



# FISH PASSAGE CENTER

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## MEMORANDUM

To: Jeff Fryer, CRITFC

From: Michele DeHart

Date: October 14, 2016

Re: Okanogan River sockeye passage timing, travel times, juvenile survival, and smolt-to-adult returns, migration years 2013-2016.

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 surplus PIT tags to the ONA in 2013, 2014, 2015, and 2016 to supplement PIT-tagging efforts at Skaha and Osoyoos lakes in the spring. Based on the results from 2013 and 2014, the CSS Oversight Committee decided to include estimates of overall SARs from these two out-migration years in the 2016 Draft CSS Annual Report (McCann et al. 2016). In response to your request, we have updated analyses from previous years data requests to include estimates of juvenile survival, timing, and travel time for the 2016 PIT-tagged sockeye smolts. In addition, we provide updated estimates of overall SARs from the 2013 and 2014 out-migrations, with adults detected at Bonneville Dam through September 16, 2016. Below are results from these updated analyses, followed by more specific details.

- With each successive year of tagging, the total number of PIT-tagged sockeye smolts released in the Okanogan River basin has increased from 4,018 in 2013 to 10,238 in 2016.
- In all years of tagging (2013-2016), reliable estimates of juvenile survival from Release to Rocky Reach Dam were possible. Juvenile survivals from Release to Rocky Reach

Dam (all release sites combined) have ranged from 0.42 (95% CI: 0.38-0.45) in 2015 to 0.57 (95% CI: 0.51-0.64) in 2014.

- Reliable estimates of juvenile sockeye survival beyond Rocky Reach Dam were not always possible and, therefore, it was not always possible to estimate survival from Release to McNary Dam. When estimable, survival from Release-MCN was 0.39 (95% CI: 0.31–0.47) in 2014, 0.32 (95% CI: 0.22-0.42) in 2015, and 0.45 (95% CI: 0.28-0.62) in 2016.
- Smolt-to-Adult Return (SAR) estimates for Rocky Reach-to-Bonneville (RRE-to-BOA) were estimated for both the 2013 and 2014 out-migrations while a McNary-to-Bonneville (MCN-to-BOA) SAR was only possible for the 2014 out-migration. The RRE-to-BOA SARs for 2013 and 2014 were 8.13% (CI: 6.96-9.45%) and 2.05% (CI: 1.61-2.52%), respectively. The MCN-to-BOA SAR for 2014 was 2.82% (CI: 2.14-3.54%).

## **Methods**

### ***Timing and Travel Time***

Juvenile passage timing and fish travel times were estimated for 2013-2016 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 (RRE), 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. Minimum, median, and maximum fish travel times were estimated from release to detection at each dam in the reach with detection capabilities. Due to a high number of PIT-tag detections in 2015, we also include estimates of travel time and passage timing to Zosel Dam on the Okanogan River.

### ***Juvenile Survival***

In April of 2016, many of the historic (MY 2013-2015) PIT-tag input files from the Okanogan River Basin wild sockeye marking program were modified with new release sites. Therefore, release site-specific estimates of survival from previous FPC analyses of Okanogan Basin wild sockeye (November 12, 2015, December 18, 2014, and March 6, 2014) are out-of-date. For this analysis, we have re-analyzed PIT-tag data for these migration years (2013-2015) to estimate juvenile survival for each release site, based on these updates to the PTAGIS database. In addition, we provide estimates for the 2016 out-migration.

For each migration year, we attempted to estimate smolt survival and associated variance estimates for all PIT-tagged juvenile sockeye from their release in the Okanogan Basin to MCN. We relied on juvenile detections at RRE, 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-RRE and RRE-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).

Over the years, PIT-tagged wild Okanogan Basin sockeye have been PIT-tagged and released from various sites, including: Osoyoos Lake Narrows Highway 3 Bridge (OSOYBR), Osoyoos Lake (OSOYOL), Skaha Dam or just below (up to 0.5 km) (SKA or SKATAL), and Skaha Lake (SKAHAL). Using the same methodologies outlined above, we attempted to estimate individual (e.g., Release-RRE and RRE-MCN) and combined reach survivals (Release-MCN) for each of these release sites, by migration year.

### *Smolt to Adult Survival (SARs)*

With the complete return of adults from the 2013 out-migration and the nearly complete return from the 2014 out-migration, we were able to estimate Smolt-to-Adult Returns (SARs). Given the juvenile detection capabilities at RRE, we estimated SARs for two different reaches: 1) juveniles at RRE to adult return to BON (RRE-to-BOA) and 2) juveniles at MCN to adult return to BON (MCN-to-BOA). To estimate SARs we relied on the same methodology used in Chapter 4 of the Draft 2016 CSS Annual Report (McCann et al., 2016) for Chinook at steelhead from the Methow and Entiat rivers.

## **Results**

To put out-migration conditions into context, Table 1 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 2013-2016.

**Table 1.** 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 (RRE), and Wells (WEL) dams in 2013-2016.

Migration Year	PRD Flow Volume (Kcfs)	Spill Proportion				
		WAN	PRD	RIS	RRE	WEL
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
2016	156.2	0.19	0.27	0.17	0.08	0.11

### *Travel Time and Timing*

Over the last four years, PIT-tagging of juvenile sockeye in the Okanogan River Basin has occurred from early to late March through early May. Tagging efforts in 2013, 2014, 2015, and 2016 resulted in 4,018, 5,055, 7,176, and 10,238 PIT-tagged juvenile sockeye each year,

respectively. Estimates of minimum, median, and maximum travel times from release to RRE, MCN, JDA, and BON dams are provided below (Table 2). Due to a high number of PIT-tag detections in 2015, travel times to Zosel Dam (ZSL) are also provided. These travel times are based on fish that were detected at each of the sites in their respective year of out-migration. Also provided are estimates of the 95% confidence limits around the estimated median travel time.

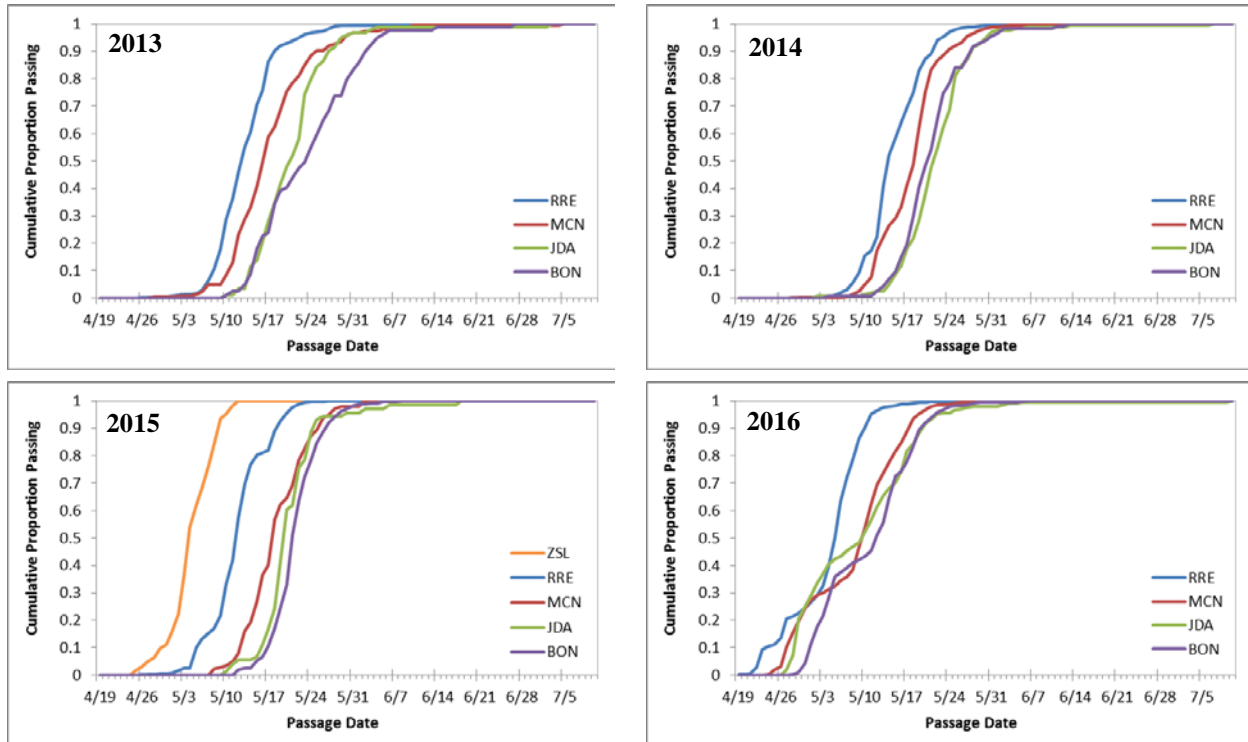
**Table 2.** Travel times from release to juvenile detection site of PIT-tagged Okanogan River Basin sockeye smolts from migration years 2013 to 2016. PIT-tag detection sites include: Zosel (ZSL), Rock Reach (RRE), McNary (MCN), John Day (JDA), and Bonneville (BON) dams.

Migration Year	Project	Release to Project Travel Time (days)			95% Confidence Limits	
		Min	Med	Max	Lower	Upper
2013	RRE	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	RRE	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
	RRE	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
2016	RRE	3.8	16.7	49.5	16.4	17.4
	MCN	8.0	21.4	51.5	20.6	22.3
	JDA	11.2	22.0	71.1	21.0	23.0
	BON	12.4	23.7	58.9	23.3	24.6

Overall, PIT-tagged sockeye smolts from the Okanogan River Basin passed through RRE from early to mid-May and Mid-Columbia Projects (MCN, JDA, and BON) in mid-May to early June (Table 3, Figure 1). In 2015, PIT-tagged sockeye smolts generally passed through Zosel Dam in late April to early May. The passage timing in 2016 appears to be slightly earlier than the previous three years. However, this could be due to the fact that 2016 tagging began in late March, which is about 2-3 weeks earlier than the previous three years.

**Table 3.** Migration timing of PIT-tagged Okanogan River Basin sockeye smolts detected at Zosel (ZSL), Rocky Reach (RRE), McNary (MCN), John Day (JDA), and Bonneville (BON) dams in migration years 2013 to 2016.

Migration Year	Project	Estimated Passage Date		
		10%	50%	90%
2013	RRE	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	2-Jun
2014	RRE	10-May	14-May	22-May
	MCN	12-May	19-May	24-May
	JDA	16-May	22-May	28-May
	BON	16-May	21-May	28-May
2015	ZSL	30-Apr	4-May	9-May
	RRE	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
2016	RRE	24-Apr	5-May	10-May
	MCN	27-Apr	10-May	18-May
	JDA	29-Apr	10-May	20-May
	BON	1-May	12-May	20-May



**Figure 1.** Cumulative passage timing of PIT-tagged wild Okanogon River basin sockeye smolts at Rocky Reach (RRE), McNary (MCN), John Day (JDA), and Bonneville (BON) dams in migration years 2013, 2014, 2015, and 2016. Cumulative passage timing to Zosel Dam (ZSL) is provided for MY 2015.

## *Juvenile Survival*

### *All Release Sites Combined*

Estimates of individual reach survival (Release-RRE and RRE-MCN) and combined survival (Release-MCN) for each migration year (all release sites combined) are provided in Table 4. For 2013, we are only able to provide reliable estimates of survival from Release-RRE (0.49, 95% CI: 0.42-0.56). The total tags released in 2013 (4,018) was not sufficient to get reliable estimates of survival below RRE. 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 RRE-MCN that was greater than 1.0 with a high standard error. Given the anomalous estimate of survival from RRE-MCN, we were also not able to estimate survival from Release-MCN for 2013.

Migration years 2014 through 2016 had much higher total release numbers (5,055 in 2014, 7,176 in 2015, and 10,238 in 2016), which allowed for the estimation of not only individual reach survivals but also a combined (Release-MCN) reach survival for each year (Table 3). These Release-MCN survivals were: 0.39 (95% CI: 0.31-0.47) in 2014, 0.32 (95% CI: 0.22-0.42) in 2015, and 0.45 (95% CI: 0.28-0.62) in 2016.

**Table 4.** Survival of PIT-tagged sockeye juveniles tagged and released into the Okanogan River Basin in 2013-2016.

<b>Migration Year</b>	<b>Number Tagged</b>	<b>Release-RRE (95% CI)</b>	<b>RRE-MCN (95% CI)</b>	<b>Release-MCN (95% CI)</b>
2013	4,018	0.49 (0.42-0.56)	N/A	N/A
2014	5,055	0.57 (0.51-0.64)	0.68 (0.52-0.84)	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)
2016	10,238	0.56 (0.53-0.59)	0.80 (0.65-0.94)	0.45 (0.28-0.62)

*Survival by Release Site*

Of the 4,018 total wild sockeye that were tagged and released in 2013, 1,178 were tagged and released from Skaha Dam or just below (SKA or SKATAL), 2,783 were tagged and released from Osoyoos Lake Narrows Bridge (OSOYBR), and 57 were tagged and released from Osoyoos Lake (OSOYOL). Too few tags were released from OSOYOL to estimate survivals for this release location. Due to the relatively low release totals for the SKA-SKATAL and OSOYBR release sites, we were only able to obtain reliable estimates of survival for the Release-RRE reach, which were 0.46 (95% CI: 0.36-0.57) for fish released at SKA-SKATAL and 0.50 (95% CI 0.41-0.58) for fish released at OSOYBR (Table 5). Estimates of survival for the RRE-MCN reach were unreliable for both release sites and, therefore, are not reported in Table 5.

In 2014, a total of 5,055 PIT-tagged sockeye were released in the Okanogan Basin. Of these, 1,348 were tagged and released from Skaha Dam or just below (SKA or SKATAL) and 3,707 were tagged and released from Osoyoos Lake Narrows Bridge (OSOYBR). For 2014, we were able to generate estimates of both individual reach survival (Release-RRE and RRE-MCN) and combined reach survival (Release-MCN) for each of the two release sites (Table 5). Fish tagged and released from SKA-SKATAL had a Release-MCN survival of 0.25 (95% CI: 0.13-0.36) whereas those from OSOYBR had a Release-MCN survival of 0.44 (95% CI: 0.34-0.54).

In 2015, 7,176 total sockeye smolts were PIT-tagged and released into the Okanogan River Basin. Of these, 5,435 were tagged and released just below Skaha Dam (SKATAL) and 1,741 were tagged and released from Osoyoos Lake Narrows Bridge (OSOYBR). We were able to generate estimates of Release-RRE for both release sites (Table 5). However, we were only able to generate a reliable estimate of RRE-MCN survival for the SKATAL release site, which was 0.70 (95% CI: 0.46-0.95). The estimate of RRE-MCN survival for the OSOYBR release site was greater than 1.0 and, therefore, deemed unreliable. Similar to 2013, this was due to the lower release total for this group and the low number of detections at and below MCN. Of the 35 OSOYBR fish that were detected at MCN in 2015, only five were subsequently detected downstream of MCN. Because the RRE-MCN survival estimate was unreliable for the OSOYBR release site, we could not estimate survival from Release-MCN for this group. However, we were able to estimate Release-MCN survival for the SKATAL release site, which was 0.28 (95% CI: 0.19-0.38).

In 2016, 10,238 total sockeye smolts were PIT-tagged and released from four different release sites in the Okanogan River Basin. Of these, 2,338 were tagged and released at Skaha Lake (SKAHAL), 3,102 were tagged and released just below Skaha Dam (SKATAL), 1,754

were tagged and released from Osoyoos Lake Narrows Bridge (OSOYBR), and 3,044 were tagged and released from Osoyoos Lake (OSOYOL). We were able generate estimates of individual reach survival (i.e, Release-RRE and RRE-MCN) for all four release sites (Table 5). In addition, we were able to estimate Release-MCN survival for all four release sites. These Release-MCN survivals were: 0.38 (95% CI: 0.23-0.53) for the SKAHAL release site, 0.39 (95% CI: 0.19-0.59) for the SKATAL release site, 0.53 (95% CI: 0.31-0.75) for the OSOYBR release site, and 0.51 (95% CI: 0.31-0.75) for the OSOYOL release site. Although the point estimates of Release-MCN survival appear to be lower for the two Skaha release sites (SKAHAL and SKATAL) compared to the two Osoyoos release sites (OSOYBR and OSOYOL), the confidence intervals for all four of these release sites overlap (Figure 2). This indicates that these differences in survival are likely not significant.

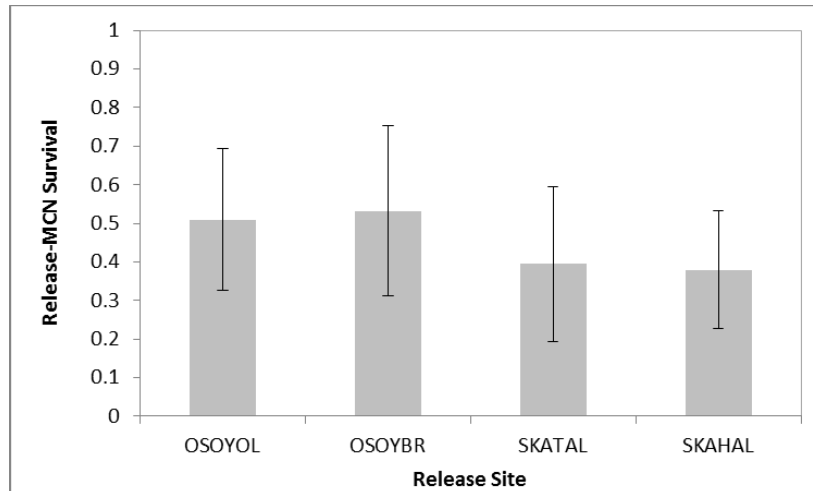
It is also worth noting that the different release sites utilized for Okanogan River Basin sockeye marking over the years have relied on three different capture methods: screw trap, purse seines, and fyke nets (Table 5). Unfortunately, it is not possible to isolate the effects of capture method on estimates of survival, as each release site relied on a single capture method each year and, therefore, capture method effects would be confounded with the effects of release site.

**Table 5.** 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	Capture Method	Release-RRE (95% CI)	RRE-MCN (95% CI)	Release-MCN (95% CI)
2013	SKA-SKATAL	1,178	ST	0.46 (0.36-0.57)	N/A	N/A
	OSOYOL	57	FN	N/A	N/A	N/A
	OSOYBR	2,783	FN	0.50 (0.42-0.59)	N/A	N/A
2014	SKA-SKATAL	1,348	ST	0.41 (0.29-0.54)	0.60 (0.27-0.92)	0.25 (0.13-0.36)
	OSOYBR	3,707	FN	0.63 (0.56-0.71)	0.69 (0.52-0.87)	0.44 (0.34-0.54)
2015	SKATAL	5,435	ST	0.41 (0.37-0.45)	0.70 (0.46-0.95)	0.29 (0.19-0.38)
	OSOYBR	1,741	FN	0.44 (0.36-0.52)	N/A	N/A
2016	SKAHAL	2,338	PS	0.48 (0.44-0.53)	0.79 (0.47-1.11)	0.38 (0.23-0.53)
	SKATAL	3,102	ST	0.47 (0.41-0.53)	0.84 (0.59-1.09)	0.39 (0.19-0.59)
	OSOYBR	1,754	FN	0.74 (0.65-0.84)	0.71 (0.41-1.02)	0.53 (0.31-0.75)
	OSOYOL	3,044	PS	0.56 (0.51-0.62)	0.91 (0.57-1.24)	0.51 (0.31-0.75)

Capture Methods: ST = Screw Trap, FN = Fyke Net, and PS = Purse Seine





**Figure 2.** Estimated Release-MCN survivals (95% confidence intervals in parentheses) of PIT-tagged wild Okanogan River wild sockeye from each of four release sites used in 2016.

### *Smolt to Adult Survival (SARs)*

As of September 16, 2016, 162 of the juveniles that were PIT-tagged and released in 2013 have been detected as adults at Bonneville Dam (BOA). Of these 162 adults, 59 returned in 2014, 99 returned in 2015, and 4 returned in 2016. For the PIT-tagged smolts that were released in 2014, 60 have been detected at BOA as adults (through September 16, 2016). Of these, 3 returned in 2015 and 57 returned in 2016.

Both Rocky Reach-to-Bonneville (RRE-to-BOA) and McNary-to-Bonneville (MCN-to-BOA) SARs are provided below (Table 6). Due to an unreliable estimate of juvenile survival for the RRH-MCN reach in 2013 (Table 4), the MCN-to-BOA SAR for 2013 is not provided.

**Table 6.** Overall McNary-to-Bonneville (MCN-to-BOA) and Rocky Reach-to-Bonneville (RRE-to-BOA) SARs for Okanogan River wild sockeye, 2013-2014.

Juvenile migration year	Smolts arriving MCN <sup>A</sup>	MCN-to-BOA			Smolts arriving RRE <sup>B</sup>	RRE-to-BOA		
		%SAR Estimate	Non-parametric CI			%SAR Estimate	Non-parametric CI	
			90% LL	90% UL			90% LL	90% UL
2013 <sup>C</sup>	--	--	--	--	1,993	8.13	6.96	9.45
2014 <sup>D</sup>	2,126	2.82	2.14	3.54	2,930	2.05	1.61	2.52

<sup>A</sup> Estimated population of tagged study fish alive to MCN tailrace (included fish detected at the dam and those estimated to pass undetected). CJS estimation of S1 uses PIT-tags detected on bird colonies in the Columbia River estuary and adult detections to augment the NOAA Trawl detections below BON.

<sup>B</sup> CJS estimation of S1 uses both the detector and recaptures at Rocky Reach Dam, as well as PIT-tags detected on bird colonies in the Columbia River estuary and adult detections to augment the NOAA Trawl detections below BON.

<sup>C</sup> Juvenile survival estimate for RRE-MCN reach was greater than 100%, resulting in an overestimate of the juvenile population at MCN. Therefore, SAR<sub>MCN-to-BOA</sub> was not estimated for this year.

<sup>D</sup> Incomplete, 2-salt returns through Sept. 16, 2016

## Conclusions

The CSS Oversight Committee continues to believe that a long-term monitoring group for wild sockeye from the Okanogan Basin would be valuable if enough PIT-tagged individuals could be released annually. Results from the last four years of tagging indicate that approximately 5,000 PIT-tagged individuals are needed to obtain reliable estimates of juvenile survival from release to MCN. With reliable estimates of juvenile survival, it also appears that estimates of SARs (RRE-to-BOA and MCN-to-BOA) are also possible. The CSS Oversight Committee hopes to continue to incorporate results from this group into future annual reports.

## References

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