FISH PASSAGE CENTER

847 NE 19th Avenue, #250, Portland, OR 97232
Phone: (503) 833-3900 Fax: (503) 232-1259
www.fpc.org/
e-mail us at fpcstaff@fpc.org

MEMORANDUM

To: Jeff Fryer, CRITFC

From: Michele DeHart

Date: November 12, 2015

Re: Okanogan River sockeye passage timing, travel times, juvenile survival, and smolt-to-adult returns, 2013–2015.

In 2013, the CSS Oversight Committee was approached with a request to explore the feasibility of adding a long-term monitoring group for sockeye trapped and released from the Okanogan River. Upon the request from the Okanogan Nation Alliance (ONA) and the Columbia River Inter-Tribal Fish Commission (CRITFC), the CSS Oversight Committee transferred 3,000 PIT tags in 2013, 2,500 tags in 2014, and 4,000 tags in 2015 to the ONA to supplement PIT-tagging efforts at Osoyoos Lake in the spring. Similar to previous years, below are results from these exploratory efforts, followed by more specific details. Also, in response to your specific request this year, we provide an analysis of the expected improvement in the precision of estimated survival from Release to Zosal Dam and from Zosal Dam to Rocky Reach Dam under several scenarios of improvements in the detection capabilities of the floating antenna in the Zosal Dam forebay.

- With each successive year of tagging, the total number of tags released in the Okanogan River basin has increased from 4,018 in 2013, to 5,055 in 2014, and 7,176 in 2015.
- Survival from release to Rocky Reach Dam was 0.49 in 2013, 0.57 in 2014, and 0.42 in 2015.

- Estimates of survival beyond Rocky Reach Dam were unreliable in 2013. This was partially due to the low survival from release to Rocky Reach Dam which contributed to a low number of detections of PIT-tagged fish at and below McNary Dam.
- The larger sample sizes in 2014 and 2015 allowed for the estimation of survival from Release to McNary Dam, which was 0.39 (95% CI: 0.31–0.47) in 2014 and 0.32 (95% CI: 0.22–0.42) in 2015.
- The estimated smolt-to-adult return (SAR) for 2013 was 7.96% (95% CI: 6.72–9.18%) for juveniles at Rocky Reach Dam to adults at Bonneville Dam. Given the uncertainty in the juvenile survival estimate below Rocky Reach in 2013, the SAR estimate for juveniles at McNary to adults at Bonneville in 2013 of 7.37% (95% CI: 5.27–9.46%) is likely an underestimate and should be interpreted with caution.
- Increasing the detection probability at Zosal Dam resulted in decreases in the standard errors of each of the reach survival estimates (e.g., Release-Zosal and Zosal-Rocky Reach). However, it appears there may be a point of diminishing returns as the Zosal detection probability increases. Increasing detection probability at Zosal had a larger impact on the standard error of the Release-Zosal survival estimate and lesser impact on the Release-Rocky Reach survival estimate.
- Results from 2013–2015 indicate that estimating survival from release to McNary Dam is possible with approximately 5,000 tags.
- Given that estimating SARs from RRH-BOA was possible for 2013 and that juvenile survival estimates for 2014 and 2015 were more reliable with larger total PIT-tag releases, we believe that incorporating this group into the CSS is warranted. The CSS Oversight Committee will discuss incorporating analyses for this group into the 2016 Annual Report.

Methods

Timing and Travel Time

Juvenile passage timing and fish travel times were estimated for 2013–2015 out-migrants based on PIT-tag detections at various dams within the Rocky Reach to Bonneville Dam reach. For each year, we estimated cumulative juvenile passage timing based on PIT-tag detections at Rocky Reach (RRH), McNary (MCN), John Day (JDA), and Bonneville (BON) dams. Daily PIT-Tag detections at each of these projects were summed and adjusted based on the average proportion of flows that passed through the powerhouse. In 2015, a new floating PIT-tag antenna was installed in the forebay at Zosal Dam (ZSL). Therefore, we also estimated juvenile timing and travel times for fish detected at ZSL in 2015. However we did not adjust daily PIT-tag detections by powerhouse flows at this site, as the fish that are detected at ZSL do not pass through the powerhouse. Minimum, median, and maximum fish travel times were estimated from release to detection at each dam in the reach with detection capabilities.

Juvenile Survival

For each migration year, we attempted to estimate smolt survival and associated variance estimates for PIT-tagged juvenile sockeye from their release in the Okanogan River Basin to MCN. We relied on juvenile detections at RRH, MCN, JDA, and BON dams, as well as downstream of Bonneville Dam using specialized trawl equipment for PIT-tag detection. Using recapture data from fish detected at these sites, single-release mark-recapture survival estimates were generated using the Cormack-Jolly-Seber (CJS) methodology as described by Burnham et al. (1987) with the Mark program (software available free from Colorado State University; White and Burnham 1999). In addition to estimating individual reach survivals (e.g., Release-RRH and RRH-MCN) we also attempted to estimate combined reach survival (i.e., Release-MCN) by multiplying individual reach estimates and determining the approximate variance using the delta method (Burnham et al. 1987).

The majority of wild sockeye were PIT-tagged in the Okanogan River Basin in 2013–2015 were tagged and released at two sites, Lake Osoyoos (OSOYOL) and Lake Skaha (SKATAL). Using the same methodologies outlined above, we attempted to estimate both individual and combined reach survivals for each of these two release sites, by migration year.

Smolt-to-Adult Survival (SARs)

With the nearly complete return of adults from the 2013 out-migration, we are able to estimate Smolt-to-Adult returns (SARs). Given the juvenile detection capabilities at RRH, we estimated SARs for two different reaches: (1) juveniles at RRH to adult return to BON (RRH-BOA), and (2) juveniles at MCN to adult return to BON (MCN-BOA). To estimate SARs we relied on the same methodology used in Chapter 4 of the 2014 CSS Annual Report (McCann et al., 2014) for Chinook at steelhead from the Methow and Entiat rivers.

Potential Improvements in Survival Estimation from Increasing Detection Capabilities of the Floating Antenna in the Zosal Dam Forebay

For migration year 2015, we incorporated PIT-tag detections at Zosal Dam (ZSL) to estimate juvenile sockeye survival from release to ZSL. In 2015, there were three possible locations where PIT-tagged juvenile sockeye could be detected at ZSL, each of the two adult ladders and the floating antenna above the spillway. Per your request, we relied on 2015 detection data at all three of these sites to investigate the potential change in the precision of survival estimates, pending an increase in the overall detection probability at the ZSL detection sites. To do this, we incorporated ZSL detections to estimate survival from Release-ZSL, ZSL-RRH, and Release-RRH using the methodology outlined above. We then simulated examined changes in the standard errors around these survival estimates, under a series of different assumed detection probabilities at ZSL. To estimate how sensitive these standard errors were to the number of tags that were released, we separately report estimates for release sizes of 7,176 tags (as seen in 2015) and 5,000 tags. We were able to examine how increases in detection probability (or equivalently more detections of individuals alive at Zosal Dam) by working the closed-form variance estimates of CJS survival provided in Skalski et al. (1998).

Results

Travel Time and Timing

Over the last three years, PIT-tagging of juvenile sockeye in the Okanogan River Basin has occurred from early to mid-April through early May. Tagging efforts in 2013, 2014, and 2015 resulted in 4,018, 5,055, and 7,176 PIT-tagged juvenile sockeye each year, respectively. Estimates of minimum, median, and maximum travel times from release to RRH, MCN, JDA, and BON dams are provided below (Table 1). These travel times are based on fish that were detected at each of the sites in their respective year of out-migration year. Also provided are estimates of the 95% confidence limits around the estimated median travel time.

Table 1. Travel times from release to juvenile detection site of juvenile sockeye PIT-tagged and released into the Okanogan River from 2013 to 2015.

Migration Year	Project	Release to Project Travel Time (days)			95% Confidence Limits	
		Min	Med	Max	Lower	Upper
2013	RRH	5.6	19.4	56.3	18.7	19.9
	MCN	10.0	23.7	63.7	22.1	24.7
	JDA	12.0	25.5	62.3	24.0	27.2
	BON	16.3	28.2	57.3	26.6	29.0
2014	RRH	4.4	16.7	40.6	16.4	17.4
	MCN	8.1	19.4	54.8	18.8	20.0
	JDA	13.0	23.0	67.5	22.1	24.0
	BON	11.8	22.7	59.0	20.8	24.6
2015	ZSL	4.7	14.2	31.0	12.0	16.0
	RRH	5.9	15.7	39.4	15.4	16.1
	MCN	14.0	23.2	43.0	21.6	24.0
	JDA	17.0	24.5	49.5	23.0	25.7
	BON	16.9	25.9	48.2	24.9	26.4

Overall, PIT-tagged sockeye juveniles from these tagging efforts passed through the Upper and Middle Columbia River from mid-May to early June (Table 2, Figures 1–3).

Table 2. Migration timing of PIT-tagged juvenile sockeye from Lake Osoyoos detected at ZSL, RRH, MCN, JDA, and BON dams from 2013 to 2015.

Migration Year	Project	Estimated Passage Date		
		10%	50%	90%
2013	RRH	8-May	13-May	18-May
	MCN	11-May	17-May	25-May
	JDA	14-May	21-May	27-May
	BON	15-May	24-May	1-Jun
2014	RRH	10-May	14-May	22-May
	MCN	12-May	19-May	24-May
	JDA	15-May	21-May	27-May
	BON	16-May	21-May	27-May
2015	ZSL	30-Apr	4-May	9-May
	RRH	6-May	12-May	19-May
	MCN	13-May	18-May	26-May
	JDA	16-May	20-May	25-May
	BON	17-May	21-May	27-May

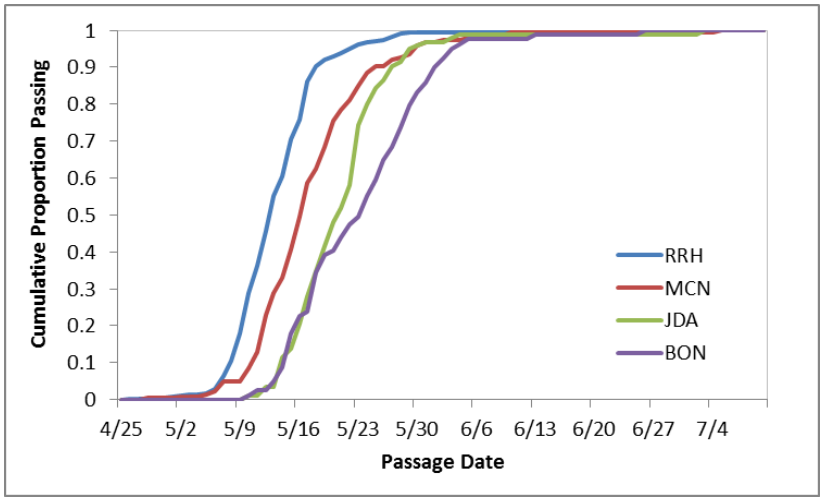

Figure 1. Cumulative passage timing at RRH, MCN, JDA, and BON dams of juvenile sockeye PIT-tagged and released into the Okanogan River by ONA in 2013.

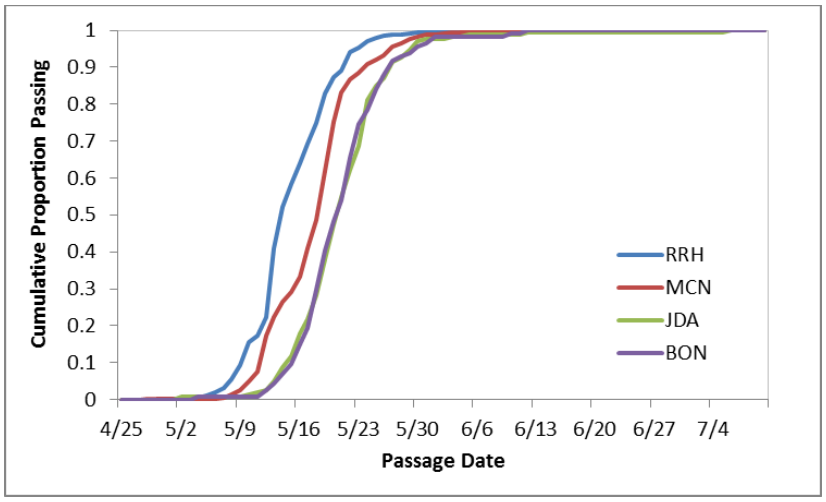

Figure 2. Cumulative passage timing at RRH, MCN, JDA, and BON dams of juvenile sockeye PIT-tagged and released into the Okanogan River by ONA in 2014.

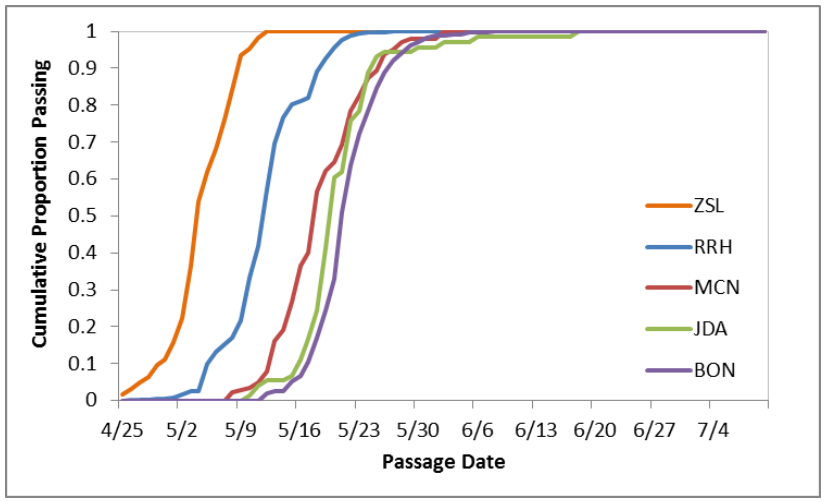

Figure 3. Cumulative passage timing at ZSL, RRH, MCN, JDA, and BON dams of juvenile sockeye PIT-tagged and released into the Okanogan River by ONA in 2015.

Juvenile Survival

Estimates of individual reach survival and combined survival for each migration year are provided in Table 3. For 2013, we were able to estimate survival from Release-RRH (0.49, 95% CI: 0.42–0.56). However, the total tags released in 2013 (4,018) was not sufficient to get reliable estimates of survival below RRH. This is largely due to low numbers of subsequent downstream detections. For example, of the 183 PIT-tagged sockeye smolts that were detected at MCN, only 19 were subsequently detected downstream of MCN. This low number of downstream detections led to an anomalous estimate of survival from RRH-MCN of 1.07 (95% CI: 0.61–1.52). Given the anomalous estimate of survival from RRH-MCN, we do not report an estimate of survival from Release-MCN for 2013.

Migration years 2014 and 2015 had much higher release numbers (5,055 in 2014 and 7,176 in 2015), which allowed for the estimation of not only individual reach survivals but also a combined reach survival for each year (Table 3). Combined reach survivals in these years were 0.39 (95% CI: 0.31–0.47) for 2014 and 0.32 (95% CI: 0.22–0.42) for 2015.

Table 3. Survival of PIT-tagged sockeye juveniles tagged and released into the Okanogan River in 2013–2015.

Migration Year	Number Tagged	Release-RRH (95% CI)	RRH-MCN (95% CI)	Release-MCN (95% CI)
2013	4,018	0.49 (0.42-0.56)	1.07 (0.61-1.52)	N/A
2014	5,055	0.57 (0.51-0.64)	0.68 (0.52-0.82)	0.39 (0.31-0.47)
2015	7,176	0.42 (0.38-0.45)	0.78 (0.53-1.03)	0.32 (0.22-0.42)

The lower release total in 2013 also meant that estimating survival for each of the two release sites (OSOYOL and SKATAL) was only possible for the Release-RRH reach (Table 4). Survivals from Release-RRH were 0.50 (95% CI 0.42–0.59) for fish released at OSOYOL and 0.46 (95% CI: 0.36–0.57) for fish released at SKATAL. Estimates of survivals for the RRH-MCN reach were unreliable and, therefore, we did not estimate Release-MCN survival for 2013.

With the higher release total in 2014, we were able to generate estimates for both individual reach and combined reach survivals for each of the two release sites (Table 4). Fish tagged and released from OSOYOL had a Release-MCN survival of 0.44 (95% CI: 0.34–0.54) whereas those from SKATAL had a survival of 0.19 (95% CI: 0.08–0.31).

For 2015, we were able generate estimates of the individual reach survival for the Release-RRH reach for both release sites (Table 4). However, we were only able to generate a reliable estimate of survival in the RRH-MCN reach for the SKATAL release site, which was 0.70 (95% CI: 0.46–0.95). The estimate of survival for the RRH-MCN reach for the OSOYOL release site was greater than 1.0 and, therefore, deemed unreliable. This was due to the lower release total for this group and the low number of detections at MCN and downstream of MCN. Of the 35 OSOYOL fish that were detected at MCN in 2015, only five were subsequently detected downstream of MCN. Because the RRH-MCN survival estimate was unreliable for the OSOYOL release site, we do not report an estimate of survival from Release-MCN for this group in 2015.

Table 4. Survival of PIT-tagged sockeye juveniles, by release site, tagged and released into the Okanogan River in 2013–2015.

Migration Year	Release Site	Number Tagged	Release-RRH (95% CI)	RRH-MCN (95% CI)	Release-MCN (95% CI)
2013	OSOYOL	2,840	0.50 (0.42-0.59)	1.09 (0.52-1.65)	N/A
	SKATAL	1,178	0.46 (0.36-0.57)	0.99 (0.25-1.74)	N/A
2014	OSOYOL	3,707	0.63 (0.56-0.71)	0.69 (0.52-0.87)	0.44 (0.34-0.54)
	SKATAL	978	0.34 (0.22-0.47)	0.56 (0.17-0.95)	0.19 (0.08-0.31)
2015	OSOYOL	1,741	0.44 (0.36-0.52)	1.15 (0.22-2.09)	N/A
	SKATAL	5,435	0.41 (0.37-0.45)	0.70 (0.46-0.95)	0.28 (0.19-0.38)

Smolt-to-Adult Survival (SARs)

To date, 158 of the juveniles that were PIT-tagged and released in 2013 have been detected as adults at Bonneville Dam (BOA). Of these 158 adults, 59 (37%) were detected at BOA in 2014 and 99 (63%) were detected in 2015. The SAR estimate for juveniles at RRH to adults at BOA ($SAR_{RRH\text{-}BOA}$) was 7.96% (95% CI: 6.72–9.18%). The anomalous estimate of juvenile survival in the RRH-MCN reach (Table 3) resulted in an overestimate in the juvenile population at MCN. Therefore, the SAR estimate for juveniles at MCN to adults at BOA ($SAR_{MCN\text{-}BOA}$) of 7.37% (95% CI: 5.27–9.46%) is likely an underestimate and should be interpreted with caution.

Estimating Potential Improvements in Survival Estimation from Increasing Detection Capabilities of the Floating Antenna in the Zosal Dam Forebay

Of the 7,175 wild sockeye juveniles that were PIT-tagged and released in the Okanogan River Basin in 2015, 63 were detected at the three PIT-tag detection sites at ZSL. These detections, and subsequent downstream detections, equated to a detection probability of approximately 0.015 (95% CI: 0.009–0.021) at ZSL. Survival from Release-ZSL and ZSL-RRH was 0.59 (95% CI: 0.41–0.76) and 0.71 (95% CI: 0.49–0.94), respectively (Table 5, Figure 4). When including ZSL detects in the estimation of survival from Release-RRH, survival for this reach was 0.42 (95% CI: 0.38-0.45) (Table 6, Figure 4).

As expected, increasing the detection probability at ZSL resulted in decreases in the standard errors of each of the reach survival estimates (Tables 5 and 6, Figure 4). The largest impacts were for the individual reach survivals (e.g., Release-ZSL and ZSL-RRH). From these simulations, it appears there may be a point of diminishing returns as the ZSL detection probability increases. For the Release-ZSL reach, this point of diminishing returns appears to occur at detection probabilities of 0.08 or greater, which would equate to a 5-fold increase in detection probability over what was seen in 2015. For example, at the 2015 detection probability of 0.015, the standard error for the Release-ZSL survival estimate was 0.090. Increasing detection probability to 0.08 resulted in a standard error of 0.038. However, when the detection probability increased even more to 0.15, the estimated standard error only decreased to 0.027.

Finally, increasing the detection probability at ZSL had less of an impact on the standard error of the combined survival estimate (Release-RRH) (Table 6, Figure 4C). The point of diminishing returns for this reach appears to occur at detection probabilities of 0.05 or greater. For example, at the 2015 detection probability of 0.015, the standard error for the Release-RRH survival estimate was 0.018. At a detection probability of 0.06, the estimated standard error only decreased to 0.011.

Table 5. Estimated standard errors and associated 95% confidence interval for estimates of survival from release to Zosal Dam and Zosal Dam to Rocky Reach Dam under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 7,176 tags released above the antenna. Row in bold-italics indicates estimated detection probability and associated standard error and confidence intervals observed in 2015. Data presented in this table are a subset of the scenarios presented in Figure 4.

Assumed Zosal Detection Probability.	Release to Zosal				Zosal to Rocky Reach			
			95% Conf. Int.				95% Conf. Int.	
	Survival.	Standard Error	Lower Limit	Upper Limit	Survival	Standard Error	Lower Limit	Upper Limit
0.01	0.59	0.111	0.368	0.803	0.71	0.140	0.438	0.987
0.015	***0.59***	***0.090***	***0.408***	***0.763***	***0.71***	***0.114***	***0.490***	***0.936***
0.02	0.59	0.078	0.433	0.739	0.71	0.102	0.513	0.913
0.03	0.59	0.064	0.461	0.710	0.71	0.086	0.545	0.881
0.04	0.59	0.055	0.478	0.693	0.71	0.076	0.564	0.862
0.05	0.59	0.049	0.490	0.682	0.71	0.070	0.576	0.849
0.06	0.59	0.044	0.499	0.673	0.71	0.065	0.586	0.840
0.07	0.59	0.041	0.505	0.666	0.71	0.061	0.593	0.833
0.08	0.59	0.038	0.511	0.661	0.71	0.058	0.598	0.828
0.09	0.59	0.036	0.515	0.656	0.71	0.056	0.603	0.823
0.10	0.59	0.034	0.519	0.652	0.71	0.054	0.607	0.819
0.11	0.59	0.032	0.523	0.649	0.71	0.052	0.610	0.816
0.12	0.59	0.031	0.526	0.646	0.71	0.051	0.613	0.813
0.13	0.59	0.029	0.528	0.643	0.71	0.050	0.616	0.810
0.14	0.59	0.028	0.530	0.641	0.71	0.049	0.618	0.808
0.15	0.59	0.027	0.533	0.639	0.71	0.047	0.620	0.806

Table 6. Estimated standard error and associated 95% confidence interval for estimates of survival from Release-Rocky Reach Dam under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 7,176 tags released above the antenna. Row in bold-italics indicates estimated detection probability and associated standard error and confidence intervals observed in 2015. Data presented in this table are a subset of the scenarios presented in Figure 4.

Assumed Zosal Detection Probability	Survival (Rel. to RRH)	Standard Error	95% Confidence Interval	
			Lower Limit	Upper Limit
0.01	0.42	0.022	0.374	0.461
0.015	***0.42***	***0.018***	***0.382***	***0.453***
0.02	0.42	0.016	0.386	0.449
0.03	0.42	0.014	0.391	0.445
0.04	0.42	0.013	0.393	0.442
0.05	0.42	0.012	0.394	0.441
0.06	0.42	0.011	0.395	0.440
0.07	0.42	0.011	0.396	0.439
0.08	0.42	0.011	0.396	0.439
0.09	0.42	0.011	0.397	0.439
0.10	0.42	0.011	0.397	0.438
0.11	0.42	0.011	0.397	0.438
0.12	0.42	0.011	0.397	0.438
0.13	0.42	0.011	0.397	0.438
0.14	0.42	0.011	0.397	0.438
0.15	0.42	0.011	0.397	0.438

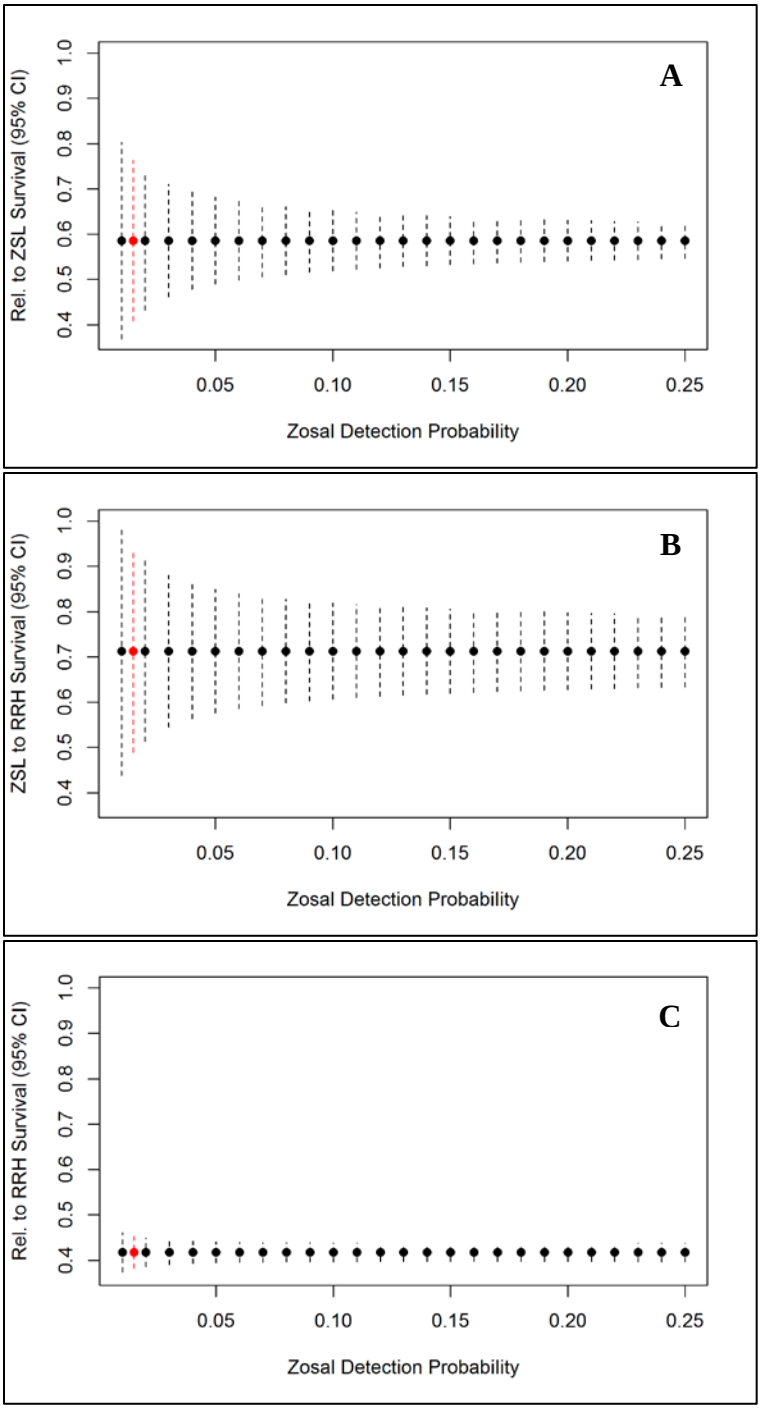

Figure 4. Estimated 95% confidence intervals for survival from Release to Zosal (A), Zosal to Rocky Reach (B), and Release to Rocky Reach (C) under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 7,176 tags released above the antenna. Red data point is actual detection probability and associated survival (and confidence interval) observed in 2015.

At any given estimate of detection probability, reducing the total number of tags released to 5,000 resulted in higher standard errors than did a release total of 7,176 (Tables 5–8, Figures 4 and 5). For example, at a detection probability of 0.03, the release total of 7,176 tags resulted in an estimated standard error of 0.064 for the Release-ZSL survival (Table 5), whereas that for a release total of 5,000 tags was 0.076 (Table 7).

Table 7. Estimated standard errors and associated 95% confidence interval for estimates of survival from release to Zosal Dam and Zosal Dam to Rocky Reach Dam under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 5,000 tags released above the antenna. Data presented in this table are a subset of the scenarios presented in Figure 5.

Assumed Zosal Detection Probability.	Release to Zosal				Zosal to Rocky Reach			
			95% Conf. Int.				95% Conf. Int.	
	Survival.	Standard Error	Lower Limit	Upper Limit	Survival	Standard Error	Lower Limit	Upper Limit
0.01	0.59	0.133	0.325	0.846	0.71	0.168	0.384	1.042
0.02	0.59	0.094	0.402	0.769	0.71	0.122	0.473	0.952
0.03	0.59	0.076	0.436	0.735	0.71	0.103	0.512	0.914
0.04	0.59	0.066	0.457	0.715	0.71	0.091	0.534	0.891
0.05	0.59	0.059	0.471	0.701	0.71	0.083	0.549	0.876
0.06	0.59	0.053	0.481	0.690	0.71	0.078	0.560	0.865
0.07	0.59	0.049	0.489	0.682	0.71	0.073	0.569	0.857
0.08	0.59	0.046	0.496	0.675	0.71	0.070	0.576	0.850
0.09	0.59	0.043	0.501	0.670	0.71	0.067	0.581	0.845
0.10	0.59	0.041	0.506	0.665	0.71	0.065	0.586	0.840
0.11	0.59	0.039	0.510	0.661	0.71	0.063	0.590	0.836
0.12	0.59	0.037	0.514	0.658	0.71	0.061	0.593	0.833
0.13	0.59	0.035	0.517	0.655	0.71	0.060	0.596	0.830
0.14	0.59	0.034	0.520	0.652	0.71	0.058	0.599	0.827
0.15	0.59	0.033	0.522	0.649	0.71	0.057	0.601	0.824

Table 8. Estimated standard error and associated 95% confidence interval for estimates of survival from Release-Rocky Reach Dam under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 5,000 tags released above the antenna. Data presented in this table are a subset of the scenarios presented in Figure 5.

Assumed Zosal Detection Probability	Survival (Rel. to RRH)	Standard Error	95% Confidence Interval	
			Lower Limit	Upper Limit
0.01	0.42	0.026	0.366	0.469
0.02	0.42	0.019	0.380	0.456
0.03	0.42	0.017	0.385	0.450
0.04	0.42	0.015	0.388	0.447
0.05	0.42	0.014	0.390	0.445
0.06	0.42	0.014	0.391	0.444
0.07	0.42	0.013	0.392	0.444
0.08	0.42	0.013	0.392	0.443
0.09	0.42	0.013	0.392	0.443
0.10	0.42	0.013	0.393	0.443
0.11	0.42	0.013	0.393	0.442
0.12	0.42	0.013	0.393	0.442
0.13	0.42	0.013	0.393	0.442
0.14	0.42	0.013	0.393	0.442
0.15	0.42	0.013	0.393	0.442

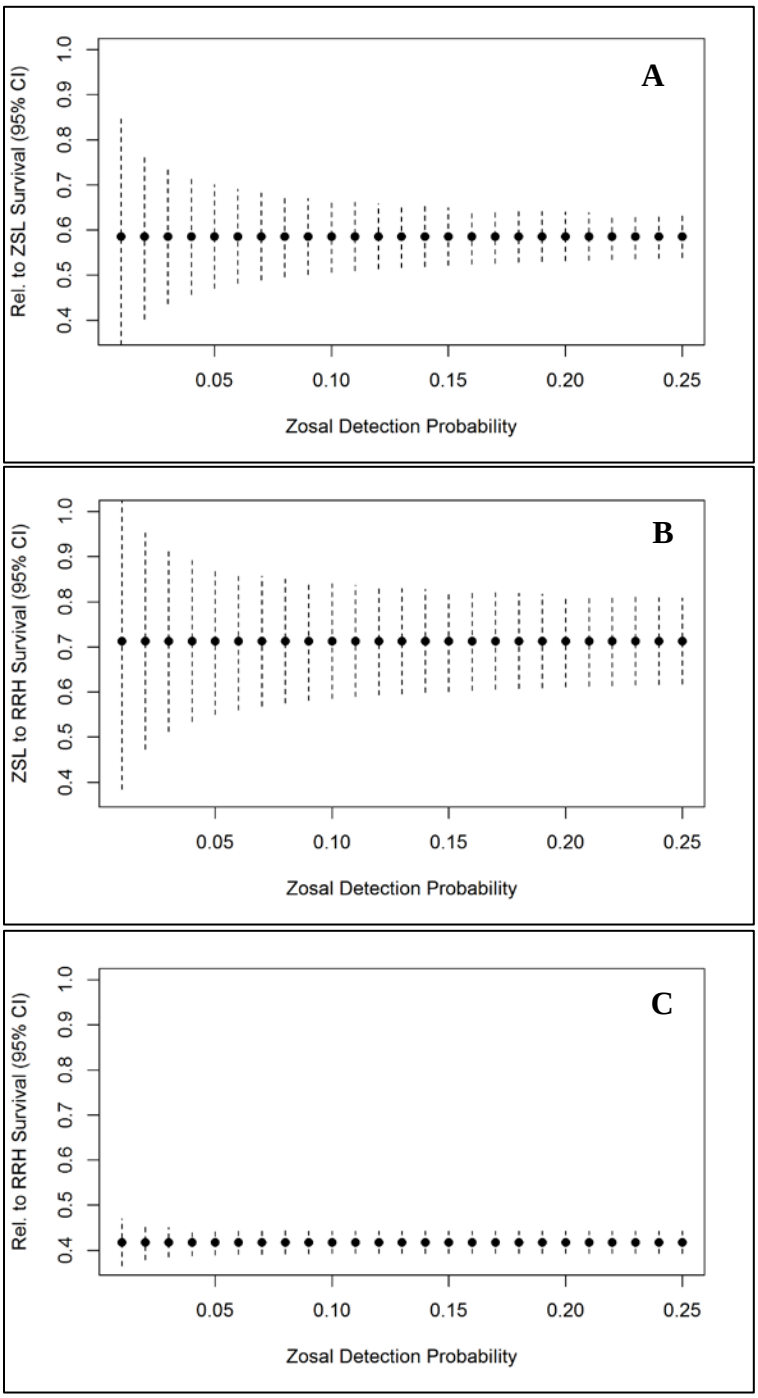

Figure 5. Estimated 95% confidence intervals for survival from Release to Zosal (A), Zosal to Rocky Reach (B), and Release to Rocky Reach (C) under different scenarios of detection probability at Zosal Dam detection sites, assuming a total of 5,000 tags released above the antenna.

Finally, to put out-migration conditions into context, Table 9 provides the average spring flow volumes (April 15–June 30) for the Upper Columbia River (as measured at Priest Rapids Dam), along with the average spring spill proportions at each of Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams in 2013–2015.

Table 9. Average spring (April 15–June 30) flow at Priest Rapids Dam (PRD) and average spill proportion at Wanapum (WAN), Priest Rapids (PRD), Rock Island (RIS), Rocky Reach (RRH), and Wells (WEL) dams in 2013–2015.

Migration Year	PRD Flow Volume (Kcfs)	Spill Proportion				
		WAN	PRD	RIS	RRH	WELL
2013	186.6	0.26	0.29	0.15	0.10	0.11
2014	189.4	0.31	0.35	0.21	0.10	0.13
2015	114.3	0.15	0.23	0.14	0.04	0.08

Conclusions

Based on these preliminary analyses, we feel a long-term monitoring group for wild sockeye from the Okanogan River Basin would be valuable to the CSS if enough PIT-tagged individuals could be released annually. Results from 2013–2015 indicate that approximately 5,000 PIT-tagged individuals are needed to obtain reliable estimates of juvenile survival from release to MCN. Based on the data from the 2013 out-migration, it appears that estimating SARs from RRH-BOA is possible for this group and, with larger sample sizes in future years, estimating SARs from MCN-BOA will also be possible. Given these points, the CSS Oversight Committee will discuss incorporating analyses from this group into the 2016 Annual Report.

References

Burnham, K. P., D. R. Anderson, G. C. White, C. Brownie, and K. H. Pollock. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph 5. Bethesda, MD. 437 pp.

McCann, J., B Chockley, E. Cooper, H. Schaller, S. Haeseker, R. Lessard, C. Petrosky, E. Tinus, E. VanDyke, and R. Ehlke. 2014. Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye: 2014 Annual Report. BPA Contract #19960200.

Skalski, J. R., S. G. Smith, R. N. Iwamoto, J. G. Williams, and A. Hoffmann. 1998. Use of passive integrated transponder tags to estimate survival of migrant juvenile salmonids in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 55:1484–1493.

White, G.C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement, 120–138.