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MEMORANDUM

TO: Andrea Pearl, Colville Tribes Fish & Wildlife

Michele DeHart

FROM: Michele DeHart

DATE: May 26, 2016

RE: Update of juvenile survival estimates and SARs of Upper Columbia River stocks

In response to your request, the FPC staff has prepared the following memo as an update to our January 25, 2013, memo entitled *Juvenile survival estimates and SARs of Upper Columbia River stocks* (www.fpc.org/documents/memos/11-13.pdf). As with the original memo, FPC staff has reviewed historic PIT-tagging efforts for wild summer Chinook from the Okanogan River in order to determine whether estimation of juvenile survivals and/or Smolt-to-Adult Returns (SARs) is possible. Since our original 2013 memo, Chief Joseph Hatchery has made limited releases of PIT-tagged hatchery summer Chinook, both directly from the hatchery (located below Chief Joseph Dam) and into the Okanogan River. For this update, we attempted to estimate juvenile survival for these PIT-tagged fish. Estimates of SARs for these hatchery releases are not yet possible, as these PIT-tag releases began in 2015.

As with the original memo, the FPC staff has reviewed various FPC Annual Reports (including FPC 2015) and the most recent Comparative Survival Study (CSS) Annual Report (McCann et al. 2015) as well as updated juvenile survival and SAR data for Upper Columbia River Chinook, steelhead, and sockeye stocks that are provided in these reports. Fish Passage Center Annual Reports are available on-line at www.fpc.org/documents/FPC_Annual_Reports.html. Annual Reports for the CSS are available on-line at www.fpc.org/documents/CSS.html. We hope you find this information useful in answering your questions about Okanogan River summer Chinook.

Estimates of Juvenile Survival and SARs of wild Okanogan River summer Chinook

In our review of historic PIT-tagging efforts of wild Okanogan River summer Chinook stocks, we found that sufficient PIT-tagging efforts of summer Chinook have occurred over the last five years (2011–2015). PIT-tagged smolts from the Okanogan River can be detected at Rocky Reach Dam, McNary Dam, John Day Dam, and Bonneville Dam. Unfortunately,

estimating juvenile survival from release to Bonneville Dam requires a juvenile PIT-tag detection site below Bonneville Dam. While such a site exists for spring migrants, the out-migration timing of these groups was too late for adequate detections below Bonneville Dam. Using recapture data (i.e., detections) from fish detected at the above listed 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). Below, we provide estimates juvenile survival for the following reaches: (1) Release to Rocky Reach Dam (Rel-RRE), (2) Rocky Reach Dam to McNary Dam (RRE-MCN), (3) McNary Dam to John Day Dam (MCN-JDA), and (4) overall survival from release to John Day Dam (Rel-JDA). When survivals from multiple reaches were combined (e.g., Rel-JDA combines three reaches: Rel-RRE, RRE-MCN, and MCN-JDA), variance estimates for the overall product of reach survivals (Rel-JDA) were generated using the delta method (Burnham et al. 1987).

Based on the total PIT tags available for these groups, we were able to estimate juvenile survival for each of the above mentioned reaches in four of the five migration years (2001–2014) (Table 1). For migration year 2015, we were able to estimate juvenile survival only for the Rel-RRE reach. Survival estimates below Rocky Reach Dam were not reliable in 2015 because of the low detection probabilities that were observed in the Lower Columbia River in that year, particularly at McNary Dam.

Table 1. Juvenile survival estimates (Rel-RRE, RRE-MCN, MCN-JDA, and Rel-JDA) of wild summer Chinook tagged and released above Wells Dam, near the mouth of the Okanogan River (95% confidence limits are in parentheses).

Migr. Year	Release Site(s)	Release Date(s)	Number Released	Rel. to RRE Survival	RRE to MCN Survival	MCN to JDA Survival	Rel to JDA Survival
2011	OKANR COLR8	6/22-7/10	13,221	0.45 (0.41-0.49)	0.67 (0.56-0.78)	0.63 (0.43-0.84)	0.19 (0.13-0.25)
2012	COLR8	6/27-7/14	15,311	0.54 (0.47-0.61)	0.72 (0.58-0.87)	0.70 (0.47-0.92)	0.27 (0.20-0.35)
2013	OKANR COLR8	4/21-7/11 ^A	17,867	0.44 (0.40-0.48)	0.91 (0.69-1.13)	0.40 (0.24-0.56)	0.16 (0.11-0.21)
2014	OKANR COLR8	5/30-7/25	8,601	0.36 (0.30-0.41)	0.50 (0.31-0.70)	0.61 (0.07-1.16)	0.11 (0.02-0.20)
2015	OKANR COLR8	5/12-7/10	7,787	0.27 (0.16-0.39)	N/A	N/A	N/A

^A Only four fish in this release group were released between April 21st and May 31st.

In addition, we estimated SARs for these wild PIT-tag groups for migration years 2011, 2012, and 2013. Estimation of these SARs followed the same methodology that the CSS uses for their Upper Columbia groups (see Chapter 4 of McCann et al. 2015). Following the convention of other Upper Columbia groups in the CSS, we provide SAR estimates for the following: (1) Rocky Reach Dam as smolts to adults at BON (RRE-to-BOA), and (2) McNary Dam as smolts to adults at BON (MCN-to-BOA) (Table 2).

Table 2. Overall **RRE-to-BOA** and **MCN-to-BOA SARs** (without jacks) for wild Okanogan River summer Chinook. Numbers in parentheses are 90% confidence intervals.

Migration Year	RRE-to-BOA	MCN-to-BOA
2011	2.70 (2.34-3.11)	3.99 (3.37-4.66)
2012 ^A	0.49 (0.36-0.64)	0.69 (0.50-0.89)
2013 ^B	0.39 (0.28-0.51)	0.44 (0.32-0.59)

^A Incomplete adult return with 3-salts through December 31, 2015.

^B Incomplete adult return with 2-salts through December 31, 2015.

Estimates of Juvenile Survival of hatchery summer Chinook from Chief Joseph Hatchery

Chief Joseph Hatchery first began releasing hatchery summer Chinook in migration year 2014. However, releases of PIT-tagged juveniles did not begin until migration year 2015. The goal of the summer Chinook PIT-tag release program is to release 5,000 PIT tags for each of four major release groups: (1) yearling summer Chinook released into Omak Creek (Integrated Program), (2) yearling summer Chinook released from the hatchery (Segregated Program), (3) subyearling summer Chinook released into Omak Creek (Integrated Program), and (4) sub-yearling summer Chinook released from the hatchery (Segregated Program). Per your request, we attempted to estimate juvenile survival for each of these 2015 release groups, as well as a combined yearling group and a combined subyearling group. Using the same methods outlined above, we attempted to estimate juvenile survival for the same four reaches as for the wild summer Chinook groups above.

We were able to estimate juvenile survival only for the Rel-RRE reach (Table 3). Survival estimates below Rocky Reach Dam were not reliable in 2015 because of the low detection probabilities that were observed in the Lower Columbia River in that year, particularly at McNary Dam where detection probabilities were generally less than 4% for each group.

Table 3. Juvenile survival estimates (Rel-RRE) for subyearling and yearling hatchery summer Chinook from Chief Joseph Hatchery released into Omak Creek (OMAK) or directly from the hatchery (CHJO). 95% confidence limits are in parentheses.

Release Age	Release Site(s)	Release Date(s)	Number Released	Rel. to RRE Survival
Yearlings	CHJO	4/15	5,017	0.70 (0.63-0.78)
	OMAK	4/15	1,204	N/A
	Combined	4/15	6,221	0.57 (0.51-0.63)
Subyearlings	CHJO	5/18	4,967	0.28 (0.11-0.44)
	OMAK	5/28	4,941	0.42 (0.21-0.63)
	Combined	5/18-5/28	9,908	0.35 (0.22-0.48)

Juvenile Survival Estimates and SARs of other Upper Columbia Stocks from FPC Annual Reports

The Smolt Monitoring Program (SMP) supports PIT-tagging efforts at many Upper Columbia River hatcheries and at Rock Island Dam (RIS) for the purpose of providing estimates of survival for these groups. Specifically, hatchery Chinook are PIT-tagged and released from Leavenworth NFH (yearling spring Chinook), Wells Hatchery (yearling and subyearling summer

Chinook), and Priest Rapids Hatchery (subyearling fall Chinook). In addition, Chinook (yearlings and subyearlings), steelhead, and sockeye juveniles are collected, PIT-tagged, and released from RIS.

Over the years, the FPC Annual Report has provided reach survival estimates for each of these groups. Most of the data presented below are from the 2014 FPC Annual Report (FPC 2015). In recent years, the Comparative Survival Study (CSS) has provided estimates of SARs for some of these Upper Columbia hatchery groups in the annual reports. These SAR estimates are from McNary Dam as smolts to adults at Bonneville Dam (MCN-to-BOA). These MCN-to-BOA SARs should be considered with caution, as they overestimate the actual SAR of Upper Columbia stocks. The MCN-to-BOA SARs for these Upper Columbia stocks do not account for the significant juvenile mortality that occurs during their out-migration through the hydrosystem above McNary Dam. For example, a review of the juvenile survival estimates from Rock Island to McNary dams (Tables 8 through 11) indicates that mortality can be substantial in this river reach alone.

Estimates of juvenile survival and SARs (where applicable) from the hatchery releases are provided below (Tables 4 through 7). Juvenile survival estimates are annual estimates from release to McNary Dam (MCN) and were taken from the Smolt Monitoring Program section of various FPC Annual Reports (FPC 2015). Juvenile survival estimates for migration year 2015 are from the draft 2015 FPC Annual Report which is to be posted to the FPC website in May or June 2016. Estimates of MCN-to-BOA SARs do not include jacks and were taken from Appendix B of the 2015 CSS Annual Report (McCann et al. 2015).

Table 4. Juvenile survival estimates and MCN-to-BOA SARs (without jacks) of Leavenworth NFH yearling spring Chinook tagged and released for the SMP. 95% (survivals) and 90% (SARs) confidence limits are in parentheses.

Migration Year	Release Date(s)	Survival (Rel. to MCN)	Overall SAR (MCN-to-BOA)
1998	4/20	0.55 (0.49-0.60)	N/A
1999	4/19	0.59 (0.55-0.62)	N/A
2000	4/18	0.59 (0.52-0.67)	1.84 (1.48-2.22)
2001	4/17	0.50 (0.48-0.52)	0.24 (0.11-0.37)
2002	4/22-4/24	0.56 (0.55-0.57)	0.36 (0.34-0.38)
2003	4/21	0.66 (0.65-0.67)	0.42 (0.40-0.45)
2004	4/19	0.48 (0.47-0.49)	0.34 (0.31-0.37)
2005	4/15	0.53 (0.50-0.55)	0.09 (0.04-0.15)
2006	4/17	0.56 (0.53-0.58)	0.89 (0.72-1.06)
2007	4/18	0.59 (0.57-0.61)	0.46 (0.34-0.58)
2008	4/28	0.57 (0.53-0.61)	1.89 (1.64-2.17)
2009	4/28	0.48 (0.44-0.52)	0.59 (0.44-0.75)
2010	4/23-4/28	0.66 (0.60-0.72)	0.82 (0.67-0.98)
2011	4/19-4/20	0.43 (0.38-0.47)	0.35 (0.24-0.48)
2012	4/17-4/19	0.59 (0.55-0.63)	1.05 (0.87-1.24)
2013	4/23-4/24	0.62 (0.57-0.68)	0.61 (0.47-0.75) ^A
2014	4/22-4/23	0.57 (0.52-0.62)	N/A
2015	4/14	0.50 (0.43-0.57)	N/A

^A Incomplete adult return with 2-salts through September 14, 2015.

Table 5. Juvenile survival estimates of Wells Hatchery subyearling Chinook tagged and released for the SMP (May Releases).

Migration Year	Release Date	Survival (Rel to MCN)	95% Confidence Limits	
			Lower	Upper
2004	5/12	0.251	0.205	0.296
2005	5/18	0.341	0.243	0.456
2006	5/12	0.376	0.285	0.478
2007	5/17	0.260	0.189	0.347
2008	5/13	0.371	0.298	0.444
2009	5/12-5/17	0.284	0.204	0.364
2010	5/15	0.317	0.241	0.393
2011	5/19	0.527	0.380	0.670
2012	5/15	0.247	0.170	0.324
2013	5/20	0.253	0.173	0.332
2014	5/16	0.257	0.192	0.322
2015 ^A	5/27	N/A	N/A	N/A

^A Survival estimates from Wells Hatchery to McNary were deemed unreliable due to high standard errors.

Table 6. Juvenile survival estimates of Wells Hatchery subyearling Chinook tagged and released for the SMP (June Releases). There have been no June releases from Wells Hatchery since 2008.

Migration Year	Release Date	Survival (Rel to MCN)	95% Confidence Limits	
			Lower	Upper
1997	24-June	0.254	0.170	0.338
1998	10-June	0.291	0.241	0.340
1999	19-June	0.373	0.281	0.465
2000	19-June	0.210	0.168	0.253
2001	20-June	0.211	0.166	0.257
2002	17-June	0.449	0.395	0.503
2003	17-June	0.456	0.406	0.506
2004	15-June	0.160	0.106	0.215
2005	13-June	N/A	N/A	N/A
2006	14-June	0.352	0.199	0.534
2007	15-June	0.281	0.155	0.454
2008	16-June	0.294	0.190	0.398

Table 7. Survival estimates of Priest Rapids Hatchery subyearling fall Chinook tagged and released for the SMP. These data were compiled from FPC Annual Reports (Smolt Monitoring Section).

Migration Year	Release Dates	Survival (Rel-MCN)	95% Confidence Limits	
			Lower	Upper
1997	6/16-6/24	0.568	0.458	0.679
1998	6/13-6/25	0.840	0.639	0.940
1999	6/14-6/23	0.757	0.679	0.836
2000	6/15-6/27	0.666	0.577	0.755
2001	6/11-6/19	0.746	0.670	0.794
2002	6/11-6/19	0.697	0.627	0.767
2003	6/12-6/20	0.633	0.590	0.677
2004	6/14-6/22	0.775	0.689	0.861
2005	6/09-6/17	0.655	0.573	0.729
2006	6/12-6/20	0.671	0.577	0.765
2007	6/13-6/21	0.686	0.564	0.808
2008	6/12-6/20	0.646	0.485	0.807
2009	6/11-6/19	0.626	0.510	0.742
2010	6/11-6/19	0.647	0.514	0.780
2011	6/15-6/23	0.820	0.452	0.962
2012	6/12-6/20	0.500	0.354	0.645
2013	6/12-6/15	0.674	0.530	0.817
2014	6/12-6/25	0.798	0.643	0.953
2015 ^A	6/12-6/25	N/A	N/A	N/A

^A Survival estimates from Wells Hatchery to McNary were deemed unreliable due to high standard errors.

To put out-migration conditions into context, Figure 1 provides the total flow volume (Apr. 15–Aug. 31) for the Upper Columbia River (as measured at Priest Rapids Dam), along with the average spill proportions at each of Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams, for each migration year.

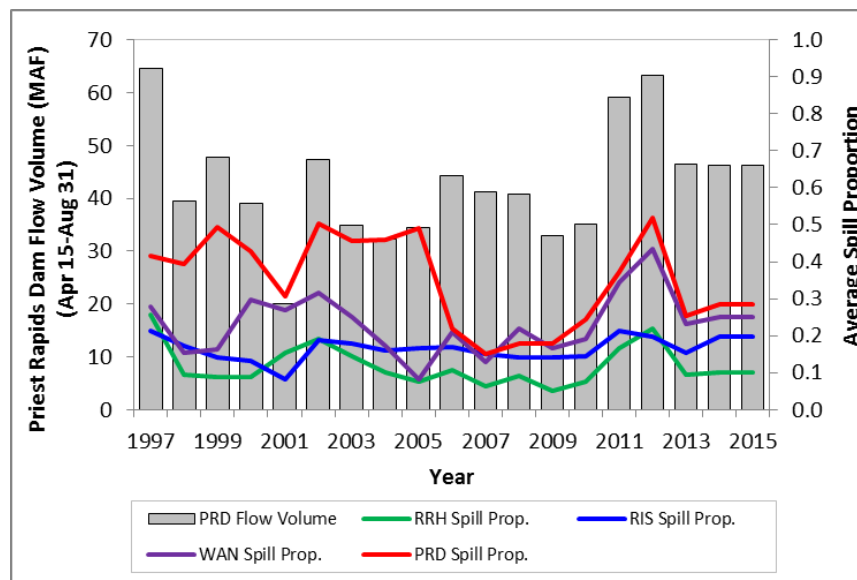


Figure 1. Total flow volume in the Upper Columbia River (at Priest Rapids Dam) and average spill proportion at Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams. Spring period is April 15–August 31.

The FPC Annual Report also provides survival estimates from juvenile salmonids that are PIT-tagged and released from Rock Island Dam (RIS). These survival estimates are for the RIS to MCN reach (Tables 8 through 11). These PIT-tagged juveniles are grouped into up to five two-week blocks for estimation of survival and environmental variables encountered by these juveniles during their out-migration. Environmental variables used in these analyses include: median fish travel time (FTT), water transit time (WTT), average spill percent, and average temperature (°C). The following lists the RIS-MCN groups that the FPC Annual Report provides estimates of survival for:

- hatchery and wild yearling Chinook (Table 8),
- hatchery and wild steelhead (Table 9),
- hatchery and wild subyearling Chinook (Table 10), and
- hatchery and wild sockeye (Table 11).

Table 8. Estimates of survival and fish travel time for hatchery and wild yearling Chinook salmon in the reach from Rock Island Dam to McNary Dam and the environmental covariates used in the analysis. These data were taken from draft 2015 FPC Annual Report (Appendix H, Table H-8). No survival data are available for 2003, due to an inoperable bypass system in the spring.

Migration Year	Release Dates	Median FTT (days)	Survival (RIS-MCN)	Survival Variance	WTT (days)	Avg. Spill Percent	Avg. Temp. (°C)
1998	4/21-5/4	12.3	0.589	0.0034	5.6	41.5	9.2
1998	5/5-5/18	10.0	0.872	0.0202	5.1	43.2	11.3
1998	5/19-6/01	12.3	0.795	0.0621	5.0	45.4	13.1
1999	4/21-5/04	13.4	0.738	0.0016	5.6	47.4	9.4
1999	5/05-5/18	9.1	0.748	0.0042	5.5	46.8	10.8
1999	5/19-6/01	8.6	0.794	0.0185	5.3	48.0	12.4
2000	4/21-5/4	14.6	0.783	0.0123	5.4	46.5	12.1
2000	5/5-5/18	12.2	0.790	0.0101	5.8	44.0	13.9
2001	4/21-5/04	30.3	0.527	0.0008	10.5	36.1	11.8
2001	5/05-5/18	17.9	0.677	0.0028	11.7	36.3	12.8
2001	5/19-6/01	16.7	0.588	0.0049	10.1	36.1	14.3
2002	4/21-5/4	15.8	0.637	0.0019	6.5	38.8	10.2
2002	5/5-5/18	10.2	0.678	0.0015	6.3	39.5	11.0
2002	5/19-6/01	9.0	0.603	0.0063	5.3	48.2	12.3
2004	5/05-5/18	8.4	0.515	0.0056	6.8	38.5	11.6
2004	5/19-6/01	10.4	0.543	0.0575	6.5	36.8	13.1
2005	4/21-5/4	11.4	0.540	0.0132	7.3	40.2	10.4
2005	5/5-5/18	9.8	0.633	0.0176	6.4	37.0	11.6
2005	5/19-6/01	10.2	0.507	0.0287	7.1	36.7	13.3
2006	4/21-5/04	10.4	0.595	0.0118	5.2	34.2	9.4
2006	5/19-6/01	10.6	0.364	0.0311	4.6	39.3	12.6
2007	4/21-5/4	8.7	0.649	0.0288	5.6	27.2	9.5
2007	5/5-5/18	9.1	0.599	0.0063	5.6	23.1	11.3
2007	5/19-6/01	8.9	0.749	0.0219	5.8	23.3	13.0
2008	4/21-5/04	14.0	0.549	0.0171	6.6	19.9	8.8
2008	5/05-5/18	8.5	0.720	0.0620	5.2	27.0	10.6
2008	5/19-6/01	6.2	0.456	0.0324	4.4	41.2	11.8
2009	4/21-5/4	20.4	0.669	0.0356	6.2	25.6	8.8
2009	5/5-5/18	11.6	0.593	0.0240	6.1	26.3	10.7
2010	4/21-5/04	11.2	0.496	0.0151	8.0	26.8	9.7
2011	4/21-5/04	11.2	0.489	0.0093	5.8	22.0	8.8
2012	4/21-5/04	13.0	0.510	0.0048	4.3	50.8	11.3
2012	5/05-5/18	7.9	0.920	0.0401	4.3	49.7	12.8
2013	4/21-5/04	12.6	0.620	0.0112	5.5	28.6	10.1
2013	5/05-5/18	9.9	0.790	0.0112	4.7	42.7	11.6
2013	5/19-6/01	8.7	0.930	0.0199	5.2	36.4	12.7
2014	4/21-5/04	10.3	0.672	0.0070	4.2	39.1	9.7
2014	5/05-5/18	8.1	0.935	0.0330	3.8	43.1	11.4
2015	4/21-5/04	12.9	0.536	0.0060	8.3	26.6	11.3
2015	5/05-5/18	11.1	0.685	0.0180	7.4	26.8	12.8
2015	5/19-6/01	9.9	0.493	0.0320	7.3	25.0	15.1

Table 9. Estimates of survival and fish travel time for hatchery and wild steelhead in the reach from Rock Island Dam to McNary Dam and the environmental covariates used the in the analysis. These data were taken from the draft 2015 FPC Annual Report (Appendix H, Table H-9). No survival data are available for 2003 due to an inoperable bypass system in the spring.

Migration Year	Release Dates	Median FTT (days)	Survival (RIS-MCN)	Survival Variance	WTT (days)	Avg. Spill Percent	Avg. Temp. (°C)
1998	4/21-5/4	8.4	0.586	0.0033	5.7	40.5	9.3
1998	5/5-5/18	5.9	0.650	0.0081	5.1	42.3	11.2
1998	5/19-6/1	7.7	0.481	0.0067	4.7	46.7	12.8
1999	4/21-5/04	6.2	0.677	0.0034	5.3	47.9	9.2
1999	5/05-5/18	6.3	0.611	0.0017	5.6	46.4	10.6
1999	5/19-6/01	7.4	0.657	0.0069	5.1	48.6	12.4
2000	4/21-5/4	6.0	0.913	0.0347	5.0	45.8	11.1
2000	5/5-5/18	5.8	0.657	0.0096	5.5	45.1	12.9
2000	5/19-6/01	7.7	0.405	0.0155	6.6	42.9	13.3
2001	4/21-5/4	19.0	0.247	0.0010	11.3	33.9	11.2
2001	5/5-5/18	17.5	0.231	0.0011	11.8	36.2	13.0
2001	5/19-6/01	17.5	0.186	0.0017	10.2	36.1	14.4
2002	4/21-5/4	6.7	0.764	0.0146	6.4	39.9	10.0
2002	5/5-5/18	7.7	0.676	0.0042	6.3	39.1	10.9
2002	5/19-6/01	7.2	0.576	0.0055	5.1	48.6	12.4
2004	4/21-5/4	8.7	0.475	0.0808	7.5	40.0	10.5
2004	5/5-5/18	7.9	0.506	0.0105	6.8	38.5	11.7
2004	5/19-6/01	8.1	0.492	0.0231	6.5	36.9	13.1
2005	4/21-5/04	8.1	0.622	0.0095	7.5	39.9	10.3
2005	5/05-5/18	8.5	0.674	0.0085	6.3	37.0	11.6
2006	4/21-5/04	7.2	0.730	0.0182	5.0	34.0	9.3
2006	5/05-5/18	6.9	0.665	0.0060	5.1	26.9	11.4
2006	5/19-6/01	5.4	0.547	0.0025	4.3	37.8	12.3
2007	4/21-5/04	5.4	0.659	0.0313	5.6	27.2	9.1
2007	5/05-5/18	5.8	0.950	0.0445	5.4	23.1	11.2
2007	5/19-6/01	7.6	0.506	0.0104	5.7	23.6	13.1
2008	4/21-5/04	9.2	0.811	0.0885	7.1	19.4	8.5
2008	5/05-5/18	8.1	0.588	0.0040	5.1	26.5	10.7
2008	5/19-6/01	6.9	0.574	0.0027	4.1	42.2	11.9
2009	4/21-5/4	9.2	0.503	0.0072	6.7	24.1	7.9
2009	5/05-5/18	8.1	0.497	0.0017	6.2	25.5	10.5
2009	5/19-6/01	6.9	0.528	0.0109	5.1	29.3	12.6
2010	4/21-5/4	8.6	0.604	0.0085	8.0	26.8	10.8
2010	5/05-5/18	8.3	0.499	0.0055	6.8	24.8	12.4
2011	4/21-5/4	7.4	0.568	0.0113	5.9	23.3	9.7
2011	5/05-5/18	5.5	0.739	0.0105	4.3	45.3	11.3
2011	5/19-6/01	4.2	0.632	0.0131	3.2	61.4	11.8
2012	4/21-5/4	5.1	0.591	0.0060	4.2	51.7	10.2
2012	5/05-5/18	5.4	0.557	0.0073	4.3	49.3	12.5
2012	5/19-6/01	5.1	0.542	0.0122	4.6	48.1	13.1
2013	5/05-5/18	5.5	0.58	0.0113	4.7	42.1	11.5
2013	5/19-6/01	5.3	0.63	0.0117	5.0	38.2	12.4
2014	4/21-5/4	5.3	0.725	0.1020	4.3	38.8	9.2
2014	5/05-5/18	5.0	0.720	0.0170	4.0	41.7	11.2
2014	5/19-6/01	4.8	0.540	0.0100	3.6	46.9	12.8
2015	5/05-5/18	8.6	0.732	0.0130	7.5	27.0	12.5
2015	5/19-6/01	7.1	0.647	0.0150	7.2	24.9	14.9

Table 10. Estimates of survival and fish travel time for hatchery and wild subyearling Chinook in the reach from Rock Island Dam to McNary Dam and the environmental covariates used in the analysis. These data were taken from the draft 2015 FPC Annual Report (Appendix H, Table H-10).

Migration Year	Release Dates	Median FTT (days)	Survival (RIS-MCN)	Survival Variance	WTT (days)	Avg. Spill Percent	Avg. Temp. (°C)
2000	6/20-7/3	21.8	0.560	0.0075	7.7	12.4	17.1
2000	7/4-7/17	20.9	0.783	0.0170	8.1	29.0	18.4
2000	7/18-7/31	18.7	0.616	0.0060	8.1	29.2	19.4
2000	8/1-8/14	11.1	0.630	0.0072	8.7	27.1	19.5
2001	6/20-7/3	32.7	0.285	0.0053	14.6	18.4	18.0
2001	7/4-7/17	25.6	0.400	0.0010	15.6	18.4	19.1
2001	7/18-7/31	23.7	0.252	0.0010	15.0	10.1	19.5
2001	8/1-8/14	18.8	0.258	0.0020	13.2	1.2	19.4
2001	8/15-8/31	16.1	0.129	0.0021	14.4	2.0	19.1
2002	6/20-7/3	12.2	0.777	0.0130	4.9	44.9	15.7
2002	7/4-7/17	11.7	0.797	0.0048	6.0	36.5	17.5
2002	7/18-7/31	16.3	0.758	0.0030	7.9	28.9	18.8
2002	8/1-8/14	11.6	0.621	0.0041	8.7	25.0	19.2
2003	6/20-7/3	11.7	0.618	0.0114	8.4	25.8	17.0
2003	7/4-7/17	12.0	0.464	0.0025	9.0	29.0	18.9
2003	7/18-7/31	8.4	0.276	0.0046	9.7	28.6	20.1
2003	8/1-8/14	9.5	0.293	0.0078	10.2	21.7	20.6
2004	6/20-7/3	13.0	0.441	0.0356	8.1	27.9	17.8
2004	7/4-7/17	12.8	0.222	0.0017	9.8	27.9	18.8
2004	7/18-7/31	11.1	0.188	0.0045	10.6	28.0	20.0
2005	7/4-7/17	10.9	0.354	0.0245	7.2	45.7	18.3
2006	6/20-7/3	13.2	0.560	0.0281	6.5	30.7	17.4
2006	7/4-7/17	11.6	0.338	0.0052	7.2	24.8	18.8
2006	8/1-8/14	21.0	0.203	0.0161	9.9	16.2	20.1
2007	6/20-7/3	23.5	0.308	0.0162	7.3	26.0	17.6
2007	7/4-7/17	17.7	0.473	0.0117	7.4	25.3	18.7
2007	7/18-7/31	11.9	0.444	0.008	7.9	25.1	19.3
2008	6/20-7/3	10.1	0.285	0.0034	5.0	37.3	15.6
2008	7/4-7/17	13.1	0.671	0.0526	7.6	28.9	17.6
2009	7/18-7/31	34.7	0.219	0.0030	11.5	33.4	19.9
2010	7/4-7/17	19.7	0.544	0.0588	8.6	29.2	20.8
2010	7/18-7/31	17.7	0.891	0.0944	9.9	31.6	21.4
2010	8/1-8/14	20.8	0.508	0.0408	11.4	33.2	20.4
2011	6/20-7/3	16.3	0.663	0.1773	4.0	55.1	16.6
2011	7/4-7/17	13.3	0.554	0.0705	4.8	50.7	17.7
2011	7/18-7/31	24.6	0.609	0.0870	6.4	33.0	20.0
2011	8/1-8/14	33.8	0.338	0.0364	9.1	13.0	20.0
2011	8/15-8/31	46.7	0.234	0.0516	10.9	1.8	
2012	7/18-7/31	13.8	0.715	0.0102	5.3	46.9	20.0
2012	8/1-8/14	22.2	0.616	0.0146	7.3	32.2	20.1
2013	6/20-7/3	19.0	0.825	0.0526	5.7	43.5	17.2
2013	8/1-8/14	12.8	0.571	0.0634	8.2	30.7	20.5
2014	6/20-7/3	15.9	0.313	0.0160	4.8	38.6	17.0
2014	7/4-7/17	16.0	0.806	0.0230	5.6	28.4	18.4
2014	7/18-7/31	7.9	0.718	0.0370	6.1	29.0	19.4
2014	8/1-8/14	10.3	0.215	0.0050	6.9	28.7	20.5
2014	8/15-8/31	9.2	0.109	0.0010	8.0	22.1	20.5

Table 10 (continued). Estimates of survival and fish travel time for hatchery and wild subyearling Chinook in the reach from Rock Island Dam to McNary Dam and the environmental covariates used the in the analysis. These data were taken from the draft 2015 FPC Annual Report (Appendix H, Table H-10).

Migration Year	Release Dates	Median FTT (days)	Survival (RIS-MCN)	Survival Variance	WTT (days)	Avg. Spill Percent	Avg. Temp. (°C)
2015 ^A	6/20-7/3	10.2			9.0	30.3	19.5
2015	7/4-7/17	8.8			9.3	30.4	20.3
2015	7/18-7/31	14.4			9.3	31.4	20.2
2015	8/1-8/14				11.5	1.6	19.4

^A Due to low detection probabilities at MCN, we were unable to reliably estimate reach survival (Rock Island Dam to McNary Dam) for subyearling Chinook in 2015.

Table 11. Estimates of survival and fish travel time for hatchery and wild sockeye in the reach from Rock Island Dam to McNary Dam and the environmental covariates used the in the analysis. These data were taken from the draft 2015 FPC Annual Report (Appendix H, Table H-11). No survival data are available for 2003 due to an inoperable bypass system in the spring.

Migration Year	Release Dates	Median FTT (days)	Survival (RIS-JDA)	Survival Variance	WTT (days)	Avg. Spill Percent
1998	4/15-5/26	10.6	0.680	0.0024	5.6	43.4
1999	4/15-5/26	6.7	0.562	0.0008	5.5	44.2
2000	4/15-5/26	10.4	0.554	0.0246	5.5	43.5
2001	4/15-5/26	8.4	0.607	0.0123	11.8	27.7
2002	4/15-5/26	7.1	0.540	0.0021	6.0	42.2
2004	4/15-5/26	8.3	0.750	0.0254	7.1	38.0
2005	4/15-5/26	8.1	0.690	0.0167	7.1	37.3
2006	4/15-5/26	6.2	0.758	0.0035	4.9	34.6
2007	4/15-5/26	7.0	0.584	0.0021	5.6	25.4
2008	4/15-5/26	5.9	0.609	0.0079	5.9	27.2
2009	4/15-5/26	7.4	0.826	0.0062	6.1	23.6
2010	4/15-5/26	12.3	0.782	0.0042	7.2	25.0
2011	4/15-5/26	7.3	0.719	0.0076	4.5	41.5
2012	4/15-5/26	4.1	0.926	0.0080	4.3	49.7
2013	4/15-5/26	7.2	0.790	0.00658	5.2	36.3
2014	4/15-5/26	5.7	0.446	0.0035	4.0	40.7
2015	4/15-5/26	9.8	0.753	0.0035	7.8	25.7

Estimates of SARs of Upper Columbia Chinook and Steelhead from CSS Analyses

In recent years, the CSS has provided analyses of PIT-tagged hatchery and/or wild Upper Columbia Chinook and steelhead. Wild Chinook and steelhead smolts are trapped and PIT-tagged with screw traps in tributaries throughout the Upper Columbia Basin. These smolt traps are typically in operation for several months, during which time fish are collected, PIT-tagged, and released. Hatchery Chinook and steelhead analyzed by the CSS are generally aggregate groups released into various tributaries of the Upper Columbia River. The long period of tagging for wild stocks, along with the lack of juvenile PIT-tag detection sites between many of the release sites and MCN, makes estimating survival from release to MCN problematic. However, the CSS has provided estimates of SARs for many of these hatchery and wild Upper Columbia PIT-tag groups. Below, we have compiled these SAR estimates for the various hatchery and wild groups that have been analyzed by the CSS so far (Tables 12 through 16). These SAR

estimates are from Appendix B of the 2015 CSS Annual Report (McCann et al. 2015), which is available at (www.fpc.org/documents/CSS.html).

Table 12. Overall MCN-to-BOA SARs for PIT-tagged hatchery and/or wild Chinook and steelhead from the Wenatchee, Entiat, and/or Methow river basins (90% confidence intervals are in parentheses). SARs for Chinook are without jacks.

Migration Year	Wenatchee River wild spring Chinook	Wenatchee River hatchery steelhead ^A	Entiat & Methow River wild spring Chinook	Wenatchee, Entiat, & Methow wild steelhead
2003	N/A	2.35 (2.12-2.58)	N/A	N/A
2004	N/A	1.46 (1.22-1.69)	N/A	N/A
2005	N/A	0.90 (0.77-1.03)	N/A	N/A
2006	N/A	2.29 (1.90-2.70)	0.43 (0.11-0.81) ^C	1.91 (0.86-3.09) ^C
2007	0.76 (0.54-1.02)	2.05 (1.61-2.56)	0.75 (0.26-1.27)	4.49 (3.19-5.81)
2008	2.75 (2.40-3.14)	5.78 (5.11-6.52)	2.94 (2.51-3.38)	6.66 (5.55-7.82)
2009	1.98 (1.57-2.44)	2.66 (2.23-3.12)	2.22 (1.58-2.87)	4.40 (3.45-5.39)
2010	1.37 (1.08-1.66)	3.63 (3.02-4.31)	1.85 (1.45-2.28)	3.51 (2.61-4.50)
2011	0.95 (0.64-1.30)	1.59 (1.27-1.94)	0.41 (0.10-0.79)	1.31 (0.70-2.01)
2012	0.95 (0.68-1.24)	1.96 (1.69-2.25)	1.23 (0.83-1.64)	6.08 (4.13-8.15)
2013 ^B	1.50 (1.11-1.92)	N/A	1.81 (1.30-2.36)	N/A

^A Wenatchee River hatchery steelhead were reared at Wenatchee, Turtle Rock, and/or Chelan hatcheries.

^B Migration year 2013 returns for Chinook incomplete with returns of 2-salts through Sept. 14, 2015.

^C Migration year 2006 is Entiat River only.

Table 13. Overall Rocky Reach to Bonneville SARs for PIT-tagged wild Chinook and steelhead from the Entiat and Methow river basins (90% confidence intervals are in parentheses). SARs for Chinook are without jacks.

Migration Year	Entiat & Methow River wild Chinook ^A	Entiat, & Methow River wild steelhead ^B
2008 ^C	1.55 (1.17-1.94)	4.77 (3.31-6.47)
2009 ^C	1.11 (0.64-1.65)	2.30 (1.57-3.17)
2010	1.13 (0.89-1.39)	1.91 (1.44-2.44)
2011	0.29 (0.07-0.55)	0.87 (0.45-1.29)
2012	0.72 (0.47-0.97)	3.65 (2.62-4.85)
2013 ^D	1.09 (0.76-1.42)	N/A

^A The Entiat/Methow wild Chinook aggregate is the same group as used for the MCN-to-BOA SARs (Table 12). SARs are calculated as the number of adults at BOA divided by the estimated number of smolts at Rocky Reach Dam.

^B The Entiat/Methow wild steelhead is a subgroup of that used for the MCN-to-BOA SARs (Table 12, excluding Wenatchee). SARs are calculated as the number of adults at BOA divided by the estimated number of smolts at Rocky Reach Dam.

^C SAR estimate uses recaptures at Rocky Reach Dam. After 2009, both the new juvenile detector and recaptures at Rocky Reach Dam are used.

^D Migration year 2013 returns for Chinook incomplete with returns of 2-salts through Sept. 14, 2015.

Table 14. Overall **RIS-to-BOA SARs** for hatchery and wild yearling Chinook, steelhead, and subyearling Chinook PIT-tagged at Rock Island Dam. Numbers in parentheses are Clopper-Pearson binomial 90% confidence intervals (Clopper and Pearson 1934). SARs for Chinook are without jacks.

Migration Year	Hatchery and wild yearling Chinook	Hatchery and wild subyearling Chinook	Hatchery and wild steelhead	Hatchery and wild sockeye
2000	0.90 (0.67-1.19)	1.94 (1.60-2.33)	1.42 (1.12-1.77)	1.98 (1.18-3.13)
2001	0.00 (0.00-0.16)	0.00 (0.00-0.07)	0.07 (0.02-0.19)	0.00 (0.00-0.61)
2002	0.05 (0.01-0.16)	1.00 (0.78-1.27)	1.88 (1.54-2.27)	0.29 (0.13-0.57)
2003 ^A	---	0.28 (0.16-0.45)	---	---
2004	0.11 (0.01-0.52)	0.03 (0.00-0.15)	0.30 (0.15-0.55)	0.74 (0.37-1.33)
2005	0.00 (0.00-0.41)	0.54 (0.35-0.79)	0.77 (0.52-1.10)	0.00 (0.00-0.34)
2006	0.18 (0.03-0.56)	0.57 (0.39-0.80)	0.88 (0.63-1.20)	1.08 (0.82-1.41)
2007	0.00 (0.00-0.35)	0.31 (0.17-0.51)	0.90 (0.66-1.21)	0.86 (0.56-1.27)
2008	0.47 (0.16-1.08)	1.06 (0.80-1.38)	3.21 (2.84-3.60)	7.80 (6.81-8.89)
2009	0.73 (0.29-1.52)	0.58 (0.33-0.96)	1.09 (0.87-1.36)	5.88 (5.05-6.80)
2010	0.50 (0.17-1.14)	0.85 (0.62-1.15)	1.22 (1.01-1.47)	2.86 (2.42-3.37)
2011	0.15 (0.03-0.47)	2.10 (1.75-2.49)	0.58 (0.44-0.75)	1.98 (1.58-2.46)
2012	0.24 (0.08-0.54)	0.87 (0.64-1.17)	0.99 (0.79-1.23)	4.18 (3.61-4.80)
2013 ^B	0.71 (0.53-0.93)	0.47 (0.31-0.69)	N/A	5.83 (5.11-6.60)

^A SAR estimates were not possible for spring migrants in 2003 due to inoperable bypass during the spring

^B Incomplete returns with 2-salts through September 14, 2015

Table 15. Overall **MCN-to-BOA SARs** for PIT-tagged hatchery and/or wild Chinook and steelhead from the Yakima River Basin (90% confidence intervals are in parentheses). SARs for Chinook are without jacks.

Migration Year	Cle Elum Hatchery spring Chinook	Yakima River Wild spring Chinook	Yakima River wild steelhead
2000	3.65 (3.35-3.96)	6.90 (6.10-7.73)	N/A
2001	0.28 (0.19-0.38)	1.54 (0.73-2.52)	N/A
2002	1.37 (1.20-1.55)	2.25 (1.73-2.82)	8.12 (5.24-11.37)
2003	0.59 (0.48-0.71)	2.47 (1.91-3.04)	7.85 (4.93-11.19)
2004	1.54 (1.30-1.78)	3.70 (2.87-4.62)	2.84 (1.46-4.67)
2005	0.66 (0.49-0.83)	1.35 (0.57-2.20)	4.94 (2.56-7.90)
2006	1.24 (1.06-1.41)	1.59 (0.76-2.65)	4.03 (2.20-5.98)
2007	1.01 (0.86-1.16)	1.93 (0.86-3.26)	7.30 (3.29-12.06)
2008	3.17 (2.86-3.46)	6.84 (4.93-8.96)	9.79 (5.67-14.26)
2009	1.82 (1.65-1.99)	4.95 (3.78-6.21)	5.27 (3.26-8.20)
2010	1.52 (1.33-1.71)	--- ^A	5.74 (2.91-9.56)
2011	0.94 (0.79-1.09)	0.97 (0.24-1.79)	3.28 (1.32-5.82)
2012	1.22 (1.07-1.37)	2.79 (1.85-3.85)	7.60 (4.52-10.87)
2013 ^B	1.37 (1.18-1.53)	1.27 (0.64-2.02)	N/A

^A No PIT-tags released in 2010

^B Incomplete returns with 2-salts through September 14, 2015.

Table 16. Overall MCN-to-MCA SARs for PIT-tagged hatchery and/or wild Chinook and steelhead from the Yakima River Basin. 90% confidence intervals are in parentheses. SARs for Chinook are without jacks.

Migration Year	Cle Elum Hatchery spring Chinook	Yakima River Wild spring Chinook	Yakima River wild steelhead
2002	1.39 (1.21-1.57)	2.16 (1.67-2.71)	6.16 (3.72-8.83)
2003	0.63 (0.52-0.76)	2.52 (1.94-3.09)	6.49 (4.05-9.29)
2004	1.34 (1.13-1.57)	3.47 (2.67-4.38)	2.58 (1.26-4.29)
2005	0.59 (0.43-0.76)	1.35 (0.57-2.20)	4.56 (2.29-7.36)
2006	1.10 (0.93-1.27)	1.42 (0.57-2.32)	3.27 (1.70-4.97)
2007	0.86 (0.72-1.00)	1.93 (0.85-3.25)	6.39 (2.87-10.55)
2008	2.79 (2.51-3.06)	5.67 (3.98-7.61)	8.85 (4.93-13.24)
2009	1.57 (1.40-1.73)	4.14 (3.15-5.29)	4.72 (2.79-7.28)
2010	1.40 (1.22-1.58)	--- ^A	4.53 (2.13-7.71)
2011	0.87 (0.73-1.00)	0.73 (0.00-1.47)	2.34 (0.88-4.57)
2012	1.07 (0.93-1.22)	2.79 (1.84-3.82)	5.24 (2.99-7.91)
2013 ^B	1.31 (1.14-1.48)	1.41 (0.74-2.27)	N/A

^A No PIT-tags released in 2010.

^B Incomplete returns with 2-salts through September 14, 2015.

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