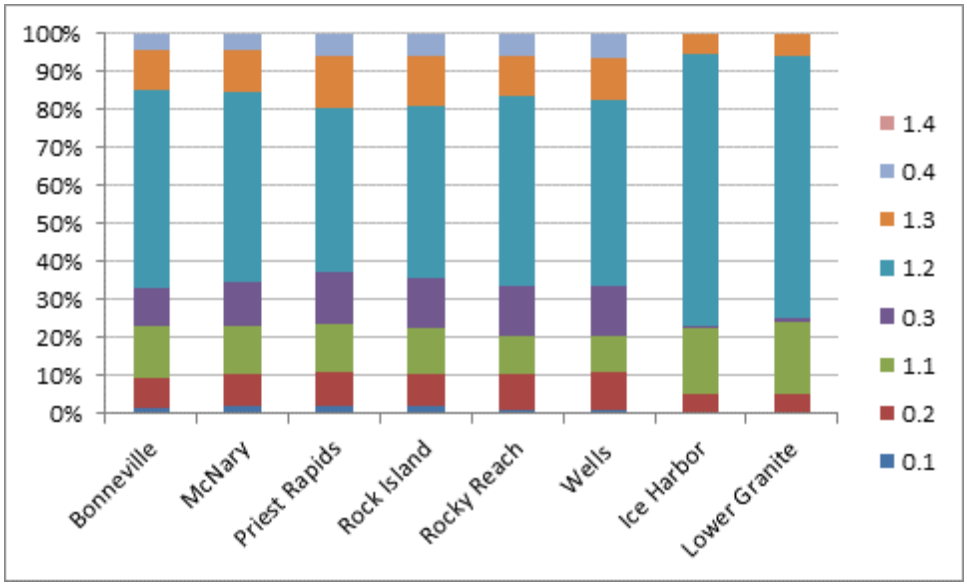

Figure 11. Summer Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project. Summer Chinook are defined as passing Bonneville Dam between June 1 and July 31, 2012.

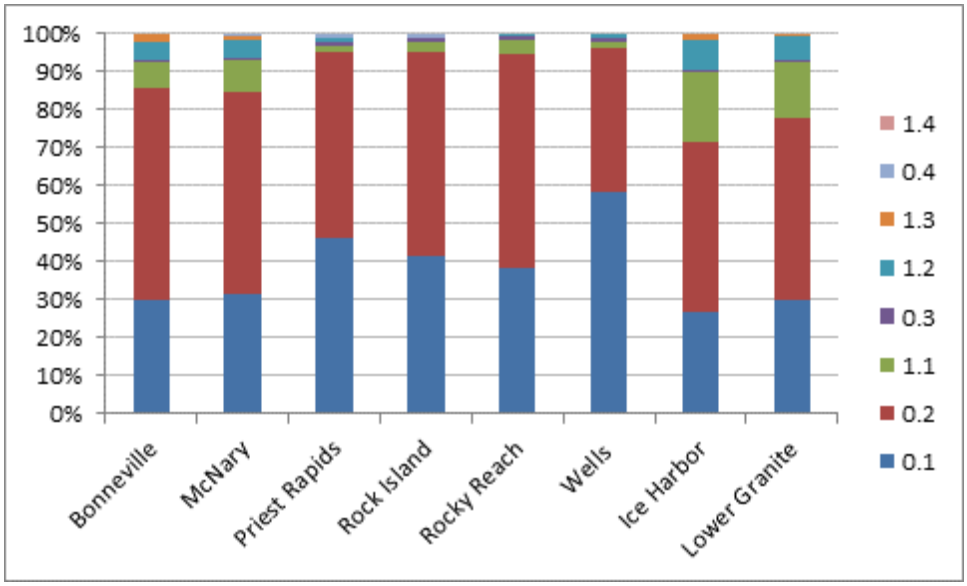

Figure 12. Fall Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project. Fall Chinook are defined as passing Bonneville Dam on or after August 1, 2012.

Table 14. Spring Chinook salmon length-at-age composition, as estimated by PIT tag detections of fish aged using scale pattern analysis that passed Bonneville Dam between on or before May 31, at Columbia and Snake River dams in 2012.

Dam	Statistic	Brood Year and Age Class						
		2010	2009		2008		2007	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3
Bonneville	μ	43.8	62.3	49.9	80.0	71.0	96.8	87.5
	s	1.8	5.0	4.8	7.8	4.8	5.3	5.6
	n	2	9	44	4	800	2	83
McNary	μ	43.8	62.4	49.1	80.0	70.9	96.8	88.0
	s	1.8	5.4	4.3	7.8	4.9	5.3	5.7
	n	2	7	36	4	481	2	55
Priest Rapids	μ		49.5	48.6	86.0	71.7	96.8	87.4
	s		--	4.3	5.0	4.4	5.3	7.9
	n		1	10	2	67	2	8
Rock Island	μ		49.5	48.6	86.0	71.7	96.8	87.4
	s		--	4.3	5.0	4.4	5.3	7.9
	n		1	10	2	66	2	8
Rocky Reach	μ		49.5	48.9	91.0	70.1		82.5
	s		--	4.6	--	4.4		7.2
	n		1	8	1	24		3
Wells	μ		49.5	48.9	91.0	70.3		82.5
	s		--	4.6	--	4.4		7.2
	n		1	8	1	23		3
Ice Harbor	μ	43.8	64.5	49.3	79.0	70.9		88.3
	s	1.8	1.3	4.2	--	5.0		5.7

	n	2	6	20	1	334		38
Lower Granite	μ	43.8	64.5	49.3	79.0	71.0		88.3
	s	1.8	1.3	4.2	--	5.1		5.9
	n	2	6	20	1	312		36

Table 15. 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 2012.

Dam	Statistic	Brood Year and Age Class						
		2010	2009		2008		2007	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3
Bonneville	μ	43.1	64.1	52.6	81.9	73.3	91.1	86.8
	s	3.5	4.5	4.5	5.1	5.1	5.2	4.5
	n	8	31	53	37	219	17	42
McNary	μ	43.1	63.8	52.5	82.1	73.2	91.3	86.4
	s	3.5	4.4	4.5	4.9	5.2	4.5	4.6
	n	8	27	41	33	165	13	36
Priest Rapids	μ	43.1	64.4	53.2	82.3	72.8	91.3	86.8
	s	3.5	3.9	4.8	4.8	5.0	4.5	3.8
	n	8	23	29	32	96	13	28
Rock Island	μ	42.4	64.3	53.0	82.3	72.8	91.3	86.8
	s	3.2	3.9	4.7	4.8	5.0	4.5	4.0
	n	7	22	27	32	96	13	26
Rocky Reach	μ	41.4	64.5	52.8	82.2	72.4	90.1	87.3
	s	3.2	3.9	4.9	4.8	4.9	3.4	3.0
	n	4	21	21	27	86	11	18
Wells	μ	42.8	64.4	53.4	81.8	71.9	89.5	87.5
	s	2.3	4.1	5.0	5.0	4.8	3.0	2.8
	n	3	19	18	23	72	10	16
Ice Harbor	μ		55.5	50.6	75.0	74.0		84.9
	s		--	3.5	--	5.2		6.3
	n		1	9	1	64		8
Lower Granite	μ		55.5	50.6	75.0	73.8		84.9
	s		--	3.5	--	5.1		6.3
	n		1	9	1	62		8

Table 16. 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 31st, for fall Chinook salmon at Columbia and Snake River dams in 2012.

Dam	Statistic	Brood Year and Age Class						
		2009	2008		2007		2006	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3
Bonneville	μ	47.4	63.7	56.9	78.7	73.1	84.8	80.2
	s	3.7	5.1	4.5	5.0	6.3	5.9	5.3
	n	415	691	85	268	58	152	19
McNary	μ	47.2	63.4	56.7	78.2	72.2	85.3	81.4
	s	3.5	5.0	4.6	4.9	6.5	5.9	6.9
	n	300	444	64	117	37	76	10
Priest Rapids	μ	46.9	63.6	57.2	77.4	79.8	83.6	
	s	3.6	4.5	3.7	4.1	2.3	5.9	
	n	73	73	5	19	2	8	
Rock Island	μ	45.8	62.7	57.0	79.6	82.0	84.0	
	s	4.4	5.4	4.1	4.1	--	0.0	
	n	20	25	4	7	1	2	
Rocky Reach	μ	44.8	62.6	57.0	80.6	82.0	84.0	
	s	4.1	6.2	4.1	2.2	--	0.0	
	n	15	18	4	4	1	2	
Wells	μ	43.9	64.2	57.0	82.0	82.0	84.0	
	s	4.6	6.3	2.0	--	--	--	
	n	5	7	2	1	1	1	
Ice Harbor	μ	47.7	63.7	56.1	78.8	70.1	69.5	80.3
	s	3.2	5.5	4.6	3.0	6.8	1.5	8.6
	n	68	123	42	10	23	2	5
Lower Granite	μ	47.5	63.4	55.9	78.8	69.7	69.5	80.8
	s	3.2	5.4	5.1	3.0	7.8	1.5	11.0
	n	62	107	29	10	16	2	3

Fallback

Estimated fallback-reascension rates based on Chinook salmon reascending fish ladders ranged from 1.1% to 58.9% (Table 17). 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 17. Estimated minimum Chinook salmon fallback rates by race at Bonneville Dam at Columbia Basin dams in 2012 as estimated by PIT tags[b].

Dam	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	1.9%	1.1%	1.9%
McNary	7.2%	1.7%	2.9%
Priest Rapids	5.3%	3.2%	58.9%
Rock Island	3.8%	14.3%	56.3%
Rocky Reach	11.4%	15.3%	15.6%
Wells	16.3%	31.6%	11.1%
Ice Harbor	6.3%	9.2%	5.4%
Lower Granite	9.9%	7.4%	5.6%
Tumwater	11.1%	17.4%	--
Mean	**11.0%**	**10.8%**	**5.3%**
Weighted by number of fish at each site	**5.5%**	**8.4%**	**6.4%**

A total of 121 tagged Chinook salmon had more than one fallback event, with one summer Chinook first tagged as a juvenile at Wells Hatchery *(*3D9.1C2D67E692 falling back 19 times over Rock Island Dam between July 15 and September 24 before being last detected at Rocky Reach Dam on October 18*.)* A total of 49 Chinook fell back over two different dams while 9 fell back over three different dams.

Fall Chinook at Priest Rapids Dam had the highest fallback rate with 78 fall Chinook generating 103 fallback events out of 185 fall Chinook detected passing the site. A total of 63 fall Chinook passed Priest Rapids dam before being detected downstream at the Priest Rapids Hatchery channel PIT tag array, 3 of these making this trip twice. A total of 40 fall Chinook fallback events (including the 3 fish traveling from Priest Rapids Dam to Priest Rapids Hatchery back to Priest Rapids Dam) were followed by a reascension of the ladder. Seven fall Chinook reascended between two and four times at Priest Rapids Dam.

Fall Chinook at Rock Island Dam generated 27 fallback events from the 48 fall Chinook passing the site. Six of these fish were detected at downstream sites subsequent to passing Rock Island Dam, including 2 at Priest Rapids Hatchery. A total of 12 fish made a total of 21 reascensions of these Rock Island fish ladders. One fish, 384.1B797647C9, reascended Rock Island ladders at

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

least five times starting October 4, 2012 and was last detected at a lower antenna on November 1, 2012.

Night Passage

Night passage (2000-0400 Pacific Standard Time) of tagged Chinook salmon was less than 1% at Bonneville, but increased further upstream (Table 18) and was highest at Prosser and Roza dams on the Yakima River. 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 2012 at Columbia Basin dams as estimated by PIT tag detections.

Site	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	0.0%	0.4%	0.4%
McNary	1.9%	1.6%	1.2%
Priest Rapids	4.3%	2.4%	5.4%
Rock Island	1.0%	1.7%	18.8%
Rocky Reach	0.0%	3.4%	4.4%
Wells	7.0%	3.4%	11.1%
Ice Harbor	1.5%	2.0%	1.3%
Lower Granite	3.4%	1.1%	2.0%
Prosser	0.0%	42.9%	37.0%
Roza	16.3%	50.0%	--
Tumwater	16.7%	0.0%	--

RESULTS-STEELHEAD

Sample Size

A total of 1431 steelhead were PIT tagged in 2012. 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 1451 (Table 19).

Table 19. Number of steelhead PIT tagged at Bonneville Dam and tracked past Bonneville by date and statistical week in 2012.

Dates	Statistical Week	Tagged (12 mm)	Tagged (9 mm)	Previously Tagged	Not Detected Passing Bonneville	Total Tracked
4/27	17	1	0	0	0	1
4/30,5/1,5/2	18	3	0	1	0	4
5/7,10,11	19	6	0	0	0	6
5/14-5/18	20	8	0	0	1	7
5/22,24,25	21	5	1	1	0	7
5/28-5/31	22	15	1	0	0	16
6/4-6/8	23	11	0	0	1	10
6/11-6/14	24	11	0	0	0	11
6/18-6/21	25	9	0	0	0	9
6/25-6/29	26	12	1	0	0	13
7/2-7/6	27	15	1	0	0	16
7/9-7/13	28	70	14	1	0	85
7/16-7/20	29	105	23	1	0	129
7/23-7/26	30	141	33	2	1	175
7/30-8/3	31	115	27	1	4	139
8/6-8/9	32	77	15	3	2	93
8/17	33	30	7	1	1	37
8/20-8/24	34	124	30	4	1	157
8/27-8/31	35	116	25	3	1	143
9/4-9/7	36	43	8	2	0	53
9/10-9/14	37	28	7	1	1	35
9/18-9/21	38	63	15	4	0	82
9/24-9/27	39	50	8	5	0	63
10/1-10/5	40	45	36	1	0	82
10/8-10/12	41	62	14	5	3	78
Total		**1165**	**266**	**36**	**16**	**1451**

Distribution of Sample

Our steelhead weekly sample distribution was closer to the weekly run distribution than in many past years (Figure 13). The run was most under-sampled during Statistical Week 33 when water temperatures exceeded 22.2C (70.0F) which stopped sampling from August 12-15. A regulatory change allowed us to resume sampling on August 16, although at reduced level until temperature dropped below 22.2C on August 23 during Statistical Week 34.

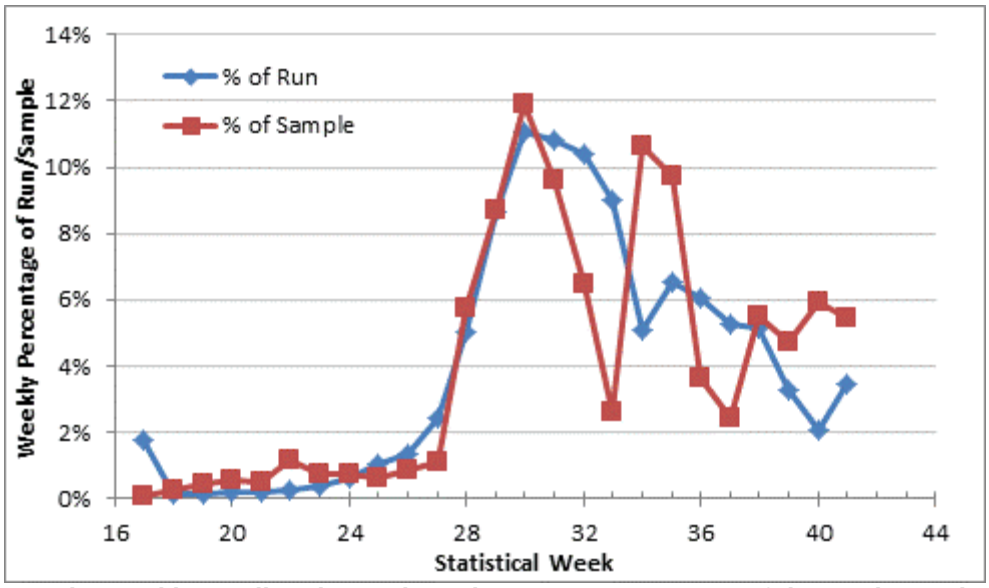

Figure 13. The weekly steelhead sample and run as a percentage of the total sample and run size at Bonneville Dam in 2012.

Detection Numbers

The 1451 steelhead tracked in 2012 generated 71752 weir detections and 6365 site detections at 98 sites. Maps (Figure A1-A16) found in the Appendix show the categorical ranges of detection numbers at the sites throughout the Columbia Basin.

Comparison of 9 and 12.5 mm tags

At 9 out of 14 sites with more than 40 detections of steelhead PIT tagged by this study (Table 20), the percentage of tagged steelhead detected with 9 mm tags was less than expected percentage of 18.2% (the percentage of steelhead in our sample that were tagged with 9 mm tags). At no site was this difference statistically significant.

Table 20. Total number of tagged steelhead detected (40 detection minimum) by site, the percentage which were 9 mm tags and the p-value for a comparison with the percentage of 9 mm tags deployed (18.2% in 2012). Significant p-values (α=0.05) are highlighted.

Site	PTAGIS Site Code	Total Tags Detected at Site (9 and 12.5 mm)	% 9 mm Tags of Total Tags Detected	P-value for a test comparing the % of 9 mm tags detected from an expected value of 18.2%
Bonneville Dam WA Shore Vertical Slots	BO4	1422	18.6%	0.400
Bonneville Dam WA Shore Fishway & AFF	BO3	1388	18.7%	0.376
McNary Dam Oregon Shore Fishway	MC1	805	19.8%	0.184
Ice Harbor Dam Fishways and Juvenile Bypass	ICH	759	20.0%	0.150
Lower Granite Dam Adult Fishway and Trap	GRA	675	19.9%	0.183
McNary Dam Washington Shore Fishway	MC2	234	20.9%	0.160
Priest Rapids Dam Adult Fishways	PRA	96	17.7%	0.453
Rocky Reach Fishway	RRF	72	18.1%	0.488
USE - Upper Salmon River at rkm 437	USE	70	17.1%	0.412
Wells Dam Adult Fishways	WEA	65	20.0%	0.357
Rock Island Dam Adult Fishways	RIA	57	14.0%	0.213
Lower SF Clearwater R at rkm 1	SC1	43	20.9%	0.325
Bonneville Dam Bradford Island Fishway	BO1	42	16.7%	0.401
Upper Salmon River (rkm 460)	USI	40	20.0%	0.386
All weirs		978	18.1%	0.244
All sites		1538	18.3%	0.401

Age Analysis

We were able to validate our scale aging techniques by using fish sampled at Bonneville for this project that were previously tagged as juveniles for other projects or hatchery programs. Age estimates from ageable scale patterns for 28 out of 30 steelhead that had been previously PIT tagged were correctly aged (93.3%). Only the total age could be compared for it was not possible to separately validate freshwater and ocean age.

In 2012 data was also available on the ocean age from genetics samples collected as part of this project. Ages estimated using the scale patterns agreed with estimates using GSI for 745 out of 803 steelhead samples (Table 21).

Table 21. Comparison of age estimates using genetics and scale pattern analysis for Chinook salmon sampled at Bonneville Dam in 2012. 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			% Correct
	1	2	3	
1	283	2	0	99.3%
2	52	456	3	89.2%
3		1	6	85.7%
Total				**92.8%**

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Data on tag detections was last downloaded from www.ptagis.org on August 15, 2013. An estimated 52.4% of the steelhead run was last detected upstream of Ice Harbor Dam while only 7.0% of the run was last detected upstream of Priest Rapids Dam (Figure 14). The proportion of steelhead bound for the Snake River steadily increased as the run progressed (Figure 15).

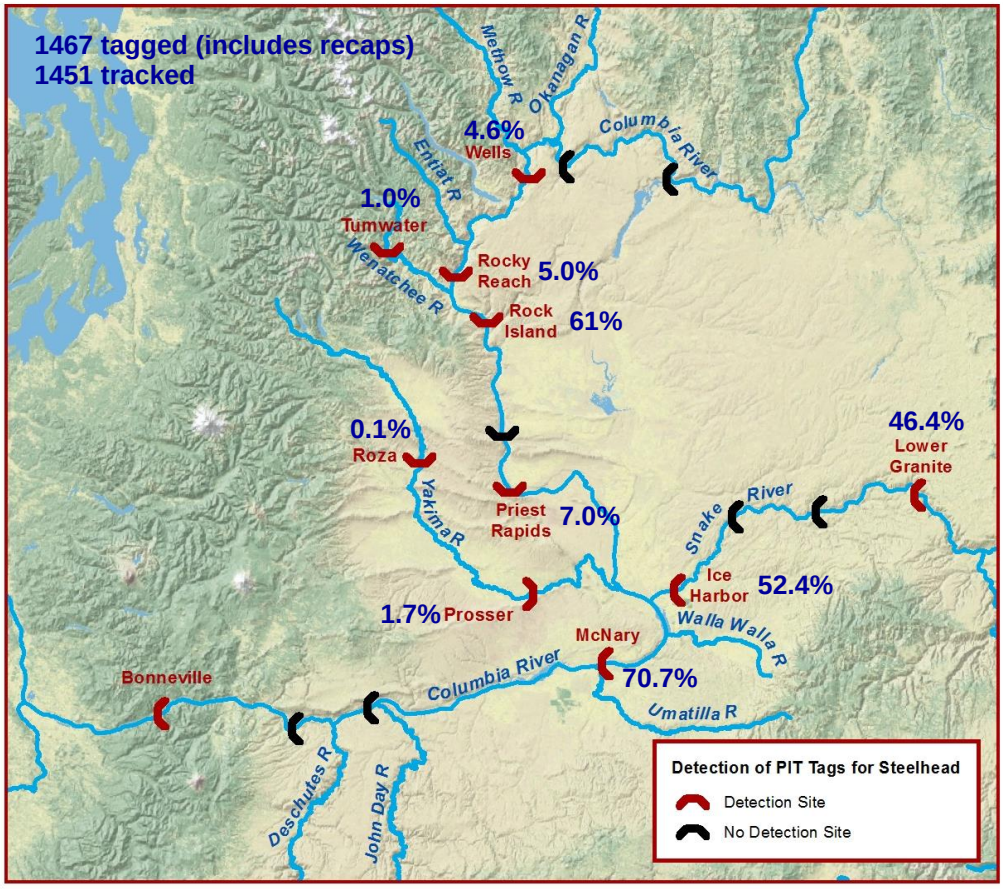

Figure 14. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of steelhead PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2012.

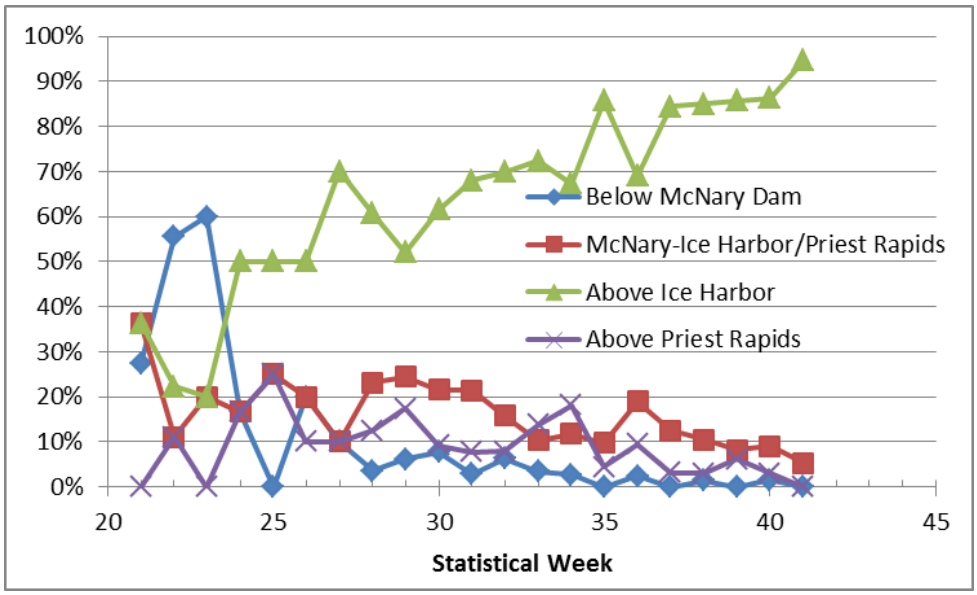

Figure 15. Distribution of final upstream detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2012 estimated as a percentage of the weekly sample.[c]

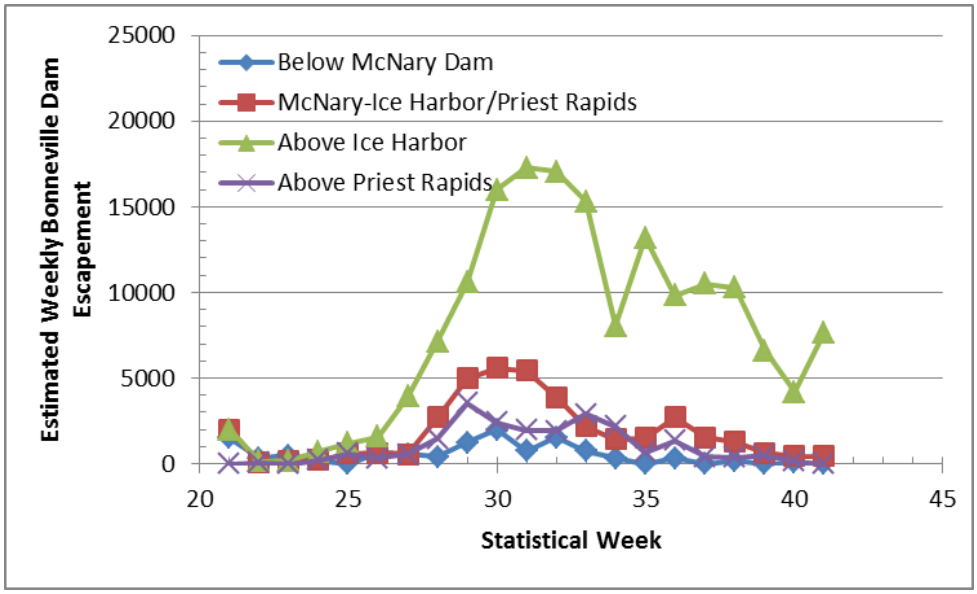

Figure 16. Distribution of final detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2012 estimated in numbers of fish passing Bonneville Dam by week.

Like Chinook salmon the percentage of steelhead PIT tagged with a 12.5 mm tag passing a dam without detection was generally under 1% (Table 22) with

[c] Note that the point indicating that 100% of those fish in Statistical Week 26 were last detected between Bonneville and McNary dams is based on only six steelhead sampled that week.

the exception of Rock Island Dam which has known detection issues due to antenna size and electrical noise (Fryer et al. 2012). Sample sizes were also relatively small at Rock Island Dam, with only 83 steelhead detected upstream, 33 of which were not detected by PIT tag arrays in Rock Island Dam fish ladders.

Table 22. Percentage of steelhead passing a dam undetected that were subsequently detected at an upstream dam in 2012.

Dam	Percent Undetected 9 mm	Percent Undetected 12.5 mm
Bonneville	0.0%	0.7%
McNary	0.0%	0.6%
Priest Rapids	0.0%	0.0%
Rock Island	52.9%	36.8%
Rocky Reach	0.0%	0.0%
Wells	0.0%	0.0%
Ice Harbor	0.0%	1.1%
Lower Granite	0.0%	0.6%
Mean (weighted by number passing each dam)	1.6%	1.7%

Migration Rates and Passage Time

The fastest median migration rate between dams, as measured in kilometers per day, was between McNary and Ice Harbor dams (28.2 km/day), while the slowest was 3.0 km/day between Rock Island and Tumwater dams (Table 23).

Table 23. Steelhead migration rate between Columbia Basin dams as estimated by PIT tag detections in 2012.

Steelhead		
Dam Pair	Distance (km)	Median Migration Rate (km/day)
Bonneville - McNary	231	21.3
McNary - Priest Rapids	167	24.1
Priest Rapids - Rock Island	89	21.4
Rock Island - Rocky Reach	33	15.8
Rocky Reach - Wells	65	24.0
Rock Island - Tumwater	73	3.0
Bonneville – Rock Island	487	22.7
Bonneville - Wells	585	22.8
McNary - Ice Harbor	67	28.2
Ice Harbor - Lower Granite	156	21.9

Median steelhead passage times (Table 24) at the mainstem dams, as measured from first to last detection within the ladders, were generally less than

that for Chinook salmon (Table 12). Lower Granite, McNary (Oregon shore), Bonneville, McNary, and Lower Granite dams had the greatest median passage time among mainstem Columbia Basin dams. At all of 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 Priest Rapids, Rock Island, Rocky Reach, and Wells dams is very short. Passage times at Lower Granite and Tumwater dams may be inflated because of fish trapping programs while the time at Bonneville Dam may possibly be increased due to steelhead taking some time to recover after sampling and tagging.

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 2012.

Dam	Median Passage Time (minutes)	Percentage with more than 12 hours between first detection and last detection at a dam
Bonneville	69.8	10.4%
McNary - OR Shore	85.6	6.4%
McNary - WA Shore	5.3	3.2%
Priest Rapids	11.3	4.5%
Rock Island	2.7	0.0%
Rocky Reach	1.2	9.8%
Wells	3.4	5.0%
Ice Harbor	82.5	12.5%
Lower Granite	102.8	42.9%
Tumwater	69.8	10.4%

Upstream Age and Length-at-Age Composition

Two age classes, 1.1 and 1.2 predominated in 2012 (Table 25, Figure 17). Length-at-age composition data is found in Table 26.

Table 25. Age composition estimates (%) as estimated by sampling at Bonneville Dam and upstream PIT tag detections of steelhead aged using scale patterns at Columbia and Snake River dams in 2012.

	Brood Year And Age Class												
	2009	2008		2007			2006	2005	Unknown				
Site	1.1	1.2	2.1	1.3	2.2	3.1	3.2	4.2	r	r.1	r.2	r.3	Repeat Spawners
BON	22.2	29.2	5.5	0.3	8.1	0.9	1.6	0.1	0.5	13.4	17.1	0.1	1.1
MCN	25.9	28.7	5.4	0.3	7.3	0.7	1.9	0.3	0.6	13.7	14.3	0.1	1.0
PRD	21.7	31.8	4.8	0.0	4.4	2.2	4.6	1.3	1.0	13.6	14.7	0.0	0.0
RIA	21.2	34.2	5.1	0.0	4.5	2.9	1.2	0.0	0.0	14.4	16.4	0.0	0.0
RRH	22.5	34.3	6.1	0.0	1.8	6.0	0.9	0.0	0.0	12.9	15.6	0.0	0.0
WEA	22.5	33.0	5.8	0.0	2.3	6.0	1.1	0.0	0.0	13.2	16.1	0.0	0.0
ICH	26.8	30.6	3.8	0.3	5.8	1.0	1.8	0.3	0.4	13.4	15.0	0.1	0.8
LWG	25.0	31.0	4.1	0.4	6.4	1.2	2.1	0.6	0.4	12.4	15.4	0.1	0.9

Table 26. Steelhead length-at-age composition, as estimated by PIT tag detections of fish aged using scale pattern analysis that passed Bonneville Dam, at Columbia Basin dams upstream of McNary Dam in 2012.

		2008	2007		2006			2005			2004	
Dam	Statistic	1.1	1.2	1.3	2.1	2.2	3.1	3.2	4.2	r.1	r.2	r.3
Bonneville	μ	58.2	74.3	87.9	58.4	71.9	59.0	69.3	70.0	57.8	72.3	90.0
	s	4.4	6.3	2.3	4.0	4.6	4.5	2.3	--	4.2	8.6	--
	n	312	461	7	76	102	11	19	1	187	248	1
McNary	μ	58.1	74.9	87.1	58.5	72.3	57.2	69.2	70.0	57.7	73.2	90.0
	s	4.3	6.4	2.6	3.9	4.3	4.5	2.2	--	4.0	5.8	--
	n	242	328	4	52	65	5	15	1	137	151	1
Priest Rapids	μ	58.0	71.0		55.6	72.2	59.5	70.1	70.0	57.0	71.9	
	s	3.7	4.2		2.7	1.9	--	1.6	--	2.6	4.8	
	n	23	30		7	6	1	4	1	11	13	
Rock Island	μ	58.0	70.6		55.8	72.0	59.5	71.3		57.2	71.9	
	s	3.9	3.5		2.8	2.1	--	0.3		2.6	4.8	
	n	20	28		6	5	1	2		10	13	
Rocky Reach	μ	58.9	70.4		55.8	74.5	59.5	71.0		57.3	71.8	
	s	3.5	3.4		2.8	0.0	--	--		2.3	5.0	
	n	17	25		6	2	1	1		8	12	
Wells	μ	58.8	70.6		56.0	74.5	59.5	71.0		57.3	70.5	
	s	3.7	3.4		3.1	0.0	--	--		2.3	4.3	
	n	15	23		5	2	1	1		8	10	
Ice Harbor	μ	58.3	75.7	87.1	59.4	73.0	56.6	69.3	70.0	57.6	73.8	90.0
	s	4.5	6.5	2.6	4.2	4.7	4.9	2.6	--	3.7	6.0	--
	n	178	272	4	24	40	4	10	1	98	120	1
Lower Granite	μ	58.4	75.8	87.1	59.7	73.2	56.6	69.3	70.0	57.4	73.9	90.0
	s	4.4	6.5	2.6	3.9	4.7	4.9	2.6	--	3.6	6.2	--
	n	150	246	4	19	38	4	10	1	81	110	1

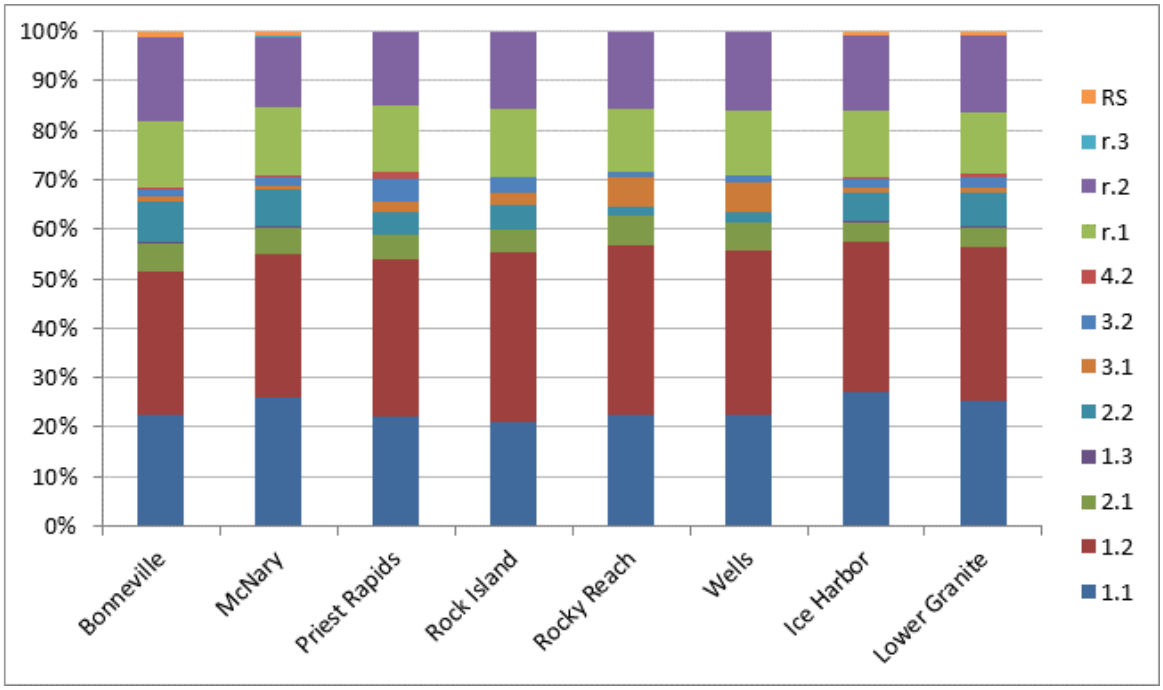

Figure 17. Steelhead age composition at Columbia and Snake river dams estimated using PIT tags in 2012. RS are repeat spawners. The "r" in age r.X means that the freshwater zone of the scale was regenerated and the age therefore not possible to determine.

Fallback

Estimated fallback-reascension rates based on steelhead reascending fish ladders ranged from 1.0% to 8.3% (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. Steelhead in 2012 had the highest fallback rate at Priest Rapids Dam.

Table 27. Estimated minimum steelhead fallback at Columbia Basin dams in 2012 as estimated by PIT tag[d] detections.

Dam	Percent Fallback%
Bonneville	1.0%
McNary	1.3%
Priest Rapids	8.3%
Rock Island	2.8%
Rocky Reach	6.2%
Wells	6.2%
Ice Harbor	5.3%
Lower Granite	1.3%

[d] 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 was under 9% at all mainstem dams (Table 28). The Bonneville Dam estimate of night passage is likely biased with low numbers due to the tagging hours, which occurred between 0700 and 1400 PST. Given the median Bonneville Dam passage time of 69.8 minutes (Table 24), steelhead would be expected to pass during daytime hours.

Table 28. Estimated steelhead night passage (2000-0400) in 2012 at Columbia Basin dams with a minimum of 15 detections as estimated by PIT tag detections.

Site	Steelhead (%)
Bonneville	3.1%
McNary	4.0%
Priest Rapids	3.1%
Rock Island	8.8%
Rocky Reach	2.8%
Wells	7.7%
Ice Harbor	8.0%
Lower Granite	7.4%

B-Run Analyses

The percentage of steelhead sampled and tagged that were classified as B-run ($\geq$78 cm) were at a peak when sampling ended in Statistical Week 41 at 52.5% of the run (Figure 18). 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) also peaked in Week 41. Overall, we estimated that 7.6% of the run at Bonneville was B-Run. 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), steelhead with fork lengths 78.0 cm and greater were almost entirely destined for the Snake River (Figure 19). Only eight steelhead were categorized in the sole week with more than 10% bound for locations other than the Snake River (Week 34).

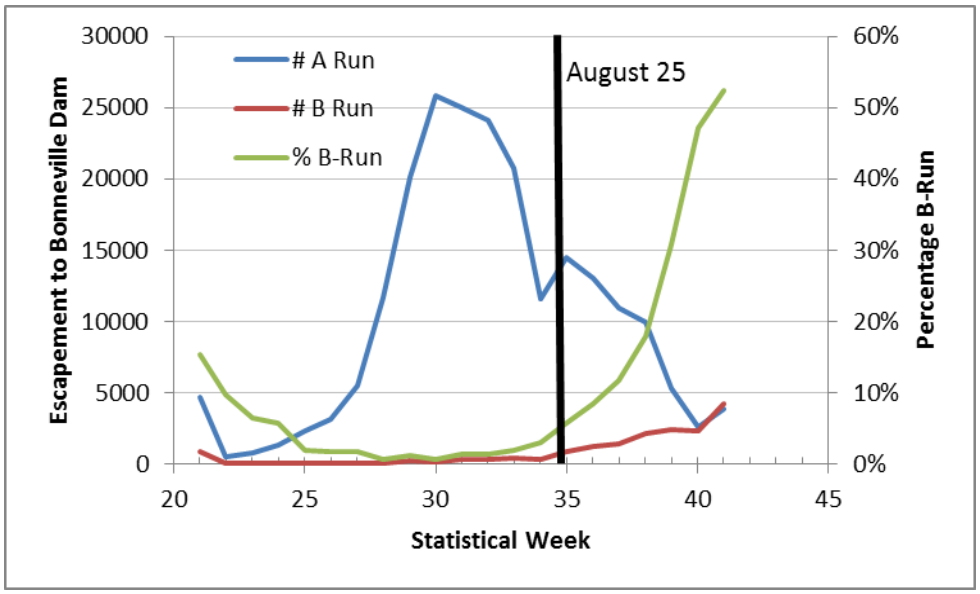

Figure 18. Percentage of B-run steelhead and estimated A- and B-run escapement at Bonneville Dam by statistical week in 2012. August 25 is noted as it is considered the date that separates A- and B-run steelhead.

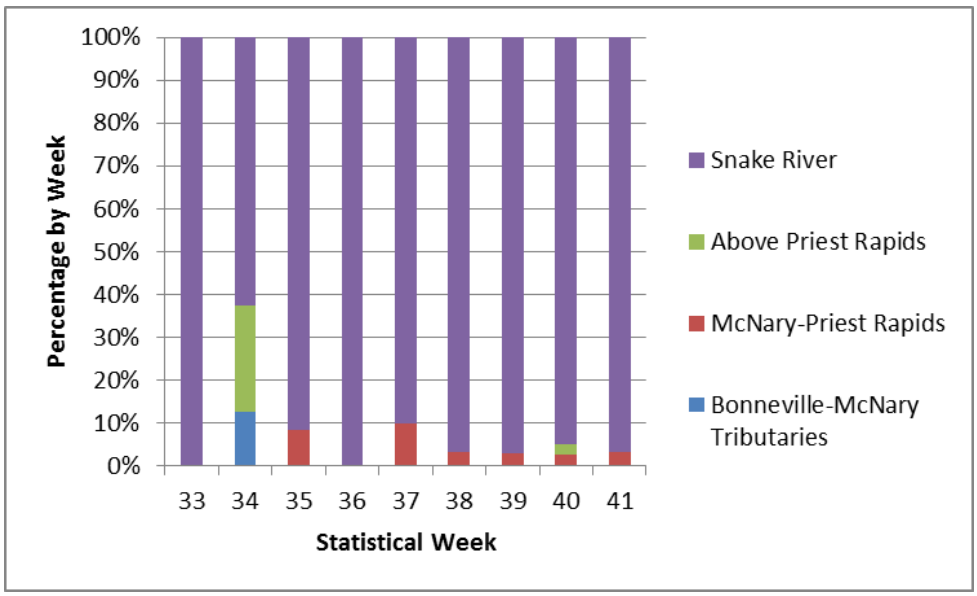

Figure 19. Final detection site for B-run steelhead (≥78 cm fork length) by Statistical Week they were sampled at Bonneville Dam in 2012.

Kelt Analyses

A total of 58 PIT tagged steelhead tracked in 2012 were detected moving downstream (mostly in juvenile bypasses) after March 31, 2013, presumably in an attempt to return to the ocean after spawning (Table A6). These steelhead we designated as kelt represented between 0.0% and 10.0% of the run at Bonneville Dam between Statistical weeks 27 and 39 (Figure 20) comprising 4.0% of the overall run (Table 29) or total steelhead tracked. Of these steelhead, 2 were last

detected at the estuary trawl (TWX, Table A5) in May 2013, 33 were last seen moving downstream through Bonneville Dam, most in the Corner Collector, some in the juvenile bypass and a few used the ladders. One of the 33 steelhead went out the Corner Collector in the spring of 2013 and later in the summer ascended the WA Shore Ladder. Other steelhead were last seen moving downstream through John Day Juvenile Bypass (6), moving out of the Umatilla River through the Threemile Dam (3), the McNary Juvenile Bypass (4), the Lower Monumental Juvenile Bypass (1), the Little Goose Juvenile Bypass (5), and the Lower Granite Juvenile Bypass (3). One steelhead tagged at Bonneville in 2012 was collected in April 2013 for the CRITFC's Kelt Project, as it moved downstream passed Prosser Dam on the Yakima River. It is expected that this fish will be released in the fall of 2013 to spawn again in the Yakima River.

We have also updated information of several kelts/respawners (as new information or new steelhead added) from past annual reports (2011 and 2010) with data from 2012/2013 movements (A7 and A8) or for steelhead returning that were not identified as a kelt/repeat spawner at the time of the report also discovered were three steelhead tagged in 2009 were detected moving around the Columbia Basin during the spring and summer of 2012 and that data is present in table A9.

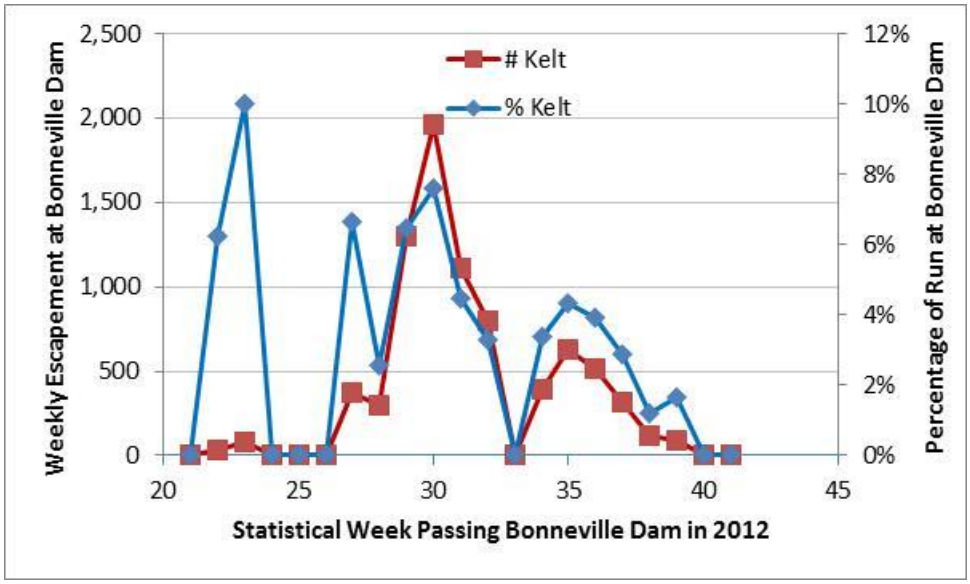

Figure 20. Percentage and number of steelhead designated as kelt passing Bonneville Dam by statistical week as sampled at Bonneville Dam in 2012.

Table 29. PIT tagged steelhead tracked from Bonneville Dam in 2009-2012 last detected moving downstream after March 31 of the year after sampling, listed by last downstream detection site.

Last site	2012	2011	2010	2009
Bonneville Corner Collector	26	10	23	61
Bonneville Juvenile Bypass	5	1	4	7
Bonneville Dam Bradford Island Ladders heading downstream	2	0	0	0
Estuary Trawl	2	0	0	1
Ice Harbor Juvenile Bypass	0	1	6	0
John Day Juvenile Bypass	6	3	11	3
Little Goose Juvenile Bypass	5	11	13	6
Lower Granite Juvenile Bypass	3	4	10	3
Lower Monumental Juvenile Bypass	1	12	9	4
Lower Washington Shore McNary Dam ladder, likely moving downstream.	0	0	2	1
McNary Dam Juvenile Bypass	4	3	2	4
Rocky Reach Juvenile Bypass	0	4	6	7
Migrating downstream in tributaries	4	0	0	0
Total	**58**	**49**	**86**	**97**
Percent of Steelhead Tracked	**4.0%**	**3.1%**	**5.2%**	**4.8%**

RESULTS-SOCKEYE[e]

Sample Size

In 2012, a total of 1610 sockeye salmon were PIT tagged and successfully scanned for those tags at Bonneville Dam between May 30 and August 1, 2012 (Table 30). Of the tagged sockeye, nine were not detected after release. These fish may have shed their tags, had defective tags, or died. It was also possible that sockeye salmon passed downstream without being detected as they 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 less likely that sockeye salmon pass upstream undetected as, at Bonneville Dam, they must pass through PIT tag antennas near the fish counting window. At Bonneville Dam (as well as 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, however data from 2006-2012 indicates that PIT tagged sockeye salmon are missed, although the percentage is normally low (Table 31). Of the 1601 sockeye tracked, 9 were not detected at the uppermost PIT tag antennas at Bonneville Dam suggesting that they may not have passed upstream. These sockeye were included in subsequent analyses.

Table 30. Number of sockeye salmon sampled and PIT tagged at Bonneville Dam and tracked upstream by date and statistical week in 2012.

Sampling Dates	Statistical Week	Sampled (n)	Tagged	Detected After Tagging and Tracked
5/30,31; 6/1,4-8	22-23	69	66	61
6/11,12,13,14,15	24	201	193	193
6/18,19,20,21,22	25	408	404	401
6/25,26,27,28,29	26	426	423	420
7/2,3,4,5,6	27	374	368	366
7/9,10,11,12,13	28	119	117	117
7/16,17,18,19,20	29	24	24	24
7/23,24,25,26; 8/1	30-31	16	15	15
Total		**1637**	**1610**	**1601**

[e] The information presented in this section of the report is a summary of Fryer et al. 2011.

Table 31. Number and percentage of PIT tagged fish not detected at dam detection sites as estimated from upstream detections in 2012 along with comparison data for 2006-2011.

Dam	2012 N	2012 %	2011	2010	2009	2008	2007	2006
Bonneville	7	0.5%	1.8%	0.7%	0.6%	0.4%	2.1%	0.2%
McNary	20	1.6%	12.1%	3.8%	5.0%	10.1%	6.5%	3.1%
Priest Rapids	2	0.2%	0.4%	0.6%	0.3%	0.3%	0.8%	0.0%
Rock Island	53	4.4%	5.4%	6.2%	2.6%	6.9%	6.8%	1.3%
Rocky Reach	7	0.7%	1.4%	0.5%	0.0%	0.2%	0.7%	12.3%
Wells	0	0.0%	0.0%	0.0%	--	--	--	--
Ice Harbor*		NA	0.0%	0.0%	20.0%	0.0%	--	--

Age Analysis

Age 1.2 was the predominant age class through the entire run (Table 32).

Table 32. Weekly and total age composition of sockeye salmon at Bonneville Dam as estimated from scale patterns in 2012.

Statistical Week	N Ageable	Age Class				
		1.1	1.2	1.3	2.1	2.2
23	66	0.0%	93.9%	6.1%	0.0%	0.0%
24	192	1.0%	95.8%	2.6%	0.0%	0.5%
25	395	0.8%	96.2%	2.0%	0.3%	0.8%
26	422	2.1%	95.5%	0.5%	0.2%	1.7%
27	365	0.5%	97.0%	0.0%	1.1%	1.4%
28	114	0.9%	95.6%	0.9%	0.9%	1.8%
29	23	4.3%	91.3%	4.3%	0.0%	0.0%
30	16	6.3%	81.3%	0.0%	6.3%	6.3%
Composite	**1593**	**1.3%**	**95.9%**	**1.1%**	**0.4%**	**1.3%**
Std. Dev		**0.6%**	**1.0%**	**0.5%**	**0.3%**	**0.6%**

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Most of the Bonneville tagged sockeye salmon that were not detected at Rock Island Dam were lost before reaching McNary Dam (Table 33, Figure 21). The reach of river below McNary is where the tribal Zone 6 fishery occurs that was estimated to harvest 45747 sockeye salmon (Table A4) with an additional 434 sockeye harvested by sport anglers (Stuart Ellis, U.S. v. Oregon Technical Advisory Committee, personal communication). However, adding this harvest to our estimated escapement to McNary Dam (424719) still leaves 44777 sockeye salmon unaccounted for between Bonneville and McNary dams.

Table 33. Percentage of PIT tagged sockeye salmon detected at upstream dams subsequent to tagging, estimated escapement from both PIT tags (12.5 mm only) and visual means, and the difference between the PIT tag and visual escapement estimate in 2012.

Dam	Estimated Percentage Reaching Dam	Estimated Escapement Using Bonneville PIT Tagged Sockeye	Visual Dam Count	Difference Between PIT Tag and Visual Estimate
Bonneville	100.0%	--	515,673	--
McNary	82.4%	424,719	364,147	16.6%
Priest Rapids[f]	77.3%	398,505	408,258	-2.4%
Rock Island	75.0%	386,778	410,614	-5.8%
Rocky Reach	62.1%	320,241	363,297	-11.9%
Wells	60.8%	313,566	326,084	-3.8%
Tumwater	12.9%	66,272	66,520[g]	1.9%
Ice Harbor	0.0%	0	453	--
Lower Granite	0.0%	0	470	--

Using detections of fish PIT tagged by this project at Bonneville Dam to estimate fish counts at dams resulted in estimates that varied from actual visual fish counts by (-11.9%) at Rocky Reach Dam to 16.6% at McNary Dam (Table 33). At McNary Dam it is possible for fish to use navigation locks to bypass fish ladders, thus avoiding both PIT tag detection and visual detection; however, we only estimated 1.6% of sockeye were missed at McNary Dam (Table 31). At all other dams except Tumwater (where the visual count was partially estimated using PIT tags), visual counts exceeded PIT tag estimates.

As in most years of this study, and also true in 2012, survival from Bonneville to Priest Rapids dams showed a significant relationship with week tagged at Bonneville Dam (Table 34, Figure 22). The relationships for survival from Bonneville to McNary and Rock Island dams, or Rocky Reach to Wells dam were not significantly related to statistical week.

[f] 29 tagged sockeye 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 would not be included in visual counts. Including these 29 sockeye increases the percentage to 78.9% and the escapement estimate to 406,917.

[g] The actual visual count was 42,411; however the video record was lost for three peak passage dates. Estimating escapement for these dates using PIT tag data suggests a total escapement of 66,520 (Todd Miller, WDFW personal communication).

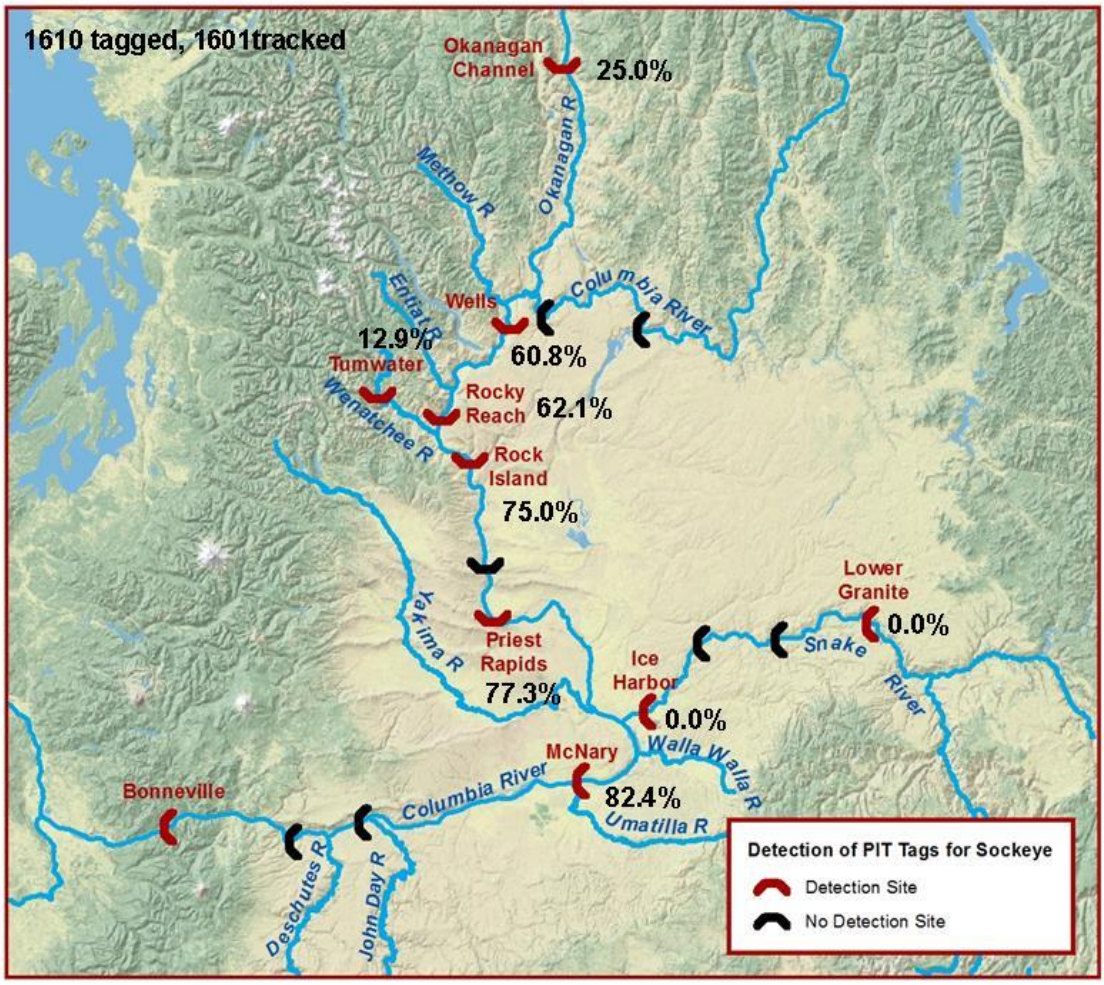

Figure 21. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fish PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass McNary, Priest Rapids, Rock Island, Rocky Reach, Wells, Ice Harbor, Lower Granite, and Tumwater dams and the Okanogan Channel in 2012.

Table 34. Sockeye salmon survival through selected reaches by statistical week as estimated by PIT tag detections in 2012.

Statistical Week at Bonneville Dam	Bonneville-McNary	Bonneville-Priest Rapids[h]	Bonneville-Rock Island	Rocky Reach-Wells
23	95.4%	95.4%	93.8%	96.6%
24	91.2%	89.1%	82.9%	98.0%
25	82.8%	80.0%	74.3%	98.9%
26	81.4%	78.8%	74.3%	95.6%
27	80.1%	75.1%	73.2%	98.1%
28	79.5%	77.8%	74.4%	98.6%
29	91.7%	83.3%	83.3%	94.7%
30	73.3%	73.3%	73.3%	90.0%
Composite	**82.4%**	**79.4%**	**75.0%**	**97.3%**
p-value	**0.092**	**0.028**	**0.149**	**0.118**

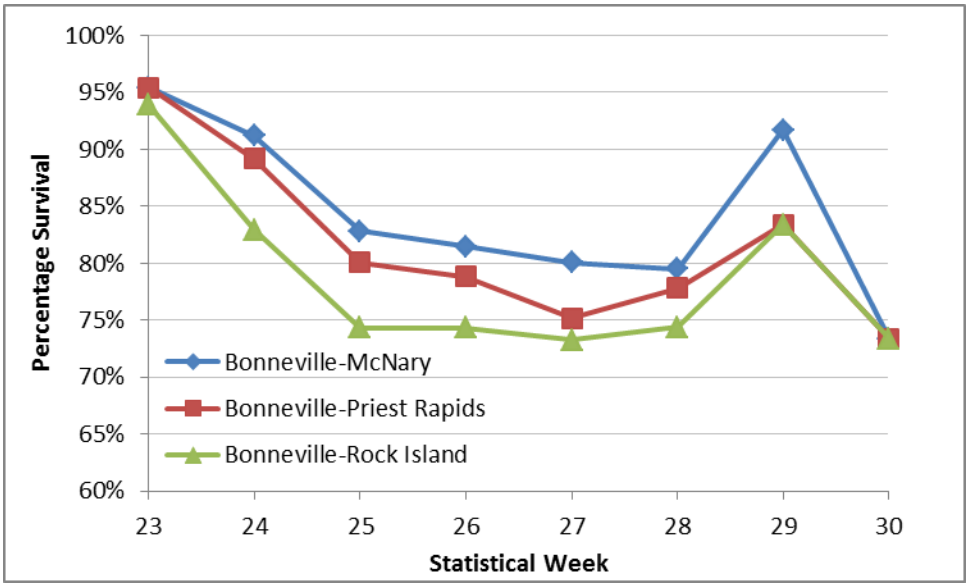

Figure 22. Survival from to McNary, Priest Rapids, and Rock Island dams by statistical week tagged at Bonneville Dam as estimated by PIT tags in 2012.

Migration Rates and Passage Time

Sockeye salmon travel quickly upstream with median migration rates between mainstem dams ranging between 21.7 and 43.2 km/ day for sockeye tagged at Bonneville Dam (Table 35). Returning adults, tagged as smolts, have slightly slower migration rates, with their median migration rate from Bonneville to Rock Island Dam being 2.1 km per day less than sockeye tagged as adults.

[h] Includes sockeye salmon only detected in the Priest Rapids Dam trap that likely were collected for the Cle Elum sockeye reintroduction project.

Sockeye salmon tagged at Bonneville Dam later in the migration travel upstream faster than those earlier in the migration (Table 36). There is a significant (α=0.05) linear relationship between statistical week passing Bonneville Dam and migration time from Bonneville to Rock Island, Rocky Reach, Tumwater, and Wells dams as well as between McNary and Rock Island, Rock Island and Rocky Reach, and Rocky Reach and Wells dams. The median difference in travel time from Bonneville Dam to all upstream mainstem dams except Wells Dam (where only four sockeye classified as Wenatchee stock were detected) was one day or less between the two major stocks (Table 36).

Table 35. Median sockeye salmon travel time and migration rates between dams as estimated by PIT tag detections of sockeye tagged at Bonneville Dam in 2012.

Dam Pair	Distance (km)	Median Travel Time (days)	Median Migration Rate (km/day)
Bonneville-McNary	231	5.3	43.2
McNary-Priest Rapids	167	6.0	27.7
Priest Rapids-Rock Island	89	3.3	26.7
Rock Island-Rocky Reach	33	1.5	21.7
Rocky Reach-Wells	65	2.3	28.6
Rock Island-Tumwater	73	16.0	4.6
Bonneville-Rock Island	487	15.7	31.0
Bonneville-Tumwater	560	32.0	17.5
Bonneville-Wells	585	20.2	29.0

The median passage time at a dam (difference between first detection and last detection) for sockeye tagged at Bonneville Dam and those tagged as smolt was six minutes or less at all dams except for Bonneville and Lower Granite dams (Table 37). Bonneville Dam, unlike many dams which only have detectors in at upper ladders, has an extensive array of antennas that include the lower ladders resulting in earlier detection than most other dams and thus a more complete view of the passage times in the ladders.

Table 36. Adult sockeye salmon travel median time in days between dam pairs by statistical week tagged at Bonneville Dam, the F-statistic for a linear regression between travel time and statistical week, and mean travel time by stock as estimated using PIT tags in 2012.

Statistical Week at Bonneville Dam	Bonneville-McNary	Bonneville-Priest Rapids	Bonneville-Rock Island	Bonneville-Rocky Reach	Bonneville-Tumwater	Bonneville-Wells	McNary-Rock Island	Rock Island-Rocky Reach	Rocky Reach-Wells	Wells to Okanogan Channel
23	6.2	15.1	21.8	27.1	50.9	30.0	14.7	4.1	2.7	89.7
24	5.3	16.1	20.9	23.8	44.0	26.1	15.8	2.2	2.3	89.3
25	5.3	14.4	18.0	19.8	39.1	22.0	12.3	1.5	2.3	85.5
26	5.2	10.9	14.2	15.8	31.2	18.3	8.8	1.3	2.3	81.4
27	5.7	10.7	13.8	15.0	26.0	17.9	8.0	1.3	2.3	75.4
28	5.1	10.1	13.5	15.0	23.0	17.0	8.0	1.3	2.0	68.9
29	5.3	10.2	12.8	14.0	19.0	16.0	7.3	1.1	2.0	62.6
30	4.9	9.8	12.0	13.5	19.9	16.1	7.5	1.2	1.9	49.9
P-value	**0.07**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.03**	**<0.01**	**<0.1**
Stock										
Okanogan	5.3	11.8	15.7	17.6	--	20.2	9.8	1.5	2.3	82.5
Wenatchee	5.4	11.8	15.9	15.4	32.0	23.1	10.0	1.1	3.0	--
Unknown[i]	5.7	12.5	15.9	--	--	--	8.6	--	--	--

Table 37. Median passage time for adult sockeye salmon PIT tagged at Bonneville Dam 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 2012.

Dam	Median Passage (Minutes)	%>12 hours
Bonneville	66	0.3%
McNary	0	2.0%
Priest Rapids	5	1.0%
Rock Island	3	1.5%
Rocky Reach	1	5.8%
Wells	2	1.7%
Tumwater	6	4.1%
Ice Harbor	--	--
Lower Granite	--	--

Fallback

Fallback rates ranged from 0.4% at Bonneville Dam to 7.9% at Rocky Reach Dam (Table 38). Fallback for sockeye salmon that, subsequent to tagging, moved downstream and crossed over to ascend the Oregon shore

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

ladder at Bonneville Dam was 43.8% (7 out of 16) compared to 0.3% on the Washington shore. Visual counts suggested that 39.1% of sockeye pass the Oregon shore ladder (DART 2013).

Table 38. Estimated fallback rates for sockeye salmon at dams in 2012[j].

Dam	Adults Tagged at Bonneville
Bonneville	0.4%
McNary	2.5%
Priest Rapids	1.2%
Rock Island	1.1%
Rocky Reach	7.9%
Wells	1.3%
Tumwater	0.5%

Night Passage

Okanogan sockeye salmon stock tagged at Bonneville Dam generally passed dams at night (2000-0400 hours) at a higher rate than Wenatchee sockeye salmon stock (Table 39). As Okanogan sockeye salmon got closer to natal areas night migration increased, reaching 31.1% when passing the Okanogan Channel PIT array during night hours. The Bonneville Dam estimate of night passage is likely biased low because tagging occurred between about 0800 and 1300 hours, and with a median passage time of 66 minutes from tagging to final detection at Bonneville Dam (Table 37), fish would be expected to pass the counting window prior to 2000 hours.

Stock Composition Estimates

The percentage of Wenatchee sockeye salmon stock was higher during the middle of the run at Bonneville Dam when compared to the beginning and end with no significant linear relationship between weekly stock composition and statistical week (p=0.85, Table 40). The overall stock composition estimate at Bonneville Dam was 17.6% Wenatchee, 82.4% Okanogan, and 0% Snake River. This stock composition estimate differed by 6.1 percentage points from that estimated by Rocky Reach Dam counts and 1.4 percentage points from that estimated using Tumwater Dam (Table 40).

[j] Does not include sockeye salmon that fell back over a dam and were not subsequently detected.

Table 39. Estimations for sockeye salmon stocks' nighttime passage (2000-0400 standard time) in 2012 at mainstem Columbia River dams as estimated by last PIT tag detection time.

Dam	Okanogan Stock	Wenatchee Stock	Unknown	All Sockeye
Bonneville	0.3%	0.0%	0.3%	0.3%
McNary-OR shore	4.1%	0.9%	3.6%	3.5%
McNary-WA shore	9.4%	1.1%	11.9%	8.5%
Okanogan Channel	31.1%	--	--	31.1%
Priest Rapids	1.9%	2.1%	2.7%	2.0%
Rock Island	1.8%	1.0%	0.0%	1.6%
Rocky Reach	3.7%	0.0%	--	3.6%
Wells	10.3%	25.0%[a]	--	10.4%
Tumwater	--	1.0%	--	1.0%
Zosel	17.1%	--	--	17.1%
Mean of McNary, Priest Rapids and Rock Island	3.4%	1.4%	3.6%	3.2%

Thirteen sockeye salmon last detected at, or upstream of, Tumwater dam were previously detected at Rocky Reach Dam with 4 of these 13 fish also detected at Wells Dam. There were no sockeye detected at Tumwater Dam that were subsequently detected anywhere downstream of Tumwater Dam.

Table 40. Weekly and composite sockeye salmon stock composition at Bonneville Dam as estimated by PIT tags in 2012 and a comparison to stock composition estimates using visual dam counts.

Statistical Week and Dates	Run Size from Bonneville Dam Visual Counts	PIT Tagged sockeye reaching terminal areas	Percent Okanogan	Percent Wenatchee	Percent Snake River
23 (May 30-June 8)	5987	61	95.1%	4.9%	0.0%
24 (June 11-14)	40159	159	91.2%	8.8%	0.0%
25 (June 18-22)	140621	298	86.2%	13.8%	0.0%
26 (June 25-29)	196832	310	79.4%	20.6%	0.0%
27 (June 27-July 1)	98658	266	77.8%	22.2%	0.0%
28 (July 5-8)	30577	84	84.5%	15.5%	0.0%
29 (July 11-14)	2901	20	95.0%	5.0%	0.0%
30 (July 18-19)	879	11	90.9%	9.1%	0.0%
Composite		**1209**	**82.4%**	**17.6%**	**0.0%**
Visual Fish Counts at dams (using difference between Rock Island and Rocky Reach counts to estimate proportion Wenatchee)			88.5%	11.5%	
Visual Fish Counts at dams (Tumwater count to estimate the proportion Wenatchee)			83.8%	16.2%	

A total of 21 adipose clipped sockeye salmon PIT tagged[k] at Bonneville Dam were adipose clipped with 2 recorded as right maxillary clipped and 1 ventral fin clipped (Table 41). Of these sockeye, 8 were last detected in the Wenatchee Basin, 3 in the Okanogan Basin, 9 downstream of McNary Dam, and 1 at Rock Island Dam.

Table 41. Last detection site of clipped sockeye salmon tagged at Bonneville Dam in 2012.

Last Detection Site	Right Maxillary Clip	Right Ventral Fin	Adipose Clipped
Bonneville Dam Fish Ladder	0	0	1
Upstream antenna Bonneville	2	0	8
Upstream antenna Rock Island	0	0	1
Upstream antenna Tumwater	0	0	4
White River antenna	0	0	4
Upstream antenna Wells	0	1	2
Okanogan Channel antenna (OKC)	0	0	1
Total	**2**	**1**	**21**

[k] Juvenile sockeye salmon are adipose clipped in Snake River and Lake Wenatchee hatchery programs.

DISCUSSION

This study sampled and PIT tagged over 6400 salmonids at Bonneville Dam in 2012 and then tracked 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 2012 marked the 7th year we have been tagging sockeye salmon, the 6th year we have tagged Chinook and the 4th year we have PIT 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.

In 2012, we tested the performance of a new version of 9mm tag at upstream PIT tag arrays. These tags were developed primarily for use in juvenile salmon tagging studies where tag size can be a limiting factor in which size of juvenile can be tagged. As part of the development process, these tags are tested to ensure adequate detection at juvenile detection systems at Snake and Columbia River mainstem dams. Their detection efficiency at adult fish ladders, in adult fish returning, as well as in-stream detection arrays are not generally tested. Therefore tests, such as what we carried out in 2012, are valuable in determining how well these new tags will be detected at these sites when juveniles with these smaller tags return as adults. Based on the results of this study, we found very few significant differences in detection at mainstem fish ladders. There were insufficient detections at most weir antennas to compare the 9mm and 12.5mm tags. When compared overall weirs, 9 mm-tagged Chinook were significantly less likely to be detected than 12.5mm-tagged Chinook; however, there was not a significant difference for steelhead.

Excluding Rock Island Dam, the percentage of salmonids passing mainstem dams undetected was generally under 2% for Chinook, steelhead, and sockeye. Chinook tagged with 9 mm tags passing mainstem Columbia Basin dams were less likely to be detected than those with 12.5 mm tags (2.0% vs 1.2%) while for steelhead the percentage missed was nearly the same (1.6% for 9 mm tagged steelhead and 1.7% for 12.5 mm tagged steelhead. Chinook tagged with 9 mm tags were less likely to be detected at in-stream weirs; for steelhead there was no difference between detection rates for those tagged with 9 and 12.5 mm tags.

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 2012 the percentage of Chinook salmon at Bonneville Dam which ultimately passed Ice Harbor Dam peaked at 51.6% of the run for the week starting May 21, declining to 4.4% for the week starting July 8, 1012. The portion of the run bound for upstream of Priest Rapids Dam over the same period increased from 11.3% to 80.0%. These results suggest that in 2012 as in both 2010 and 2011, 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.

As at Bonneville Dam, Chinook runs 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 instance, 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 18.1% of spring, 1.2% of the summer, and 1.6% 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 all classified as falls, and misclassified fall Chinook were all classified as summer Chinook at Priest Rapids Dam. This study found that 2.0% of spring, 10.2% of the summer, and 0.0% of

the fall Chinook at Bonneville Dam were classified differently at Ice Harbor Dam. Incorrectly classified Bonneville Dam spring Chinook were classified as summers at Ice Harbor Dam and incorrectly classified summer Chinook were classified as spring Chinook.

Escapement estimates using PIT tag data for mainstem dam passage varied from the traditional methods (i.e. visual counts) and ranged from -18.1% to +7.4% for the entire Chinook salmon run; however there was considerably greater variation when looking at individual runs. Escapement estimates for sockeye salmon at Columbia River dams differ between the methods by -11.9% to +16.6%. Many factors can cause these discrepancies, including inaccuracies of visual or video counts, fallback/reascension rates, tagging effects, and a biased sample of fish being PIT tagged. Tagging additional adults, as well as better detection in terminal areas, would likely improve the precision and accuracy of stock specific escapement and survival estimates.

The number of steelhead returning in 2012, which were last detected heading downstream in spring or summer of 2013 (kelts), was estimated as 4.0% of the 2012 run. This is an increase over the 3.1% for the 2011 run, but a decrease from the 5.2% estimated in 2010 and 4.8% in 2009. The percentage of B-run steelhead at Bonneville Dam in 2012 comprised 7.6% of the run compared to 11.4% in 2011, 18.0% in 2010, and 8.0% in 2009.

The overall number of fish tagged in 2012 was greater than that in the previous three years (Table 42). We tagged more of both Chinook and sockeye than in previous years, though the number of steelhead tagged in 2012 was an increase over 2011, it still lagged 2009 and 2010. The overall percentage of the run sampled, at 0.45%, was greater than that of the past three years. With few sampling days impacted by high temperatures our sample distribution was relatively similar to the run distribution with the exception of the steelhead and fall Chinook peaks when we cannot sample sufficient hours to sample proportionally.

Table 42. 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	6291	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%

From 2008 through 2010 this study documented delays in sockeye salmon passage at Tumwater Dam that was likely attributable to 24 hour operation of the trap at that facility (Table 43). The median passage time reported was up to 4.6 days in 2008 and PIT tag detection records suggested that up to 33.3% (in 2010) of sockeye salmon reaching Tumwater Dam never passed over it. Trap operations were changed in 2011 so that passage through the fish ladder was not blocked 24 hours per day. The result was that the median passage time dropped to 6 minutes in both 2011 and 2012. For 2011, we reported 100% of PIT tagged sockeye reaching Tumwater Dam successfully passed through the ladder (Fryer et al. 2012.) In 2012, 99.5% of Bonneville PIT tagged sockeye reaching Tumwater Dam successfully passed through the ladder.

Table 43. Sockeye salmon delays at Tumwater Dam 2008-2012.

Year	N	Run Size	% Last Detected at Downstream Antenna	% Taking More Than 12 Hours to Pass	Median Delay (minutes)
2008	96	28034	8.3%	62.1%	4554
2009	87	16034	26.4%	41.4%	158
2010	111	35821	33.3%	72.1%	8494
2011	103	18634	1.0%	12.6%	6
2012	194	66520	0.5%	*4.1%*	*6*

Spring Chinook tagged by this project had a median passage time at Tumwater Dam of just less than 9 minutes, while summer Chinook had a median time of 10 minutes. However, the percentage taking more than 12 hours to pass was 22.2% for spring Chinook and 39.1% for summer Chinook.

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APPENDIX

Table A1. Probability of tag detection at PIT tag detectors by weir at Columbia Basin fish ladders, and the overall probability of detection, for Chinook salmon in 2012. Right or left is determined by looking downstream at the dams, thus the right bank at Wells would be the west bank.

Dam, Site, Tag Type, and Number		Weir and Probability of Detection at Weir				Overall Detection Probability
Bonneville	**N**	**1**	**2**	**3**	**4**	
BO1 12.5 mm	66	95.4	95.4	98.4	100.0	100.0
BO1 9 mm	13	92.3	92.3	92.3	100.0	100.0
BO4 12.5 mm	2748	98.5	97.1	98.9	98.4	100.0
BO4 9 mm	632	96.0	89.7	97.8	96.0	100.0
McNary	**N**	**1**	**2**			
MC1 12.5 mm	1264	98.3	99.5			100.0
MC1 9 mm	295	95.3	99.0			100.0
	N	**1**	**2**	**3**		
MC2 12.5 mm	518	95.4	99.6	96.1		100.0
MC2 9 mm	99	96.2	97.7			100.0
Priest Rapids	**N**	**3**	**7**			
East 12.5 mm	355	97.5	100.0			100.0
East 9 mm	75	93.3	100.0			100.0
	N	**3**	**5**			
West 12.5 mm	87	98.9	100.0			100.0
West 9 mm	25	84.0	100.0			100.0
Rock Island	**N**	**1-2**	**3-4**			
Left (east) 12.5 mm	181	99.4	100.0			100.0
Left (east) 9 mm	40	100.0	97.5			99.1
	N	**5-6**	**7-8**			
Middle 12.5 mm	38	97.4	100.0			100.0
Middle 9 mm	4	75.0	100.0			100.0
	N	**09-0A**	**0B-0C**			
Right (west) 12.5 mm	142	95.1	88.0			99.4
Right (west) 9 mm	23	95.7	73.9			98.9
	N	**1-2**	**3-4**			
Rocky Reach 12.5 mm	247	99.2	98.4			100.0
Rocky Reach 9 mm	46	97.8	93.5			99.9

Wells	**N**	**1-2**	**3-4**			
Left (east) 12.5 mm	148	100.0	100.0			100.0
Left (east) 9 mm	35	100.0	100.0			100.0
	N	**5-6**	**7-8**			
Right (west) 12.5 mm	56	100.0	100.0			100.0
Right (west) 9 mm	11	100.0	100.0			100.0
Ice Harbor	**N**	**438**	**437**	**436**	**435**	
South 12.5 mm	557	99.8	99.8	99.8	99.6	100.0
South 9 mm	109	100.0	99.1	99.1	100.0	100.0
North 12.5 mm	176	98.9	98.9	100.0	99.4	100.0
North 9 mm	35	100.0	100.0	100.0	100.0	100.0
	N	**733**	**732**	**731**	**730**	
Lower Granite 12.5 mm	643	99.7	99.5	99.8	99.4	100.0
Lower Granite 9 mm	139	89.2	100.0	100.0	99.3	100.0
	N	**A1**	**A2**			
Tumwater 12.5 mm	35	100.0	100.0			100.0
Tumwater 9 mm	6	100.0	100.0			100.0

Table A2. Probability of tag detection at PIT tag detectors by weir at mainstem Columbia Basin fish ladders, and the overall probability of detection, for steelhead in 2012. Right or left is determined by looking downstream at the dams, thus the right bank at Wells would be the west bank.

Dam, Site, Tag Type, and Number		Weir and Probability of Detection at Weir										Overall Detection Probability
Bonneville	**N**	**1**	**2**	**3**	**4**							
BO4-12.5 mm	1115	97.1	96.5	99.1	98.2							100.0
BO4-9 mm	214	75.2	82.2	94.4	93.5							
BO1 12.5 mm	42	92.3	100.0	100.0	100.0							
BO1 9 mm	3	100.0	100.0	33.3	100.0							100.0
McNary	**N**	**1**	**2**	**288**	**287**	**286**	**284**	**283**	**282**	**280**	**279**	
MC1 12.5 mm	633	98.3	99.7									
MC1 9 mm	119	97.5	91.6	94.4	93.5	94.4	95.1	52.8	95.5	94.9	95.2	100.0
	N	**1**	**2**	**3**	**312**	**311**	**309**	**308**	**306**	**303**	**302**	
MC2 12.5 mm	137	99.3	98.5	99.3								
MC2 9 mm	33	84.8	90.9	87.9	89.1	51.5	40.6	81.5	83.0	48.8	85.5	100.0
Priest Rapids	**N**	**3**	**7**									
East 12.5 mm	38	100.0	100.0									
East 9 mm	10	60.0	90.0									100.0
	N	**3**	**5**									
West 12.5 mm	12	100.0	100.0									
West 9 mm	3	33.3	100.0									100.0
Rock Island	**N**	**1-2**	**3-4**									
Left (east) 12.5 mm	3	100.0	100.0									
Left (east) 9 mm	0											
	N	**5-6**	**7-8**									
Middle12.5 mm	1	100	100									
Middle 9 mm	0											
	N	**09-0A**	**0B-0C**									
Right (west) 12.5 mm	37	100.0	81.1									
Right (west) 9 mm	4	100.0	75.5									99.3
	N	**1-2**	**3-4**									
Rocky Reach 12.5 mm	40	100.0	97.5									
Rocky Reach 9 mm	8	100.0	87.5									99.7
Wells	**N**	**1-2**	**3-4**									
Left (east) 12.5 mm	22	100	100									
Left (east) 9 mm	2	100	100									100.0
	N	**5-6**	**7-8**									

Right (west) 12.5 mm	14	100	100									
Right (west) 9 mm	6	100	100									100.0
Ice Harbor	**N**	**438**	**437**	**436**	**435**							
South 12.5 mm	567	100.0	99.6	99.8	99.5							
South 9 mm	68	95.9	95.9	100.0	100.0							
North 12.5 mm	82	100.0	100.0	100.0	100.0							100.0
North 9 mm	11	100.0	90.9	100.0	100.0							100.0
	N	**733**	**732**	**731**	**730**							
Lower Granite 12.5 mm	563	93.1	91.7	90.1	95.9							100.0
Lower Granite 9 mm	109	94.5	90.8	87.2	91.7							100.0

Table A3. Probability of detection at PIT tag detectors by antenna at mainstem Columbia Basin fish ladders, and the overall probability of detection, for sockeye salmon in 2012.

Dam, Site, Tag Type, and Number		Antenna and Probability of Detection at Antenna				Overall Detection Probability
Bonneville	**N**	**1**	**2**	**3**	**4**	
BO1	16	100.0	100.0	100.0	93.8	100.0
BO4	1573	98.9	98.7	99.4	99.0	100.0
McNary	**N**	**1**	**2**	**3**		
MC1 (Oregon)	677	98.8	97.9			100.0
MC2 (Washington)	647	97.7	99.4	90.6		100.0
Priest Rapids	**N**	**Upper**	**Lower**			
West	158	99.4	100.0			100.0
East	1103	97.6	99.9			100.0
Rock Island	**N**	**Upper**	**Lower**			
Left	491	98.8	99.6			100.0
Middle	77	98.7	100.0			100.0
Right	539	89.1	89.1			98.8
Rocky Reach	**N**	**Upper**	**Lower**			
Right	1020	99.6	98.0			100.0
Wells	**N**	**Upper**	**Lower**			
Left-	746	99.6	100.0			100.0
Right	259	99.3	99.3			100.0
Tumwater	**N**	**Upper**	**Lower**			
12.5	194	100.0	100.0			100.0

Right or left is determined by looking downstream at the dams, thus the right bank at Wells would be the west bank.

Table A4. Harvest by fishery for Columbia Basin sockeye salmon in 2012.

Location	Fishery Type	Source	Totals
Zone 1-5	Sport and Commercial	TAC	4,321
Zone 6	Commercial, Ceremonial and Subsistence	TAC	45,747
	Sport	TAC	434
Priest Rapids Tailrace	Wanapum Ceremonial and Subsistence	TAC	44
Lake Wenatchee	Sport	WDFW	12,107
Priest Rapids to Chief Joseph Dam	Sport	DFO	27,500
Colville Harvest (Lake Pateros and Okanogan River)	Colville Tribal Net	DFO	1,532
	Colville Tribal Purse Seine	DFO	12,826
	Chief Joseph Tailrace	DFO	57
	Tribal anglers and net	DFO	1,262
Canada Okanagan Basin	Okanagan Nation Alliance Communal	DFO	5,225
	Okanagan Nation Alliance Economic Demo	DFO	778
	Recreational	DFO	439
Priest Rapids Dam	Yakama Broodstock Removals[l]	YN	10,000

[l] Although not a true "harvest", the Yakima Nation collect live, adult sockeye salmon at Priest Rapids Dam each year and place them in Cle Elum and Cooper Lakes to spawn. This sockeye reintroduction project was initiated in 2009.

Table A5. List of PTAGIS interrogation sites (three letter code, name, and description) to use with maps that follow.

Site Code	Site Name	Site Description
ACB	Asotin Cr. at Cloverland Brdg.	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.
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.
BHL	Adult Fishway at BONH	In-stream detection system located in Bonneville Hatchery Ladder.
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
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.
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.
CRT	Crooked River Satellite Fac.	Ladder of the Crooked River Satellite Facility. The Crooked River is a tributary to the South Fork Clearwater River. The array consists of two overflow antennas.
CRW	Chewuch River above Winthrop	Chewuch River at river km 1, above Winthrop, WA.
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.
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 Riverwood subdivision.
ESJ	Easton Acc. Pond	Easton Acclimation Pond Outfall
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.
GLC	Gold Creek, Methow River	Gold Creek, Methow River Basin
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	Mouth of the Hood River against the west side jetty just inside the bar where the Hood River meets the Columbia River.
HYC	Hayden Creek In-stream 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.
IR1	Lower Imnaha River ISA @ km 7	Lower Imnaha River at river km 7 (N 45.761162, W -116.750658).
IR2	Lower Imnaha River ISA @ km 10	Lower Imnaha River at river km 10 (N 45.742839 W -116.764563).
IR3	Upper Imnaha River ISA @ 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
JDJ	John Day Dam Juvenile	John Day Dam Juvenile Fish Bypass and Sampling Facility
JOC	Joseph Creek ISA @ km 3	Joseph Creek, Grande Ronde basin at river km 3 (N 46.030016, W -117.016042).
KRS	SF Salmon River at Krassel Cr.	Krassel Creek at rkm 65 on the South Fork Salmon River.
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.
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.
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.
LWD	Lowden Diversion Dam	At the entrance to the fish ladder at Lowden Diversion Dam. Lowden Dam is located at rkm 51 on the Walla Walla River.
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.
LWN	Little Wenatchee River	Little Wenatchee River rkm 4, located at the old fish weir site.
MAD	Mad River, Entiat River Basin	Mad River rkm 1, located at Ardenvoir, WA.
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.

Table A5. Continued.

Site Code	Site Name	Site Description
MCJ	McNary Dam Juvenile	McNary Dam Juvenile Fish Bypass/Transportation Facility
MCL	Lower Mission Creek Instream	Located at rkm 0.7 on Mission Creek (Wenatchee River Basin), near Cashmere, WA.
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	Outlet of the Washington Department of Fish and Wildlifes (WDFW) Methow Hatchery located on the Methow River at Rk 82.3 from the confluence with the Columbia River.
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.
MWC	Maxwell Canal	Maxwell Canal is located at rkm 24 on the Umatilla River.
MWE	Middle Wenatchee River	Wenatchee River rkm 50 above Tumwater Dam, consisting of a single antenna array floated off the bottom spanning the 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.
NFW	North Fork Walla Walla River	North Fork Walla Walla River approximately 267 meters upstream from the confluence with the South Fork Walla Walla River.
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.
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.
ORB	Oasis Road Bridge	In-stream arrays at Oasis Road Bridge, lower Walla Walla River
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
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.
RCS	Rock Creek (WA) at rkm 14	Rock Creek (WA) at rkm 14 at the confluence of Rock and Squaw Creeks.
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.
RRT	Red River Satellite Facility	Ladder of the Red River Satellite Facility. The Red River is a tributary to the South Fork Clearwater 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.
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.
SWK	Lower Swauk Creek	Located at rkm 0.5 on lower Swauk creek, just above the highway 10 bridge.
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
TMF	Three Mile Falls Dam Combined	Adult Fishway and Juvenile Bypass/subsampling facility at Three Mile Falls Dam
TRC	Trout Creek, Wind River	Trout Creek located at river km 2 on Trout Creek, in the Wind River (WA.) Basin above Hemlock Lake.
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
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)
WFC	Wolf Creek, Methow River	Wolf Creek, Methow River Basin
WHC	Lwr White Creek, Klickitat Bsn	White Creek (Klickitat River Basin) approximately 150 meters upstream from the mouth.
WSH	Warm Springs Hatchery	Adult Fishway at Warm Springs NFH
WTL	White River, Wenatchee Basin	White River rkm 4, located at the old fish weir site.
WW1	Harris Bridge S F Walla Walla	Harris County Park Bridge, South Fork Walla Walla River
WW2	SF Walla Walla at Bear Creek	Bear Creek, South Fork Walla Walla 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.
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 in the town of Oroville, Washington.

Table A6. Season by season activities of steelhead tagged in 2012 and later labeled as kelts when they began migrating downstream presumably to the ocean, after spawning in late winter or early spring.

Tag Year	Tag Number	Last Summer Detection After Tagging 2012	Fall 2012	Winter 2012/13	Spring 2013	Summer 2013	Comments
2012	384.1B7976468D	Bonneville Washington Shore Ladder - August 29th		McNary - December 16th Walla Walla R - February 24th	Bonneville Dam Corner Collector - April 19th		
2012	384.1B79764936	Bonneville Washington Shore Ladder - July 25th	Ice Harbor - September 25th		Lower Lemhi River - April 2nd Hayden Cr (Lemhi) - April 30th Bonneville Dam Corner Collector - May 23rd		
2012	384.1B79764AD1	McNary - August 15th		Ice Harbor - February 1st	Bonneville Dam Corner Collector - May 6th		
2012	384.1B79764CED	Bonneville Washington Shore Ladder - August 7th	Lower Granite - September 28th		Upper Salmon River - April 1st	Bonneville Dam Corner Collector - June 4th	
2012	384.1B797690C9	Bonneville Washington Shore Ladder - July 17th			Bonneville Dam Corner Collector - April 6th		
2012	384.1B7976926D	Bonneville Washington Shore Ladder - September 7th	McNary - October 10th		John Day Dam Juvenile Bypass - April 4th Lower Deschutes River - April 5th Buckhollow Cr (Deschutes) - April 11th to 18th Bonneville Bradford Island - April 24th		
2012	384.1B7976A6DC	Bonneville Washington Shore Ladder - July 25th			Bonneville Dam Corner Collector - April 23rd		
2012	3D9.1C2D27FD3B	McNary - August 30th	Wells - September 13th		Rocky Reach Juvenile Bypass - April 13th McNary Juvenile Bypass - April 22nd Bonneville Dam Corner Collector - April 27th		
2012	3D9.1C2DAEC16E	Bonneville Washington Shore Ladder - June 8th			Bonneville Juvenile Bypass - April 28th		
2012	3D9.1C2DB11E37	Bonneville Washington Shore Ladder - May 29th	Lyle Falls (Klickitat) - July 14th		Bonneville Juvenile Bypass - April 1st		
2012	3D9.1C2DB3039F	Bonneville Washington Shore Ladder - August 7th	McNary - September 23rd		Bonneville Dam Corner Collector - May 21st		
2012	3D9.1C2DB6B102	Bonneville Washington Shore Ladder - August 7th	Lower Granite - September 28th		Bonneville Dam Corner Collector - May 17th		
2012	3D9.1C2DDC27FF	Bonneville Washington Shore Ladder - August 22nd	Hood River Mouth - October 13th		Bonneville Dam Corner Collector - April 17th		
2012	3D9.1C2DE1DC10	Bonneville Washington Shore Ladder - August 23rd	McNary Juvenile Bypass - October 28th			Bonneville Dam Corner Collector - June 3rd	
2012	3D9.1C2DE788F2	Lyle Falls (Klickitat) - July 14th			Bonneville Dam Corner Collector - April 28th		
2012	3D9.1C2DE7C9CB	McNary - August 17th	Lower Granite - October 4th		Bonneville Dam Corner Collector - April 27th		
2012	3D9.1C2DE7E8D5	McNary - August 8th	Prosser Dam (Yakima) - November 1st	Status Cr (Yakima) - February and March	Bonneville Juvenile Bypass - April 16th		
2012	3D9.1C2DE7FF72	Bonneville Washington Shore Ladder - July 18th	Sherars Falls Trap (Deschutes) - October 1st		Bonneville Dam Corner Collector - May 2nd		
2012	3D9.1C2DE8278D	Tumwater Dam (Wenatchee) - August 16th			Nason Cr (Wenatchee) - March 14th Bonneville Dam Corner Collector - May 16th		
2012	3D9.1C2DE828BB	Bonneville Washington Shore Ladder - July 19th	John Day River - October 30th		Bonneville Dam Corner Collector - May 3rd		
2012	3D9.1C2DE844D9	Bonneville Washington Shore Ladder - July 24th	Sherars Falls Trap (Deschutes) - October 5th		Warm Springs Hat. (Deschutes) - April and May Bonneville Juvenile Bypass - Mat 14th		
2012	3D9.1C2DE851ED	Bonneville Washington Shore Ladder - September 21st	Lower Granite - October 12th		Bonneville Dam Corner Collector - May 17th		
2012	3D9.1C2DE85CD7	McNary - August 14th			Bonneville Dam Corner Collector - May 15th		
2012	3D9.1C2DE87280	Bonneville Washington Shore Ladder - August 31st	Lower Granite - September 11th		Bonneville Dam Corner Collector - May 16th		
2012	3D9.1C2DE8911A	Bonneville Washington Shore Ladder - August 2nd	Lower Granite - September 20th	Alpowa Cr (Snake) - January 30th	Alpowa Cr (Snake) - March 25th Bonneville Dam Corner Collector - April 25th		
2012	3D9.1C2DE8B047	Bonneville Washington Shore Ladder - July 24th	John Day River - October 29th		Bonneville Dam Corner Collector - May 6th		
2012	3D9.1C2DE8B182	McNary - August 12th	Ice Harbor - October 11th	John Day River - February 14th	Bonneville Dam Corner Collector - May 2nd		
2012	3D9.1C2DE8C29F	Bonneville Washington Shore Ladder - September 4th	McNary - October 21st	Walla Walla R - January 31st	John Day Dam Juvenile Bypass - April 22nd Bonneville Dam Corner Collector - April 24th		
2012	3D9.1C2DE8D011	Bonneville Washington Shore Ladder - September 27th	McNary - October 23rd		McNary Juvenile Bypass - April 24th Bonneville Bradford Island - May 3rd		
2012	3D9.1C2DE8FE38	Bonneville Washington Shore Ladder - August 1st	Lower Granite - September 28th		Bonneville Dam Corner Collector - April 23rd		
2012	3D9.1C2DE930E9	Bonneville Washington Shore Ladder - July 25th	McNary - October 25th		McNary - March 16th Bonneville Dam Corner Collector - May 8th		
2012	3D9.1C2D7C36AB	McNary - August 1st	Lower Granite - September 13th		Lower Imnaha River - April 23rd Upper Imnaha River - April 29th Lower Imnaha River - May 21st	Bonneville Dam Corner Collector - June 12th	

Table A6 (Continued).

Tag Year	Tag Number	Last Summer Detection After Tagging 2012	Fall 2012	Winter 2012/13	Spring 2013	Summer 2013	Comments
2012	3D9.1C2DE720D5	Lyle Falls (Klickitat) - July 14th			Bonneville Dam Corner Collector - April 5th	Bonneville Washington Shore Ladder - August 6th	May have spent a few months in the ocean before returning.
2012	384.1B79769F5D	Bonneville Washington Shore Ladder - July 26th	Upper Salmon River - October 14th		Valley Cr (Salmon) - March 14th to 27th Upper Salmon River - April 20th Bonneville Dam Corner Collector - May 13th Estuary - May 15th		
2012	3D9.1C2DE8EA88	Bonneville Washington Shore Ladder - September 25th	Lower Granite - November 30th		Estuary - May 25th		
2012	3D9.1C2DB69D70	Bonneville Washington Shore Ladder - August 2nd			Feed Diversion Dam (Umatilla) - March 14th John Day Dam Juvenile Bypass - April 30th		
2012	3D9.1C2DE8B0FB	Bonneville Washington Shore Ladder - July 26th	Lower Granite - October 11th		Lower Imnaha River - April 11th Horse Cr (Imnaha) - April and May Little Goose Juvenile Bypass - May 28th	John Day Dam Juvenile Bypass - June 6th	
2012	3D9.1C2DE83CC0	Bonneville Washington Shore Ladder - August 2nd	Lower Granite - September 22nd		John Day Dam Juvenile Bypass - April 19th		
2012	3D9.1C2DE80ECB	McNary - August 6th	Lower Granite - October 14th		Lower Walla Walla R - April 6th Burlingame Dam (Walla Walla) - April 8th John Day Dam Juvenile Bypass - May 5th		
2012	384.1B7976971E	Bonneville Washington Shore Ladder - August 7th			John Day Dam Juvenile Bypass - May 23rd		
2012	384.1B7976442B	Bonneville Washington Shore Ladder - August 30th	Lower Granite - October 24th		Joseph Cr (Grande Ronde) - March and April John Day Dam Juvenile Bypass - May 11th		
2012	384.1B79764604	Bonneville Washington Shore Ladder - July 24th	McNary - October 21st		Threemile Dam (Umatilla) - May 7th		
2012	3D9.1C2DDD30F5	Bonneville Washington Shore Ladder - August 30th	McNary - September 22nd		McNary - April 8th Ice Harbor - April 10th Threemile Dam (Umatilla) - May 18th		
2012	3D9.1C2DE881AC	Bonneville Washington Shore Ladder - July 24th			Threemile Dam (Umatilla) - May 23rd		
2012	384.1B79769D86	McNary - August 5th	Ice Harbor - November 6th	Little Goose Juvenile Bypass - December 7th	Burlingame Dam (Walla Walla) - April 5th McNary Juvenile Bypass - April 30th		
2012	3D9.1C2DE8805F	Bonneville Washington Shore Ladder - July 24th	McNary - September 27th	Walla Walla River - December 5th	Burlingame Dam (Walla Walla) - March 1st Burlingame Dam (Walla Walla) - March 28th McNary Juvenile Bypass - April 7th		
2012	3D9.1C2DE7F247	McNary - August 31st	Lower Granite - September 11th		Lolo Cr (Clearwater) - March to May McNary Juvenile Bypass - May 21st		
2012	384.1B79769B83	McNary - July 24th	Ice Harbor - September 6th	Tucannon River - December 7th	Tucannon River - March 3rd to 14th McNary Juvenile Bypass - April 11th		
2012	384.1B79764517	Lower Granite - August 27th			Upper Grande Ronde River - March 29th Lower Monumental Juvenile Bypass - May 24th		
2012	3D9.1C2DE8ADFD	McNary - August 16th	Lower Granite - September 20th		Upper Salmon River - April 3rd Little Goose Juvenile Bypass - April 29th		
2012	3D9.1C2DE89AE0	Bonneville Washington Shore Ladder - August 31st	Lower Granite - September 26th		Upper Salmon River - March 31st Sawtooth Hat. (Salmon) - April 28th Little Goose Juvenile Bypass - May 14th		
2012	3D9.1C2DE87837	Bonneville Washington Shore Ladder - July 16th	Lower Granite - November 2nd		Upper Salmon River - April 1st Little Goose Juvenile Bypass - May 2nd		
2012	3D9.1C2DE76C59	Bonneville Washington Shore Ladder - August 22nd	Lower Granite - September 15th		Little Goose Juvenile Bypass - May 13th		
2012	384.1B79769CB0	Bonneville Washington Shore Ladder - September 12th	Ice Harbor - October 13th	Lower Granite - December 7th	Little Goose Juvenile Bypass - April 14th		
2012	3D9.1C2DE84A43	Bonneville Washington Shore Ladder - August 31st	Ice Harbor - September 25th		Lower Granite - April 6th Lower Granite Juvenile Bypass - May 14th		
2012	384.1B797698C6	Bonneville Washington Shore Ladder - August 21st	Lower Granite - September 26th		Lower Imnaha River - April 18th Upper Imnaha River - May 3rd Lower Granite Juvenile Bypass - May 16th		
2012	384.1B79764D82	Bonneville Washington Shore Ladder - August 27th	Lower Granite - October 15th		Lower Granite Juvenile Bypass - May 13th		
2012	3D9.1C2DE7FED6	Bonneville Washington Shore Ladder - September 12th	Prosser Dam (Yakima) - October 29th		CHANDL - Chandler Canal Kelt Project Collection - April 23rd		Steelhead reconditioned in CRITFC Kelt Project will be released in the fall of 2013.

Key - - - Upstream | Downstream | Spawning

Table A7. Season by season activities of several steelhead tagged in 2011 and later labeled as kelts when they began migrating downstream and upstream presumably to and from the ocean. Any new steelhead or steelhead with additional information from the 2011 report table is included here as new data on migration as detections became available in 2013.

Tag Year	Tag Number	Last Summer Detection After Tagging 2011	Fall 2011	Winter 2011/12	Spring 2012	Summer 2012	Fall 2012	Winter 2012/13	Spring 2013	Summer 2013	Fall 2013	Comments
2011	3D9.1C2DABFB17	Bonneville Washington Shore Ladder - May 27th					Bonneville Washington Shore Ladder - October 3rd		Bonneville Dam Corner Collector - May 9th			New information added for Spring 2013.
2011	3D9.1C2DB4D354	Bonneville Washington Shore Ladder - August 26th			Maxwell Canal - May 20th Threemile Dam (Umatilla) - May 21st		Bonneville Oregon Shore Ladder - September 12th McNary - September 20th			Bonneville Bradford Island - July 29th		New steelhead added.
2011	3D9.1C2DB5075D	Bonneville Washington Shore Ladder - August 9th	McNary - September 18th Ice Harbor - September 20th Lower Granite - September 26th							Bonneville Bradford Island - August 11th Deschutes River Mouth - August 28th Deschutes River Mouth - September 29th	McNary - October 2nd Ice Harbor - October 4th Lower Granite - October 9th	New steelhead added. May have spent 2012 in the ocean.
2011	3D9.1C2DB53ABE	Bonneville Washington Shore Ladder - August 11th								The Dallas - August 7th Deschutes River Mouth - August 9th	McNary - October 3rd McNary Juvenile Bypass - October 16th John Day River - November 8th	New steelhead added. May have spent 2012 in the ocean.

Table A8. Season by season activities of several steelhead tagged in 2010 and later labeled as kelts when they began migrating downstream and upstream presumably to and from the ocean. Any new steelhead or steelhead with additional information from the 2010 report table is included here as new data on migration as detections became available in 2013.

Tag Year	Tag Number	Last Summer Detection After Tagging 2010	Fall 2010	Winter 2010/11	Spring 2011	Summer 2011	Fall 2011	Winter 2011/12	Spring 2012	Summer 2012	Fall 2012	Winter 2012/13	Spring 2013	Comments
2010	3D9.1C2D3F1CC4	Bonneville Washington Shore Ladder - July 20th								Bonneville Washington Shore Ladder - July 22nd			Bonneville Dam Corner Collector - May 12th	New information added for Spring 2013
2010	3D9.1C2D3FE181	Bonneville Washington Shore Ladder - July 20th			McNary - March 11th Walla Walla River - March 12th and 24th Bonneville Dam Corner Collector - May 8th					Bonneville Cascade Island - July 29th	McNary - November 27th	Walla Walla River - February 5th and 6th	Walla Walla River - March 2nd and 10th Walla Walla River - March 27th and 28th McNary Juvenile Bypass - April 6th	New information added for Spring 2013. Tracked to the Walla Walla River for spawning in 2011 and 2013. May have spent 2012 in the ocean.
2010	3D9.1C2D416459	Bonneville Washington Shore Ladder - July 26th	McNary - October 23rd Ice Harbor - October 26th Lower Granite - November 9th		Joseph Creek (Grande Ronde) - March 4th Little Goose Juvenile Bypass - May 6th					Bonneville Washington Shore Ladder - August 17th	McNary - October 21st Ice Harbor - October 23rd Lower Granite - November 6th		Joseph Creek (Grande Ronde) - March 12th Joseph Creek (Grande Ronde) - May 1st	New information added for Spring 2013. Tracked to a Grande Ronde Trib for spawning in 2011 and 2013. May have spent 2012 in the ocean.
2010	3D9.1C2D3CA357	Bonneville Washington Shore Ladder - July 10th								Bonneville Bradford Island - July 11th Lyle Falls Klickitat - July 15th			Bonneville Dam Corner Collector - May 13th	New information added for Spring 2013.

Table A9. Season by season activities of several steelhead tagged in 2009 and later labeled as kelts when they began migrating downstream and upstream presumably to and from the ocean. Any new steelhead or steelhead with additional information from the 2009 report table is included here as new data on migration as detections became available in 2013.

Tag Year	Tag Number	Last Summer Detection After Tagging 2009	Fall 2009	Winter 2009/10	Spring 2010	Summer 2010	Fall 2010	Winter 2010/11	Spring 2011	Summer 2011	Fall 2011	Spring 2012	Summer 2012	Comments
2009	3D9.1C2D07EA94	Bonneville Washington Shore Ladder - July 6th	Sherars Falls Trap (Deschutes) - October 2nd							Bonneville Washington Shore Ladder - September 5th		Trout Cr (Deschutes) - March 20th Bonneville Juvenile Bypass - April 26th		New information added for 2012. Tracked to the Deschutes River for spawning in 2009 and 2012. May have spent a year in the ocean.
2009	3D9.1C2D0A1E39	Bonneville Washington Shore Ladder - July 21st			Threemile Dam Umatilla R - May 17th					Bonneville Washington Shore Ladder - July 1st		Threemile Dam Umatilla R - May 5th		New information added for 2012.
2009	3D9.1C2D0A2039	Bonneville Washington Shore Ladder - August 11th	McNary - September 7th	Rock Creek two sites - February 6th to 27th.	Bonneville Dam Corner Collector - April 14th	Bonneville Oregon Shore Ladder - August 21st	McNary - September 21st	Rock Creek Lower - February 6th into March	Rock Creek two sites - From February to March 22nd				Bonneville Bradford Island - July 22nd	New information added for 2012. Tracked to Rock Creek for spawning in two consecutive years 2010 and 2011 and found migrating from the ocean for a third year 2012 .

Key - - - Upstream | Downstream | Spawning

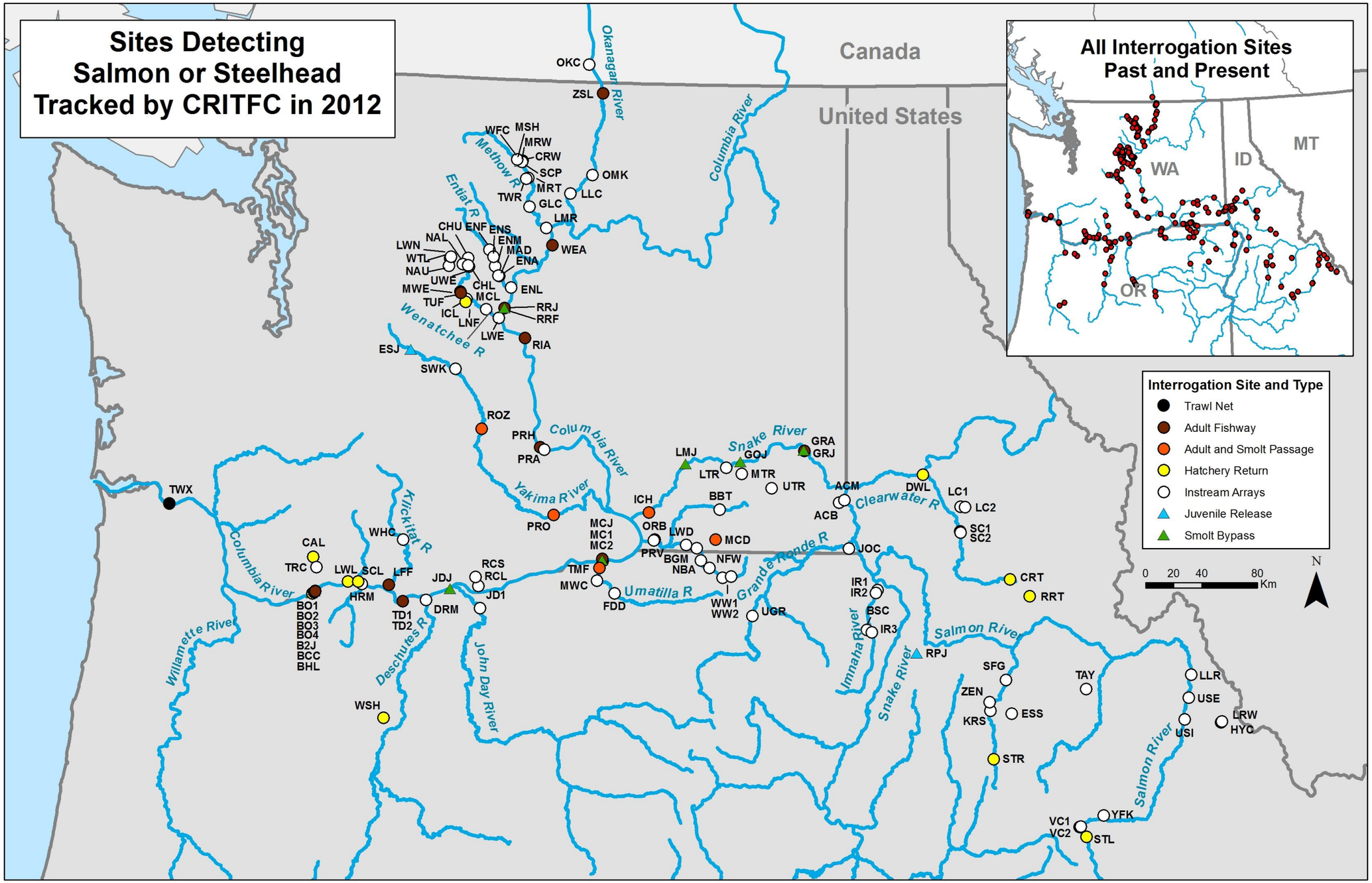

Figure A1. Map of Columbia River interrogation sites that detected Chinook and sockeye salmon, and steelhead in 2012. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

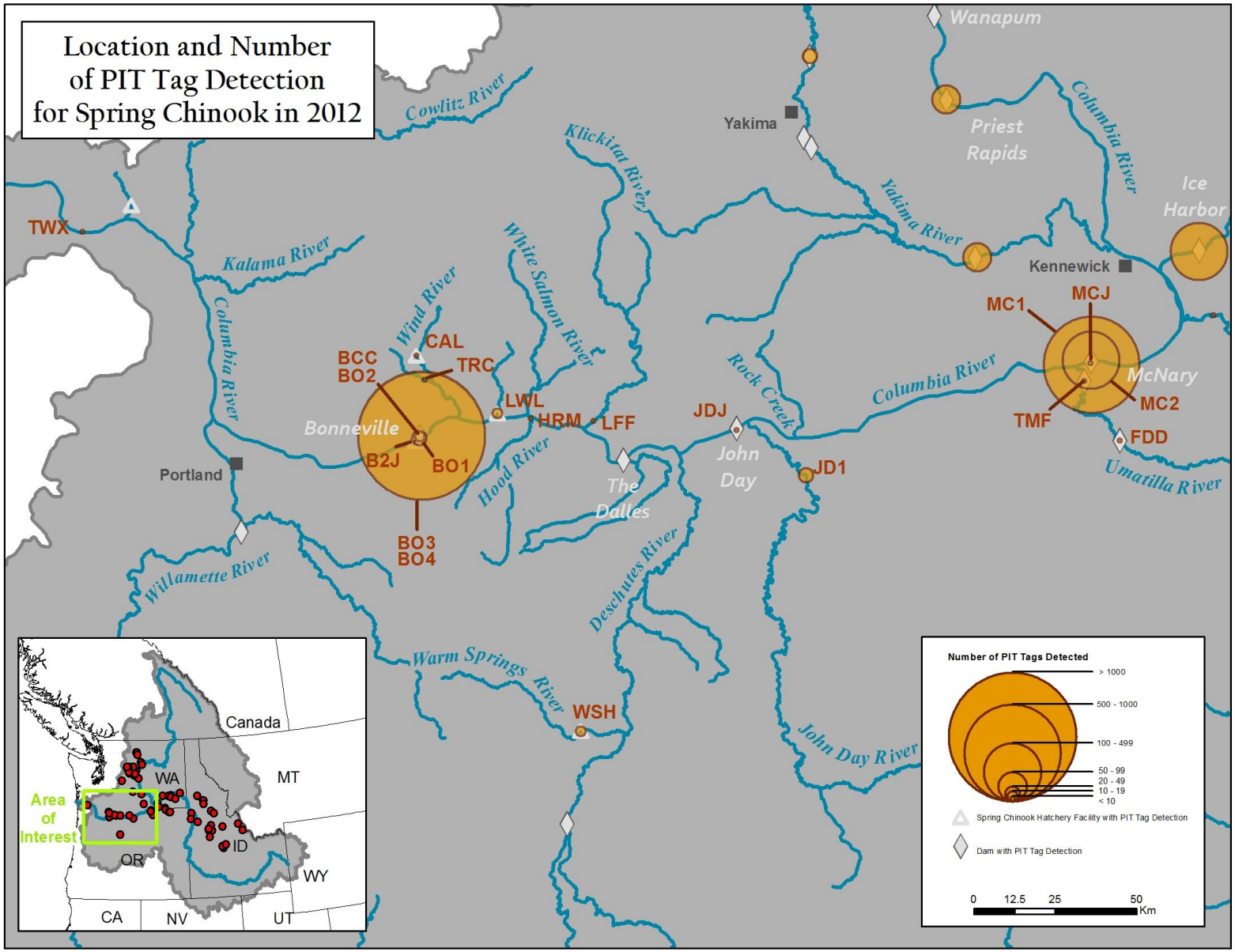

Figure A2. Map of Lower Columbia River detections sites and number of spring Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

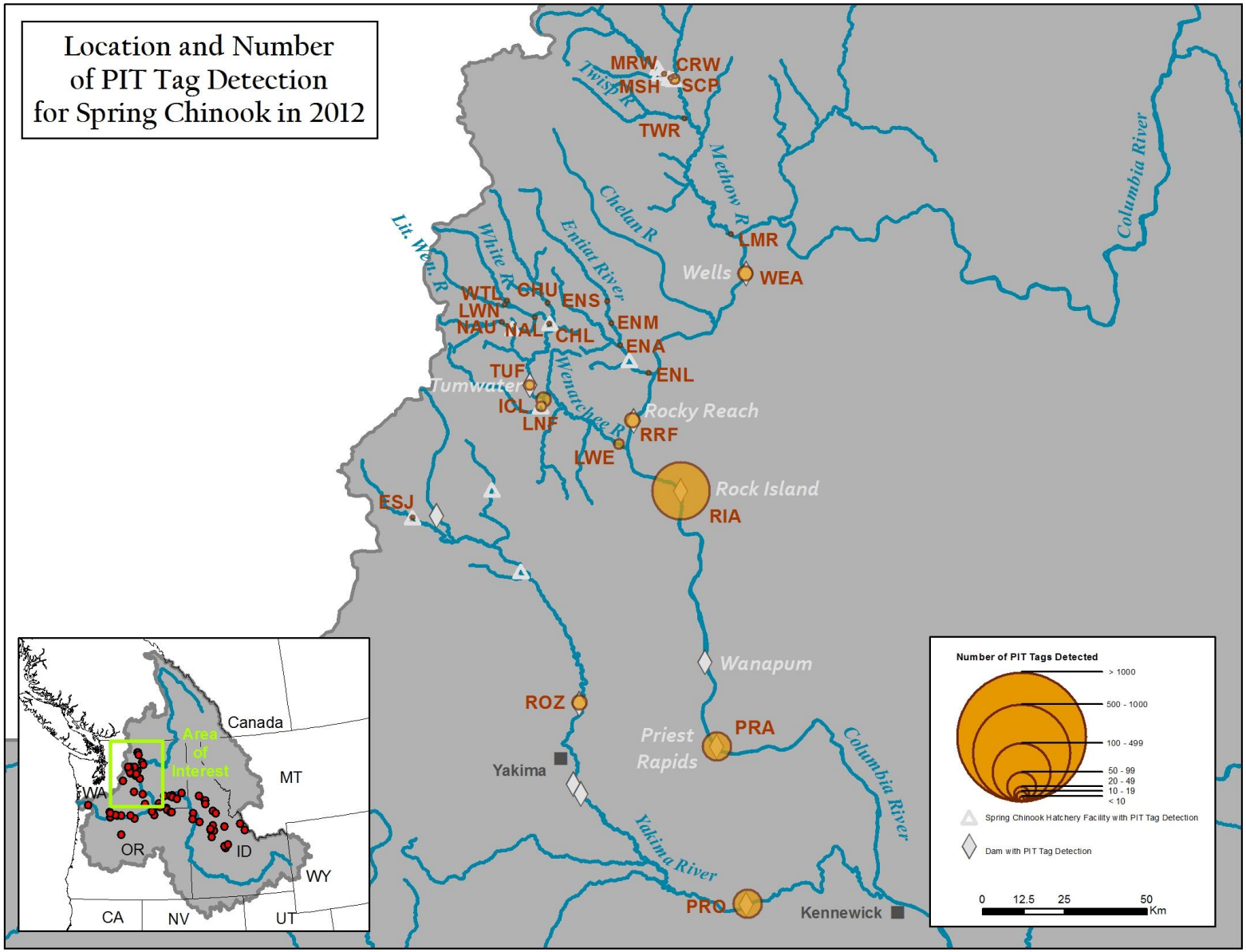

Figure A3. Map of Upper Columbia River detections sites and number of spring Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

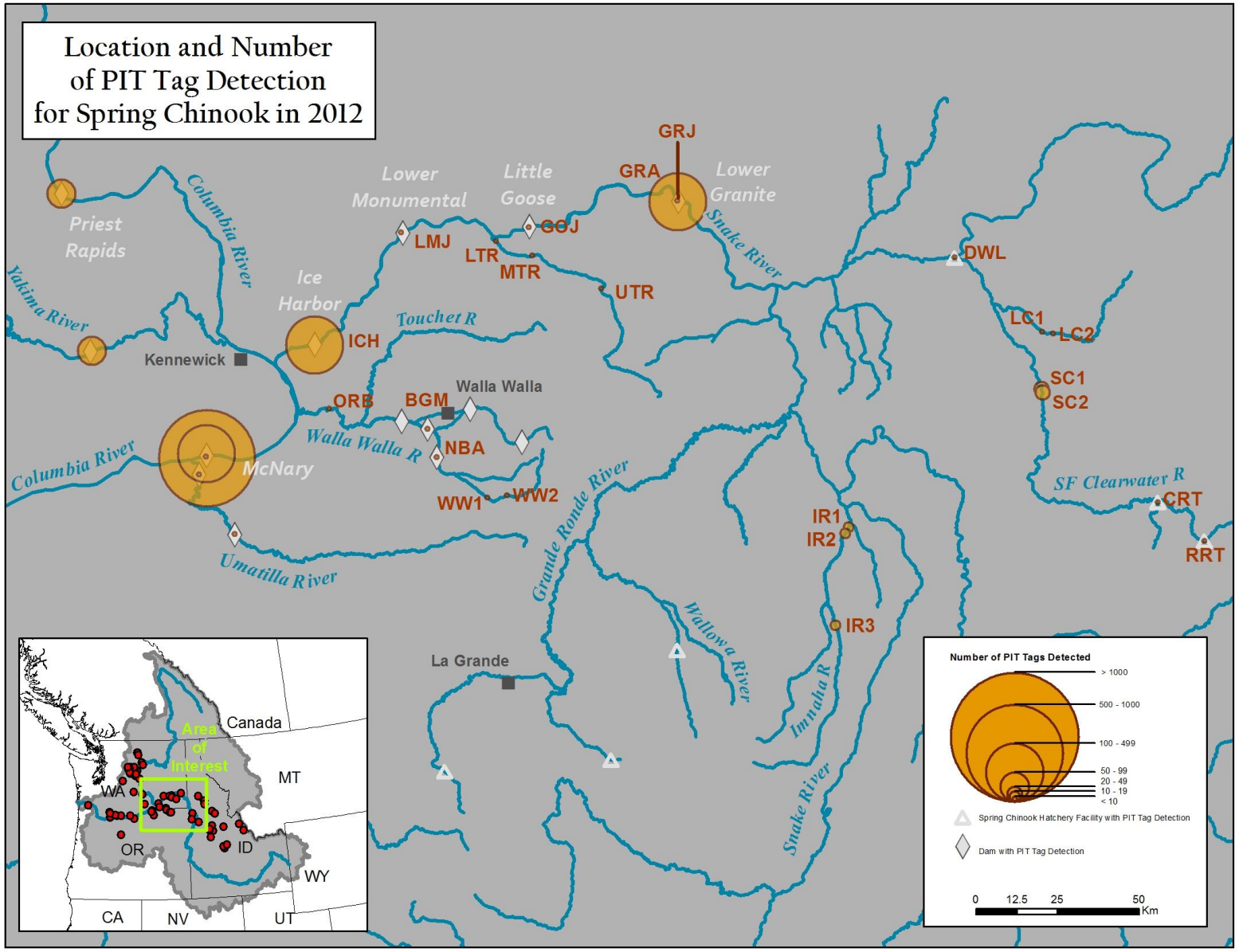

Figure A4. Map of Lower Snake River detections sites and number of spring Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

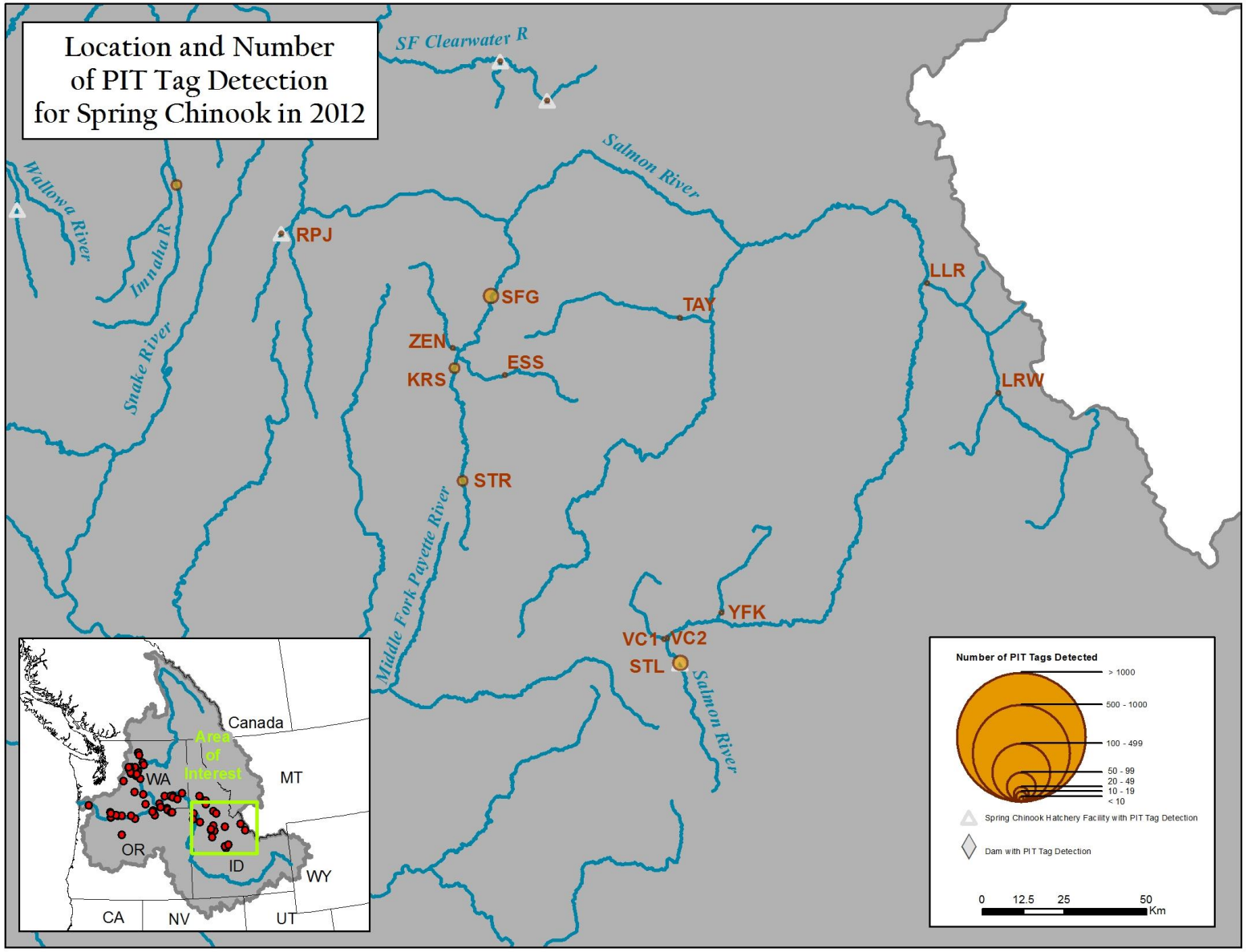

Figure A5. Map of Salmon River detections sites and number of spring Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Spring Chinook is defined as fish passing Bonneville Dam from January 1 to June 1.

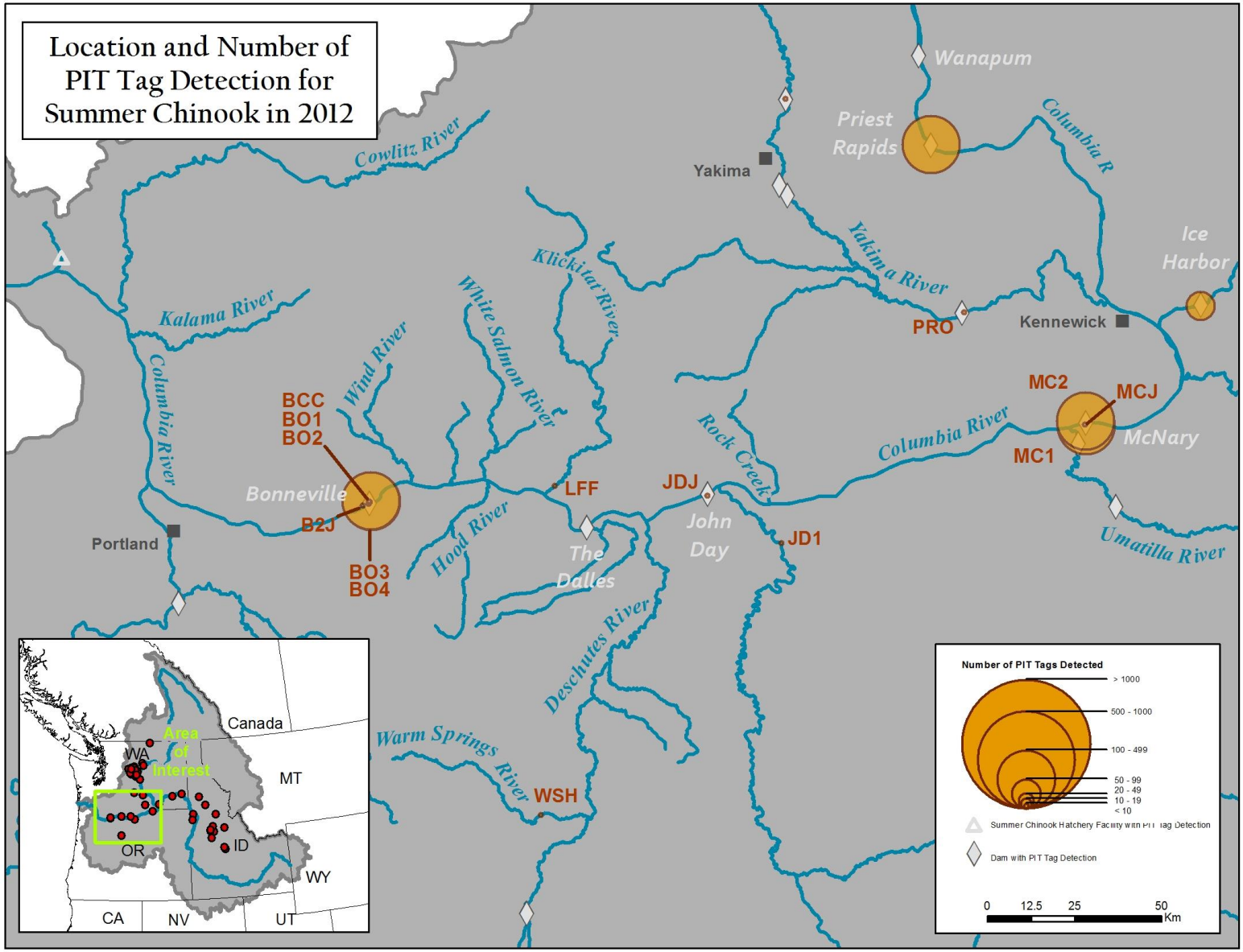

Figure A6. Map of Lower Columbia River detections sites and number of summer Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

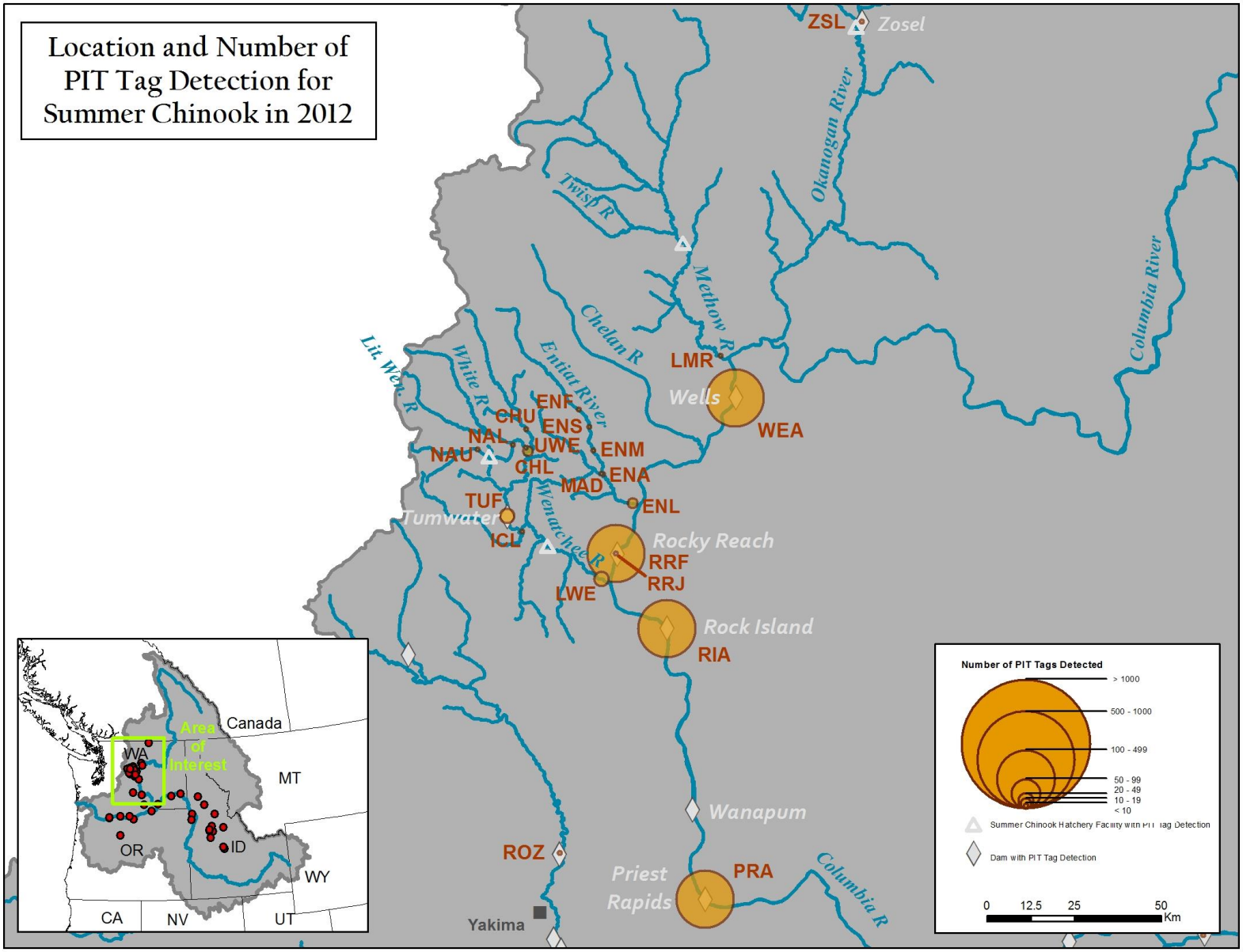

Figure A7. Map of Upper Columbia River detections sites and number of summer Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

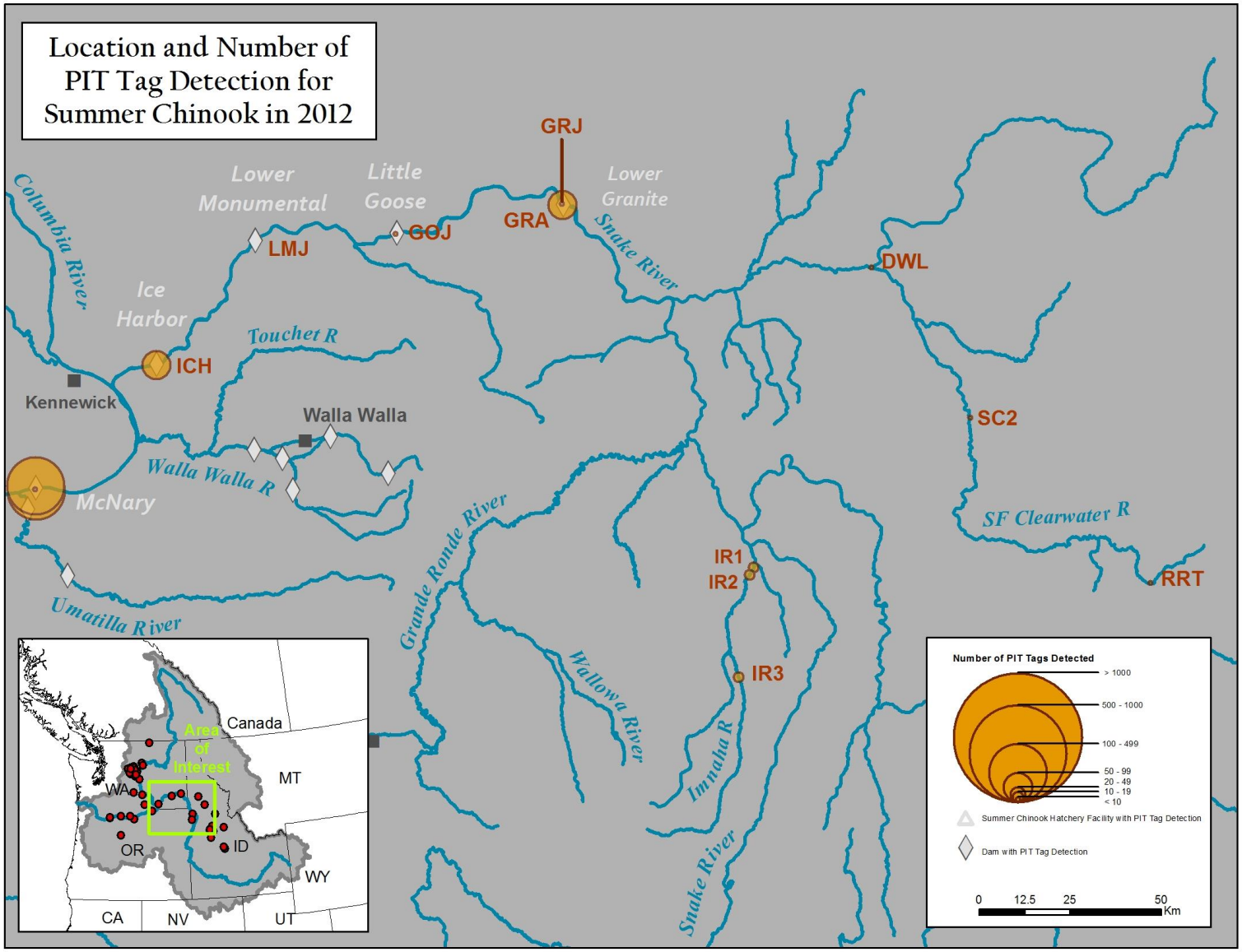

Figure A8. Map of Lower Snake River detections sites and number of summer Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

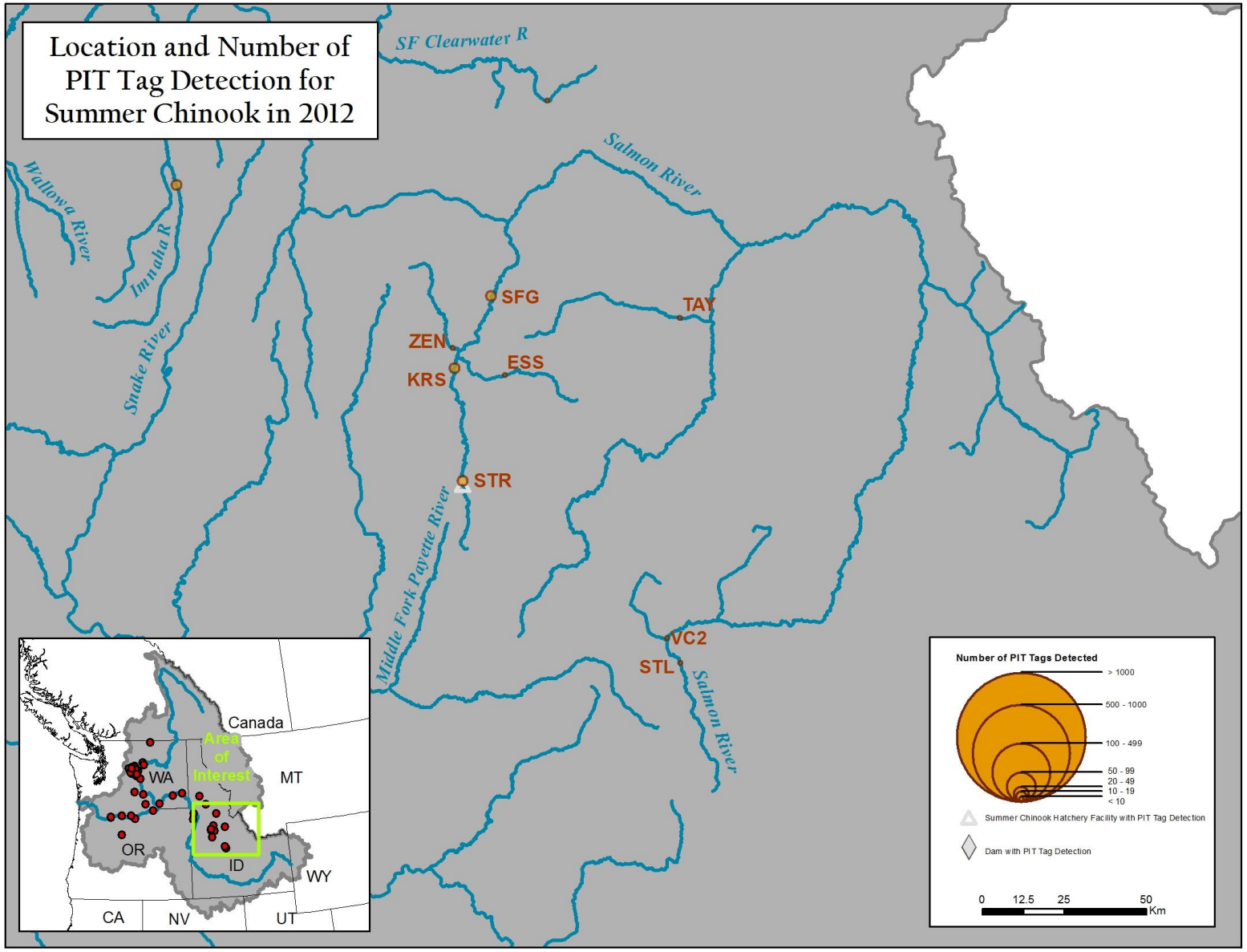

Figure A9. Map of Salmon River detections sites and number of summer Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Summer Chinook is defined as fish passing Bonneville Dam from June 1 to August 1.

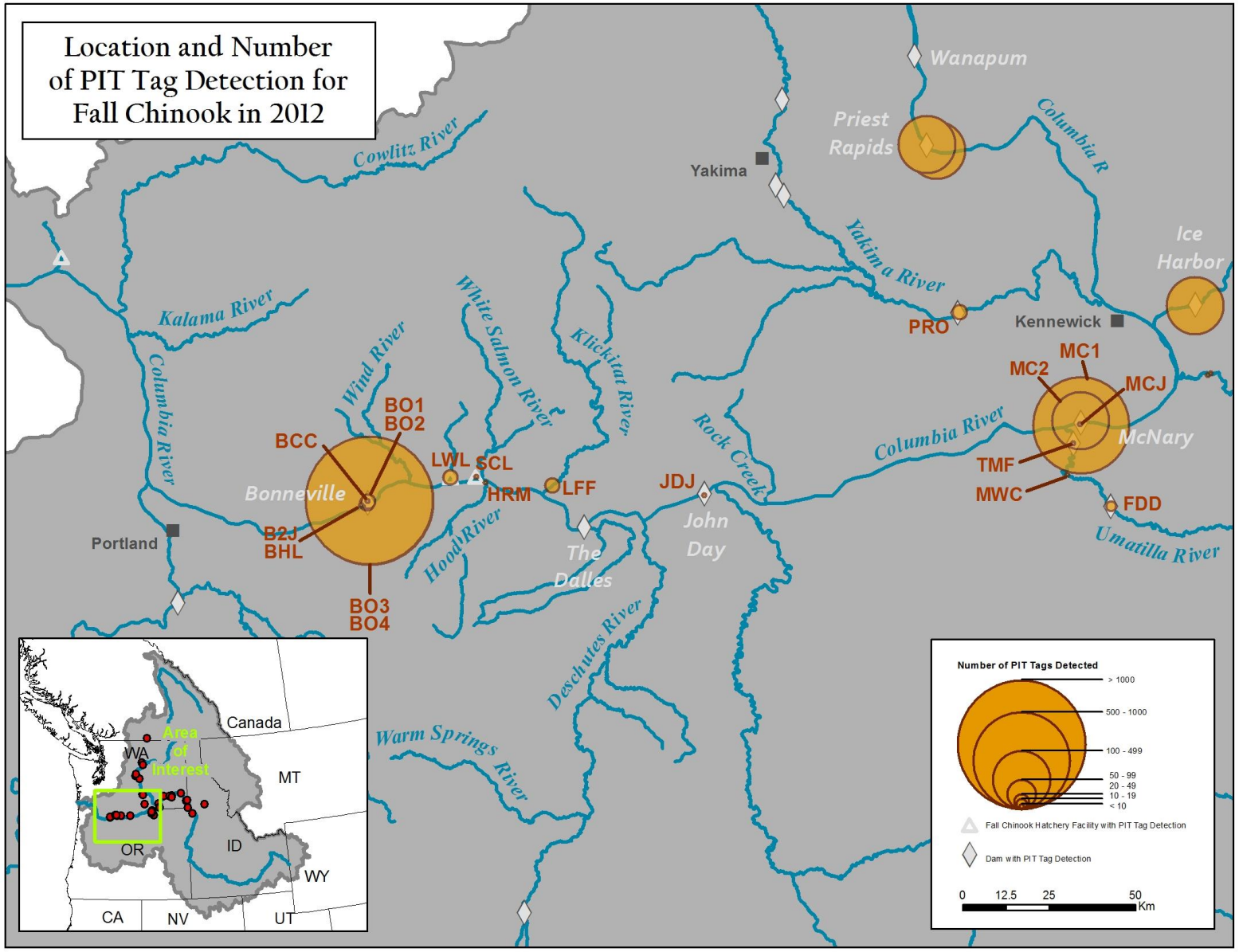

Figure A10. Map of Lower Columbia River detections sites and number of fall Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

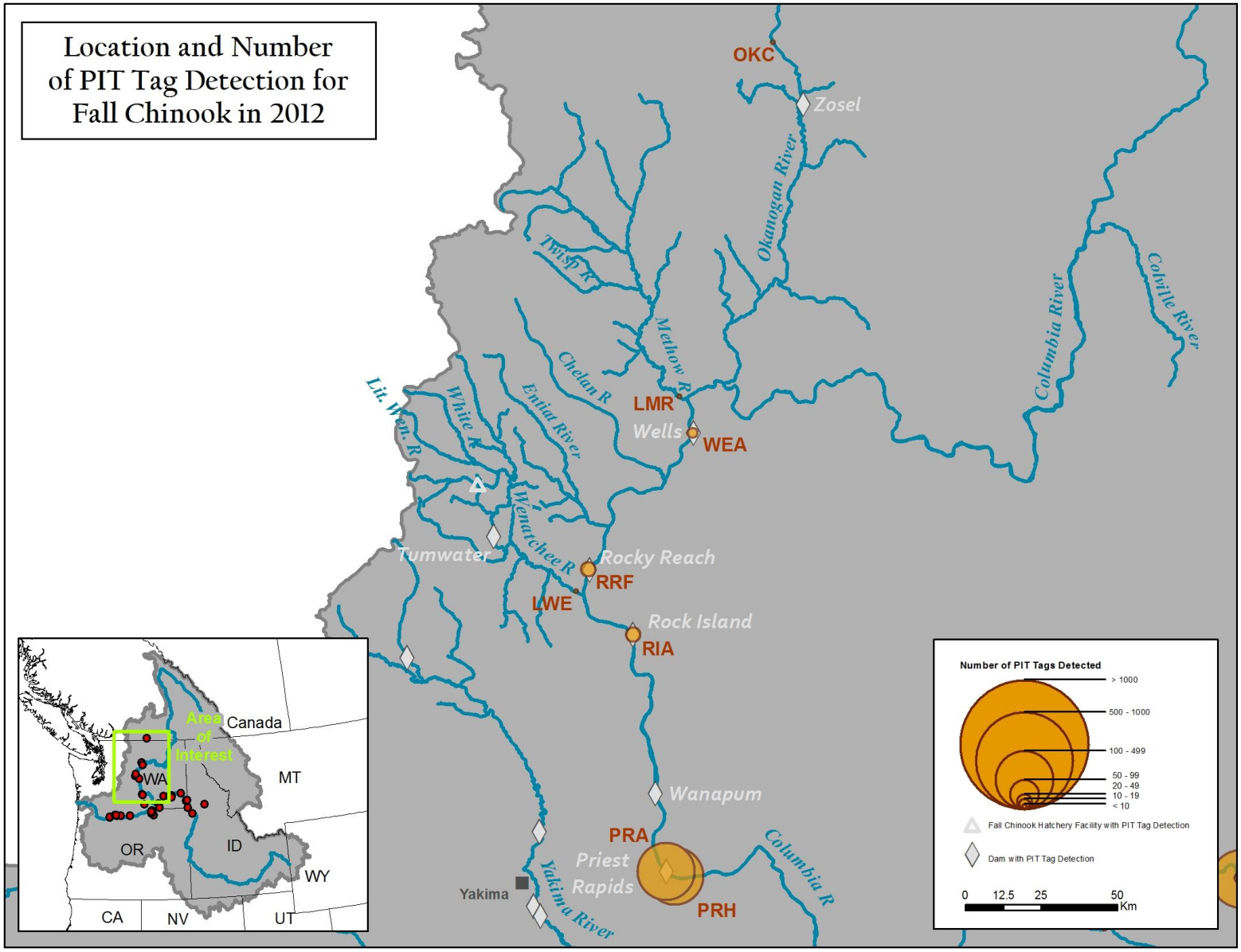

Figure A11. Map of Upper Columbia River detections sites and number of fall Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

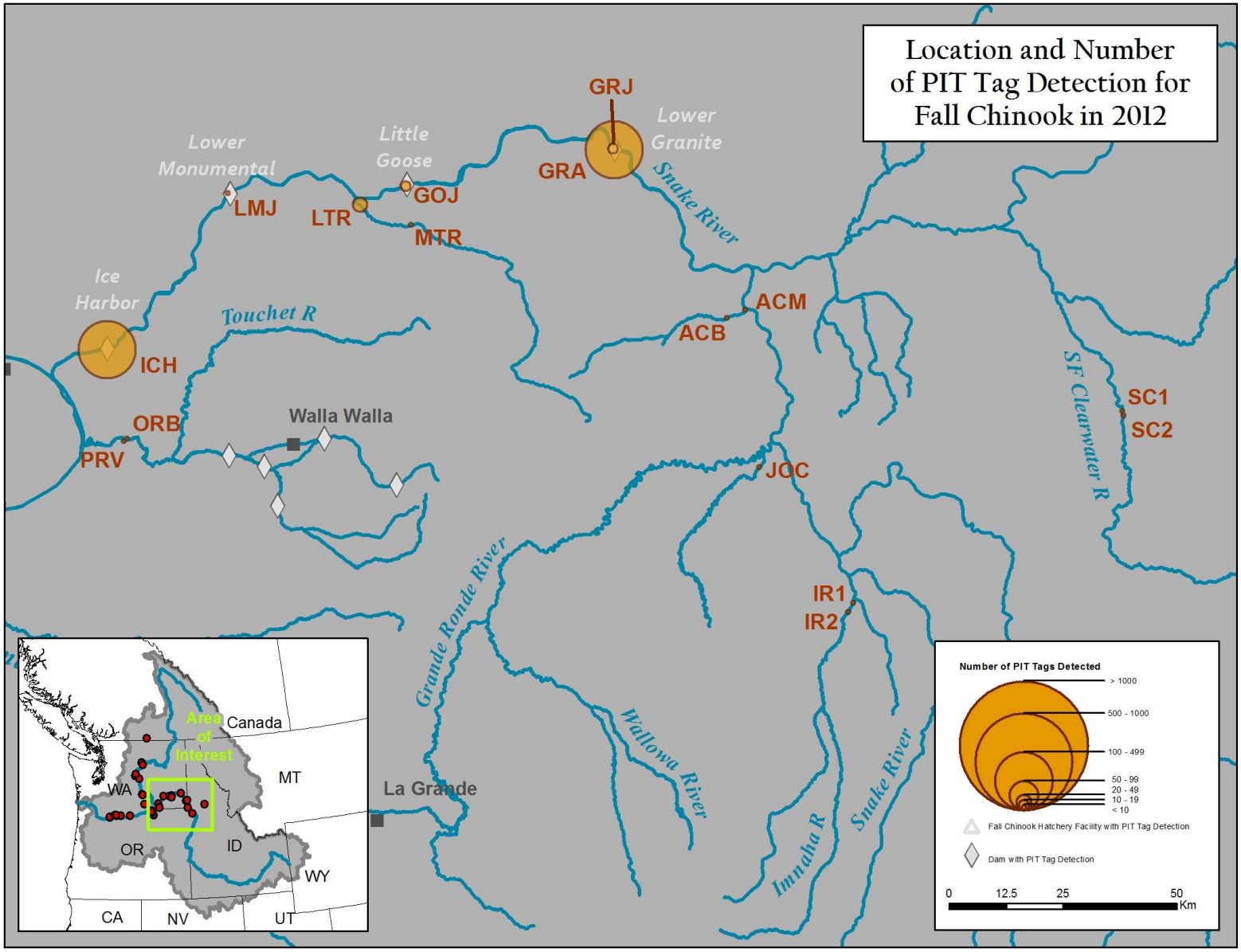

Figure A12. Map of Lower Snake River detections sites and number of fall Chinook detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map. Fall Chinook is defined as fish passing Bonneville Dam from August 1 to end of year.

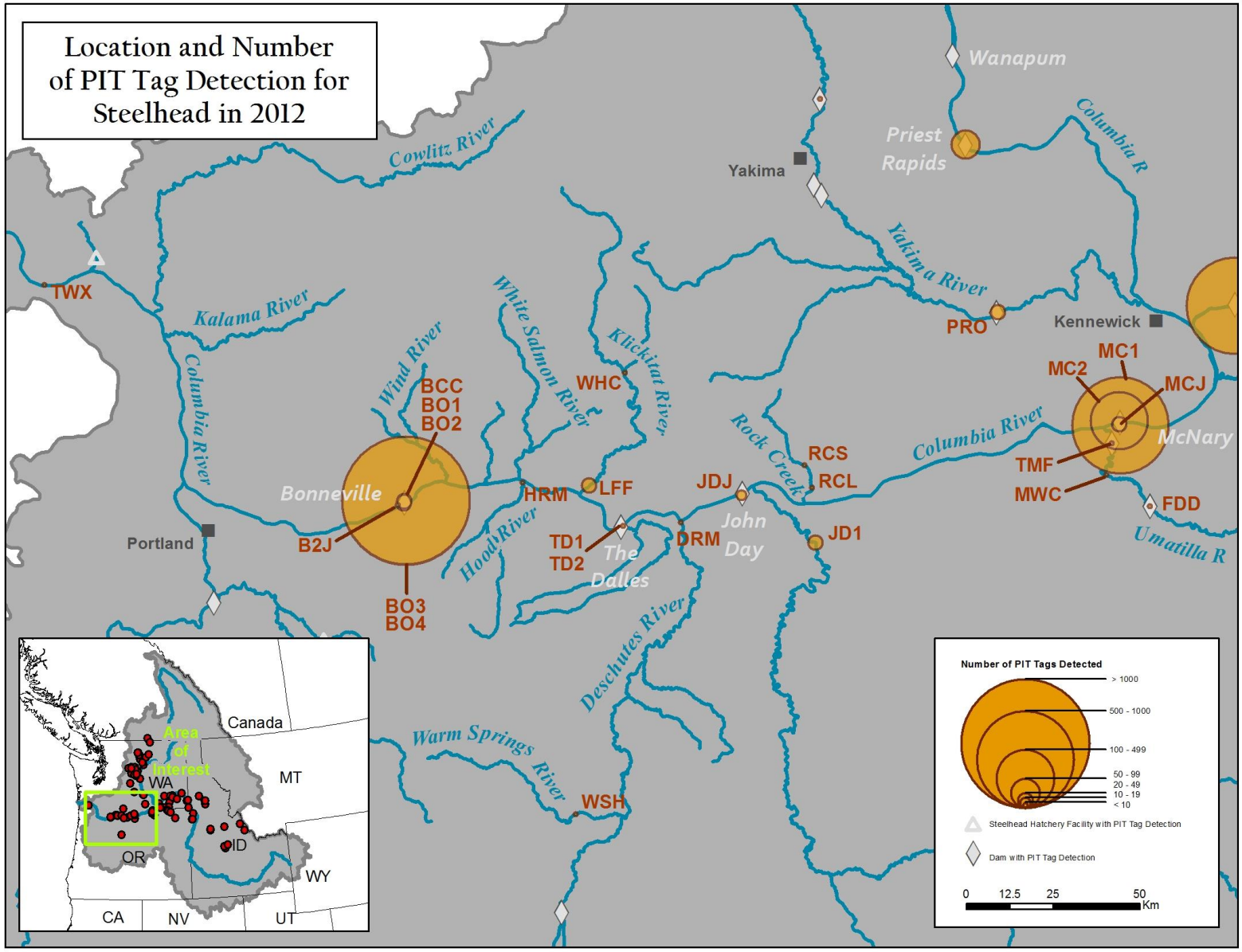

Figure A13. Map of Lower Columbia River detections sites and number of steelhead detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

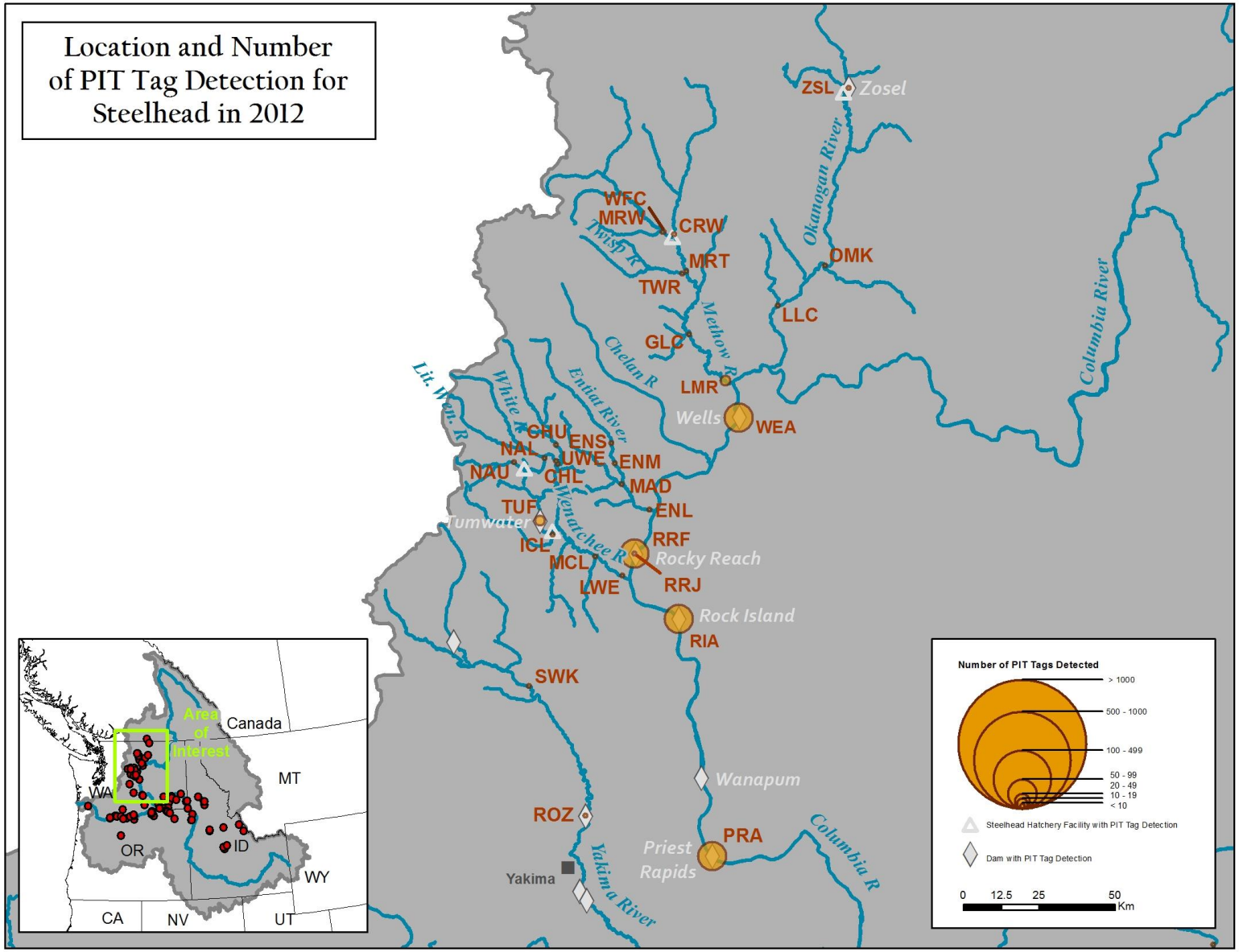

Figure A14. Map of Upper Columbia River detections sites and number of steelhead detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

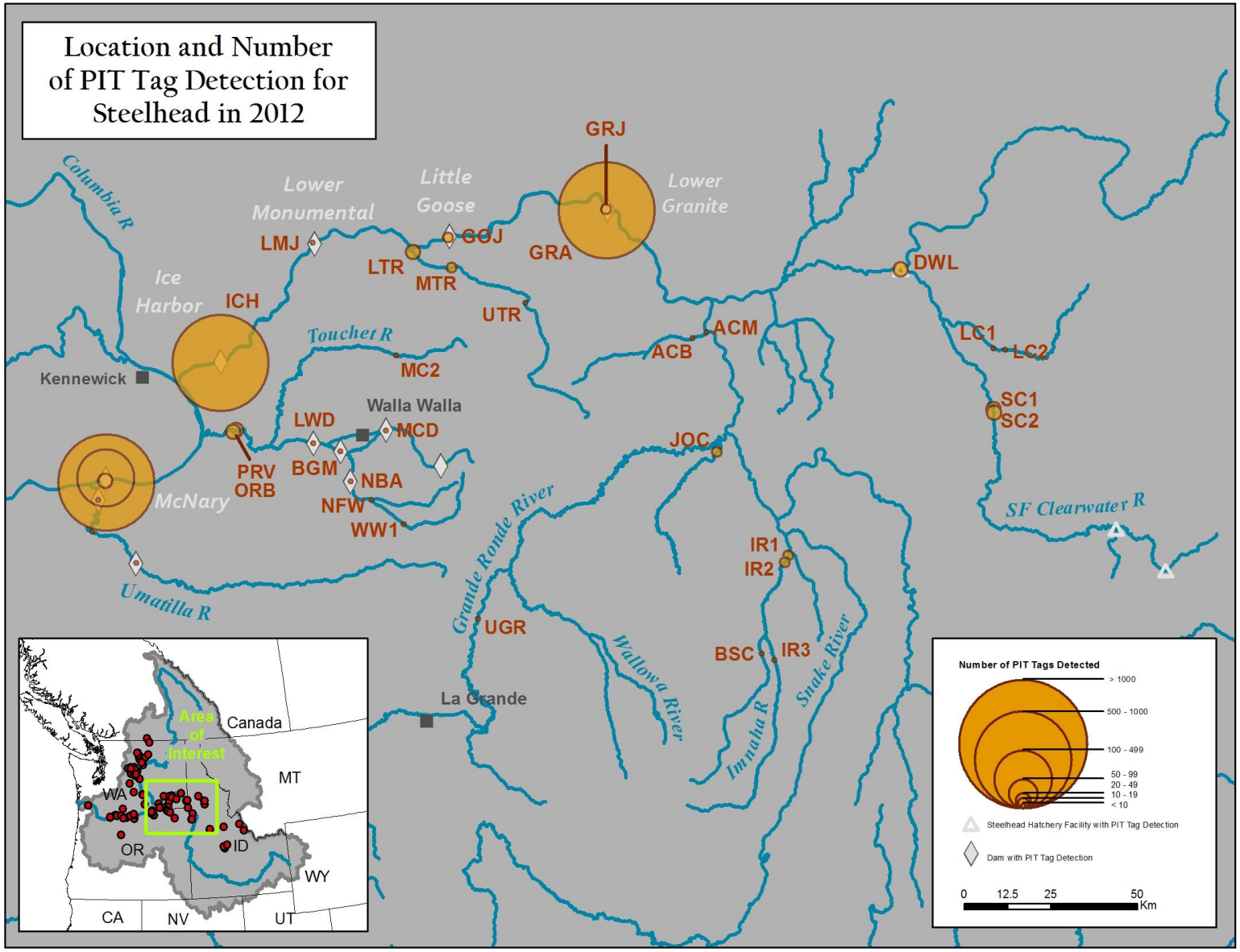

Figure A15. Map of Lower Snake River detections sites and number of steelhead detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

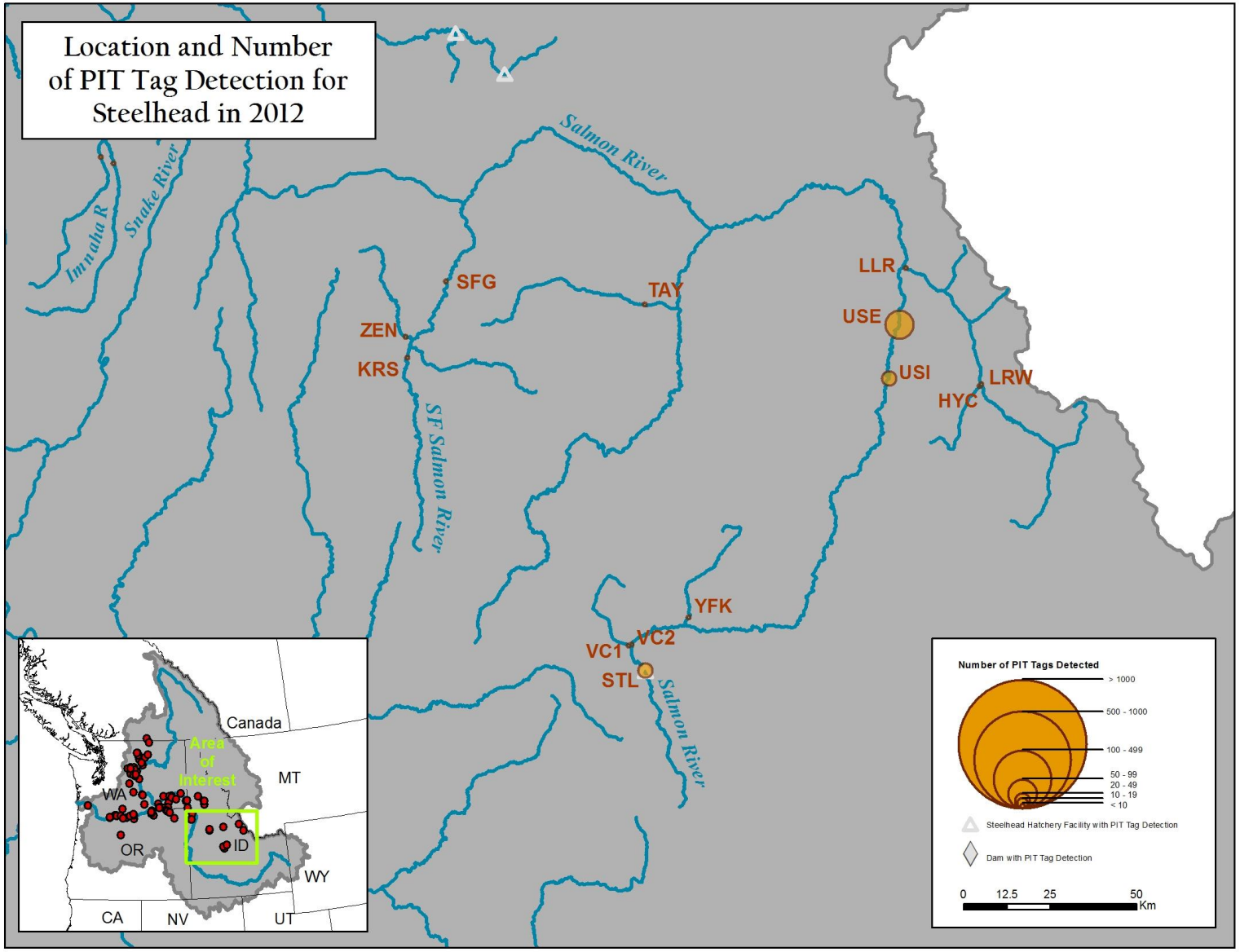

Figure A16. Map of Salmon River detections sites and number of steelhead detected. Table A5 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.