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Upstream Migration Timing of Columbia Basin Chinook Salmon, Sockeye Salmon, and Steelhead in 2010

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March 31, 2012

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ABSTRACT

In 2010 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 1004 spring Chinook, 495 summer Chinook, 1060 fall Chinook, 1708 steelhead, and 870 sockeye salmon.

Chinook travel rates between mainstem dams ranged between 20 and 53 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 did not pass 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 -11.4% to +22.3% at mainstem dams.

Steelhead median rates between mainstem dams ranged from 16.3 km to 44.5 km/day. Steelhead classified as B-run (greater or equal to 78 cm fork length) were overwhelmingly last detected in the Snake River. Based on the data reported, the percentage of steelhead classified as B-run at Bonneville Dam peaked in September at nearly 70% of the run, while the estimated weekly number of B-run steelhead passing Bonneville Dam peaked in August at over 15,000 fish. A total of 86 PIT tagged steelhead tracked in 2010 were detected moving downstream (mostly in juvenile bypasses) after February, 2011, presumably in an attempt to return to the ocean after spawning.

The estimated stock composition of sockeye salmon passing Bonneville Dam was 81.8% Okanagan, 17.3% Wenatchee, and 0.9% Snake. Upstream survival of sockeye salmon steadily declined as the migration progressed; Bonneville-Rock Island survival declined from as much as 93.5% for sockeye salmon passing Bonneville Dam during June to less than 80% during July.

The mean travel rate between Bonneville and Rock Island Dam was 37.8 km per day. Fish 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, PIT tagged fish information is readily available to all managers and researchers on a 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 the our project randomly samples adult salmon and steelhead passing the dam, this study will likely tag 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 12 through October 21, 2010, 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.

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 A3 and Figure A1). Many of the receivers automatically upload (real-time) PIT tag detection data to www.ptagis.org, which is then accessible to registered users of the site.

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*).* 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.

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 called a "site detection". For example, the configuration of PIT tag antennas at Rock Island Dam is shown in Figure 1.

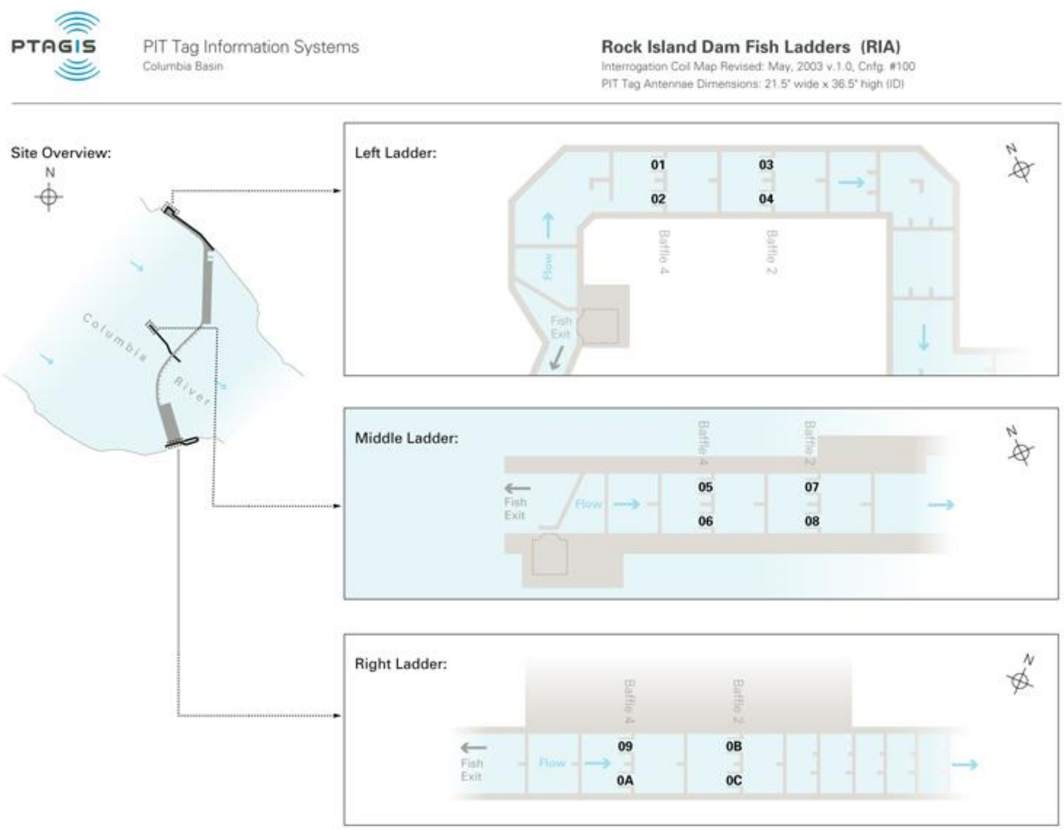

Figure 1. Example PIT tag configuration at Rock Island Dam showing two adjoining antennas at two weirs in each fish ladder.

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).

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. Escapement estimates were not calculated for sites where $\sum T_i < 15$. 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.

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; for example, the percentage missed at Rocky Reach Dam was calculated as:

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

where R_m was the number of fish missed at Rocky Reach Dam but detected upstream at Wells Dam and R_d was the number of fish detected passing 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 and A2.

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.

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 Pacific Standard Time, while fish at 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).

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 it. 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 lower weir is defined as lowest PIT tag detector in 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 downstream dam. 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 after February, 2011 were

not considered fallbacks; rather they were considered kelts on their way downstream.

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) after February 2011 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 small 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 Okanagan 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 993 spring Chinook, 490 summer Chinook, and 1055 fall Chinook salmon were PIT tagged in 2010 (Table 1). No sampling was conducted during Statistical Week 34 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 Chinook shedding tags, mortalities, or Chinook missing PIT tag antennas on their way up or downstream), the numbers of Chinook tracked upstream consisted of 1004 spring Chinook, 495 summer Chinook, and 1060 fall Chinook salmon (Table 1).

Table 1. Number of Chinook salmon PIT tagged at Bonneville Dam and tracked, by date and statistical week in 2010.

Spring Chinook

Dates	Statistical Week	Tagged (n)	Previously Tagged	Not Detected above Bonneville	Total Tracked (including recaps)
4/12-16	16	38	2	0	40
4/19,21-23	17	150	0	0	150
4/26-30	18	231	4	2	233
5/3-7	19	230	5	1	234
5/10,12-14	20	144	1	1	144
5/17-21	21	105	3	3	105
5/24-27	22	95	4	1	98
Total		**993**	**19**	**8**	**1004**

Summer Chinook

Dates	Statistical Week	Tagged (n)	Previously Tagged	Not Detected above Bonneville	Total Tracked (including recaps)
6/1-6/4	23	105	2	1	106
6/7-6/11	24	110	3	1	112
6/14-6/18	25	57	1	0	58
6/21-6/25	26	55	0	1	54
6/28-7/2	27	66	3	0	69
7/7-7/9	28	43	0	0	43
7/12-7/16	29	23	0	1	22
7/19-7/23	30	16	0	0	16
7/26-7/29	31	15	0	0	15
Total		**490**	**9**	**4**	**495**

Fall Chinook

8/4-8/6	32	6	1	0	7
8/10-8/13	33	17	1	1	17
8/24-8/26	35	87	1	0	88
8/30-9/3	36	175	3	2	176
9/7-9/10	37	157	1	2	156
9/13-9/17	38	150	3	0	153
9/20-9/24	39	170	2	0	172
9/27-10/1	40	149	1	2	148
10/5-10/8	41	102	0	1	101
10/11-10/13	42	37	0	0	37
10/20-10/21	43	5	0	0	5
Total		**1055**	**13**	**8**	**1060**
Grand Total		**2538**	**41**	**20**	**2559**

Distribution of Sample

Compared to the run distribution, spring Chinook were under-sampled early in the run and over-sampled during the middle and end of the run (Figure 2). With the exception of Statistical Week 23, 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). Unlike many previous years, we did not under-sample the portion of the Chinook run that passed Bonneville Dam during periods of high temperatures when sampling is usually shut down (>22.1C) or reduced (21.1-22.2 C) which occurred primarily during Statistical Week 33 as well as portions of weeks 32 and 35.

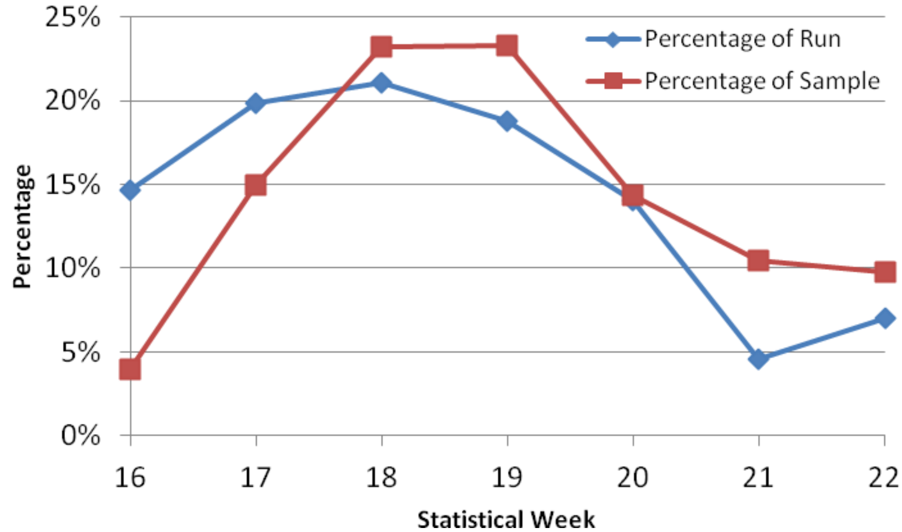

Figure 2. Percentage of the spring Chinook sample size and run size by statistical week at Bonneville Dam in 2010.

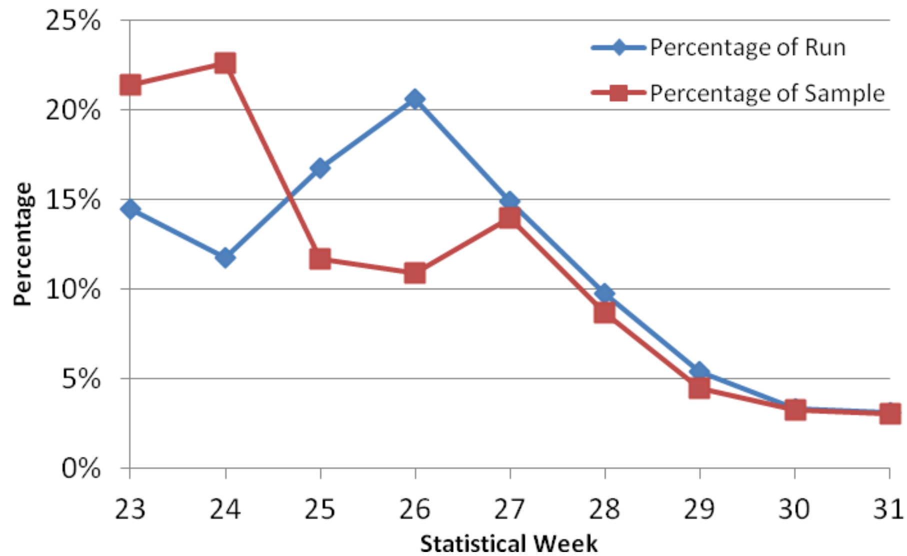

Figure 3. Percentage of the summer Chinook sample size and run size by statistical week at Bonneville Dam in 2010.

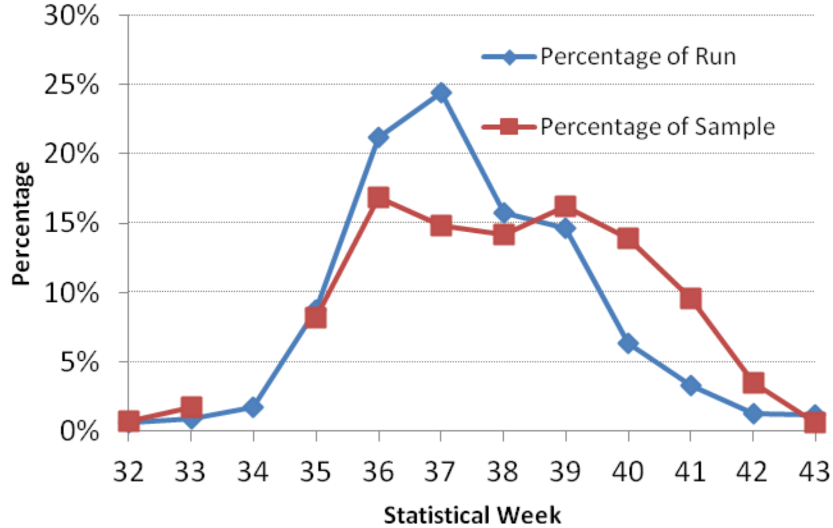

Figure 4. Percentage of the fall Chinook sample size and run size by statistical week at Bonneville Dam in 2010. Due to high water temperature, sampling did not occur during Week 34.

Detection Numbers

The tracking of 1004 spring Chinook generated 46,439 weir detections, which were grouped into 4,059 site detections at 62 sites. The 495 summer Chinook generated 26,392 weir detections, grouped into 2,559 site detections at 42 sites, and the 1060 fall Chinook generated 40,486 weir detections grouped into 3,261 site detections at 28 sites. Maps found in the Appendix (Figure A2-A12) show the categorical ranges of detection numbers at the sites throughout the Columbia Basin. Note that the Chinook tracked in each run is determined by the migration timing at Bonneville, spring Chinook run ends May 31st, summer Chinook run ends July 31st, and the fall Chinook run starts August 1st (FPC 2012).

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. Age estimates from ageable scale patterns of 38 Chinook salmon that had been previously PIT tagged were correctly aged as follows: all 13 spring Chinook, all 14 summer Chinook, and 7 out of 8 fall Chinook salmon. Only the total age was compared, for it is not possible to separately validate freshwater and ocean age.

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 are less than 36 cm in length. 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 sampled with lengths of 37.0 and 46.0 cm were identified from scale patterns as being Age 1.0 and therefore minijacks. Although these fish were PIT tagged they were excluded from all analyses in this study[a].

Mainstem Dam Recoveries, Mortality, and Escapement Estimates

Spring Chinook salmon that traveled upstream of McNary Dam were primarily bound for the Snake River (Table 2, Figures 5 and 6), while summer Chinook were primarily bound for the Columbia River upstream of Priest Rapids Dam (Table 2, 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 2, Figures 5 and 8). Over the first half of the 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 Chinook that ultimately passed Ice Harbor Dam rose through the early part of the run before dropping after Statistical Week 24. The majority of the fall Chinook run, after Statistical Week 38, is 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.

[a] The first minijack (3D9.1C2D079D13) was tagged at Bonneville Dam on May 12 and last detected at Roza Dam on the Yakima River on June 9. The second minijack (3D9.1C2D3F3A83) was tagged on September 10 and last detected at McNary Dam on September 30.

Table 2. 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, or mortality between dams in 2010.

	Spring Chinook		Summer Chinook		Fall Chinook	
Dam	**Reach Dam**	**Decrease from Downstream Dam**	**Reach Dam**	**Decrease from Downstream Dam**	**Reach Dam**	**Decrease from Downstream Dam**
Bonneville	100.0%	--	100.0%	--	100.0%	--
McNary	57.4%	42.6%	77.2%	22.8%	56.5%	43.5%
Priest Rapids	10.7%	81.4%	45.8%	40.7%	5.8%	89.7%
Rock Island	10.5%	1.6%	44.6%	2.7%	2.0%	66.5%
Rocky Reach	3.8%	63.7%	32.1%	28.1%	1.3%	32.7%
Wells	3.3%	13.2%	26.0%	19.1%	0.5%	65.3%
Ice Harbor	37.9%	34.0%	29.3%	62.1%	20.0%	64.6%
Lower Granite	35.3%	6.8%	28.1%	4.2%	18.2%	9.1%

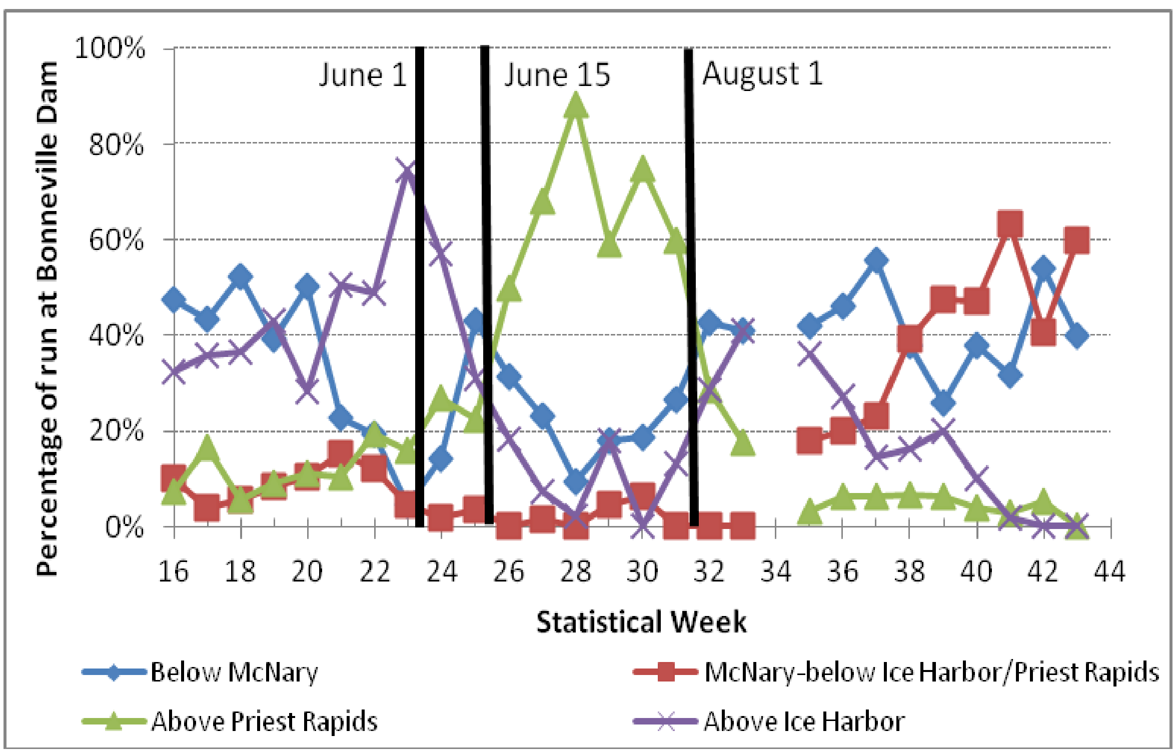

Figure 5. Distribution of final detection areas of the Columbia Basin by statistical week for Chinook salmon that were PIT tagged at Bonneville Dam in 2010.

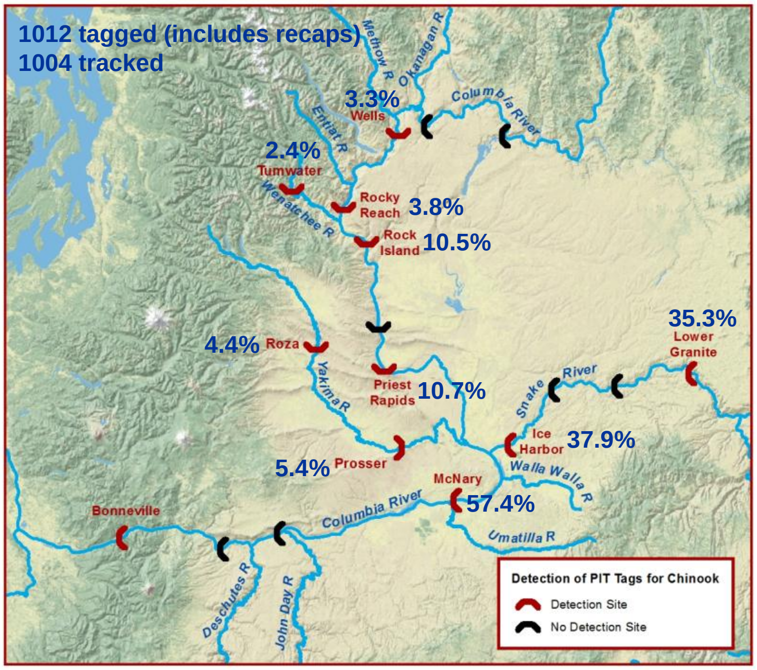

Figure 6. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of spring Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2010.

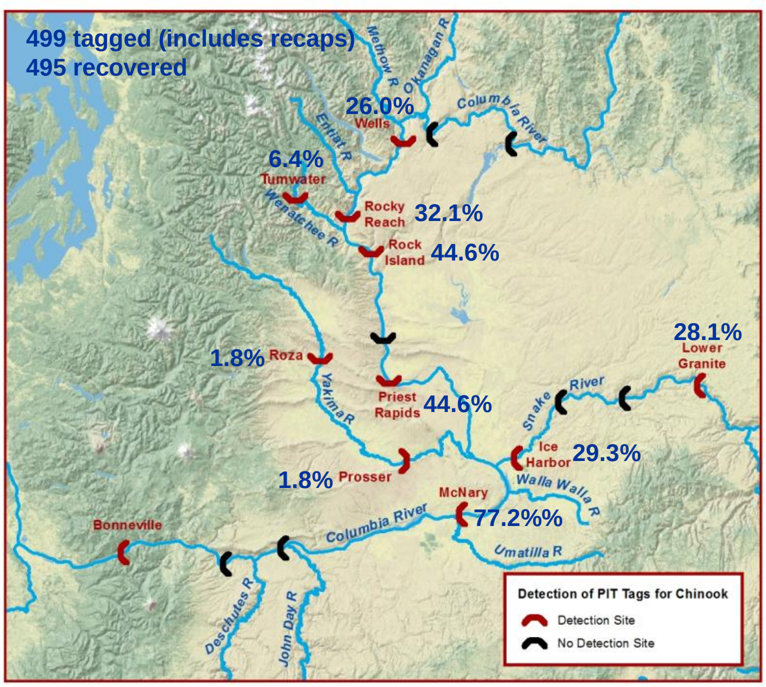

Figure 7. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of summer Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2010.

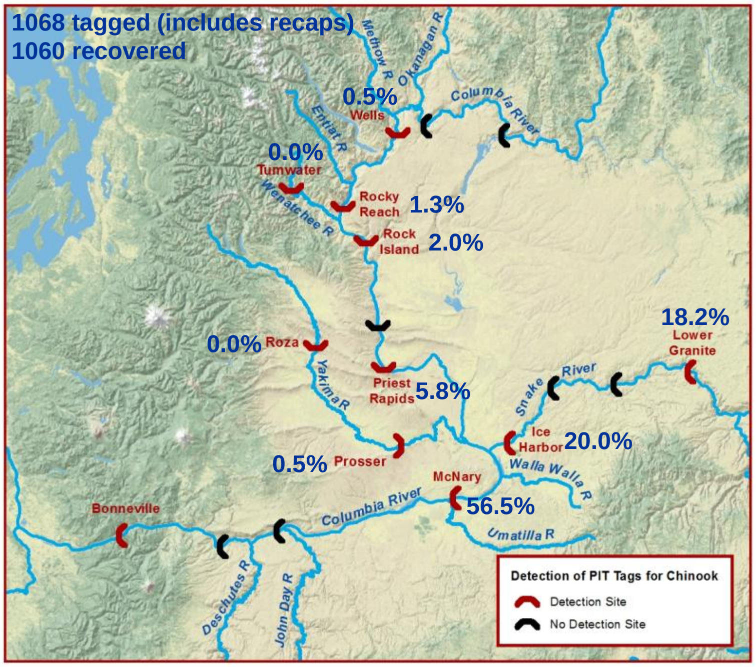

Figure 8. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fall Chinook salmon PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2010.

The percentage of PIT tagged Chinook salmon passing a dam without detection was generally under 2% (Table 3). Exceptions were summer and fall Chinook at Rock Island Dam, which is known to have problems with detection due to the antenna size and electrical noise (D. Marvin, Pacific States Marine Fisheries Commission, personal communication), and summer Chinook at Ice Harbor Dam which has navigation locks where fish can pass undetected. The detection efficiency of individual weirs within ladders is found in the Appendix (Table A1).

Table 3. Percentage of Chinook salmon passing a dam undetected that were subsequently detected at an upstream dam in 2010.

Dam	Spring Chinook	Summer Chinook	Fall Chinook
Bonneville	1.0%	1.2%	1.0%
McNary	0.5%	1.5%	0.5%
Priest Rapids	1.8%	0.5%	0.0%
Rock Island	0.9%	4.7%	12.0%
Rocky Reach	0.0%	0.0%	0.0%
Wells	0.0%	0.0%	0.0%
Ice Harbor	0.2%	3.2%	0.5%
Lower Granite	0.0%	0.0%	0.0%

Escapement estimates for the entire Chinook run derived from PIT tag detections result in estimates that are relatively similar to visual counts for spring and summer Chinook; however, there are large differences for fall Chinook (Table 4). Our fall Chinook sampling, for some unknown reason at this time, apparently over-sampled Snake River Chinook, while under-sampling Chinook salmon migrating upstream of Priest Rapids Dam.

Table 4. Chinook salmon escapement in 2010, by run, at Columbia Basin mainstem dams upstream of Bonneville Dam. Estimations 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	162685	147630	-9.3%	74589	87427	17.2%
Priest Rapids	31471	27420	-12.9%	50482	51851	2.7%
Rock Island	31197	26986	-13.5%	51238	50473	-1.5%
Rocky Reach	9183	9793	6.6%	35897	36308	1.1%
Wells	8257	8496	2.9%	28950	29383	1.5%
Ice Harbor	107235	97400	-9.2%	33086	33153	0.2%
Lower Granite	100612	90818	-9.7%	34072	31774	-6.7%
	Fall Chinook Salmon			**All Chinook Salmon**		
McNary	200464	300333	49.8%	437738	535390	22.3%
Priest Rapids	42490	30959	-27.1%	124443	1102308	-11.4%
Rock Island	14226	10376	-27.1%	96661	87834	-9.1%
Rocky Reach	10803	6981	-35.4%	55883	53082	-5.0%
Wells	4203	2424	-42.3%	41410	40303	-2.7%
Ice Harbor	58771	106373	81.0%	199092	236926	19.0%
Lower Granite	54710	96740	76.8%	189394	219331	15.8%

Tributary escapement estimates for five sites, with more than 15 detections, are found in Table 5 alongside estimates using visual or trap counts at those sites. PIT tag estimates of tributary escapement differed from visual or trap count estimates by a much greater percentage than at mainstem dams (Table 4). This is likely the result of very few tagged fish entering tributary sites, creating smaller sample sizes for analysis.

Chinook destined for the Yakima, Wenatchee, and South Fork Salmon were primarily spring Chinook, while Chinook destined for the Umatilla River were primarily fall Chinook (Figure 9).

Table 5. Estimated 2010 Chinook salmon escapement, as estimated using PIT tag detections, to Tumwater, Prosser, and Roza dams and the South Fork Salmon Weir.

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	56	7955	13330	67.6%
South Fork Salmon River Weir	43	9737	10097	3.7%
Prosser Dam, Yakima River	69	15567	18129	18.2%
Roza Dam, Yakima River	54	9905	13405	35.3%

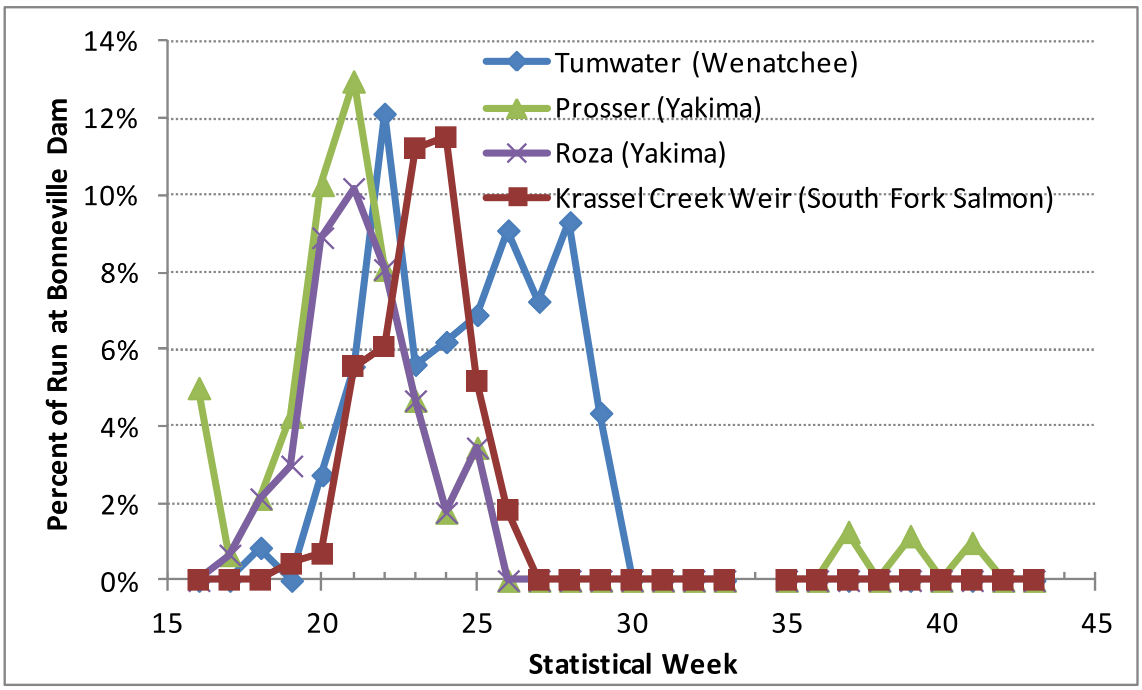

Figure 9. Percentage of Chinook salmon by statistical week tagged at Bonneville Dam in 2010 destined for the Yakima, Wenatchee, and the South Fork Salmon based on upstream PIT tag detections at Prosser, Roza, and Tumwater dams, and the Krassel Creek weir.

Migration Timing and Passage Time

Chinook travel rates between mainstem dams generally ranged between 20 and 40 km/day (Table 6). The slowest travel rates were observed between Rocky Reach and Wells dams, which were often half the rate for all three Chinook runs compared to the rates between other dams. Travel rates within tributaries were generally less than those in the Columbia and Snake rivers (Table 6).

Table 6. Chinook salmon travel rates between Columbia Basin sites with more than 40 fish detected as estimated using PIT tag detections in 2010.

		Median Travel Rate (km/day)		
Between Mainstem Dams	**Distance (km)**	**Spring Chinook**	**Summer Chinook**	**Fall Chinook**
Bonneville - McNary	231	44.8	39.2	39.7
McNary - Priest Rapids	167	33.9	39.5	23.1
Priest Rapids - Rock Island	89	27.5	29.9	27.1
Rock Island - Rocky Reach	33	30.1	32.6	16.7
Rocky Reach - Wells	65	19.9	21.0	16.7
Bonneville - Rock Island	487	32.8	34.9	30.7
Bonneville - Wells	585	32.8	30.7	32.1
McNary - Ice Harbor	67	47.3	30.5	53.0
Ice Harbor - Lower Granite	156	25.2	37.9	32.7
Between Mainstem and/or Tributary Sites				
Rock Island - Tumwater	73	2.7	4.0	--
McNary - Prosser	141	29.2	33.9	18.3
Prosser - Roza	133	12.0	14.2	--
Lower Granite - South Fork Salmon (SFG)	375	14.2	28.8	--

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 7). 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. 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 Tumwater Dam on the Wenatchee River had the greatest median passage time of 2.7 days (3821.5 minutes, Table 7), while summer Chinook were slightly less at 2.2 days (3099.3 minutes). The percentage of Chinook taking more than 12 hours to pass the dam only dropped from 87.0% to 78.1%, between spring and summer Chinook. No fall Chinook passed Tumwater Dam.

Table 7. 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 detection and last detection in 2010.

	Median Passage Time (minutes)			Percentage with more than 12 hours between first detection and last detection at a dam		
Dam	Spring Chinook	Summer Chinook	Fall Chinook	Spring Chinook	Summer Chinook	Fall Chinook
Bonneville	39.5	37.9	42.9	3.2%	2.8%	10.3%
McNary	53.2	45.6	37.5	10.1%	7.1%	3.8%
Priest Rapids	3.0	2.8	1.6	3.8%	2.5%	5.2%
Rock Island	14.5	17.8	79.0	12.4%	12.1%	16.7%
Rocky Reach	5.3	4.8	7.8	3.1%	3.6%	0.0%
Wells	0.3	0.3	0.4	0.0%	8.3%	0.0%
Ice Harbor	1.8	1.3	1.2	4.0%	9.0%	1.6%
Lower Granite	38.7	35.9	43.3	6.1%	9.1%	9.0%
Tumwater	3821.5	3099.3	--	87.0%	78.1%	--
Prosser	6.8	3.2	4.5	1.9%	0.0%	0.0%
Roza	0.7	0.8		11.4%	0.0%	--

Upstream Age and Length-at-Age Composition

Age 1.2 was the predominant age class for spring and summer Chinook at all Columbia and Snake River dams (Table 8, Figures 10 and 11). Fall Chinook were primarily Age 0.2 (Table 8 and Figure 12). The percentage of subyearling juvenile Chinook life history types (i.e. Age 0.x for the summer and fall runs) passing upstream of Ice Harbor into the Snake River was much greater than the percentage passing upstream of Priest Rapids Dam into the mid-Columbia River. Mean length-at-age composition estimates at mainstem dam sites are given in Tables 9-11.

Table 8. 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 2010.

		Brood Year and Age Class								
Run, Site, Number		**2008**	**2007**		**2006**		**2005**		**2004**	
Spring	**N**	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**0.4**	**1.3**	**0.5**	**1.4**
Bonneville	848	0.1%	0.1%	6.6%	0.0%	91.7%	0.1%	1.3%	0.0%	0.0%
McNary	530	0.1%	0.2%	8.9%	0.0%	89.0%	0.2%	1.6%	0.0%	0.0%
Priest Rapids	93	0.0%	0.0%	7.8%	0.0%	91.0%	0.8%	0.4%	0.0%	0.0%
Rock Island	91	0.0%	0.0%	8.2%	0.0%	90.5%	0.8%	0.4%	0.0%	0.0%
Rocky Reach	31	0.0%	0.0%	12.6%	0.0%	85.1%	0.0%	2.3%	0.0%	0.0%
Wells	27	0.0%	0.0%	14.0%	0.0%	83.6%	0.0%	2.3%	0.0%	0.0%
Ice Harbor	367	0.2%	0.4%	8.9%	0.0%	88.4%	0.0%	2.1%	0.0%	0.0%
Lower Granite	347	0.2%	0.4%	8.7%	0.0%	88.5%	0.0%	2.3%	0.0%	0.0%
Summer										
Bonneville	447	0.4%	3.3%	11.9%	8.3%	62.1%	3.9%	9.0%	0.0%	1.1%
McNary	363	0.4%	3.9%	12.6%	9.4%	60.0%	4.1%	8.8%	0.0%	0.9%
Priest Rapids	187	0.3%	4.5%	7.9%	13.3%	51.5%	7.2%	14.6%	0.0%	0.7%
Rock Island	183	0.3%	4.6%	8.1%	13.8%	51.2%	7.6%	13.8%	0.0%	0.7%
Rocky Reach	131	0.4%	3.9%	9.6%	5.3%	62.1%	4.3%	13.7%	0.0%	0.9%
Wells	101	0.6%	4.5%	11.9%	7.1%	57.3%	5.3%	13.3%	0.0%	0.0%
Ice Harbor	164	0.2%	1.6%	30.8%	2.2%	60.0%	0.0%	5.1%	0.0%	0.0%
Lower Granite	159	0.2%	1.6%	35.1%	2.4%	53.4%	0.0%	7.3%	0.0%	0.0%
Fall										
Bonneville	1060	2.5%	47.7%	4.5%	20.8%	13.4%	10.3%	0.6%	0.2%	0.2%
McNary	592	2.9%	50.1%	5.7%	16.6%	14.0%	10.1%	0.4%	0.2%	0.0%
Priest Rapids	59	5.3%	58.0%	7.3%	16.2%	4.4%	8.7%	0.0%	0.0%	0.0%
Rock Island	21	7.0%	46.9%	11.4%	12.4%	16.1%	6.1%	0.0%	0.0%	0.0%
Rocky Reach	16	10.5%	49.5%	0.0%	18.7%	9.0%	12.3%	0.0%	0.0%	0.0%
Wells	5	0.0%	33.2%	0.0%	63.4%	3.4%	0.0%	0.0%	0.0%	0.0%
Ice Harbor	167	4.0%	61.0%	9.9%	4.7%	18.7%	0.5%	1.0%	0.0%	0.0%
Lower Granite	155	4.4%	66.7%	5.5%	5.2%	17.1%	0.6%	0.4%	0.0%	0.0%

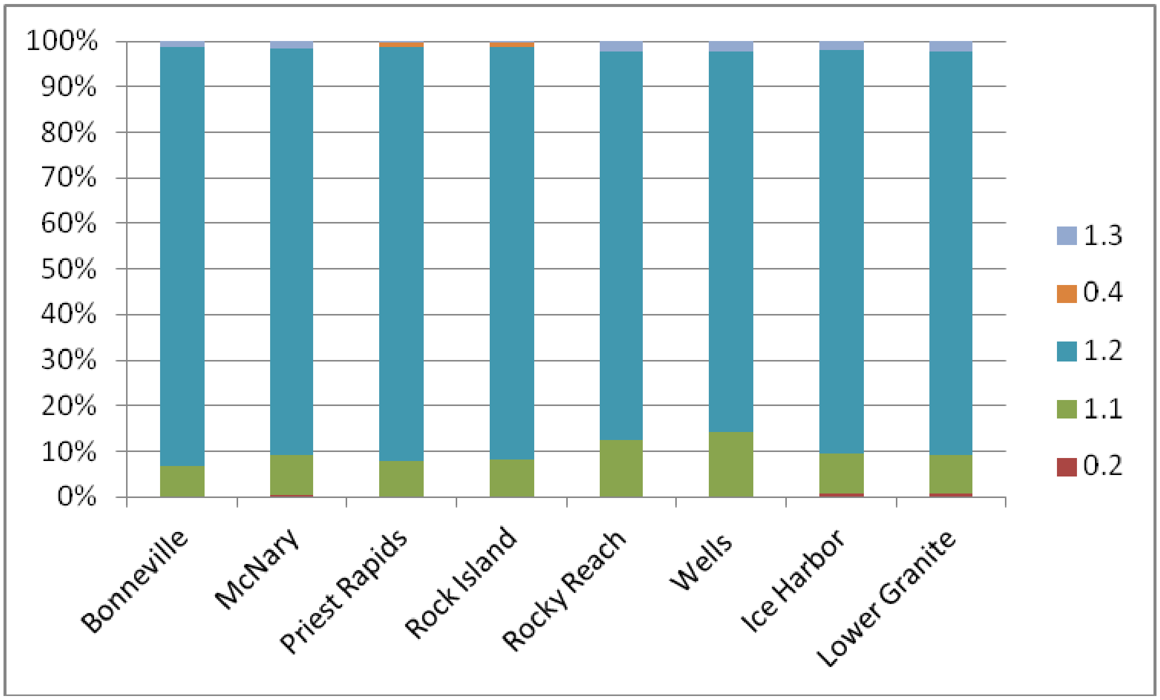

Figure 10. Spring Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project passing Bonneville Dam between April 1 and May 31, 2010.

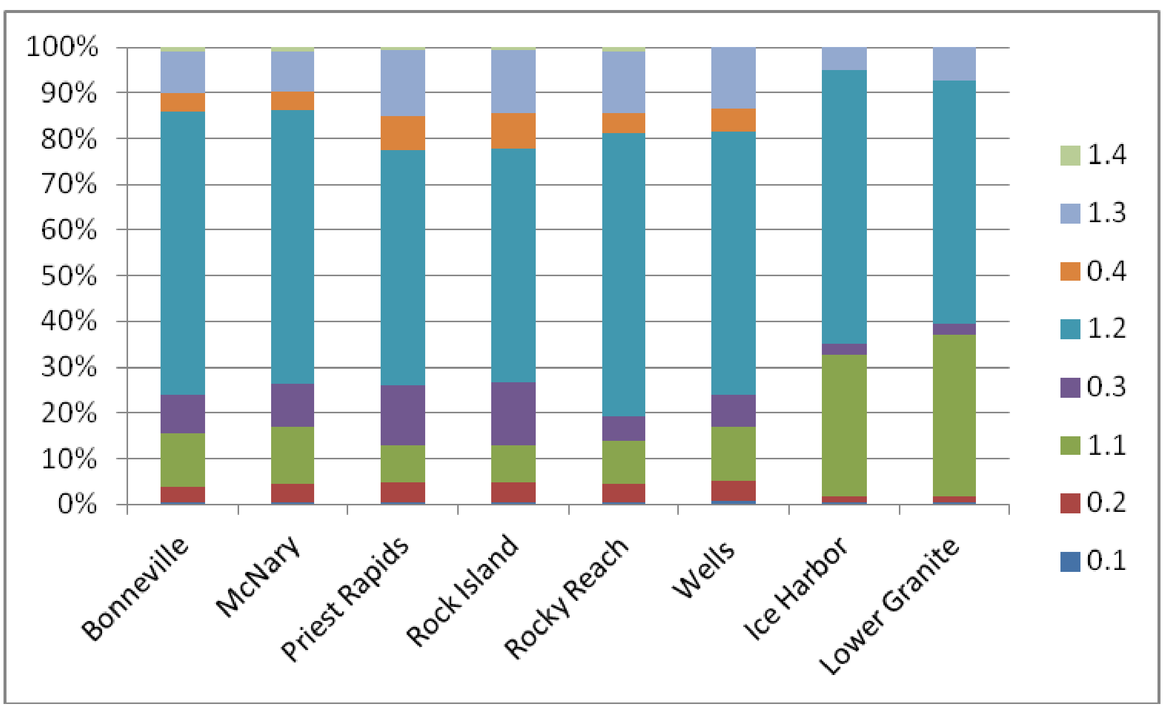

Figure 11. Summer Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project passing Bonneville Dam between June 1 and July 31, 2010.

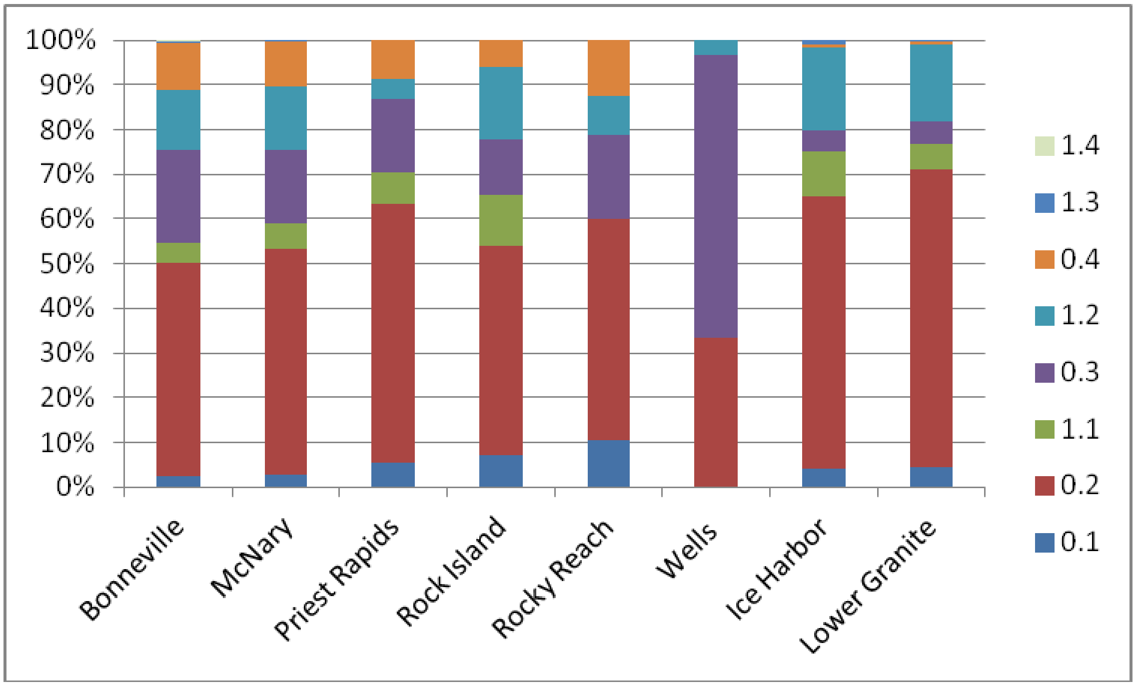

Figure 12. Fall Chinook age composition at Columbia and Snake river dams estimated using PIT tagged Chinook tracked by this project passing between August 1 and October 31, 2010.

Table 9. 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 April 1 and May 31, at Columbia and Snake river dams in 2010.

Dam	Statistic	Brood Year and Age Class								
		2008	2007		2006		2005		2004	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Bonneville	µ	44.0	78.0	51.2		74.5	93.5	87.8		
	s	-		4.4		4.4	6.4	4.1		
	n	1	1	65		758	2	12		
McNary	µ	44.0	78.0	50.8		74.4	93.5	86.7		
	s	-	-	4.2		4.6	6.4	3.2		
	n	1	1	52		464	2	8		
Priest Rapids	µ			51.2		75.8	93.5	88.5		
	s			4.5		4.3	6.4	-		
	n			6		83	2	1		
Rock Island	µ	93.5		51.2		75.8		88.5		
	s	6.4		4.5		4.3		-		
	n	2		6		81		1		
Rocky Reach	µ			49.1		74.3		88.5		
	s			2.3		4.3		-		
	n			4		25		1		
Wells	µ			49.2		73.7		88.5		
	s			2.8		3.4		-		
	n			3		22		1		

Ice Harbor	μ	44.0	78.0	50.1		74.3		86.4		
	s	-	-	3.4		4.6		3.3		
	n	1	1	33		323		7		
Lower Granite	μ	44.0	78.0	50.0		74.4		86.4		
	s	-	-	3.5		4.5		3.3		
	n	1	1	31		305		7		

Table 10. 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 2010.

Dam	Statistic	Brood Year and Age Class								
		2008	2007		2006		2005		2004	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Bonneville	μ	44.8	66.1	54.0	83.6	76.2	90.2	86.8		88.0
	s	0.4	6.5	8.4	4.8	5.8	5.4	4.8		3.9
	n	2	13	56	31	292	15	34		4
McNary	μ	44.8	65.0	55.2	83.8	76.2	90.9	87.2		87.3
	s	0.4	6.5	4.3	5.1	5.7	5.2	4.9		4.5
	n	2	11	44	26	240	12	24		3
Priest Rapids	μ	45.0	64.7	55.3	84.7	74.2	90.9	87.9		89.5
	s	-	6.7	4.9	4.3	6.4	5.2	4.7		3.5
	n	1	10	16	23	102	12	21		2
Rock Island	μ	45.0	64.7	55.3	84.7	74.1	90.9	87.9		89.5
	s	-	6.7	4.9	4.3	6.5	5.2	4.8		3.5
	n	1	10	16	23	99	12	20		2
Rocky Reach	μ	45.0	63.8	55.3	84.5	73.1	91.7	87.3		89.5
	s	-	6.3	5.5	5.1	6.5	5.3	5.1		3.5
	n	1	7	13	10	76	6	16		2
Wells	μ	45.0	63.9	55.5	84.5	72.6	91.7	87.3		
	s	-	6.9	5.8	5.1	6.5	5.3	5.5		
	n	1	6	11	10	54	6	13		
Ice Harbor	μ	44.5	69.0	55.8	76.2	77.7		82.0		
	s	-		3.5	4.2	4.5		3.5		
	n	1	1	18	3	137		3		
Lower Granite	μ	44.5	69.0	55.8	76.2	77.7		82.0		
	s	-		3.5	4.2	4.6		3.5		
	n	1	1	18	3	132		3		

Table 11. 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 2010.

Dam	Statistic	Brood Year and Age Class								
		2008	2007		2006		2005		2004	
		0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Bonneville	μ	52.0	68.2	57.9	81.4	74.8	88.3	85.6	91	86.0
	s	4.1	6.7	5.0	5.9	6.3	4.9	6.9	-	-
	n	26	481	46	205	120	97	6	1	1
McNary	μ	51.3	68.3	57.9	80.7	73.9	88.6	81.7	91	69.9
	s	4.2	4.8	4.3	6.4	6.9	4.9	7.9	-	7.5
	n	17	304	31	106	70	60	3	1	39
Priest Rapids	μ	50.5	67.7	56.8	80.3	73.6	89.9	60.5		70.2
	s	6.0	4.9	2.8	8.1	8.5	2.3	19.1		10.9
	n	3	34	3	9	5	5	2		61
Rock Island	μ	50.5	67.5	57.8	85.3	73.6	91.0			
	s	-	6.4	3.2	0.4	8.5	-			
	n	1	10	2	2	5	1			
Rocky Reach	μ	50.5	65.6		85.3	74.9	91.0			47.0
	s	-	4.4		0.4	9.2	-			-
	n	1	8		2	4	1			1
Wells	μ		64.8		85.0	70.8				
	s		4.6		-	11.7				
	n		2		1	2				
Ice Harbor	μ	50.8	69.1	59.5	80.4	72.7	77.5	79.3		
	s	4.0	5.0	4.3	3.6	7.1	-	9.5		
	n	8	100	15	10	31	1	2		
Lower Granite	μ	50.8	69.0	71.8	80.4	72.5	77.5	71.2	59.2	69
	s	4.0	5.0	7.3	3.6	-	-	7.5	4.47	7.78
	n	8	99	26	10	1	1	18	10	173

Fallback

Estimated fallback-reascension rates based on Chinook salmon reascending fish ladders ranged from 0% to 18.2% (Table 12). 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 12. Estimated Chinook salmon fallback and reascension at mainstem Columbia River dams in 2010 as estimated by PIT tags.

Dam	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	1.8%	0.2%	0.2%
McNary	4.3%	1.5%	1.3%
Priest Rapids	5.6%	2.9%	1.6%
Rock Island	8.5%	2.0%	18.2%
Rocky Reach	2.8%	3.5%	0.0%
Wells	0.0%	8.9%	0.0%
Ice Harbor	6.5%	13.7%	3.7%
Lower Granite	5.0%	9.6%	9.8%
Mean	**1.8%**	**0.2%**	**0.2%**

A total of 14 tagged Chinook salmon were detected falling back over multiple dams (Table 13).

Table 13. Chinook salmon from our study that fell back over multiple dams as indicated by PIT tag detection data in 2010.

Tag Code	Run	Dams Fell Back Over	Last Detection Site	Last Detection Date
3D9.1C2D0C78A0	Summer	Wells, Rocky Reach	Wells	7/11
3D9.1C2D07E71D	Spring	Rocky Reach, Rock Island, Priest Rapids, McNary	McNary	6/11
3D9.1C2D07E1F2	Spring	Wells, Rocky Reach, Rock Island, Priest Rapids	Rock Island	7/7
3D9.1C2D078B80	Spring	Priest Rapids, McNary	Rock Island	7/13
3D9.1C2D3C9003	Summer	Ice Harbor, McNary	McNary	7/13
3D9.1C2D3C9E6A	Summer	Ice Harbor, McNary	Lower Granite	10/3
3D9.1C2D0790A1	Spring	Ice Harbor, McNary, Bonneville	Bonneville	6/13
3D9.1C2D07E8D4	Spring	Ice Harbor, McNary	Lower Granite	5/23
3D9.1C2D07F236	Spring	Ice Harbor, McNary	McNary	5/7
3D9.1C2D06C2A1	Spring	Ice Harbor, McNary	Wells	6/21
3D9.1C2D06E946	Spring	Ice Harbor, McNary	Lower Granite	6/17
3D9.1C2D07947E	Spring	Ice Harbor, McNary, John Day, The Dalles, Bonneville	Bonneville	6/3
3D9.1C2D07DD8C	Spring	Ice Harbor, McNary, John Day, The Dalles, Bonneville	Wells Dam	6/20
3D9.1C2D07E901	Spring	McNary, John Day, The Dalles, Bonneville	Lower Granite	5/23

Night Passage

Night passage (2000-0400 Pacific Standard Time) by tagged Chinook salmon was less than 1% at Bonneville and McNary dams, but increased further upstream (Table 14). At some tributary dams and weirs night passage was higher than the mainstem dams, ranging from 0% up to 51.7% (summer Chinook passing the South Fork Salmon weir). 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, given the median Bonneville Dam passage time of less than two hours, Chinook would be expected to pass during daytime hours.

Table 14. Estimated Chinook salmon night passage (2000-0400) in 2010 at mainstem Columbia River dams as estimated by PIT tags.

Site	Spring Chinook (%)	Summer Chinook (%)	Fall Chinook (%)
Bonneville	0.1%	0.0%	0.2%
McNary	0.6%	3.0%	0.3%
Priest Rapids	0.0%	2.4%	3.3%
Rock Island	1.9%	3.1%	10.5%
Rocky Reach	8.3%	1.4%	0.0%
Wells	3.2%	4.5%	33.3%
Ice Harbor	1.2%	0.6%	0.5%
Lower Granite	4.2%	2.8%	1.7%
Prosser	5.6%	0.0%	0.4
Roza	31.8%	33.3%	--
Tumwater	0.0%	3.1%	--
South Fork Salmon weir	35.7%	51.7%	--

RESULTS-STEELHEAD

Sample Size

A total of 1718 steelhead were PIT tagged in 2010. 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, mortality, or the fish moving downstream after tagging), the number of steelhead tracked upstream totaled 1708 (Table 15).

Table 15. Number of steelhead PIT tagged at Bonneville Dam and tracked by date and statistical week in 2010. No sampling occurred during Statistical Week 34 due to water temperatures above 22.2 C (72.0 F).

Dates	Statistical Week	Tagged (n)	Previously Tagged	Not Detected Passing Bonneville	Total Tracked
4/12-16	16	5	0	0	5
4/19,21-23	17	4	0	0	4
4/26-30	18	5	0	0	5
5/3-7	19	12	1	0	13
5/10,12-14	20	15	0	0	15
5/17-21	21	13	0	1	12
5/24-27	22	22	0	1	21
6/1-6/4	23	23	1	0	24
6/7-6/11	24	51	2	1	52
6/14-6/18	25	30	1	2	29
6/21-6/25	26	33	2	1	34
6/28-7/2	27	62	0	2	60
7/7-7/9	28	88	0	1	87
7/12-7/16	29	177	1	7	171
7/19-7/23	30	280	3	4	279
7/26-7/29	31	174	5	3	176
8/4-8/6	32	125	1	1	125
8/12-8/13	33	133	1	5	129
No sampling	34	0	0	0	0
8/24-8/26	35	73	4	1	76
8/30-9/3	36	62	0	0	62
9/7-9/10	37	63	0	0	63
9/13-9/17	38	35	0	1	34
9/20-9/24	39	114	1	1	114
9/27-10/1	40	60	0	0	60
10/5-10/8	41	35	0	1	34
10/11-10/13	42	19	0	0	19
10/20-10/21	43	5	0	0	5
Total		**1718**	**23**	**33**	**1708**

Distribution of Sample

Our steelhead sample distribution was much closer to the run distribution than in most past years. We over-sampled week 30 and under-sampled weeks 32 through 37, however during the five peak weeks of the run (Statistical weeks 29-33), we collected 49.6% of our sample (911 fish) representing 51.8% of the run (Figure 13). No sampling was conducted during Statistical Week 34 due to water temperatures above 22.2C (72.0 F) closing the Bonneville Dam Adult Fish Facility; a week in which 5.4% of the steelhead run passed. This contributed to our under-sampling weeks 34-38, where we collected 13.5 % of our sample (354 fish) representing 24.9% of the run.

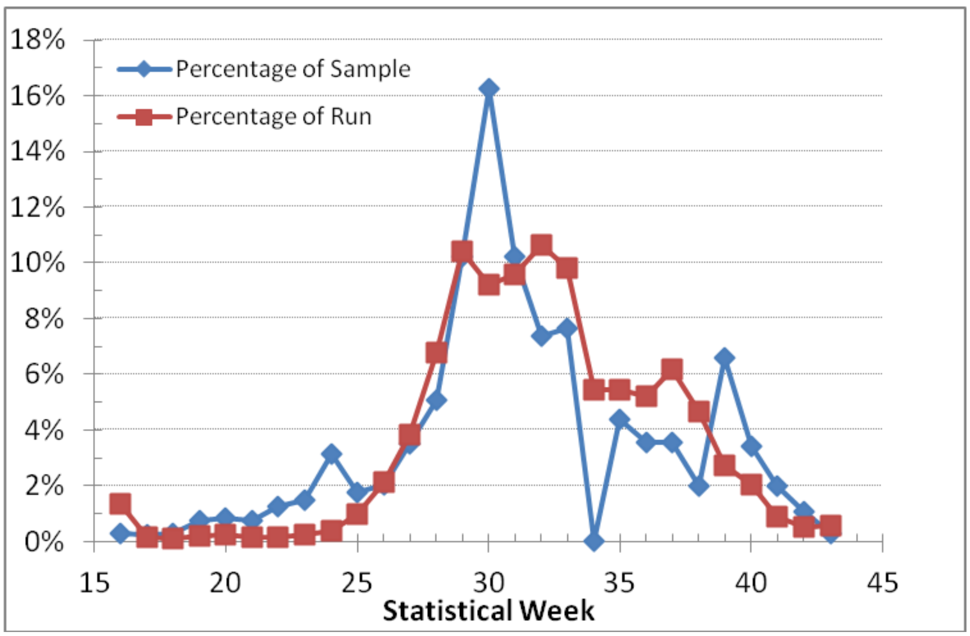

Figure 13. Percentage of the steelhead sample size and run by statistical week at Bonneville Dam in 2010.

Detection Numbers

The 1708 steelhead tracked in 2010 generated 79519 weir detections and 6967 site detections at 77 sites. Maps (Figure A13-A16) found in the Appendix show the categorical ranges of detection numbers at the sites throughout the Columbia Basin.

Age Analysis

We were able to validate our scale aging techniques by using fish sampled at Bonneville for this project that were previously tagged as juveniles for

other projects or hatchery programs. Age estimates from ageable scale patterns for 21 out of 23 steelhead that had been previously PIT tagged were correctly aged (91.3%). Only the total age could be compared for it was not possible to separately validate freshwater and ocean age.

Mainstem Dam Recoveries and, Mortality,

Data on tag detections was last downloaded from www.ptagis.org on February 13, 2012. An estimated 54.1% of the steelhead run was last detected upstream of Ice Harbor Dam while only 7.1% of the run was last detected upstream of Priest Rapids Dam (Table 16, Figure 14). The proportion of steelhead bound for the Snake River steadily increased as the run progressed (Figures 15 and 16).

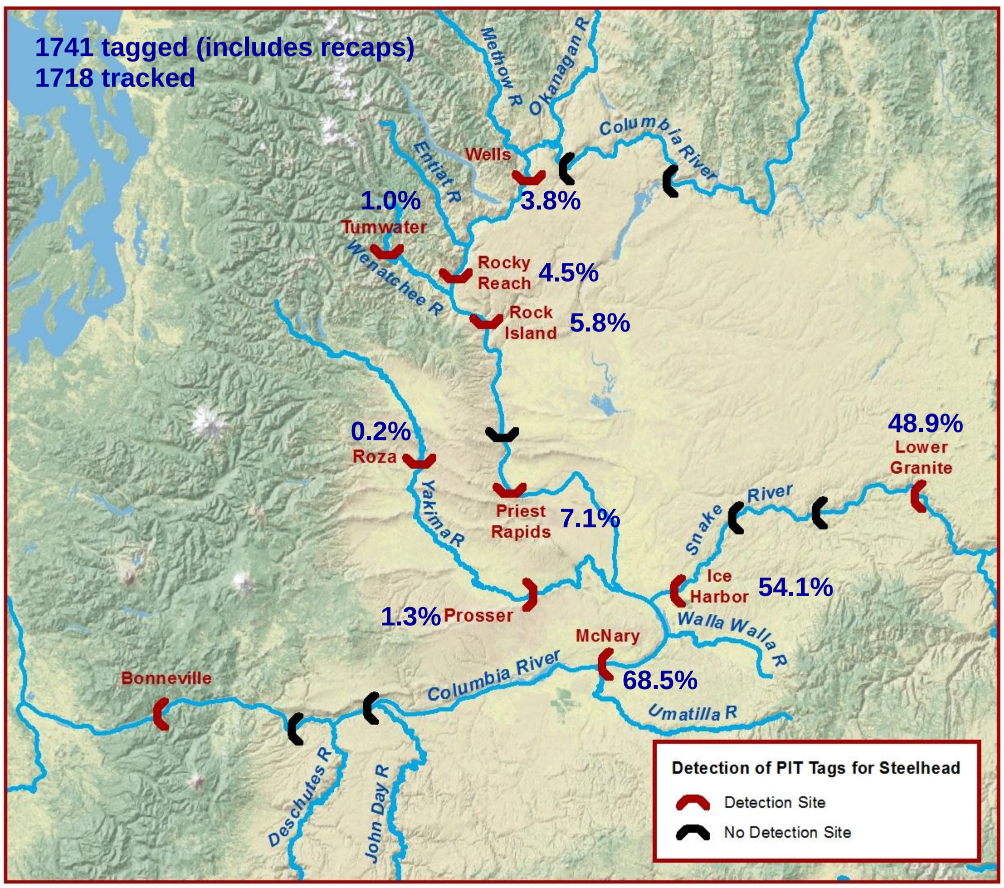

Figure 14. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of steelhead PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass upstream dams in 2010.

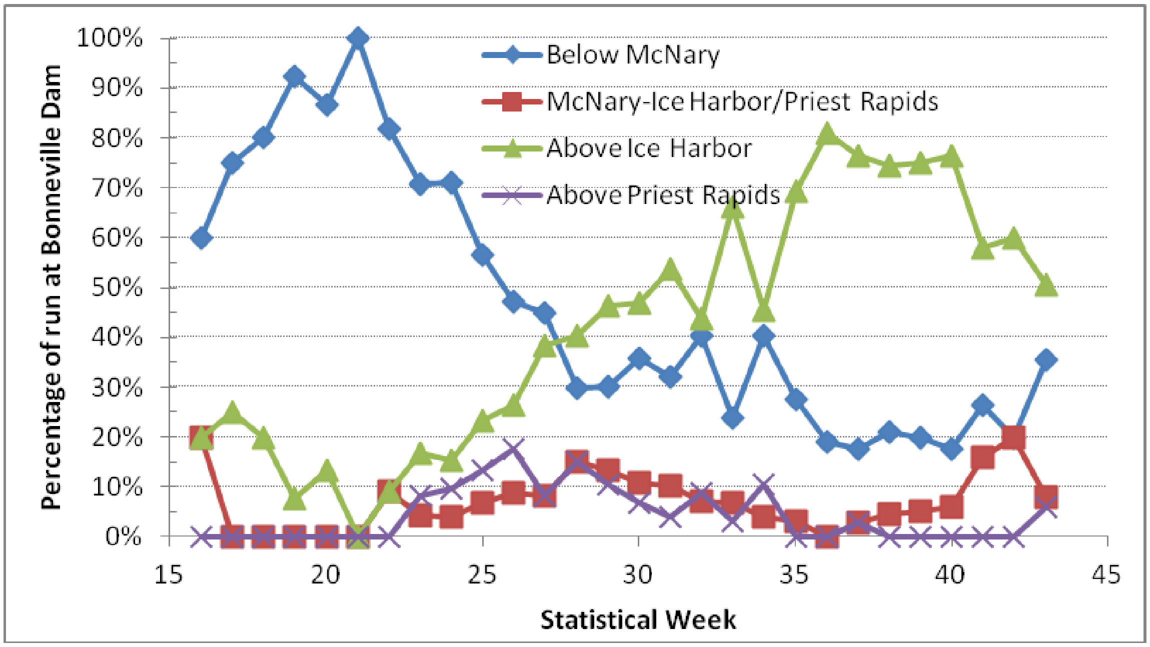

Figure 15. Distribution of final upstream detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2010 estimated as a percentage of the weekly sample.

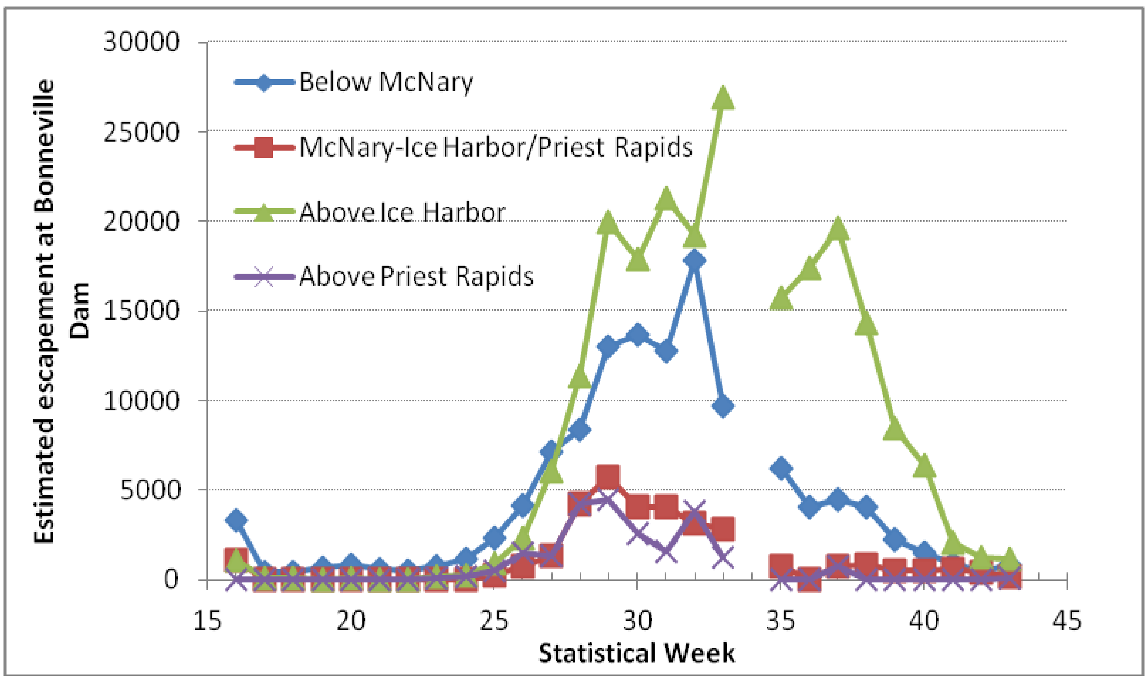

Figure 16. Distribution of final detection site by statistical week for steelhead PIT tagged at Bonneville Dam in 2010 estimated in numbers of fish passing Bonneville Dam by week.

Like Chinook salmon the percentage of PIT tagged steelhead passing a dam without detection was generally under 1% (Table 16).

Table 16. Percentage of steelhead passing a dam undetected that were subsequently detected at an upstream dam in 2010.

Dam	Percent Undetected
Bonneville	0.4%
McNary	0.5%
Priest Rapids	1.7%
Rock Island	0.8%
Rocky Reach	1.4%
Wells	0.0%
Ice Harbor	0.3%
Lower Granite	0.0%

Migration Timing and Passage Time

The fastest median travel rate between dams, as measured in kilometers per day, was between Rocky Reach and Wells dams (44.5 km per day), while the slowest was 5.1 km/day between Rock Island and Tumwater dams (Table 17).

Table 17. Steelhead travel rate between Columbia Basin dams as estimated by PIT tag detections in 2010.

Steelhead		
Dam Pair	**Distance (km)**	**Median Travel Rate (km/day)**
Bonneville - McNary	231	16.3
McNary - Priest Rapids	167	23.9
Priest Rapids - Rock Island	89	22.9
Rock Island - Rocky Reach	33	16.5
Rocky Reach - Wells	65	44.5
Rock Island - Tumwater	73	5.1
Bonneville – Rock Island	487	21.5
Bonneville - Wells	585	17.7
McNary - Ice Harbor	67	25.4
Ice Harbor - Lower Granite	156	19.8

Median steelhead passage times (Table 18) at the mainstem dams, as measured from first to last detection within the ladders, were generally less than that for Chinook salmon (Table 7). Bonneville, McNary, and Lower Granite dams had the greatest median passage time among mainstem Columbia Basin dams. 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. Travel 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 our project samples fish at Bonneville Dam). Tumwater Dam, a tributary dam in the Wenatchee, had 24 hour trapping program for Chinook that likely impeded steelhead passage.

Table 18. 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 2010.

Dam	Median Passage Time (minutes)	Percentage with more than 12 hours between first detection and last detection at a dam
Bonneville	75.2	10.6%
McNary - OR Shore	94.6	7.6%
McNary - WA Shore	51.2	3.3%
Priest Rapids	4.6	4.8%
Rock Island	5.0	7.1%
Rocky Reach	5.6	25.0%
Wells	0.6	1.8%
Ice Harbor	3.8	8.5%
Lower Granite	86.3	15.0%
Tumwater	5364	88.2%

Upstream Age and Length-at-Age Composition

Three age classes, 1.1, 1.2, and 2.2 predominated in 2010 (Table 19, Figure 17.) Length-at-age composition data is found in Table 20.

Table 19. 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 2010.

	Brood Year And Age Class											
	2008	2007		2006			2005			2004		Unknown
Site	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	3.3	4.2	Repeat Spawners
Bonneville	25.8	35.7	4.0	9.0	20.5	0.5	1.3	2.6	0.1	<0.1	0.1	0.3
McNary	30.3	32.1	3.5	8.7	19.7	0.6	1.5	3.0	0.2	<0.1	0.1	0.2
Priest Rapids	20.6	36.1	0.0	7.2	28.9	0.0	0.0	6.2	1.0	0.0	0.0	0.0
Rock Island	26.8	26.9	0.0	10.5	32.0	0.0	0.0	1.6	2.2	0.0	0.0	0.0
Rocky Reach	37.0	30.4	0.0	3.9	28.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Wells	38.7	26.7	0.0	4.8	29.2	0.0	0.0	0.6	0.0	0.0	0.0	0.0

Ice Harbor	34.1	32.8	3.6	7.3	17.2	0.5	1.4	2.5	0.1	<0.1	0.2	0.2
Lower Granite	32.0	34.1	3.8	7.4	17.2	0.5	1.2	3.1	0.1	<0.1	0.3	0.2

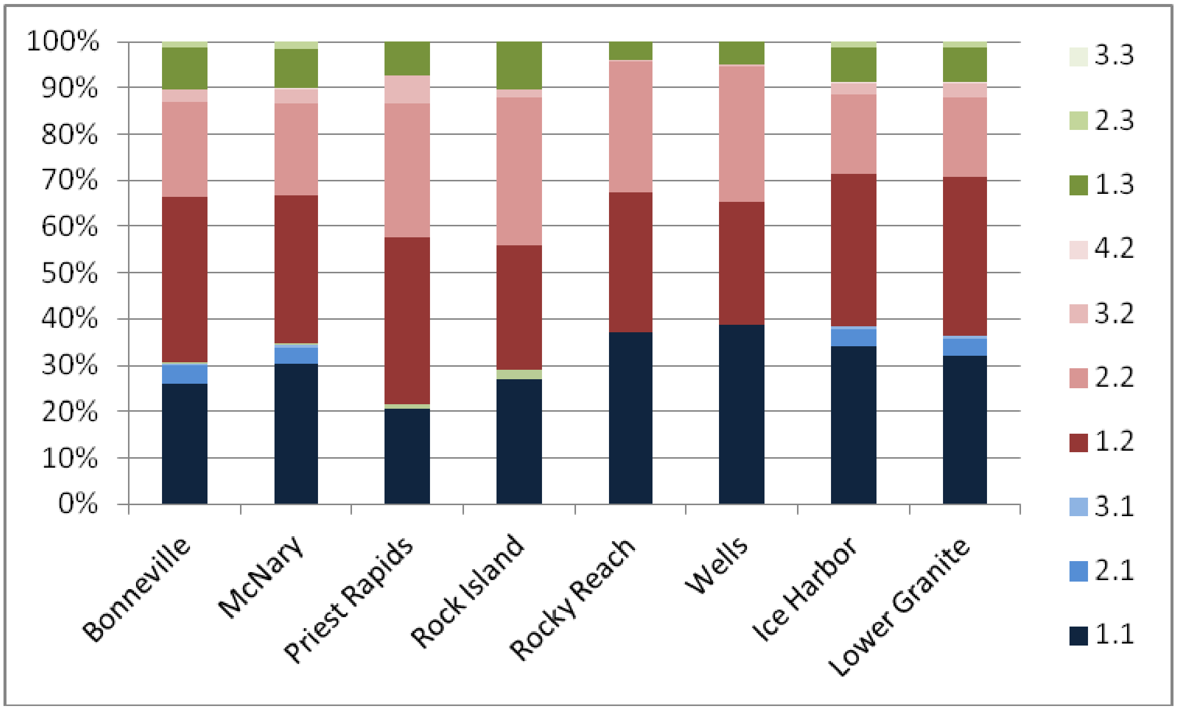

Figure 17. Steelhead age composition at Columbia and Snake river dams estimated using PIT tags in 2010.

Table 20. 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 2010.

Dam	Statistic	2008	2007		2006			2005			2004	
		1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	3.3	4.2
McNary	μ	57.6	75.2	58.3	85.8	72.4	59.6	84.0	72.9	57.0	78.5	73.0
	s	2.9	7.9	3.9	3.4	4.8	2.3	3.0	5.7		3.6	-
	n	251	292	72	42	158	13	6	24	1	3	1
Priest Rapids	μ	58.2	72.0	57.9		72.2			72.0		82.5	
	s	2.9	4.2	3.9		4.3			3.6		-	
	n	20	35	7		28			6		1	
Rock Island	μ	58.3	72.2	57.9		73.1			72.5		82.5	
	s	2.8	4.4	3.9		4.1			3.1		-	
	n	17	30	7		23			3		1	
Rocky Reach	μ	58.3	71.8	58.2		72.3			70.0			
	s	2.8	4.2	4.3		3.1			-			
	n	17	25	3		15			1			
Wells	μ	58.7	70.6	58.2		72.5			70.0			

	s	2.3	4.1	4.3		3.2						
	n	13	17	3		14			1			
Ice Harbor	µ	57.6	75.5	58.6	85.6	72.9	60.8	84.8	73.1	57.0	76.5	73.0
	s	2.9	8.2	3.9	3.4	5.3	1.9	2.6	6.3	-	1.4	-
	n	209	244	43	39	101	8	5	17	1	2	1
Lower Granite	µ	57.5	75.6	58.8	85.5	73.1	60.7	84.8	73.1	57.0	76.5	73.0
	s	2.8	8.4	4.0	3.4	5.4	2.2	2.6	6.3	-	1.4	-
	n	175	227	37	38	86	6	5	17	1	2	1

B-Run Analyses

The percentage of steelhead sampled and tagged that were classified as B-run (>78 cm) peaked between Statistical weeks 38 and 41 with over 68% of the run in each week being B-run. In contrast, the estimated B-Run escapement at Bonneville Dam (estimated by multiplying the weekly run size using counting window data by the percentage B-run in that week estimated by this project) peaked in Week 37 (Figure 18). 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).

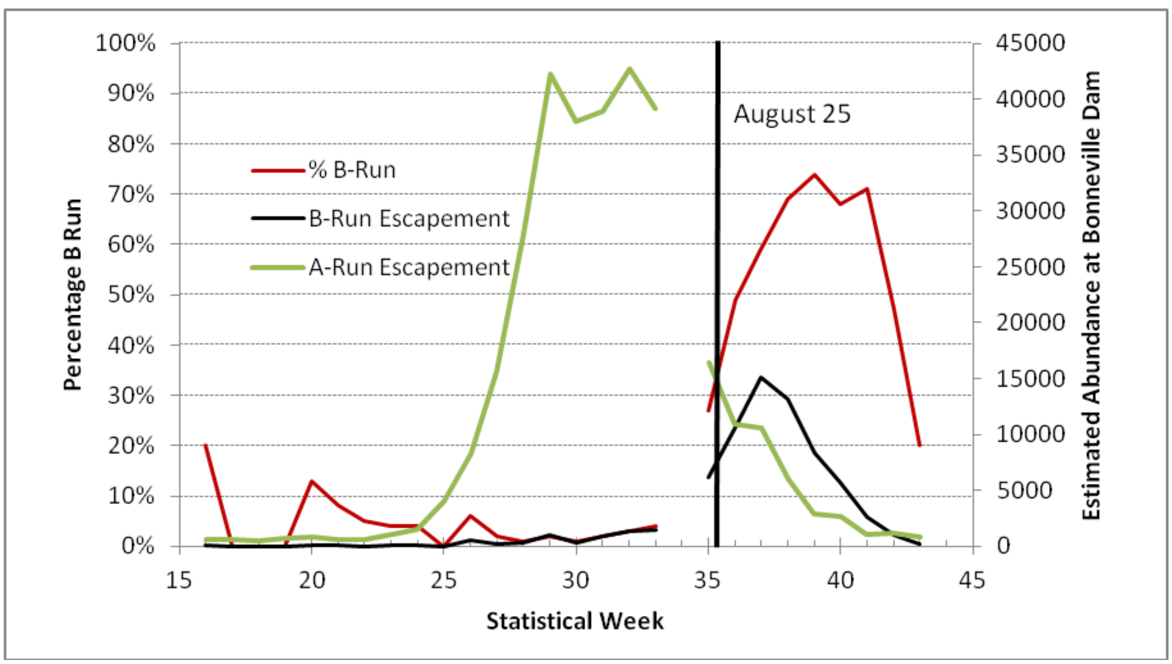

Figure 18. Percentage of B-run steelhead and estimated A- and B-run escapement at Bonneville Dam by statistical week in 2010. August 25 is noted as it is considered the date that separates A- and B-run steelhead.

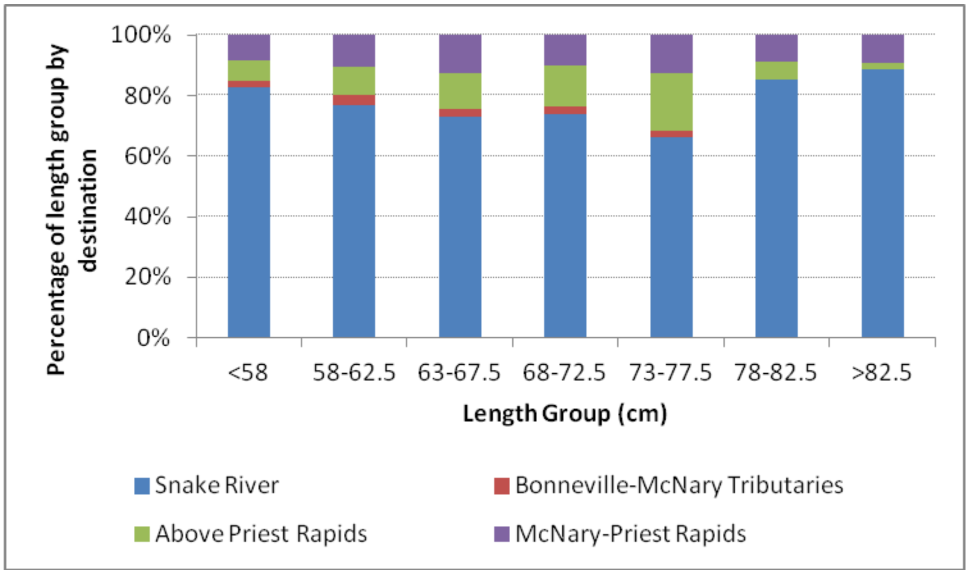

Figure 19. Final detection site for steelhead PIT tagged at Bonneville Dam in 2010 by length group. Steelhead were grouped into 5 cm groupings above and below the 78 cm B-run threshold.

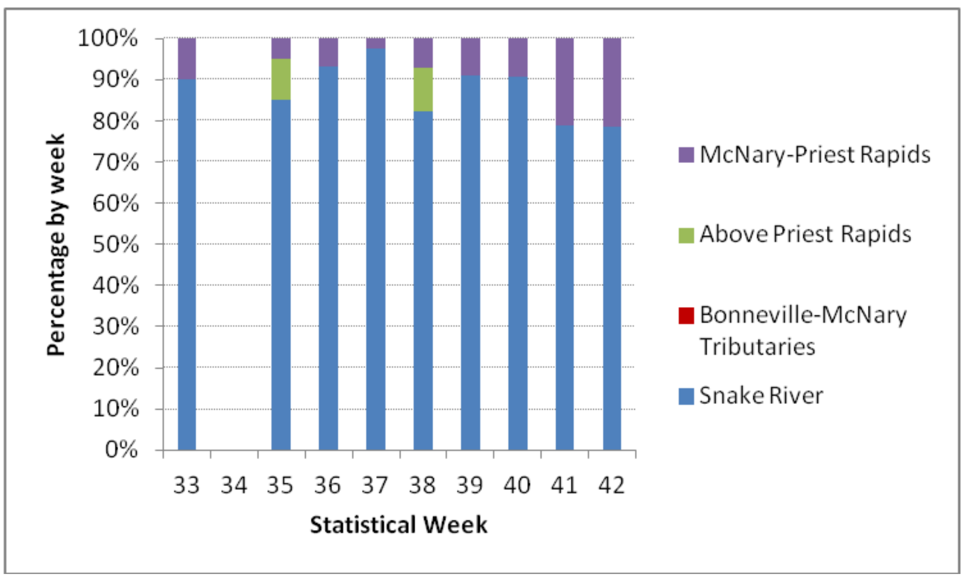

Figure 20. Final detection site for B-run steelhead (>78 cm fork lengh)by Statistical Week. No B-run steelhead were detected in Bonneville-McNary tributaries.

Kelt Analyses

A total of 86 PIT tagged steelhead tracked in 2010 were detected moving downstream (mostly in juvenile bypasses) after February, 2011, presumably in an attempt to return to the ocean after spawning (Table 21). Of these steelhead, three were detected after July, 2011 and were tracked in the Columbia Basin into the fall of 2011 (Table 22). One fish 3D9.1C2D416B93, was detected at Prosser Dam on October 3, 2010 and next detected again at Prosser Dam on October

26, 2011, this fish was collected for reconditioning and kept in freshwater for a year in the Kelt Reconditioning Project. The 86 steelhead we designated as kelt represented between 3.3% and 11.8% of the run at Bonneville Dam between Statistical weeks 22 and 35 (Figure 21). We were also able to add additional information to the table of kelts tagged in 2009 (Table 23) as new fish or previous kelts displayed additional migration behavior in the Columbia Basin. One fish was detected again since first reported (3D9.1C2D0B162E) and five more were added to the original table when they were detected at Bonneville Dam during the summer of 2011.

Table 21. PIT tagged steelhead tracked from Bonneville Dam in 2010 and 2009 last detected moving downstream listed by last downstream detection site.

Last site	2010	2009
Bonneville Corner Collector	23	61
Bonneville Juvenile Bypass	4	7
Estuary trawl	0	1
Ice Harbor Juvenile Bypass	6	0
John Day Juvenile Bypass	11	3
Little Goose Juvenile Bypass	13	6
Lower Granite Juvenile Bypass	10	3
Lower Monumental Juvenile Bypass	9	4
Lower Washington Shore McNary Dam ladder, likely moving downstream.	2	1
McNary Dam Juvenile Bypass	2	4
Rocky Reach Juvenile Bypass	6	7
Total	**86**	**97**

Table 22. 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.

Tag Year	Tag Number	Last Summer Detection After Tagging 2010	Fall 2010	Winter 2010/11	Spring 2011	Summer 2011	Fall 2011	Comments
2010	3D9.1C2D416B93	McNary - June 30th	Prosser Dam - October 3rd				Prosser Dam - October 26th	Female steelhead collected at Prosser Dam for reconditioning in 2010 and released in October 2011 for spawning.
2010	3D9.1C2D3F364C	Bonneville Washington Shore Ladder - August 6th	McNary - September 13th	McNary - January 25th (Upstream) McNary - January 25th (Downstream)	McNary - March 5th	Bonneville Washington Shore Ladder - September 23rd	McNary - October 3rd	
2010	3D9.1C2D3F0E59	Lower Granite - August 10th				Bonneville Washington Shore Ladder - August 19th	Lower Granite - September 18th	

Key - - - Upstream | Downstream | Spawning

Table 23. 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. Additional information was added to this 2009 report table as new data on migration information became available in 2011.

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	Comments
2009	3D9.1C2D2CA56A	Bonneville Washington Shore Ladder - August 19th	John Day Juvenile - November 27th	Rock Creek Lower - January 22nd to February 24th	Rock Creek Lower - March 5th Bonneville Dam Corner Collector - April 14th	Bonneville Oregon Shore Ladder - August 21st		Rock Creek Lower - December 21st to February 22nd	Bonneville Dam Corner Collector - April 7th			Tracked to Rock Creek for spawning in two consecutive years.
2009	3D9.1C2D0B162E	Bonneville Washington Shore Ladder - August 11th	Bonneville Oregon Shore Ladder - October 19th Bonneville Washington Shore Ladder - October 21st		Bonneville Dam Corner Collector - April 15th		Bonneville Oregon Shore Ladder - September 10th			Bonneville Oregon Shore Ladder - September 10th Bonneville Washington Shore Ladder - September 23rd		New information added for Fall 2011 from first time reported.
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			Tracked to Rock Creek for spawning in two consecutive years.
2009	3D9.1C2D07DAB8	Bonneville Washington Shore Ladder - June 8th			Bonneville Dam Corner Collector - April 14th	Bonneville Washington Shore Ladder - July 29th			Bonneville Dam Corner Collector - April 18th			
2009	3D9.1C2D077D0D	Bonneville Washington Shore Ladder - August 20th	Lower Granite - September 27th		Bonneville Dam Corner Collector - May 5th	Bonneville Oregon Shore Ladder - August 27th	Lower Granite - September 17th					
2009	3D9.1C2D070406	McNary - July 17th	Ice Harbor - November 4th							Bonneville Washington Shore Ladder - July 12th		
2009	3D9.1C2D0A1E39	Bonneville Washington Shore Ladder - July 21st			Threemile Dam Umatilla R - May 17th					Bonneville Washington Shore Ladder - July 1st		
2009	3D9.1C2D08326A	Ice Harbor - July 26th	Lower Monumental Juvenile - October 12th		Bonneville Juvenile - April 26th to 28th	Bonneville Washington Shore Ladder - July 14th Ice Harbor - August 14th						Spent 36 hours in Bonneville Juvenile Bypass, moving up and down passed the detection coils .
2009	3D9.1C2D2C8D5A	Priest Rapids Dam - August 13th	Prosser Dam - November 4th				Prosser Dam - October 14th					Female steelhead collected at Prosser Dam for reconditioning and released in October 2010 for spawning.
2009	3D9.1C2D07E182	Lower Granite - July 24th			Bonneville Dam Corner Collector - April 28th					Bonneville Cascade Ladder - August 6th	Ice Harbor - October 7th	Newly added to this Kelt based on return detections.
2009	3D9.1C2D07EA94	Bonneville Washington Shore Ladder - July 6th								Bonneville Washington Shore Ladder - September 5th		Newly added to this Kelt based on return detections.
2009	3D9.1C2D099E0C	Ice Harbor - August 28th	Lower Granite - September 7th		Bonneville Dam Corner Collector - May 24th					Bonneville Cascade Ladder - August 10th Bonneville Washington Shore Ladder - August 11th		Newly added to this Kelt based on return detections.
2009	3D9.1C2D2CB69F	Tagged in the Fall 2009	Lower Granite - October 11th		Bonneville Dam Corner Collector - May 5th					Bonneville Washington Shore Ladder - September 5th		Newly added to this Kelt based on return detections.
2009	3D9.1BF26F89BF	Bonneville Washington Shore Ladder - July 18th	Lower Granite - September 11th							Bonneville Washington Shore Ladder - July 22nd Ice Harbor - August 4th		Newly added to this Kelt based on return detections.

Key - - - Upstream | Downstream | Spawning

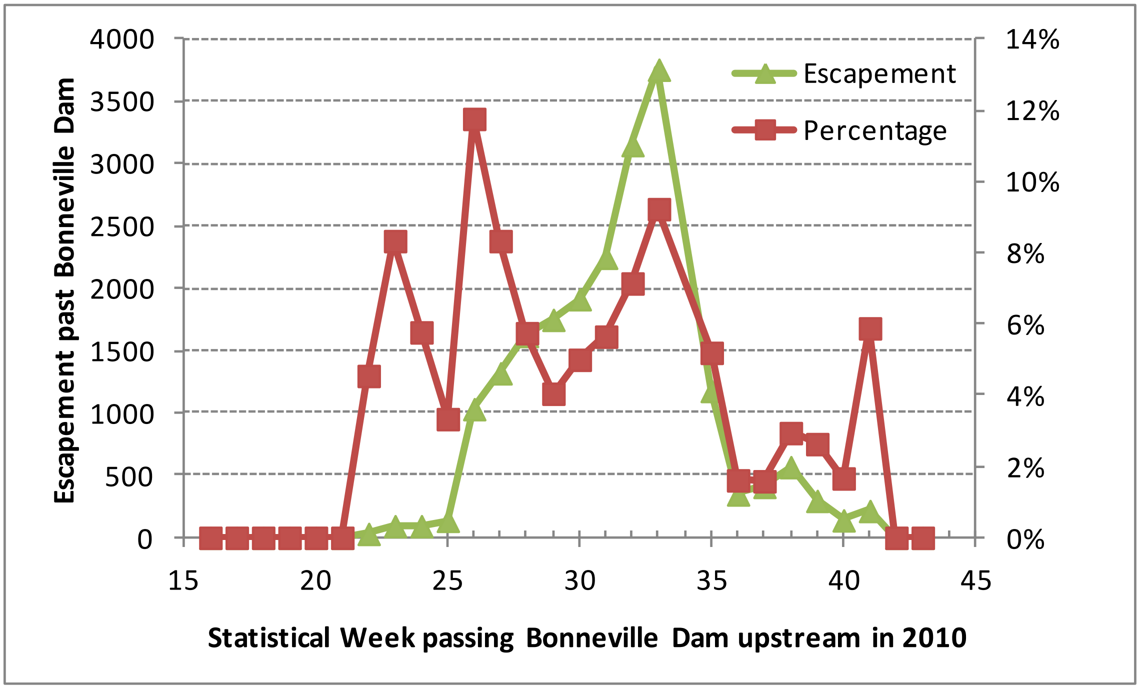

Figure 21. Percentage and number of steelhead designated as kelt (based on 2011 detections) passing Bonneville Dam by statistical week in 2010.

Fallback

Estimated fallback-reascension rates based on steelhead reascending fish ladders ranged from 1.8% to 13.9% (Table 24). 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 2010 had the highest fallback rate at Priest Rapids Dam. Of the 112 steelhead detected at Priest Rapids Dam, 15 were subsequently detected downstream at other dams on the mainstem or in other systems; 10 at Ice Harbor Dam, 4 at Prosser Dam, and 1 at Nursery Bridge on the Walla Walla River. Six more steelhead ultimately passed upstream of Priest Rapids Dam.

Table 24. Estimated 2010 steelhead fallback/reascension.

Dam	Percent Fallback%
Bonneville	1.8%
McNary	5.6%
Priest Rapids	13.9%
Rock Island	3.0%
Rocky Reach	7.9%
Wells	7.9%
Ice Harbor	2.6%
Lower Granite	11.1%

Night Passage

Night passage (2000-0400 Pacific Standard Time) by tagged steelhead was under 6% at all mainstem dams (Table 25). For steelhead that passed Prosser Dam, 25% passed at night (out of 20 that passed Prosser). The Bonneville Dam estimate of night passage is likely biased with low numbers due to the day time tagging, which occurred between 0700 and 1400 PST. Given the median Bonneville Dam passage time of 75.2 minutes (Table 18), steelhead would be expected to pass during daytime hours.

Table 25. Estimated steelhead night passage (2000-0400) in 2010 at Columbia Basin dams with a minimum of 15 detections as estimated by PIT tags.

Site	Steelhead (%)
Bonneville	1.3%
McNary	4.3%
Priest Rapids	1.8%
Rock Island	5.7%
Rocky Reach	4.2%
Wells	0.0%
Ice Harbor	3.7%
Lower Granite	4.9%
Prosser	25.0%
Tumwater	0.0%

RESULTS-SOCKEYE[b]

Sample Size

A total of 918 sockeye salmon were sampled between May 27 and July 14, 2010 (Table 26). We halted sampling when PIT tag detections at Ice Harbor and Lower Granite dams indicated we had exceeded our permitted sample size of three ESA-listed Snake River sockeye salmon. Less than 1.5% of the sockeye run passed Bonneville Dam subsequent to the termination of sampling. Of the 918 fish sampled, a total of 913 sockeye salmon were released with working PIT tags (Table 26). The remaining 5 fish were either not PIT tagged, or were PIT tagged, but the tags were not detected when scanned. An additional 43 fish, believed to have working tags, 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 in those weirs where the antennas in the vicinity of the fish trap are located (Table A3). It is less likely that sockeye salmon pass upstream undetected as they must swim through antennas at fish counting windows although they can also pass upstream through navigation locks at Bonneville Dam, as well as at McNary, Ice Harbor, and Lower Granite dams (Table 27) PIT tag detection data were last downloaded from www.ptagis.org on March 4, 2011.

Table 26. Number of PIT tagged sockeye salmon tracked at Bonneville Dam by date and statistical week in 2010.

Sampling Dates	Statistical Week	Sampled (n)	Number Tagged	Number Tracked
5/27,6/1,2,3,4	22-23	34	34	33
6/7,8,9,10,11,	24	62	62	60
6/14,15,16,17,18	25	224	224	215
6/22,23,24,25	26	262	262	244
6/28,29,30,7/1,2	27	206	203	197
7/7,8,9	28	84	84	80
7/12,13,14	29	46	44	41
	Total	**918**	**913**	**870**

[b] The information presented in this section of the report is a summary of Fryer et al. 2010.

Table 27. Percentage of PIT tagged fish by tag type not detected at dam detection sites as estimated from upstream detections in 2010 with comparison data for 2006-2009.

Dam	2010	2009	2008 (12.5mm tags only)	2007	2006	Mean
Bonneville*	0.7%	0.6%	0.4%	2.1%	0.2%	**0.8%**
McNary*	3.8%	5.0%	10.1%	6.5%	3.1%	**5.7%**
Priest Rapids	0.6%	0.3%	0.3%	0.8%	0.0%	**0.4%**
Rock Island	6.2%	2.6%	6.9%	6.8%	1.3%	**4.8%**
Rocky Reach	0.5%	0.0%	0.2%	0.7%	12.3%	**2.7%**
Ice Harbor*	0.0%	20.0%	0.0%	--	--	**6.7%**
Tumwater	0.0%	--	--	--	--	**0.0%**

*Navigation locks at these dams permit adult sockeye to bypass weirs equipped with PIT-tag antennas.

Upstream Recoveries, Mortality, and Escapement

Most of the tagged sockeye salmon that were not detected at Rock Island Dam were lost before reaching McNary Dam (Table 28, Figure 22). This reach of river is where the Zone 6 tribal fishery occurs, which was estimated to harvest 24,843 sockeye salmon in 2010 with an additional 21 sockeye harvested by sport fishers (Fryer et al. 2011).

Table 28. Percentage of PIT tagged sockeye salmon detected subsequent to tagging at upstream dams, estimated escapement from both PIT tags and visual means, and the difference between the PIT tag and visual escapement estimate in 2010.

Dam	Estimated Percentage Reaching Dam	Estimated Escapement Using PIT Tag Data	Visual Dam Count	Difference Between PIT Tag and Visual Estimate
Bonneville	100.0%	--	386,525	--
McNary	81.5%	314,928	278,799	13.0%
Priest Rapids	78.4%	303,173	357,058	-15.1%
Rock Island	76.3%	294,847	338,310	-12.8%
Rocky Reach	63.7%	246,129	295,638	-16.3%
Wells	62.6%	241,886	291,764	-16.6%
Tumwater	13.3%	51,480	35,821	40.9%
Ice Harbor	0.7%	2,674	1,302	104.8%
Lower Granite	0.5%	2,123	2,201	-3.9%

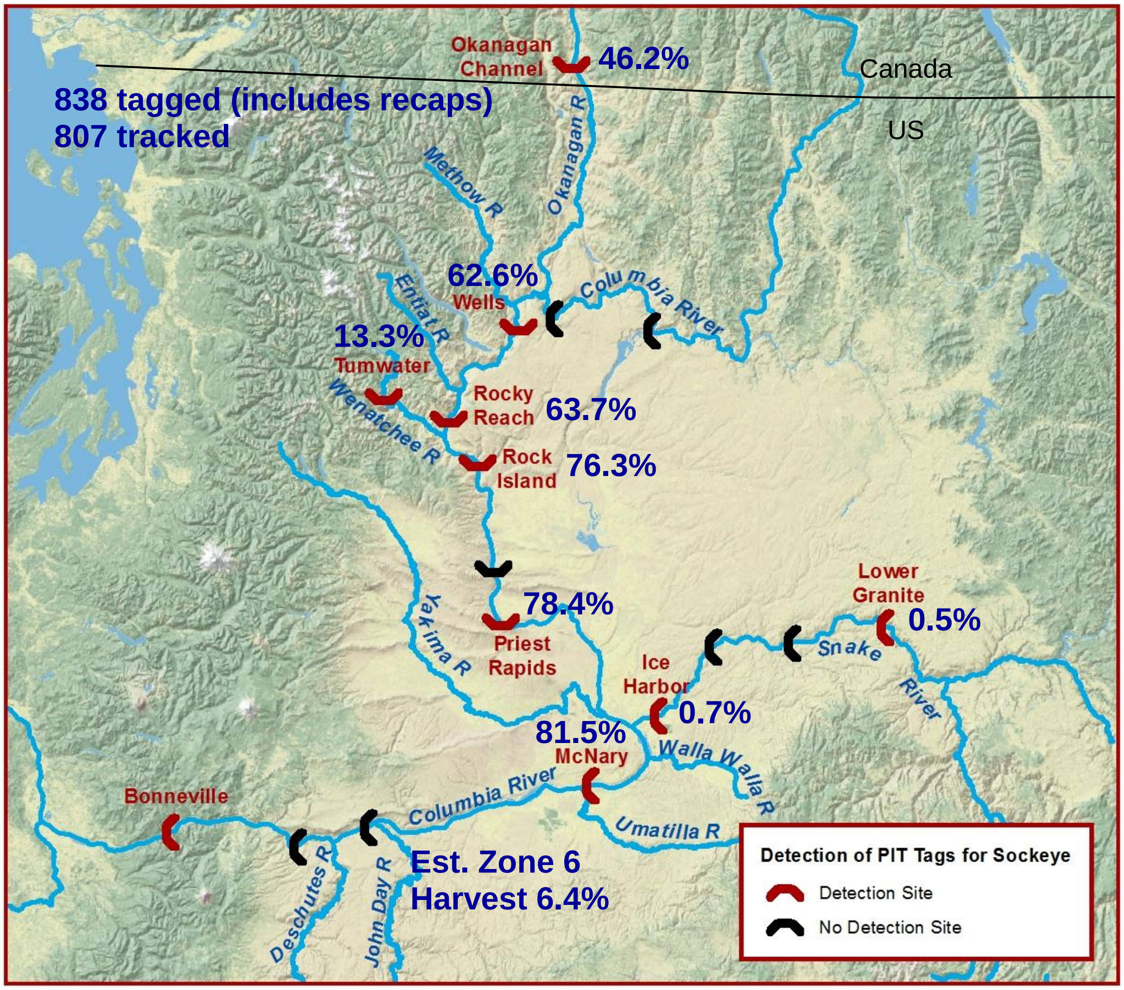

Figure 22. Map of the Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fish PIT tagged at Bonneville Dam, and the percentage of the run estimated to pass McNary, Priest Rapids, Rock Island, Rocky Reach, Wells, Ice Harbor.

Using detections of fish PIT tagged by this program to estimate fish counts at dams resulted in greater variation from visual fish counts than in most previous years. For instance, in 2008 estimates from this project were within 6.4% of the visual count at Priest Rapids, Rock Island, Rocky Reach, and Wells dams whereas, in 2009 these estimates differed by up to 16.1% and in 2010 by 16.6%. At McNary, Ice Harbor, and Lower Granite dams, it is possible for fish to use navigation locks to bypass fish ladders, thus avoiding both PIT tag detection and visual detection. In 2010, PIT tag estimates exceeded visual counts at McNary Dam, likely due at least in part to navigation lock passage, but at all other Columbia River dams, visual counts exceeded PIT tag estimates (Table 28).

The 2010 results were similar to 2006-2009 results where there were significant linear relationships between survival within specific river segments and the statistical week in which the fish were tagged; fish tagged later in the migration exhibiting a lower survival rate (Table 29).

Table 29. Sockeye salmon survival through selected reaches by statistical week as estimated by PIT tag detections in 2010 and the p-value for a linear regression of survival and Statistical Week.

Statistical Week at Bonneville Dam	Bonneville-McNary	Bonneville-Priest Rapids	Bonneville-Rock Island	Rocky Reach-Wells
23	93.5%	93.5%	93.5%	100.0%
24	91.5%	89.8%	89.8%	100.0%
25	84.2%	81.4%	79.5%	96.6%
26	81.9%	79.0%	77.4%	96.3%
27	79.7%	77.1%	74.5%	99.1%
28	76.3%	73.8%	72.5%	100.0%
29	78.0%	78.0%	73.2%	100.0%
Composite	**81.1%**	**78.4%**	**76.5%**	**97.6%**
p-value	**<0.01**	**0.01**	**<0.01**	**<0.01**

Bonneville to McNary survival significantly decreased with increasing temperatures measured at The Dalles Dam (p=0.01, Figure 23) but there was not a significant linear relationship with flow measured at The Dalles Dam (p=0.20).

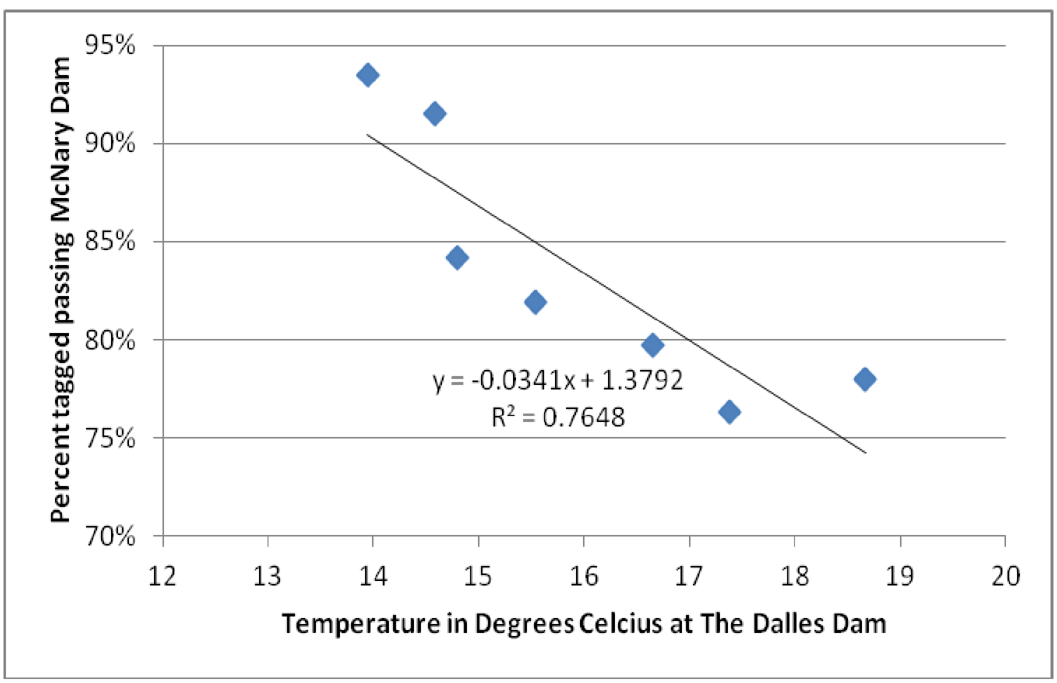

Figure 23. Figure showing the linear relationship between the survival of PIT tagged sockeye salmon from Bonneville to McNary Dam and mean water temperature at The Dalles Dam by statistical week in 2010.

Migration Timing and Passage Time

Sockeye salmon travel quickly upstream with a median travel time between Bonneville and Rock Island Dam of 12.9 days (Table 30). Sockeye salmon passing Bonneville Dam later in the migration travel upstream faster than those earlier in the migration. There is a significant (α=0.05) linear relationship between statistical week passing Bonneville Dam and passage time from Bonneville Dam to McNary, 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 two sockeye classified as Wenatchee stock were detected) was 1.2 days or less between the two major stocks (Table 31).

Table 30. Median sockeye salmon migration time and travel rates between dams as estimated by PIT tag detections in 2010.

Dam Pair	Distance (km)	Median Time (days)	Median Travel Rate (km/day)
Bonneville-McNary	231	5.1	45.3
McNary-Priest Rapids	167	4.1	40.7
Priest Rapids-Rock Island	89	3.0	29.7
Rock Island-Rocky Reach	33	1.0	33.0
Rocky Reach-Wells	65	2.0	32.5
Rock Island-Tumwater	73	13.3	5.5
Bonneville-Rock Island	487	12.9	37.8
Bonneville-Tumwater	560	27.8	20.1
Bonneville-Wells	585	16.0	36.6

Table 31. Median adult sockeye salmon travel time in days between dam pairs by statistical week passing 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 2010.

	Travel Time in Days Between Paired Dams								
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
23	5.9	10.3	14.6	15.4	–	17.2	8.9	1.2	2.6
24	5.2	10.0	14.8	17.0	37.6	19.3	9.2	1.8	2.8
25	5.1	9.8	13.9	14.9	28.5	17.2	8.4	1.2	2.2
26	5.2	9.4	12.7	13.6	25.0	15.9	7.1	1.1	2.1
27	5.0	8.8	11.7	12.8	22.2	15.2	6.7	1.1	2.1
28	4.8	8.8	11.6	12.4	21.8	14.5	6.4	1.0	2.1
P-value	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.02**	**<0.01**
Stock									
Okanagan	5.1	9.7	12.8	13.8	31.0	16.0	7.2	1.0	2.0
Wenatchee	5.1	9.8	14.0	14.8	27.8	--	8.5	0.8	--
Snake River	4.9	--	--	--	--	--	--	--	--
Unknown[c]	5.0	9.1	11.1	--	--	--	--	--	--

The median time for passage between first detection and last detection was six minutes or less at most dams except for Bonneville, Lower Granite, and Tumwater dams (Table 32). At Bonneville Dam, many sockeye were detected in underwater orifices just upstream and downstream of the fish trap where sampling occurred, inflating the median passage time. At both Lower Granite and Tumwater dams, all sockeye were trapped which likely resulted in migration delays and therefore increased passage times.

Table 32. Sockeye salmon median passage time, from time of first detection at a dam to last detection at a dam and the percentage of sockeye salmon taking greater than 12 hours between first detection and last detection in 2010.

Dam	Median Passage Time (Minutes)	Taking more than 12 hours (%)
Bonneville	63	6.1%
McNary	0	2.2%
Priest Rapids	6	1.2%
Rock Island	3	0.8%
Rocky Reach	1	2.1%

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

Wells	2	2.5%
Tumwater	8494	72.1%
Ice Harbor	5	0.0%
Lower Granite	704	50.0%

Stock Composition Estimates

The percentage of Wenatchee stock sockeye salmon was higher during the middle of the run when compared to the beginning and end with no significant linear relationship between weekly stock composition and statistical week ($p=0.85$, Table 33). The overall stock composition estimate was 17.3% Wenatchee, 81.8% Okanagan, and 0.9% Snake River. The Wenatchee/ Okanagan split differed by 4.8 percentage points from that estimated by Rocky Reach Dam counts and 6.8 percentage points from that estimated using Tumwater Dam counts (Table 33).

Table 33. Weekly and composite sockeye salmon stock composition at Bonneville Dam as estimated by PIT tags in 2010 and a comparison to stock composition estimates estimated using visual dam counts.

Statistical Week and Dates	Run Size	PIT Tag Sample Size	Percent Wenatchee	Percent Okanagan	Percent Snake River
23 (On or before June 4)	1129	34	3.2%	96.8%	0.0%
24 (June 5-11)	4776	62	11.3%	88.7%	0.0%
25 (June 12-18)	51141	224	20.4%	79.6%	0.0%
26 (June 19-25)	182178	262	19.8%	79.7%	0.5%
27 (June 26-July 2)	90356	203	16.1%	81.9%	2.0%
28 (July 2-8)	44082	84	9.4%	89.1%	1.6%
29 (On or after July 9)	12863	44	8.3%	91.7%	0.0%
Composite	**386525**	**913**	**17.3%**	**81.8%**	**0.9%**
Standard Deviation			**0.7%**	**1.5%**	**0.0%**
Visual Fish Counts at dams (using difference between Rock Island and Rocky Reach counts to estimate proportion Wenatchee)			12.5%	86.6%	
Visual Fish Counts at dams (Tumwater count to estimate the proportion Wenatchee)			10.5%	88.6%	

A total of 31 adipose clipped sockeye salmon were PIT tagged[d]. Of these, 5 were last detected in the Snake Basin (1 of which had a ventral fin clip in

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

addition to an adipose fin clip), 12 were last detected in the Wenatchee Basin, 3 were last detected at or upstream of Rocky Reach Dam, and 12 were last detected at a Columbia River dam downstream of Rocky Reach Dam.

Okanagan, Wenatchee, and Snake Age and Length-at-Age Composition

The 1.2 age class was predominant for all three stocks (Table 34). One-ocean sockeye salmon (age 1.1 and 2.1) were found only in the Okanagan stock. The age composition was similar whether estimated by PIT tag or by sampling at Tumwater Dam for the Wenatchee stock. However, this was not the case for the Okanagan stock where trap size selectivity, which was also observed in 2008 and 2009 (Fryer 2009, Fryer 2010), resulted in larger fish being over represented in the sample obtained at Wells Dam. Length-at-age estimates are found in Table 35.

Table 34. Age composition (%) of Columbia Basin sockeye salmon stocks as estimated by PIT tag recoveries as well as by sampling at Tumwater and Wells dams in 2010. Standard deviations are in parentheses.

		Age					
Stock-Method	**Sample Size**	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**
Bonneville-mixed sample	870	1.6 (0.5)	92.2 (1.0)	2.8 (0.6)	0.4 (0.2)	3.0 (0.7)	--
Wenatchee-PIT tag estimate	110	--	81.7 (4.0)	10.2 (3.2)	--	6.6 (2.7)	--
Wenatchee-Tumwater sample	395	--	73.9 (2.8)	3.6 (1.1)	--	22.3 2.7	0.2 (2.0)
Okanagan- PIT tag estimate[e]	567	2.0 (0.7)	95.2 (1.0)	0.5 (3.4)	0.6 (0.3)	1.7 (0.6)	--
Okanagan-Wells sample	394	1.2 (0.5)	95.3 (1.0)	3.4 (0.9)	--	0.1 (0.1)	--
Snake River PIT tag estimate	5	--	72.0	28	--	--	--

Table 35. Length-at-age composition of Wenatchee and Okanagan stock sockeye salmon estimated by PIT tag detection and sampling at Tumwater and Wells dams in 2010.

		Age					
Stock	**Statistic**	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**
Bonneville-Mixed stock	Mean	40.8	50.1	57.3	41.9	52.2	--
	St. Dev.	2.0	4.7	2.4	1.8	2.5	--
	N	15	776	22	5	26	--
Okanagan-	Mean	41.0	49.8	59.0	41.9	51.9	41.0

[e] The estimated Okanagan stock age composition determined from otoliths collected on the spawning ground (n=501) was .1=3.5%, 1.2=87.9%, 1.3=5.4%, 2.2 =3.3% (Kim Hyatt, personal communication).

PIT tags	St. Dev.	2.0	4.4	2.0	1.8	2.8	2.0
	N	13	523	3	5	8	13
Okanagan-Wells Sampling	Mean	41.1	53.0	56.4	--	51.0	--
	St. Dev.	2.3	2.4	2.4	--	--	--
	N	5	374	14	--	1	--
Wenatchee-PIT tags	Mean	--	51.9	57.3	--	52.1	--
	St. Dev.	--	1.9	1.8	--	3.5	--
	N	--	83	13	--	8	--
Wenatchee-Tumwater Sampling	Mean	--	53.9	58.0	--	54.3	60.5
	St. Dev.	--	2.0	1.6	--	2.4	--
	N	--	304	16	--	74	1

Night Passage

Okanagan stock sockeye salmon generally passed dams at night (2000-0400 hours) at a higher rate than Wenatchee stock (Table 36). The Bonneville Dam estimate of nighttime passage is likely biased low because tagging occurred between about 0900 and 1500 hours, and with a median passage time of 63 minutes from tagging to last detection at Bonneville Dam (Table 32), fish would be expected to pass the counting window prior to 2000 hours.

Table 36. Estimated sockeye salmon nighttime passage (2000-0400 standard time) in 2010 at Columbia and Snake river dams as estimated by PIT tag detections.

Dam	All Sockeye (includes unknown)	Okanagan Stock	Wenatchee Stock	Snake Stock
Bonneville	0.5	0.4	0.0	0.0
McNary-Oregon Shore	5.6	6.6	0.0	0.0
McNary-Washington Shore	7.7	7.3	6.4	0.0
Priest Rapids	2.2	2.6	0.0	NA
Rock Island	3.0	2.8	2.9	NA
Rocky Reach	11.4	11.3	20.0[a]	NA
Wells	12.1	12.2	0.0[a]	NA
Tumwater	9.0	0.0[a]	9.1	NA
Ice Harbor	0.0	NA	NA	0.0
Lower Granite	25.0[a]	NA	NA	25.0[a]
Mean of McNary, Priest Rapids and Rock Island	4.8	4.2	2.5	NA

a - Based on fewer than five fish detected at dam.

Fallback

The highest fallback-reascension rates for sockeye salmon were at Lower Granite and Ice Harbor dams; however these rates were based on only four and five fish respectively (Table 37). Fallback rates elsewhere were low, ranging from 0.0% at Tumwater to 3.1% at Rocky Reach Dam. All fish except five only fell over one dam, of the five; four fish back over two dams and one fell back over three dams. A fish tagged with 3D9.1C2D07DF6A was detected in the Okanagan River on September 17 before dropping downstream of Rock Island Dam and

was last detected at Rocky Reach Dam on October 22. Another sockeye, 3D9.1C2D3CAE16, passed Wells Dam on July 3 then was detected 133 times at the Tumwater Dam fish ladder between July 16 and August 4 but never passed over that dam. The fish was last detected at Rocky Reach Dam on August 7.

Table 37. Estimated 2010 sockeye salmon fallback/reascension.

Dam	Percent Fallback%
Bonneville	1.7%
McNary	1.0%
Priest Rapids	1.0%
Rock Island	1.2%
Rocky Reach	3.1%
Wells	0.7%
Tumwater	0.0%
Ice Harbor	20.0%
Lower Granite	25.0%

DISCUSSION

This study sampled and PIT tagged over 5000 salmonids at Bonneville Dam in 2010 and then tracked these fish upstream to estimate parameters such as upstream escapement, age composition, length composition, and migration rates at mainstem dams and other tributary interrogation sites. PIT tags provide an easier, much cheaper, and less intrusive method of monitoring the upstream migration of fish than radio tags used in past studies. However, PIT tags do not always provide the same amount of data as can be collected in a radio tag study. For example, PIT tag detection is not installed at all mainstem dams, nor is it present in many tributaries. It is far less expensive, and often more feasible, to add a radio tag receiver at a desired site, than a PIT tag antenna. New detection sites for PIT tags are continually being added into the system, particularly in tributaries, making PIT tag data more useful, but also much more complex to analyze.

Detection rates of salmon and steelhead PIT tagged by this study passing PIT tag detection sites at dams was generally over 99% in 2010. Notable exceptions were steelhead at Priest Rapids (98.3%) and Rocky Reach (98.6%), sockeye at McNary (93.8%) and Rock Island (93.8%), spring Chinook at Priest Rapids (98.2%), and summer Chinook at Bonneville (98.8%), McNary (98.5%), Rock Island (95.3%) and Ice Harbor (96.8%). Undetected passage likely occurs at Bonneville, McNary, Ice Harbor, and Lower Granite dams which have navigation locks that migrating fish could pass through. However, Priest Rapids, Rock Island, and Rocky Reach dams do not have lock passage, and therefore lower detections rates are not easily explained. Rock Island is known to have some issues with noise/interference that adversely affect detection of tags (Fryer et al. 2011).

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 passage 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 2010 the percentage of Snake River origin Chinook salmon at Bonneville Dam peaked at 74.5% of the run for the week starting May 30, declining to 7.2% for the week starting June 27. The portion of the run bound for upstream of Priest Rapids Dam over the same period increased from 16.0% to 68.1%. These results suggest that in 2010, 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 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 97.2% of spring, 92.7% of the summer, and 98.4% of the fall Chinook at Bonneville Dam were classified similarly at Priest Rapids Dam. Incorrectly classified Bonneville spring Chinook were all classified as summers, summers were all classified as springs, and the only incorrectly classified fall Chinook was classified as a summer Chinook at Priest Rapids Dam. This study found that 99.5% of spring, 97.1% of the summer, and 99.5% of the fall Chinook at Bonneville Dam were classified similarly at Ice Harbor Dam. Incorrectly classified Bonneville Dam spring Chinook were classified as summers at Ice Harbor Dam, 84.8% of the incorrectly classified summer Chinook were classified as spring Chinook with the remainder as fall Chinook, while the sole incorrectly classified fall Chinook was classified as a summer Chinook at Ice Harbor Dam.

Escapement estimates using PIT tag data for mainstem dam passage varied from the traditional methods (i.e. visual counts) and ranged from -2.7% to

+22.3% for the entire Chinook salmon run. Summer Chinook estimates between the two methods were most consistent differing by 6.7% or less for all dams but McNary. Fall Chinook estimates varied the most, with the PIT tag estimate being 27.1-42.3% less than the visual count at Columbia River dams upstream of McNary but 76.8-81.0% greater than the visual count at Ice Harbor and Lower Granite dams. Escapement estimates for sockeye salmon at Columbia River dams different between the two methods by 12.8 to 16.6%. Many factors can cause these discrepancies including inaccuracies of visual or video counts, fallback/reascension rates, tagging effects, and a biased sampled 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 weekly distribution of our sample was much more similar to the weekly distribution of the run for steelhead, sockeye, and Chinook than it was in 2009. In 2009, during higher temperatures, we under-sampled relative to the run distribution, this was not the case in 2010. This is likely a result of generally cooler water temperatures in 2010 than in 2009, as well as changes in trap protocols. When water temperatures exceeded 70.0 F (21.1 C) as measured at Bonneville Dam, we operate under restrictions. In 2009, sampling (which included trap set up) at the Adult Fish Facility was restricted to four mornings per week from 6 AM to 10 AM. Since fish typically take 1.0 to 1.5 hours to reach the sampling tank after the trap is set up, in the past this only allowed for 2.5 to 3.0 hours to actually sample fish. In 2010 we were required to raise picket leads after four hours but were allowed an additional hour from 10 AM to 11 AM to trap fish already in the system. This meant that our sampling effort was not reduced as much as it was in 2009.

Despite easing of temperature restrictions, when compared to 2009 our steelhead sample size decreased by 29.7% in 2010, our Chinook sample decreased by 13.0%, and our sockeye sample increased by 7.8%. Over all three species, our sample size decreased by 16.8% despite the fact that the overall number of sockeye, Chinook, and steelhead passing Bonneville Dam increased by 15%. The likely reason for decrease in sample size, despite an increase in run sizes and an increase in sampling hours, was a new protocol which required the picket leads to be raised for 30 minutes every hour when ladder abundance met a certain criteria. This especially impacted our summer Chinook sample size, which reduced from 907 in 2009 to 495 in 2010, even though sampling

effort was equal or greater than in 2009.

As in both 2008 and 2009, delays were observed for both sockeye and Chinook salmon in passing Tumwater Dam in 2010. At this site, all salmonids were required to pass through a fish trap that was shut down during night hours. The median delay for Chinook was 4.5 days (compared to less than one hour at other dams), for sockeye salmon it was 5.9 days (compared to six minutes or less at all dams other than Lower Granite and Bonneville) and for steelhead it was 3.7 days (compared to 95 minutes or less at all other dams). Fryer et al. (2010, 2011) estimated, based on individual fish last detected at the downstream antenna at Tumwater Dam, that 20.4% of sockeye salmon reaching the Tumwater Dam fish ladder in 2009 did not pass over the dam. In 2010 this increased to 33.3%. Using similar methods for Chinook, the percentage increased from 14.5% in 2009 to 44.6% in 2010. Only 16 steelhead from this study were detected at Tumwater Dam. PIT tag data suggests that three (18.8%) of these fish did not pass over the dam. The increase in the percentage not passing over Tumwater Dam in 2010 may be related to the sockeye salmon run in 2010 being over twice as large as in 2009 (35,821 versus 16,304) while the Chinook run was similar (8,755 versus 9,304). If the passage through the trap is a constraint on passage, then an increased number of fish passing would be expected to increase delays (the median sockeye delay went from 159 minutes in 2009 and for Chinook it also increased) and likely an increase in the percentage of fish that do not successfully pass. Trap operations were changed in 2011 so that the fish ladder was left open at least part of each day for fish passage and preliminary data indicates delays were greatly reduced.

REFERENCES

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

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

Fish Passage Center (FPC). 2010. Adult fish counts online at www.fpc.org..

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

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

Fryer, J.K. 2010. Studies into factors limiting the abundance of Okanagan and Wenatchee sockeye salmon. Columbia River Inter-Tribal Fish Commission Technical Report

Fryer, J.K., H. Wright, S. Folks, K. Hyatt. 2011. Studies into Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon in 2010. U.S. Dept. of Energy Bonneville Power Administration Report Project #2008-503-00.

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

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

APPENDIX

Table A1. Probability of tag detection at PIT tag detectors by weir at mainstem Columbia Basin fish ladders, and the overall probability of detection, for Chinook salmon in 2010. 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	2507	98.4	98.5	99.2	99.1							100.0
BO1	51	96.1	100.0	100.0	100.0							100.0
McNary	**N**	**1**	**2**	**288**	**287**	**286**	**284**	**283**	**282**	**280**	**279**	
MC1	859	97.9	99.3	59.3	61.2	55.1	65.5	54.2	53.4	48.1	39.5	100.0
	N	**1**	**2**	**3**	**312**	**311**	**309**	**308**	**306**	**303**	**302**	
MC2	756	97.9	100.0	99.7	71.7	71.1	68.9	67.6	70.5	74.3	69.3	100.0
Priest Rapids	**N**	**3**	**7**									
East	299	98.0	99.3									100.0
	N	**3**	**5**									
West	74	93.2	100									100.0
Rock Island	**N**	**1-2**	**3-4**									
Left (east)	51	100.0	100									100.0
	N	**5-6**	**7-8**									
Middle	52	70.6	99.0									100.0
	N	**09-0A**	**0B-0C**									
Right (west)	238	97.9	84.9									99.7
	N	**1-2**	**3-4**									
Rocky Reach	195	97.9	96.4									99.9
Wells	**N**	**1-2**	**3-4**									
Left (east)	94	100	100									100.0
	N	**5-6**	**7-8**									
Right (west)	189	99.5	100									100.0
Ice Harbor	**N**	**438**	**437**	**436**	**435**							
South	677	95.3	99.9	99.9	99.7							100.0
North	232	94.4	99.1	98.7	99.6							100.0
	N	**733**	**732**	**731**	**730**							
Lower Granite	360	99.7	99.4	99.2	99.8							100.0
	N	**A1**	**A2**									
Tumwater	56	100	98.2									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 2010. 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	2507	98.6	98.8	99.3	98.9							100.0
BO1	78	96.1	96.2	100.0	100.0							100.0
McNary	**N**	**1**	**2**	**288**	**287**	**286**	**284**	**283**	**282**	**280**	**279**	
MC1	816	99.2	99.9	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	330	99.3	99.7	99.7	89.1	51.5	40.6	81.5	83.0	48.8	85.5	100.0
Priest Rapids	**N**	**3**	**7**									
East	77	100.0	100.0									100.0
	N	**3**	**5**									
West	37	75.7	100									100.0
Rock Island	**N**	**1-2**	**3-4**									
Left (east)	3	100.0	100									100.0
	N	**5-6**	**7-8**									
Middle	8	75.0	100.0									100.0
	N	**09-0A**	**0B-0C**									
Right (west)	63	96.8	77.8									99.3
	N	**1-2**	**3-4**									
Rocky Reach	72	97.2	87.5									99.7
Wells	**N**	**1-2**	**3-4**									
Left (east)	30	100	100									100.0
	N	**5-6**	**7-8**									
Right (west)	26	96.2	100									100.0
Ice Harbor	**N**	**438**	**437**	**436**	**435**							
South	900	99.4	99.6	99.0	99.6							100.0
North	167	94.2	99.4	99.4	98.3							100.0
	N	**733**	**732**	**731**	**730**							
Lower Granite	774	99.2	99.0	98.6	99.2							100.0

Table A3. Probability of tag detection at PIT tag detectors by weir at mainstem Columbia Basin fish ladders, and the overall probability of detection, for sockeye salmon in 2010.

Dam, Site, Tag Type, and Number		Weir and Probability of Detection at Weir				Overall Detection Probability
Bonneville	**N**	**1**	**2**	**3**	**4**	
BO4	744	99.2	98.9	98.9	99.3	100.0
BO1	108	99.1	98.1	99.1	97.2	100.0
McNary	**N**	**1**	**2**	**3**		
MC1	187	99.5	99.5	NA		100.0
MC2	490	99.6	99.6	98.8		100.0
Priest Rapids	**N**	**3**	**7**			
East	592	98.8	99.5			100.0
	N	**3**	**5**			
West	85	95.3	100.0			100.0
Rock Island	**N**	**1-2**	**3-4**			
Left	149	100.0	100.0			100.0
	N	**5-6**	**7-8**			
Middle	89	77.0	100.0			100.0
	N	**09-0A**	**0B-0C**			
Right	379	97.3	75.6			99.3
	N	**1-2**	**3-4**			
Rocky Reach	557	97.7	95.7			99.9
Wells	**N**	**1-2**	**3-4**			
Left	357	99.8	100			100.0
	N	**5-6**	**7-8**			
Right	197	100	100.0			100.0
	N					
Tumwater	108	100.0	99.1			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. List of PTAGIS interrogation sites (three letter code, name, and description).

Site Code	Site Name	Description
AB1	Abernathy Creek, Technology Center Bridge	Bridge over Abernathy Creek at Abernathy Fish Technology Center (AFTC)
AB2	Abernathy Creek, Farmer's Bridge	Private bridge over Abernathy Creek, 1.6 km downstream from Abernathy FTC
AB3	Lower Abernathy Creek	Instream detectors at Abernathy Creek, rkm 1
AB4	Abernathy Creek Hatchery Channel	Abernathy Creek Hatchery Channel
ACB	Asotin Creek ISA at Cloverland Bridge	Instream detectors at the Cloverland Bridge, Asotin Creek rkm 4.6.
ACM	Asotin Creek ISA at Mouth	Instream detectors on Asotin Creek at the mouth, 50m upstream of Hwy 129 bridge.
AFC	Asotin Creek ISA at North/South fk junction	Instream detectors on Asotin Creek at the junction of the North and South forks.
ANT	Antoine Creek Instream Array	Antoine Creek, 0.48 km upstream of the confluence with the Okanogan River
B1J	Bonneville Dam DSM1 Flat Plate Detector	Flat Plate Detector in the Bonneville Dam PH1 Downstream Migrant Bypass Channel
B2A	Bonneville Dam Adult Fish Facility	Adult Fish Facility in the WA Shore Fishway at Bonneville Dam; replaced by BO3
B2J	Bonneville Dam PH2 Juvenile Bypass System	Bonneville Dam PH2 Juvenile Bypass and Sampling Facility
BCC	Bonneville Dam PH2 Corner Collector	Bonneville Dam 2nd Powerhouse Corner Collector Outfall Channel
BCP	Butcher Creek Acclimation Pond	Butcher Creek Acclimation Pond, Wenatchee River Basin. (Yakama Nation)
BDP	Biddle Acclimation Pond (Wolf Creek)	Biddle Acclimation Pond, Wolf Creek, Methow River Basin
BGM	Burlingame Diversion Dam	Burlingame Diversion Dam, lower Walla Walla River
BHC	Bohannon Creek (ID) Lemhi River Basin	Instream site on Bohannon Creek 0.9 km upstream of confluence with Lemhi River
BO1	Bonneville Dam Bradford Island Fishway	Bradford Island Adult Fishway at Bonneville Dam
BO2	Bonneville Dam Cascades Island Fishway	Cascades Island Adult Fishway at Bonneville Dam
BO3	Bonneville Dam WA Shore Fishway & AFF	Washington Shore Adult Fishway and AFF at Bonneville Dam; replaces B2A and BWL
BO4	Bonneville Dam WA Shore Vertical Slots	Washington Shore Fishway Vertical Slots at Bonneville Dam
BSC	Big Sheep Creek (Imnaha) ISA at river km 6	In-stream detectors on Big Sheep Creek (Imnaha River Basin) at river km 6.
BTC	Big Timber Creek,Lemhi River Basin	In-stream array on Big Timber Creek, Lemhi River Basin near Leadore, ID.
BVC	Beaver Creek In-stream Array, Methow River	Instream detectors on Beaver Creek, Methow River watershed
BVJ	Bonneville Dam DSM1 Subsample	Bonneville Dam PH1 Juvenile Bypass (DSM1) sub-sample
BVP	Beaver Creek Acclimation Pond	Beaver Creek Acclimation Pond, Wenatchee River Basin. (Yakama Nation)
BVX	Bonneville Dam PH1 Flat Plate (Experimental)	Flat Plate Detector (experimental) at Bonneville Dam PH1 DSM; replaced by B1J
BWL	Bonneville Dam Washington Shore Fishway	Washington Shore Adult Fishway at Bonneville Dam; replaced by BO3
CAC	Canyon Creek (Lemhi Basin) ISA at river km 1	In-stream detectors on Canyon Creek (Lemhi River Basin) at river km 1.
CAL	Carson NFH Adult Return Ladder	Adult Fishway at Carson National Fish Hatchery
CAP	Carlton Acc. Pond	Carlton Acclimation Pond, Methow River Basin (Chelan PUD)
CCA	Charley Creek ISA at rkm 0.5	Instream detectors on Charley Creek at rkm 0.5.
CCC	Carrolls Channel, Lwr Col Riv	Instream detectors in upper Carrolls Channel, lower Columbia River at rkm 115
CCP	Catherine Creek Acclimation Pond	Catherine Creek Acclimation Pond, operated by CTUIR
CFF	Castile Falls Fishway	Castile Falls Fishway
CFJ	Clark Flat Acclimation Ponds	Clark Flat Acclimation Pond Outfall
CHL	Lower Chiwawa River	Instream MUX at Chiwawa River rkm 1
CHM	Chumstick Creek	Chumstick Creek PIT Tag Detection Site, rkm 0.4, near North Road Bridge
CHN	Challis - North	Challis Diversion (North)
CHP	Chiwawa Acclimation Pond	Chiwawa Acclimation Pond, Wenatchee River Basin
CHS	Challis - South	Challis Diversion (South)
CHU	Upper Chiwawa River	Instream MUX at Chiwawa River rkm 12, between the FR-62 bridge and Alder Creek
CHW	Chiwaukum Creek	Chiwaukum Creek PIT Tag Detection Site, rkm 0.4, near Tumwater Campground
CIC	Cottonwood Island, Lwr Col Rvr	Instream detectors on Cottonwood Island, lower Columbia River at rkm 112
CLE	Cle Elum Dam Interim Spillway Bypass	Cle Elum Dam interim (experimental) Spillway Bypass
CLJ	Clearwater River Trap	Clearwater River Juvenile Migrant Trap, operated by IDFG
CLP	Coulter Creek Acclimation Pond	Coulter Creek Acclimation Pond, Wenatchee River Basin. (Yakama Nation)
COC	Cow Creek ISA at stream mouth	Instream detectors on Cow Creek at river km 0.5
CR1	Chinook River at Sea Resources Hatchery	Chinook River, below Sea Resources Hatchery adult capture facility
CR2	Chinook River at HWY 101 Bridge	Chinook River, tidal gates at the Hwy 101 Bridge
CR3	Chinook River at a Culvert	Chinook River, at a road culvert
CRW	Chewuch River above Winthrop	In-stream array on the Chewuch River above Winthrop, WA.

Table A4. Continued.

Site Code	Site Name	Description
DRP	Dryden Acc. Pond	Dryden Acclimation Pond, Wenatchee River Basin
DWL	Dworshak NFH adult trap	Dworshak National Fish Hatchery Adult Trap
EMC	Eightmile Creek In-stream Array, Methow River	Instream detector on Eightmile Creek, Methow River Basin
ENA	Upper Entiat River at rkm 17.1	Instream antenna array on Entiat river at rkm 17.1, above Mad River
ENF	Upper Entiat River Instream at rkm 40.6	Instream detectors near USFS property boundary, Entiat River rkm 40.6.
ENL	Lower Entiat River	Instream MUX at Entiat River rkm 2, immediately upstream of Entiat, WA.
ENM	Middle Entiat River	Instream MUX at Entiat River rkm 26, below the McKenzie Diversion Dam
ENS	Upper Entiat River at rkm 35.7	Instream antenna array on Entiat River rkm 35.7, above Stormy Creek
ESJ	Easton Acclimation Pond	Easton Acclimation Pond Outfall
ESS	East Fk South Fk Salmon River at Parks Cr.	Instream MUX on the East Fk South Fk Salmon River (rkm 21) at Parks Creek
ESX	Estuary Saltwater Trawl (Experimental)	Salt Water & Estuary Trawl Detector, operated by NOAA Fisheries
FDC	Feed Canal, Umatilla River	Feed Canal, Umatilla River
FDD	Feed Diversion Dam	Feed Diversion Dam, Umatilla River
GL2	SF Gold Creek In-stream Array, Methow River	Instream detector on South Fork Gold Creek, Methow River watershed
GLC	Gold Creek In-stream Array, Methow River	Instream detector on Gold Creek, Methow River watershed
GOJ	Little Goose Dam Juvenile Bypass System	Little Goose Dam Juvenile Fish Bypass/Transportation Facility
GRA	Lower Granite Dam Adult Fishway and Trap	Lower Granite Adult Fishway and Fish Trap
GRJ	Lower Granite Dam Juvenile Bypass System	Lower Granite Dam Juvenile Fish Bypass/Transportation Facility
GRP	Grande Ronde Acclimation Pond	Upper Grande Ronde River Acclimation Pond, operated by CTUIR
GRX	Lower Granite Dam Sep-by-Code (Experimental)	Lower Granite Juvenile Bypass Experimental Site
HLM	Potlatch River near Helmer	Potlatch River near Helmer
HLX	Hemlock Dam (Trout Cr, Wind River) Fishway	Hemlock Dam Adult Fishway, on Trout Creek in the Wind River (WA) watershed
HYC	Hayden Creek in-stream array, Lemhi Basin	In-stream array near the mouth of Hayden Creek, Lemhi River Basin
ICH	Ice Harbor Dam Fishways and Juvenile Bypass	Ice Harbor Dam Adult Fishways (both) and Full Flow Bypass
ICL	Lower Icicle Creek at rkm 0.4	Lower Icicle Creek Instream PIT Tag Detection Site, rkm 0.4
IHA	Ice Harbor Adult Fishways	Ice Harbor Dam Adult Fishways (both)
IMJ	Imnaha River Juvenile Trap	Imnaha River Smolt Trap
IR1	Lower Imnaha River ISA at river km 7	Instream detectors on the Imnaha River at river km 7
IR2	Lower Imnaha River ISA at river km 10	In-stream detectors on the Imnaha River at river km 10.
IR3	Upper Imnaha River ISA at rm 41	Instream detectors on the Upper Imhaha River at river km 41
JCJ	Jack Creek Acclimation Pond	Jack Creek Acclimation Pond Outfall
JD1	John Day River near McDonald Ferry at RM 20	John Day River in-stream detection, near McDonald Ferry at RM 20
JDJ	John Day Dam Juvenile Bypass System	John Day Dam Juvenile Fish Bypass and Sampling Facility
JOC	Joseph Creek (Grande Ronde) ISA at river km 3	In-stream detectors on Joseph Creek (Grande Ronde River Basin) at river km 3.
JUL	Potlatch River near Juliaetta	Potlatch River near Juliaetta
KCB	Kiwanis Camp Bridge, upper Mill Creek	Instream detectors at Kiwanis Camp Bridge, upper Mill Creek, Walla Walla Basin
KEN	Kenney Creek In-stream Arrays	In-stream array near the mouth of Kenney Creek, Lemhi River Basin
KHS	Big Bear Cr. at Kendrick HS	Mouth of Big Bear Creek (Potlach River Watershed) at Kendricks High School
KRS	SF Salmon River at Krassel Cr.	Instream MUX on the South Fork Salmon River (rkm 65) near Krassel Creek
LAP	Lapwai Creek near the mouth	Instream detectors on Lapwai Creek, near the confluence with the Clearwater R.
LBC	Libby Creek In-stream Array, Methow River	Instream detector on Libby Creek, Methow River watershed
LEA	Leaburg Dam smolt bypass and adult fishways	Leaburg Dam smolt bypass and adult fishways
LFF	Lyle Falls Fishway and Adult Wet Lab	Lyle Falls Fishway
LHC	Leavenworth NFH Juvenile Coho Releases	Leavenworth NFH Coho Releases
LLR	Lower Lemhi River ISA at Salmon	Instream array on the lower Lemhi River in Salmon, ID.
LLS	Lemhi Little Springs (ID), Lemhi River Basin	Instream interrogation system on Lemhi Little Springs, .1km upstream of Lemhi R.
LMJ	Lower Monumental Dam Juvenile Bypass System	Lower Monumental Dam Juvenile Fish Bypass/Transportation Facility
LMR	Lower Methow River near Pateros	Instream MUX on the lower Methow River immediately upstream of Pateros
LMT	Lower Mainstem Teanaway River	In-stream array at km 0.4 on the Teanaway River, upper Yakima River Basin
LOP	Lostine River Acclimation Pond	Lostine River Acclimation Pond, operated by the Nez Perce Tribe

Table A4: Continued.

Site Code	Site Name	Description
LRW	Lemhi River ISA below the IDFG weir	In-stream array on the Lemhi River below the IDFG weir
LTP	Lower Twisp Acclimation Pond	Lower Twisp Acclimation Pond, Methow River Basin
LTR	Lower Tucannon River,near the river mouth	Instream detectors on the lower Tucannon River below Starbuck, WA.
LWD	Lowden Diversion Dam	Lowden Diversion Dam
LWE	Lower Wenatchee River	Instream MUX at Wenatchee River rkm 2
LWL	Little White Salmon NFH adult fish ladder	Adult Fishway at Little White Salmon National Fish Hatchery
LWN	Little Wenatchee River	Instream MUX at Little Wenatchee River rkm 4, at the old fish weir site
MAD	Mad River,Entiat River Basin	Instream MUX at Mad River rkm 1, at Ardenvoir, WA.
MC1	McNary Dam Oregon Shore Fishway	Oregon Shore Adult Fishway at McNary Dam
MC2	McNary Dam Washington Shore Fishway	Washington Shore Adult Fishway at McNary Dam
MCD	Placed at Mill Cr Diversion Dam (StreamNet Data) in Walla Walla River Basin	Fish Bypass and Adult Fishway at Mill Creek Diversion Project, Walla Walla Basin
MCI	Mill Creek Intake Dam Adult Fishway	Adult fishway at Mill Creek Intake Dam, Walla Walla Basin
MCJ	McNary Dam Juvenile Bypass System	McNary Dam Juvenile Fish Bypass/Transportation Facility
MCX	McNary Dam Juvenile Experimental Site	McNary Dam - Full-Flow Bypass (NMFS, 2002); non-ISO coils (Chelan Co. PUD, 1996)
MRB	Lower Methow River Basin below Twisp	Instream detectors deployed in tributaries to the lower Methow River
MRT	Methow River array at Twisp	In-stream array on the Methow River at Twisp, WA.
MRW	Methow River array at Winthrop	In-stream array on the Methow River at Winthrop, WA.
MSC	Methow River Side Channel Array	Instream arrays on a side channel to the Methow River
MSH	Methow Fish Hatchery Outfall	Methow Fish Hatchery Outfall, Methow River Basin
MWC	Maxwell Canal, Umatilla River	Maxwell Canal, Umatilla River
MWE	Middle Wenatchee River	Instream MUX at Wenatchee River rkm 50, above Tumwater Dam
NAL	Lower Nason Creek	Instream MUX at Nason Creek rkm 1, located within Lake Wenatchee State Park
NAU	Upper Nason Creek	Instream MUX at Nason Creek rkm 19
NBA	Nursery Bridge Diversion Dam Fishways	Nursery Bridge Dam Fishways (both), Walla Walla River at Milton-Freewater
NMC	Ninemile Creek Instream Array	Ninemile Creek, 0.78 km upstream of the confluence with Lake Osoyoos
OKC	Okanagan Channel at VDS-3	Okanagan Channel VDS-3, at Okanogan River km 149 upstream of Osoyoos Lake
OMK	Omak Creek Crump Weir	Omak Creek, near the confluence with the Okanogan River.
ORB	Oasis Road Bridge, lower Walla Walla River	Instream detectors at Oasis Road Bridge, lower Walla Walla River
PD7	Columbia River Estuary at rkm 70	Columbia River Estuary at rkm 70
PES	Peshastin Creek	Instream MUX at Peshastin River rkm 3, below the bridge at Smithson's property
PRA	Priest Rapids Dam Adult Fishways	Priest Rapids Dam Adult Fishways (both)
PRJ	Prosser Dam screened Juvenile Diversion	Chandler Canal Diversion Bypass and Sampling Facility at Prosser Dam
PRO	Prosser Dam Fishways and screened Diversion	Adult Fishways (all three) and Juvenile Bypass/Sampling Facility at Prosser Dam
RBF	Round Butte Dam Fish Transfer Facility	Round Butte Dam Fish Transfer Facility
RCL	Rock Creek (WA) near Yakima Nation Longhouse	Instream detection system on Rock Creek (WA) near the Yakama Nation Longhouse
RCS	Rock Creek (WA) at Squaw Creek	Instream detection system on Rock Creek (WA) at Squaw Creek
RCX	Rattlesnake Creek Flat Plates (Experimental)	Flat Plate Monitors on Rattlesnake Creek (Wind River), operated by USGS
RFP	Rolfing Acclimation Pond	Rolfing Acclimation Pond, Wenatchee River Basin. (Yakama Nation)
RIA	Rock Island Dam Adult Fishways	Rock Island Dam Adult Fishways (all three)
ROZ	Roza Dam Juvenile Diversion	Roza Diversion Dam Spillway and Adult Fishway detectors
RPJ	Rapid River Hat. Juvenile Volitional Release	Rapid River Hatchery (IDFG) Outfall
RRF	Rocky Reach Fishway	Rocky Reach Dam Adult Fishway
RRJ	Rocky Reach Dam Juvenile Bypass System	Rocky Reach Dam (Chelan Co. PUD) Juvenile Fish Bypass System
RSB	Roosevelt Street Bridge	Instream detectors on Mill Creek at the Roosevelt St. bridge, Walla Walla, WA.
RZF	Roza Dam Adult Fishway	Adult Fishway at Roza Dam
SA1	Salmon Creek Instream Array	Salmon Creek, 2.9 km upstream of the confluence with the Okanogan River
SAJ	Salmon River Trap	Salmon River Juvenile Migrant Trap, operated by IDFG
SC1	Lower SF Clearwater R at rkm 0.9	Instream site on South Fork Clearwater River 0.9 km upstream of mouth
SC2	Lower SF Clearwater R at rkm 2	Instream site on South Fork Clearwater River 2 km upstream of mouth

Table A4. Continued.

Site Code	Site Name	Description
SCL	Spring Creek NFH Adult Ladder	Adult Fishway at Spring Creek National Fish Hatchery
SCP	Spring Creek Acc. Pond behind Winthrop NFH	Instream array on Spring Creek/Foghorn Diversion below Winthrop NFH.
SFG	SF Salmon River near Guard Station Rd. Bridge	Instream MUX on the SF Salmon River (rkm 30) at the Guard Station Road Bridge
SFL	Shipherd Falls Ladder	Detectors at Shipherd Falls ladder, Wind River, WA.
SIP	Similkameen Acc. Pond	Similkameen Acclimation Pond
SNJ	Snake River Trap	Snake River Juvenile Migrant Trap, operated by IDFG
SSJ	Sunnyside Dam Juvenile Diversion	Sunnyside Dam Smolt Bypass
STL	Sawtooth Hatchery Adult Trap	Sawtooth Hatchery Adult Trap
STR	SF Salmon Satellite Facility	South Fork Salmon Satellite Facility downstream of Knox Bridge
SUJ	Sullivan Dam Juvenile Bypass System	Sullivan Dam (Willamette Falls) Juvenile Fish Bypass System, operated by PGE
SWT	Sweetwater Creek near its mouth	Instream detectors on Sweetwater Creek, near the confluence with Lapwai Creek
TAN	Taneum Creek Instream	Instream detectors on Taneum Creek at rkm 0.1
TAY	Big Creek (Idaho) at Taylor Ranch	Instream detectors centered around the bridge at Taylor Ranch, Big Creek, ID
TMA	Three Mile Falls Dam Adult Fishway	Three Mile Falls Dam (Umatilla River) Adult Fishway
TMF	Three Mile Falls Dam Fishway and Diversion	Adult Fishway and Juvenile Bypass/subsampling facility at Three Mile Falls Dam
TMJ	Three Mile Falls Dam Juvenile Diversion	Three Mile Falls Dam (Umatilla River) Juvenile Fish Bypass System
TRC	Trout Creek In-stream Detection, Wind River	Trout Creek in-stream detection site, Wind River watershed.
TUF	Tumwater Dam Adult Fishway	Adult Fishway at Tumwater Dam
TWR	Lower Twisp River near MSRF Ponds	Instream MUX on the lower Twisp River adjacent to the MSRF ponds
TWX	Estuary Towed Array (Experimental)	Columbia River Estuary Trawl Detector, operated by NOAA-Fisheries
UM1	NF Umatilla River at Forks Campground Bridge	Instream Detectors on the North Fork Umatilla River at Forks Campground
UM2	Umatilla River Array above Imeques Acc. Pond	Instream Detectors on the mainstem Umatilla River upstream of Imeques Acc. Pond
UWE	Upper Wenatchee River	Instream MUX at Wenatchee River rkm 86, below the Chiwawa River
VC1	Valley Creek,in-river at Stanley, ID	Instream detectors in Valley Creek at Stanley, ID
VC2	Valley Creek,in-river below Stanley, ID	Instream detectors in Valley Creek downstream of Stanley, ID
WAJ	Wanapum Dam Juvenile (gatewell dip)	Wanapum Dam Smolt Bypass (Gatewell Dip)
WEA	Wells Dam Adult Fishways	Wells Dam (Douglas Co. PUD) Adult Fishways (both)
WFC	Wolf Creek In-stream Array, Chewuck River	Instream detector on Wolf Creek, Methow River Basin
WFF	Willamette Falls Adult Fishway	Willamette Falls Adult Fishway (ODFW)
WHC	Mouth of White Creek, Klickitat River Basin	Instream detection system near the mouth of White Creek, Klickitat River Basin
WLT	Walterville Fish Bypass Exit	The screened Walterville Fish Bypass is located 17 miles east of Eugene on the McKenzie River.
WPJ	Wapato Dam Juvenile Diversion	Wapato Dam Smolt Bypass
WSH	Adult fishway at Warm Springs NFH	Adult Fishway at Warm Springs National Fish Hatchery
WTL	White River,Wenatchee Basin	Instream MUX at White River rkm 4, at the old fish weir site
WW1	SF Walla Walla River at Harris Park Bridge	Instream detectors at Harris County Park Bridge, South Fork Walla Walla River
WW2	SF Walla Walla River at Bear Creek	Instream detectors at Bear Creek, South Fork Walla Walla River
Y1J	Yakima River Trap	Yakima River Smolt Trap
YHC	Yellowhawk Creek	Yellowhawk Creek in-stream detection site, between Mill Creek and Walla Walla R.
ZEN	Secesh River near Zena Creek Ranch	In-stream array on the Secesh River near Zena Creek Ranch
ZSL	Zosel Dam Adult Fishways	Adult Fishways at Zosel Dam, Okanogan River below Osoyoos Lake

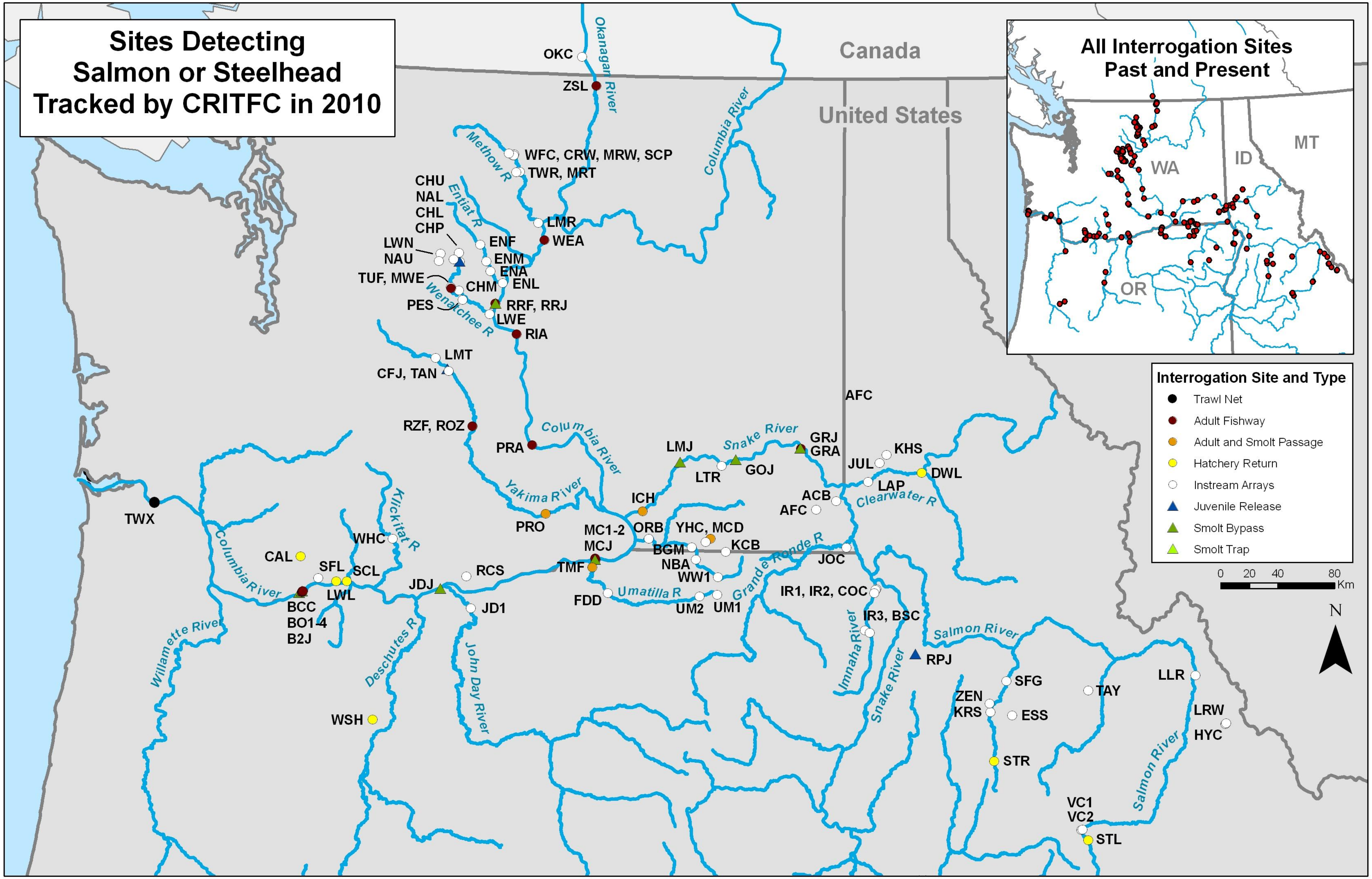

Figure A1. Map of Columbia River interrogation sites that detected Chinook and sockeye salmon, and steelhead in 2010. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

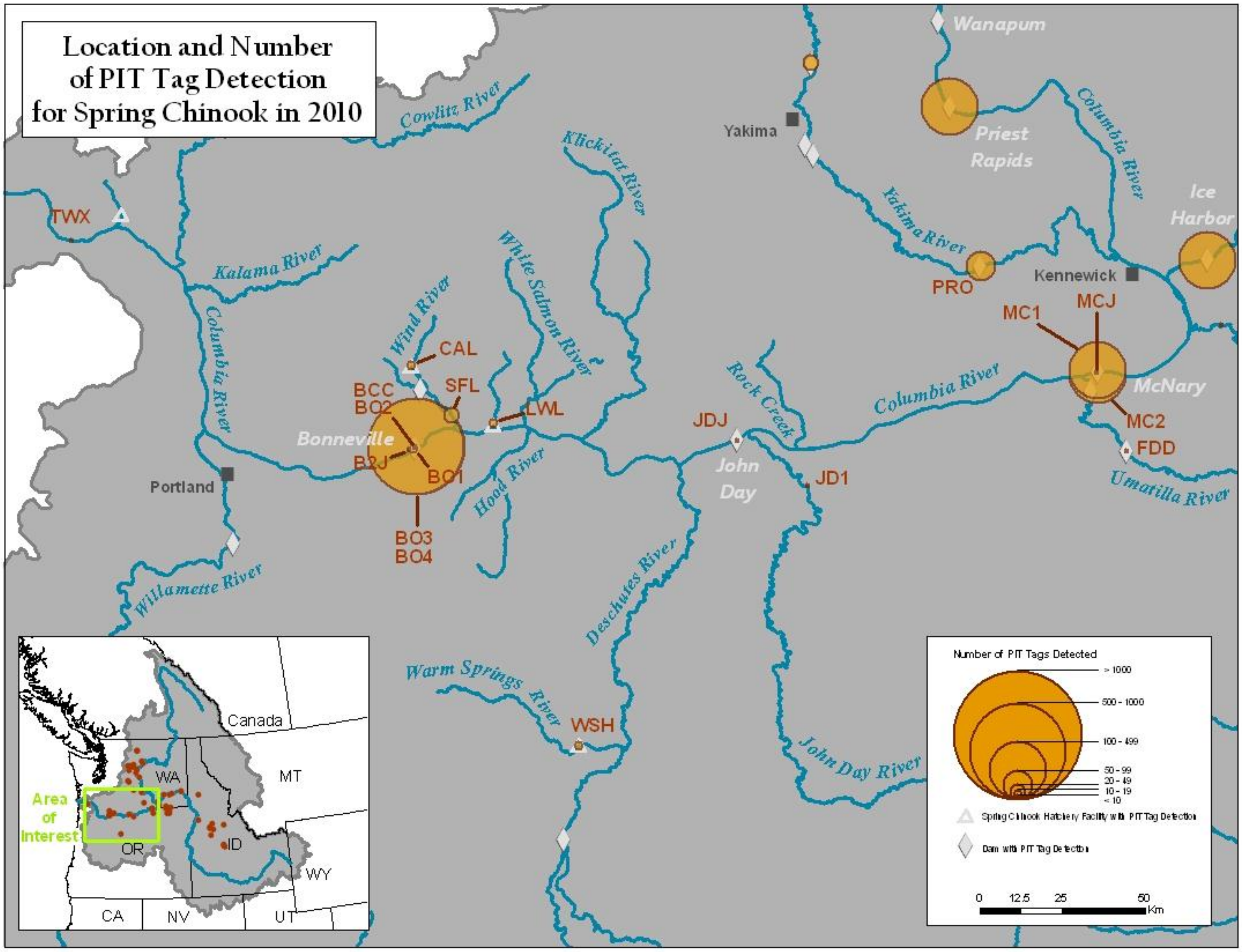

Figure A2. Map of Lower Columbia River detections sites and number of spring Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

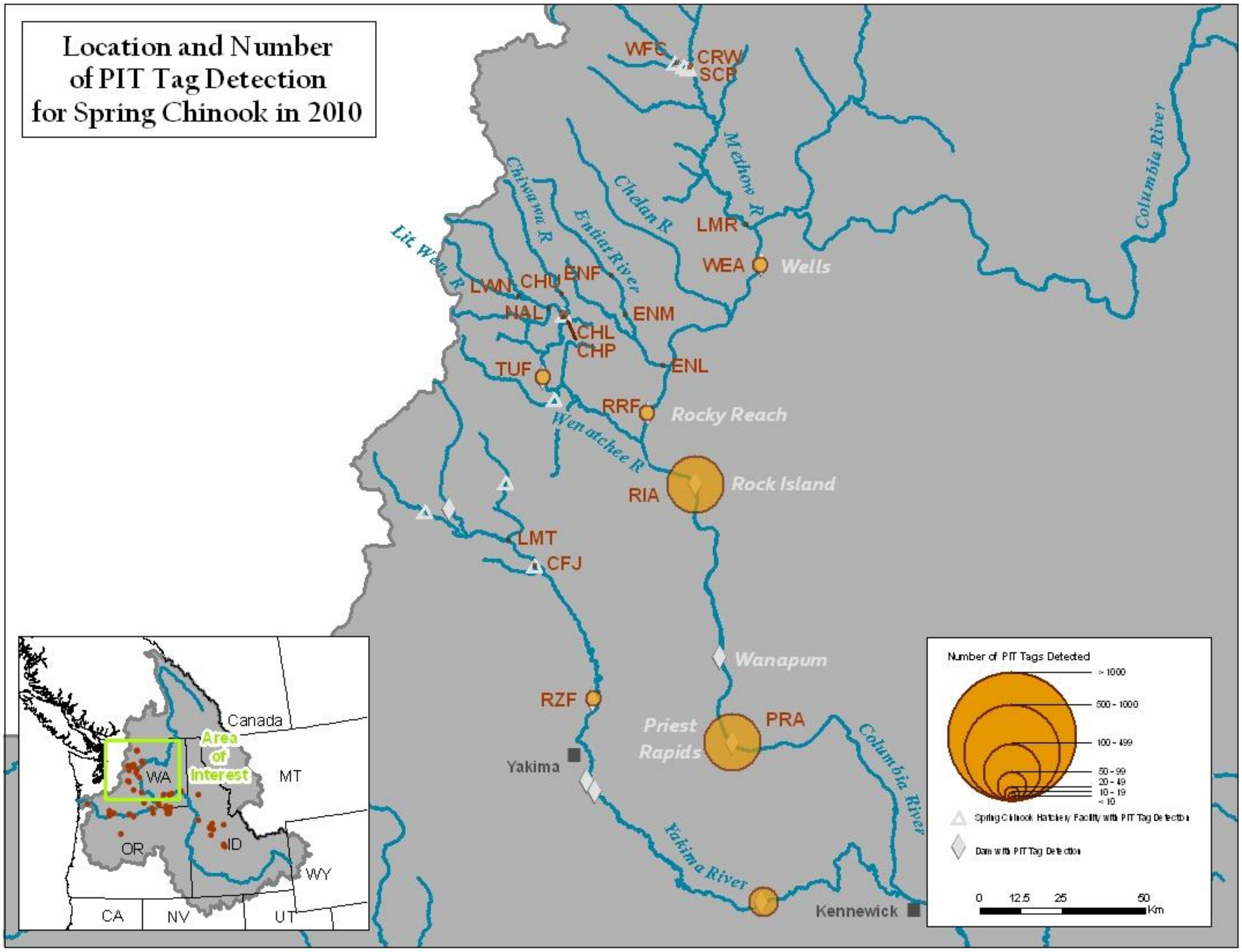

Figure A3. Map of Upper Columbia River detections sites and number of spring Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

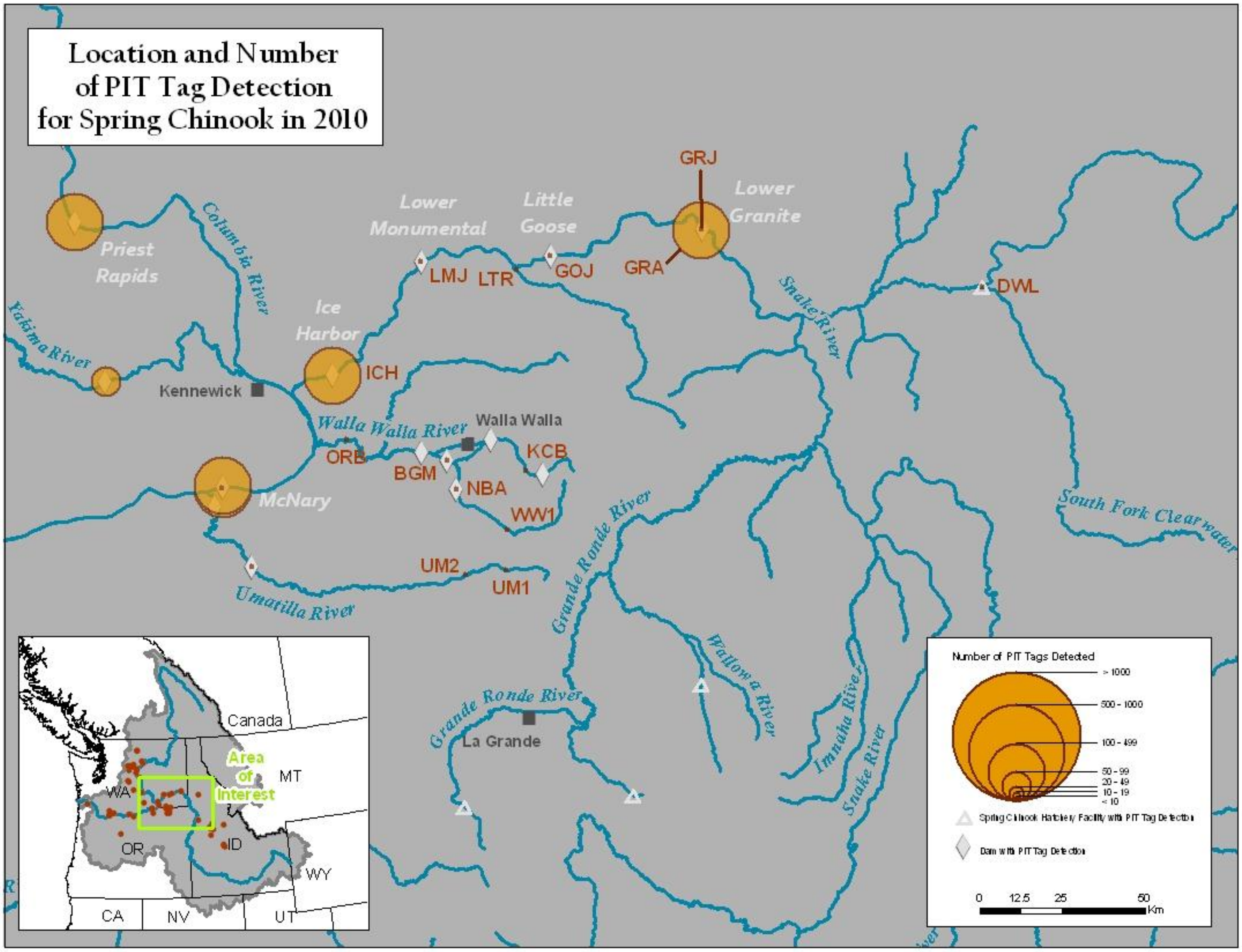

Figure A4. Map of Lower Snake River detections sites and number of spring Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

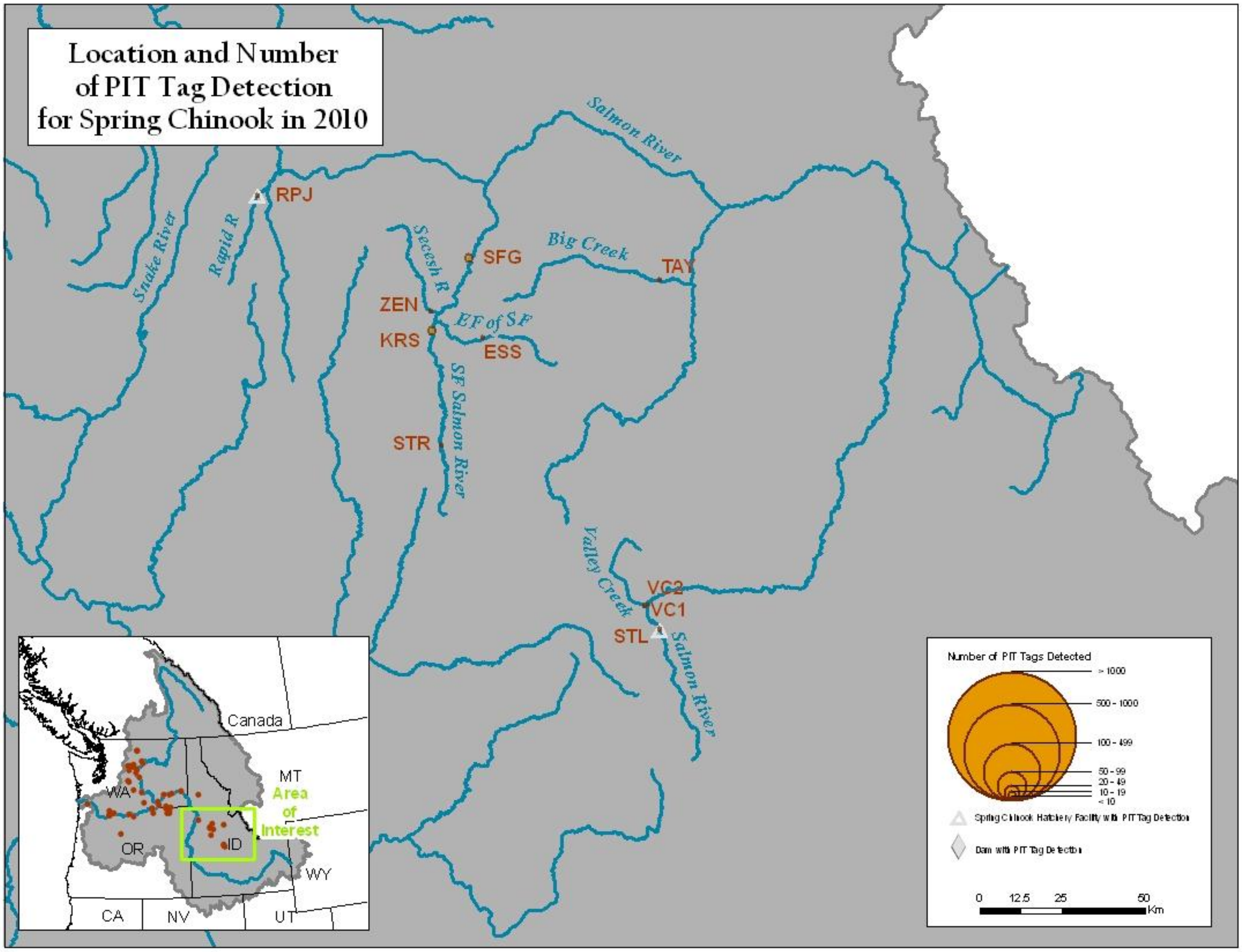

Figure A5. Map of Salmon River detections sites and number of spring Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

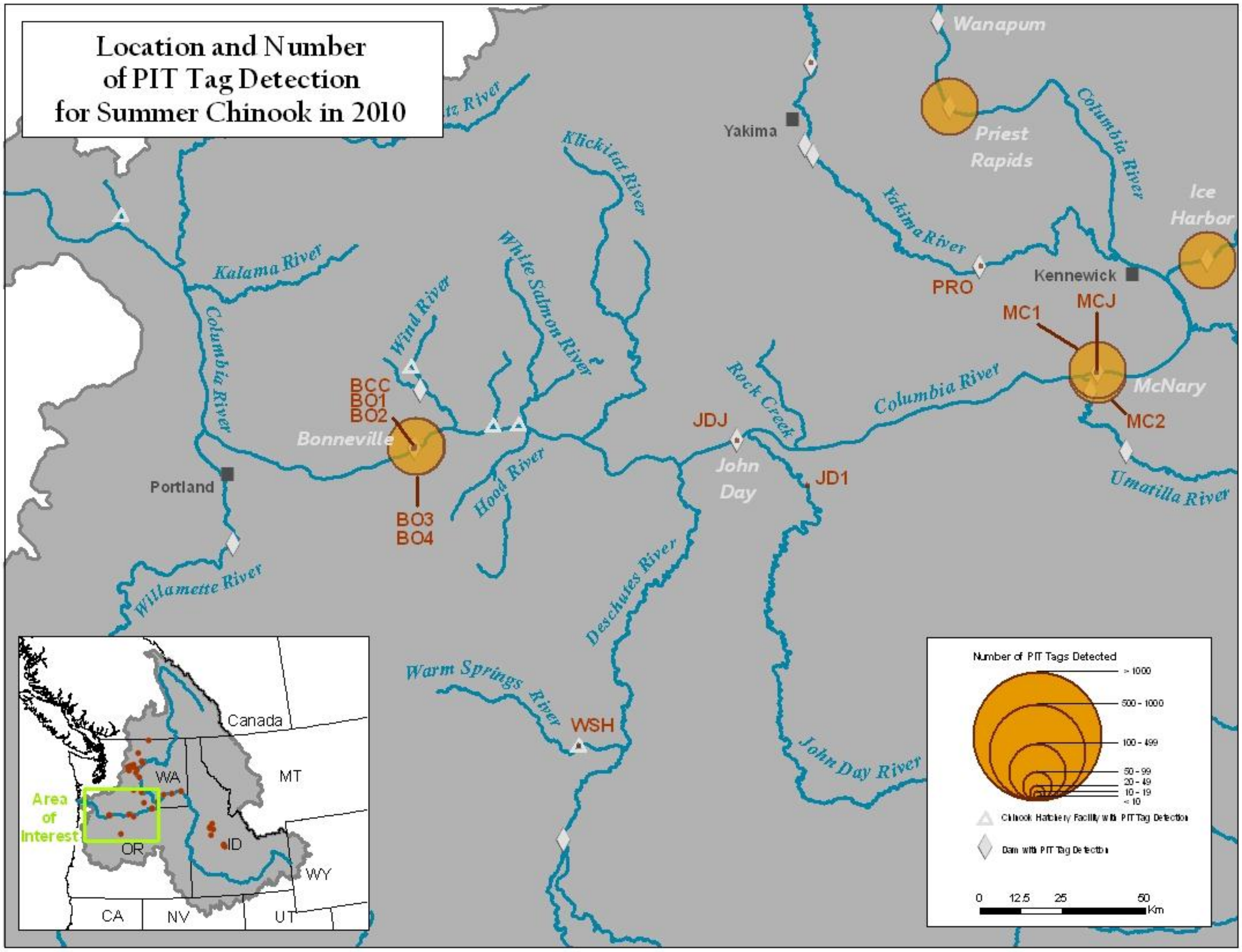

Figure A6. Map of Lower Columbia River detections sites and number of summer Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

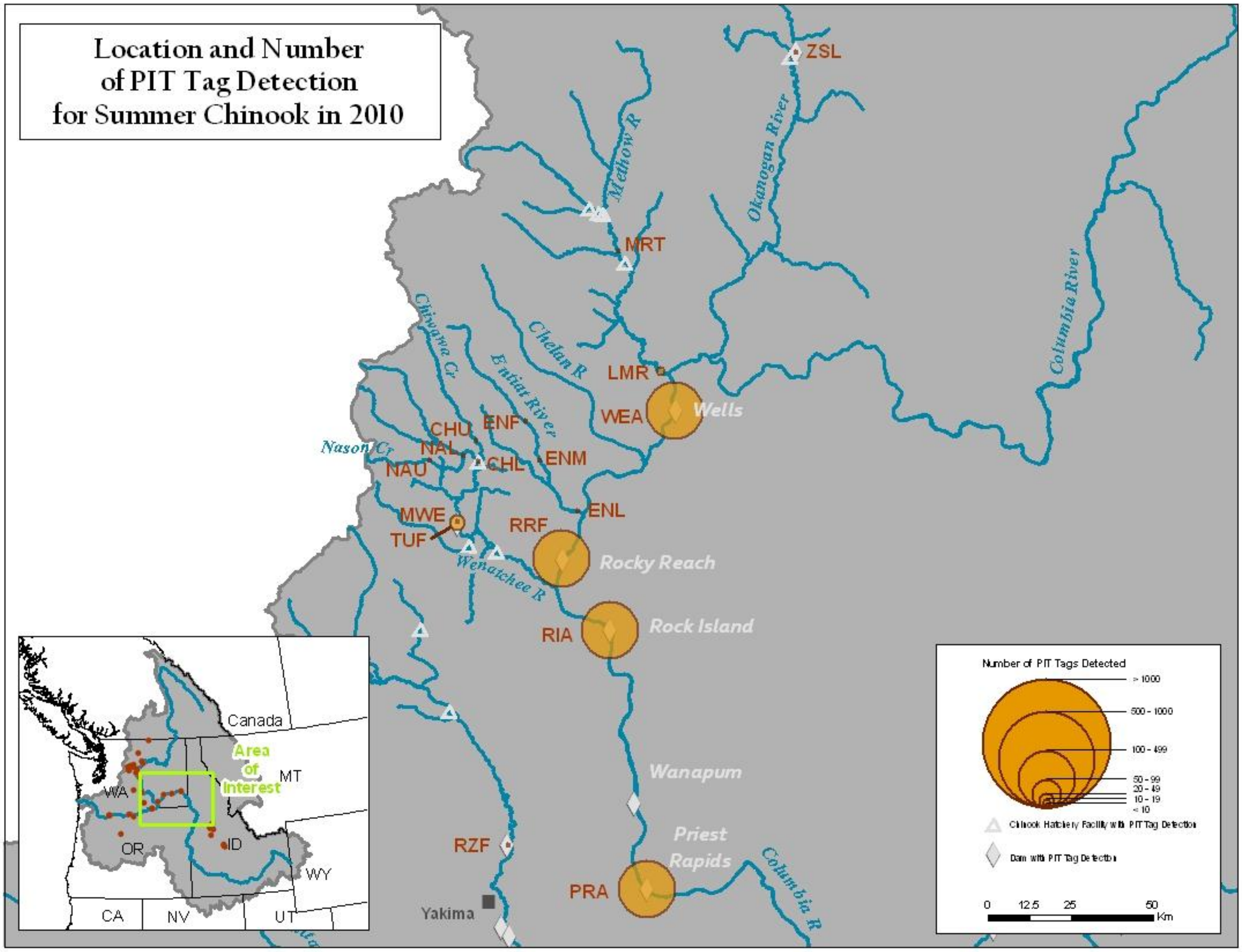

Figure A7. Map of Upper Columbia River detections sites and number of summer Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

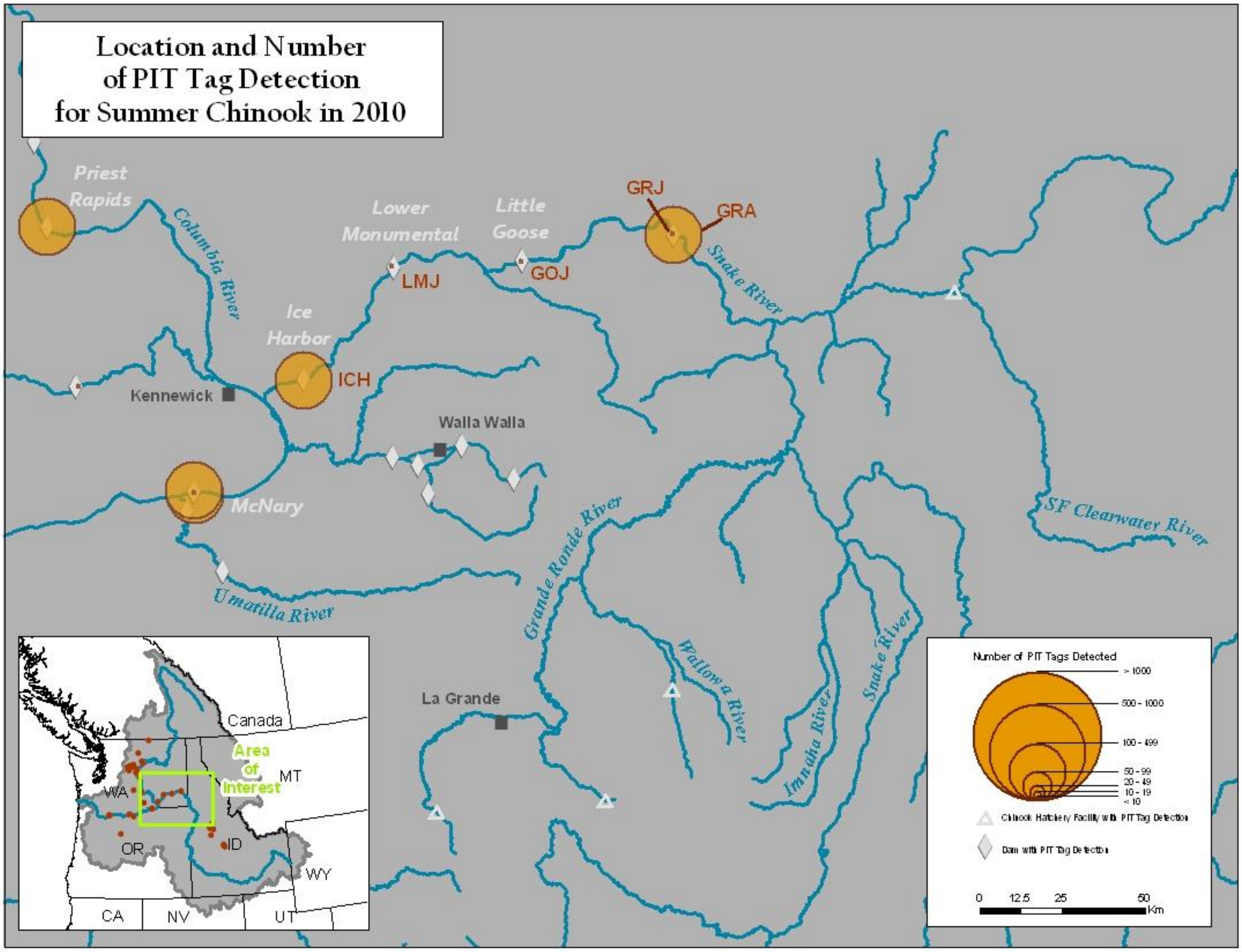

Figure A8. Map of Lower Snake River detections sites and number of summer Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

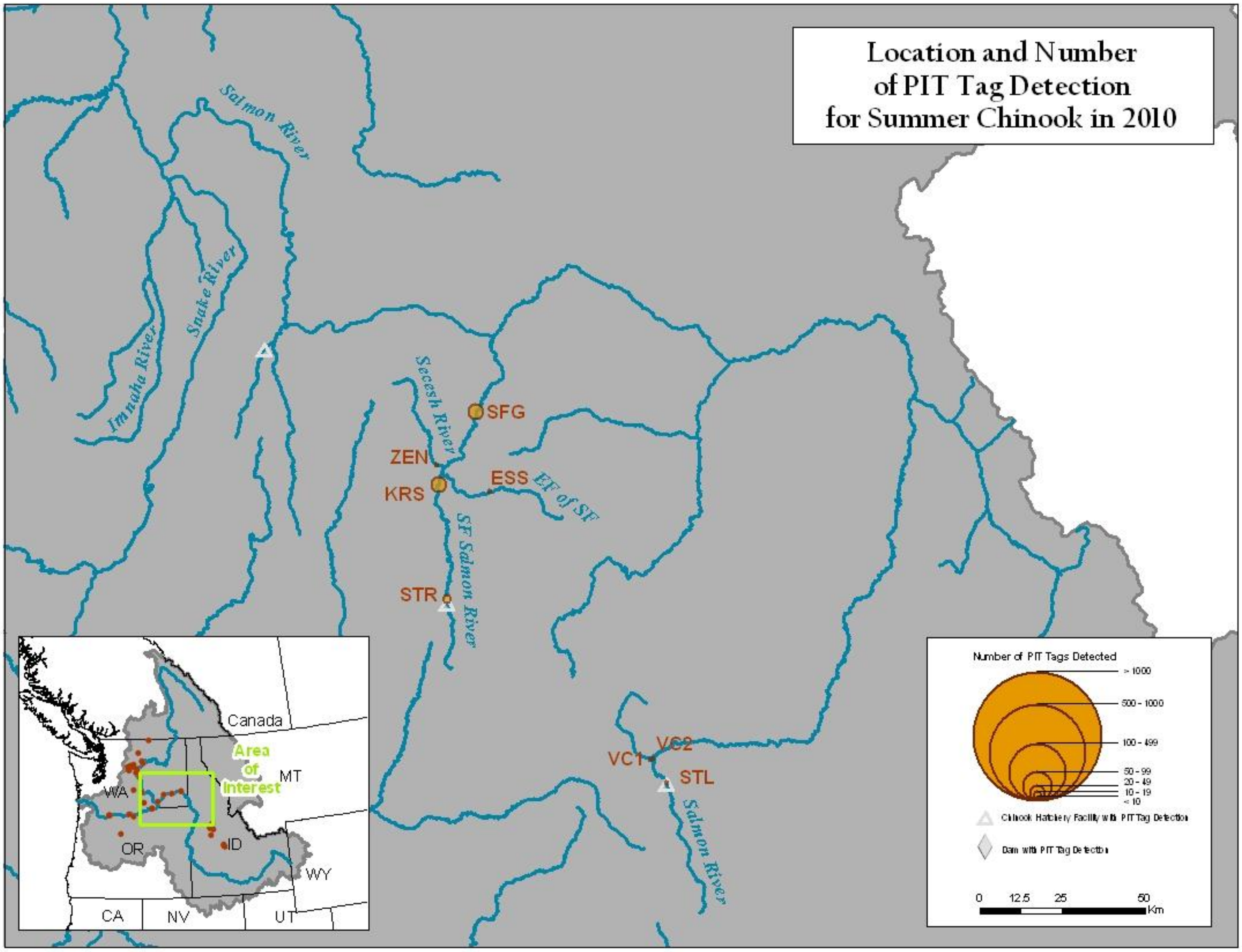

Figure A9. Map of Salmon River detections sites and number of summer Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

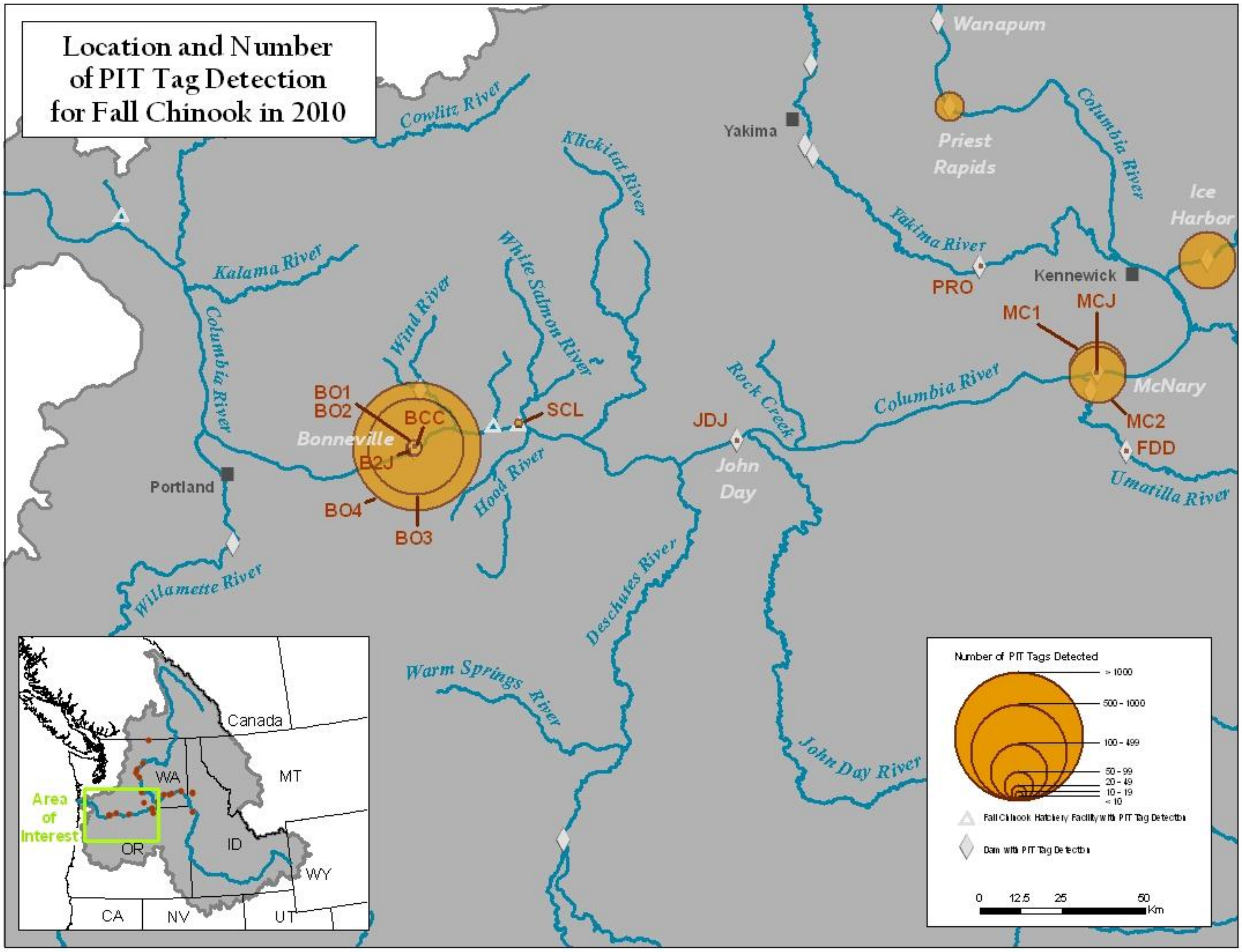

Figure A10. Map of Lower Columbia River detections sites and number of fall Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

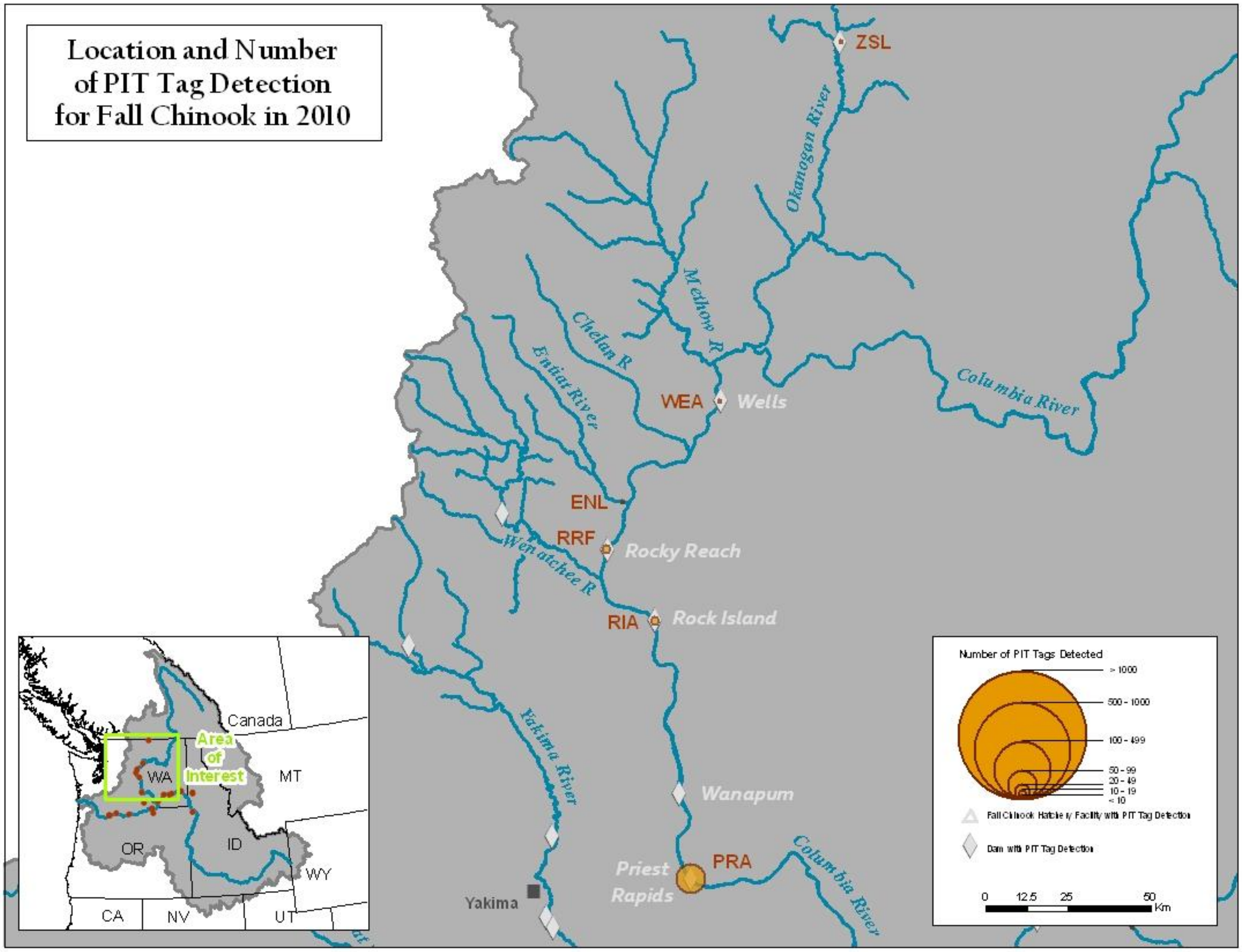

Figure A11. Map of Upper Columbia River detections sites and number of fall Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

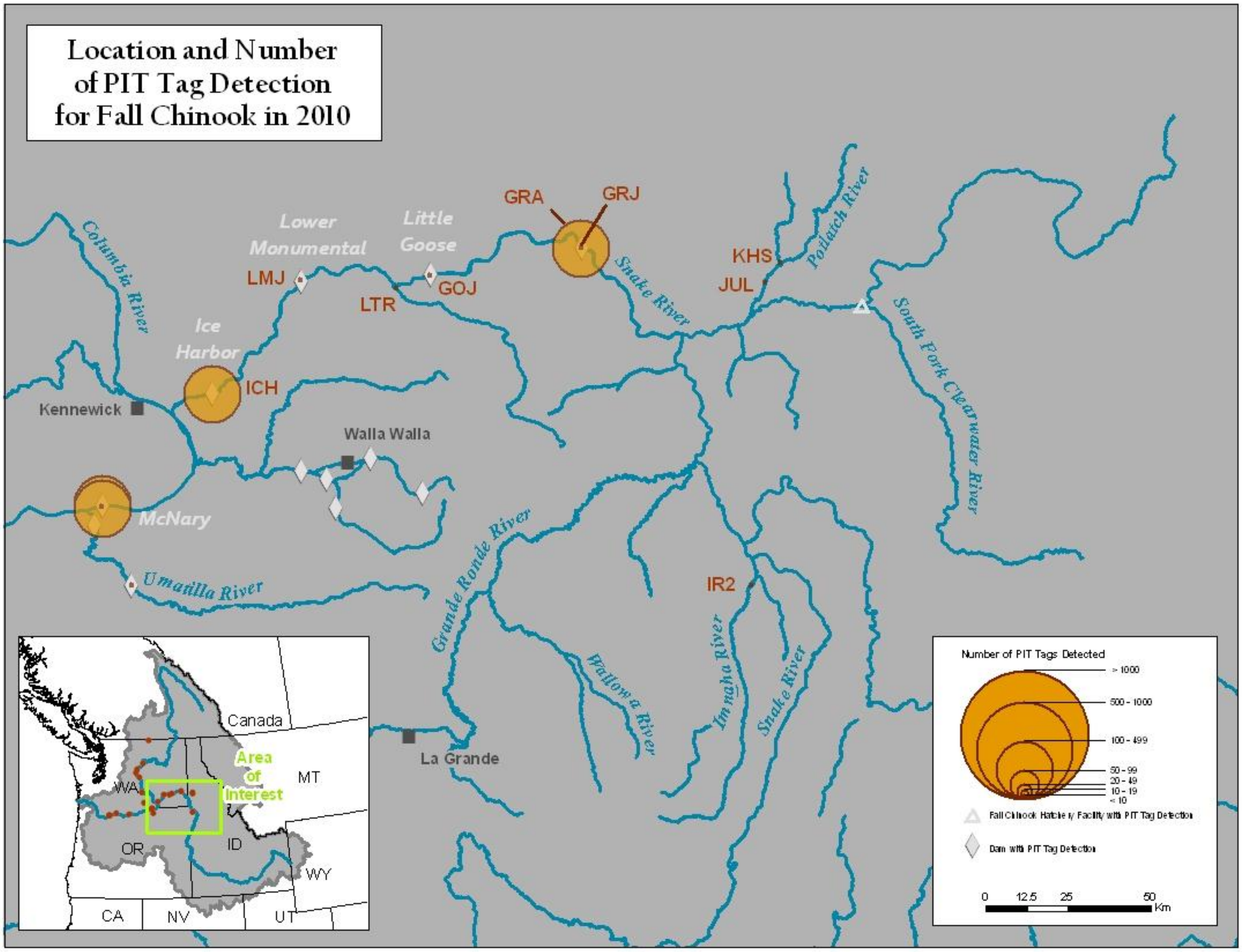

Figure A12. Map of Lower Snake River detections sites and number of fall Chinook detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

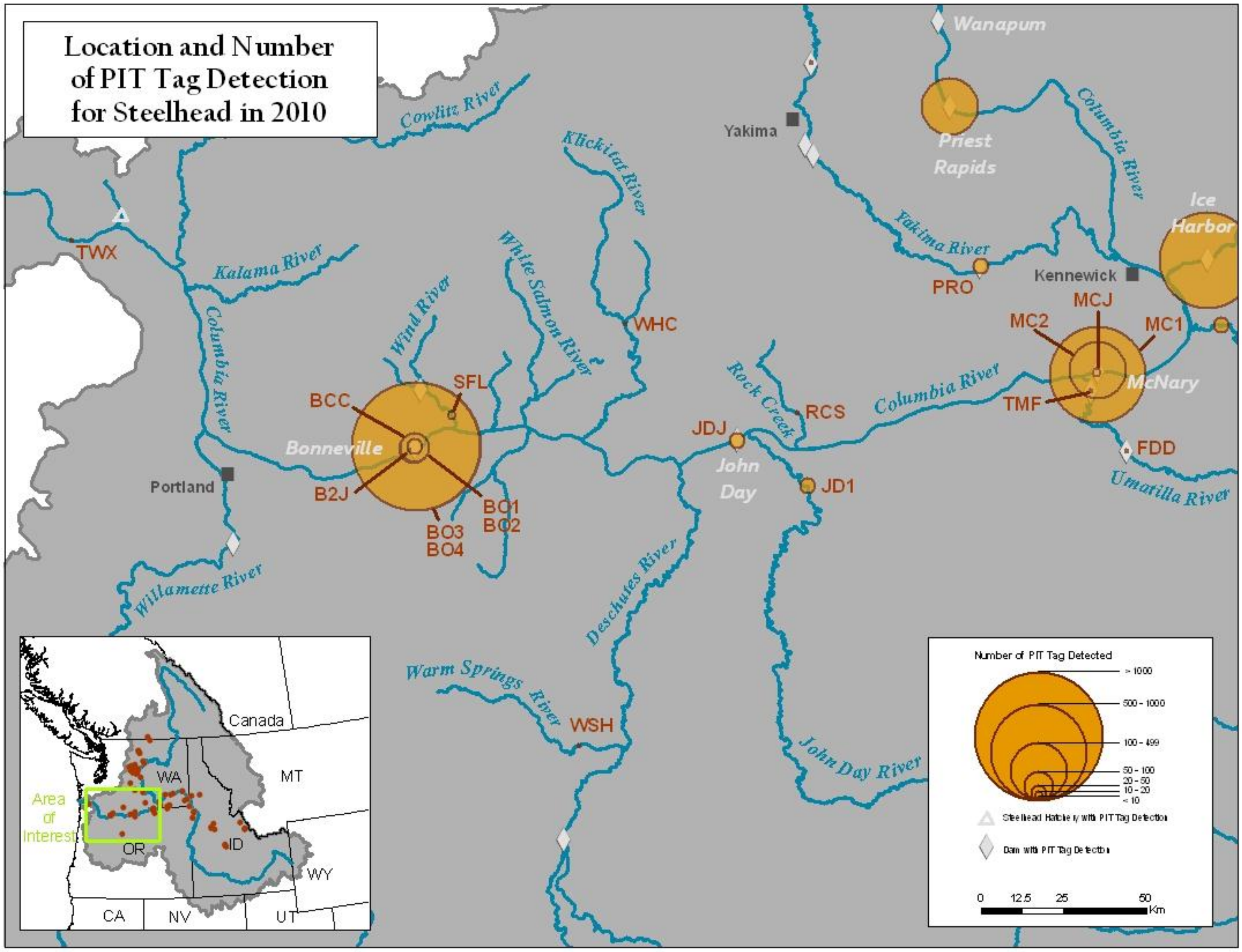

Figure A13. Map of Lower Columbia River detections sites and number of steelhead detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

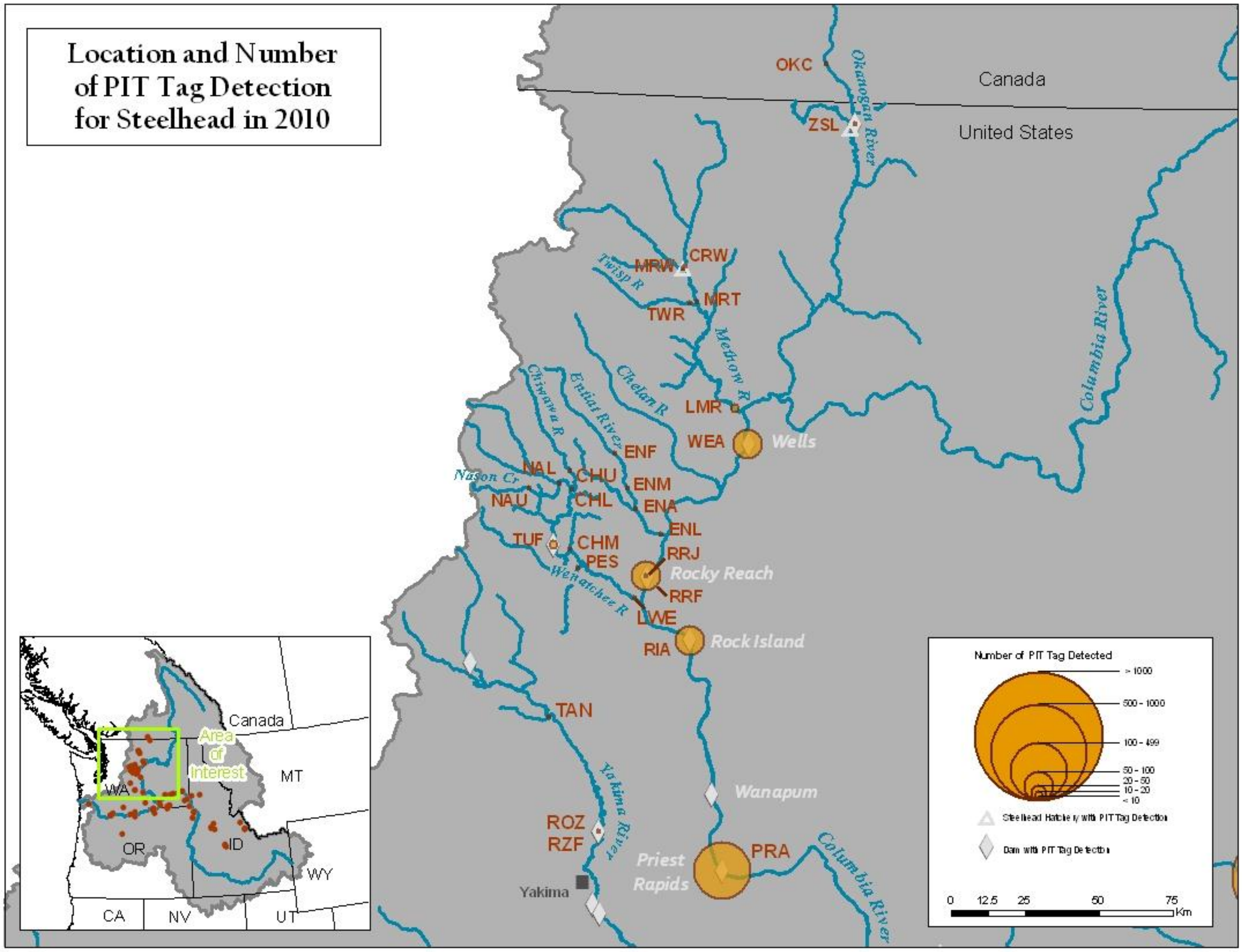

Figure A14. Map of Upper Columbia River detections sites and number of steelhead detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

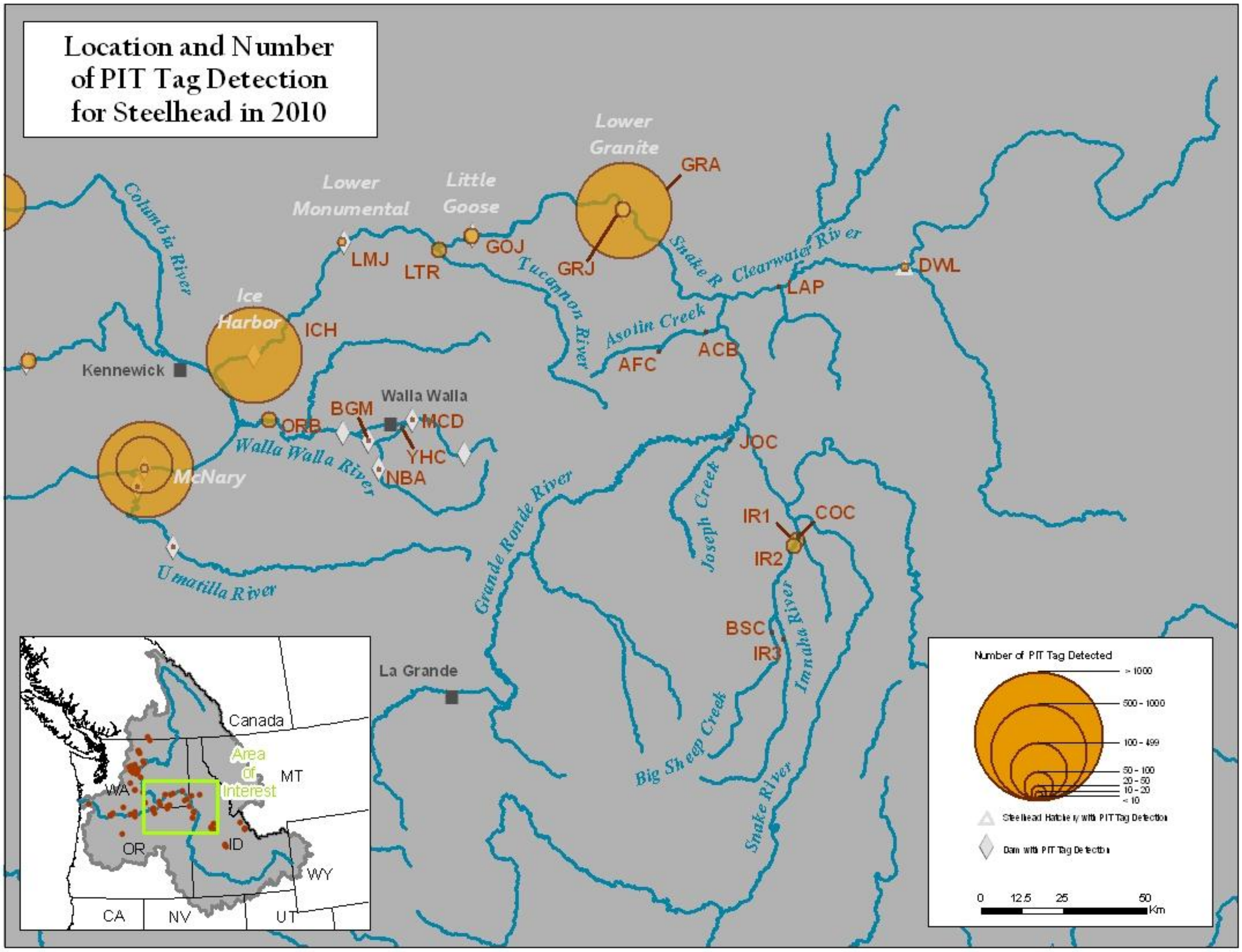

Figure A15. Map of Lower Snake River detections sites and number of steelhead detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.

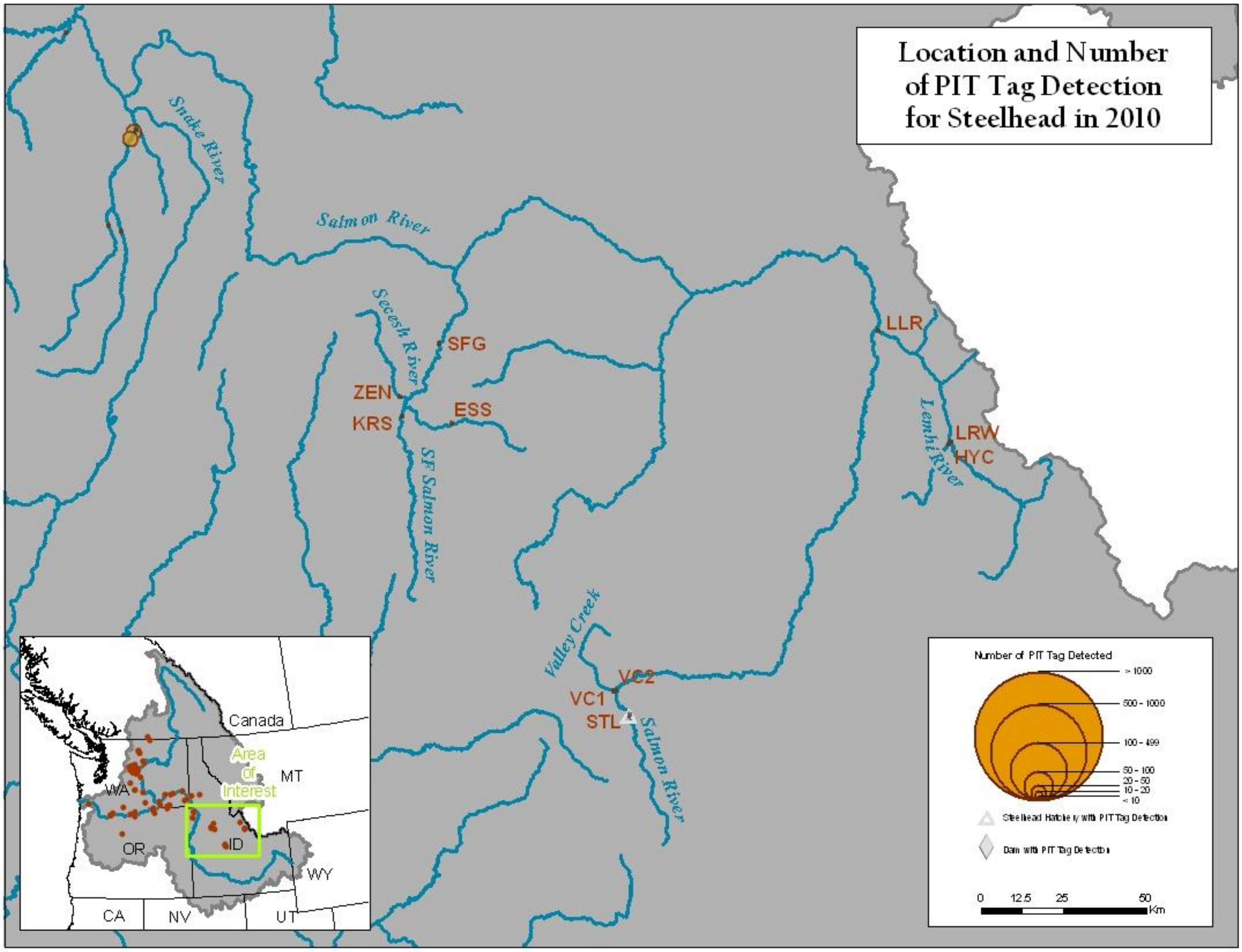

Figure A16. Map of Salmon River detections sites and number of steelhead detected. Table A4 in the Appendix lists the PTAGIS sites full name and the three-letter codes on this map.