



# FISH PASSAGE CENTER

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## MEMORANDUM

TO: Teresa Scott, WDFW

*Michele DeHart*

FROM: Michele DeHart

DATE: December 19, 2011

RE: Juvenile survival estimates of Upper Columbia River stocks

In response to your request, the FPC staff has reviewed various FPC Annual Reports and the most recent Comparative Survival Study (CSS) Annual Report and compiled juvenile survival data for several Upper Columbia River stocks. The long time series of analyses for the SMP and CSS consistently show that juvenile salmon and steelhead survival is related to flow and spill, indicating that higher flow levels and higher spill levels result in higher juvenile survival. Fish Passage Center Annual Reports are available on-line at [http://www.fpc.org/documents/FPC\\_Annual\\_Reports.html](http://www.fpc.org/documents/FPC_Annual_Reports.html). Furthermore, CSS Annual Reports are available on-line at <http://www.fpc.org/documents/CSS.html>.

### **Survival Estimates from FPC Annual Reports:**

The Smolt Monitoring Program (SMP) provides for PIT-tagging efforts at many Upper Columbia River hatcheries and 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, 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 2010 FPC Annual Report ([http://www.fpc.org/documents/annual\\_FPC\\_report/FPC%202010%20ANNUAL%20REPORT--FINAL.pdf](http://www.fpc.org/documents/annual_FPC_report/FPC%202010%20ANNUAL%20REPORT--FINAL.pdf)). Survival estimates from the hatchery releases are for the release to McNary Dam (MCN) reach and are annual estimates (Tables 1 through 4).

**Table 1.** Survival estimates of Leavenworth National Fish Hatchery yearling spring Chinook tagged and released for the SMP. These data were compiled from FPC Annual Reports (Smolt Monitoring Section).

Migration Year	Release Date(s)	Survival (Rel. to MCN)	Confidence Limits (95%)	
			Lower	Upper
1998	20-Apr	0.546	0.491	0.602
1999	19-Apr	0.586	0.550	0.622
2000	18-Apr	0.593	0.520	0.667
2001	17-Apr	0.501	0.484	0.517
2002	22-Apr, 24-Apr	0.560	0.553	0.567
2003	21-Apr	0.662	0.655	0.669
2004	19-Apr	0.483	0.473	0.494
2005	15-Apr	0.526	0.500	0.553
2006	17-Apr	0.558	0.531	0.585
2007	18-Apr	0.593	0.571	0.615
2008	28-Apr	0.571	0.528	0.614
2009	28-Apr	0.481	0.442	0.520
2010	23-Apr, 26-Apr	0.662	0.603	0.721
2011*	19-Apr, 20-Apr	0.426	0.385	0.469

\* 2011 survival estimate is preliminary and taken from 2011 Leavenworth NFH Hatchery Report (posted to FPC website on December 15, 2011). Final estimate of survival will be available in 2011 FPC Annual Report (due out in draft form in June 2012).

**Table 2.** Survival estimates of Wells Hatchery yearling and subyearling Chinook tagged and released for the SMP (May Releases). These data were compiled from FPC Annual Reports (Smolt Monitoring Section).

Migration Year	Release Date	Survival (Rel to MCN)	95% Confidence Limits	
			Lower	Upper
2004	12-May	0.251	0.205	0.296
2005	18-May	0.341	0.243	0.456
2006	12-May	0.376	0.285	0.478
2007	17-May	0.260	0.189	0.347
2008	13-May	0.371	0.298	0.444
2009	15-May	0.284	0.204	0.364
2010	17-May	0.317	0.241	0.393
2011*	19-May	0.527	0.380	0.670

\*2011 survival estimate is preliminary and taken from 2011 Wells Hatchery Report (posted to FPC website on November 2, 2011). Final estimate of survival will be available in 2011 FPC Annual Report (due out in draft form in June 2012).

**Table 3.** Survival estimates of Wells Hatchery yearling and subyearling Chinook tagged and released for the SMP (June Releases). These data were compiled from FPC Annual Reports (Smolt Monitoring Section). There have been no June releases from Wells Hatchery since 2008.

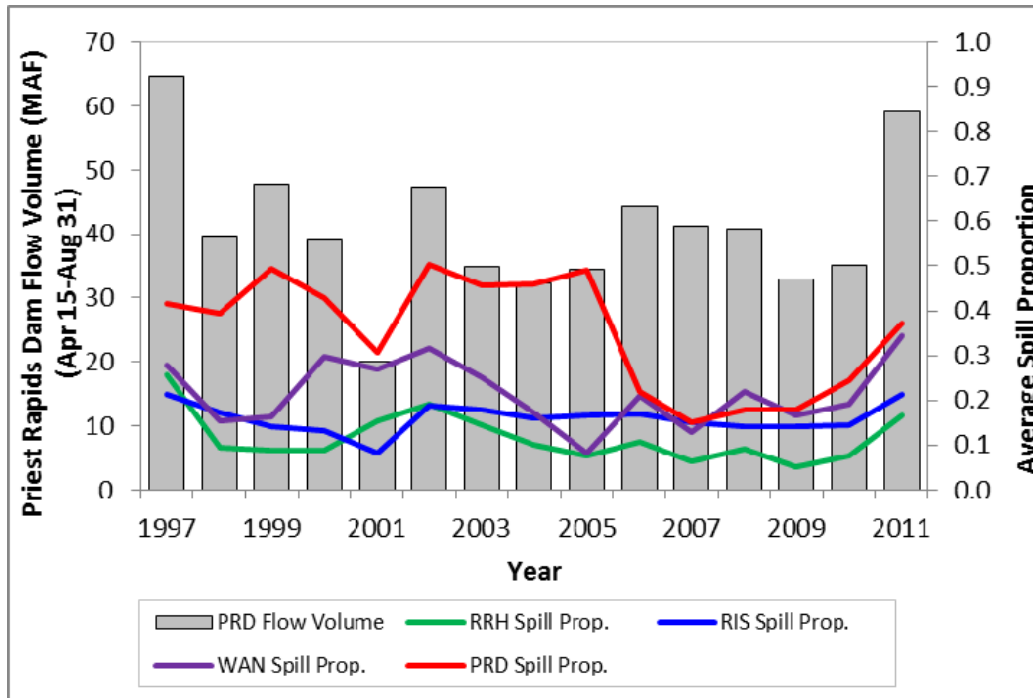
Migration Year	Release Date	Survival (Rel to MCN)	95% Confidence Limits	
			Lower	Upper
1997	24-June	0.254	0.170	0.338
1998	10-June	0.291	0.241	0.340
1999	19-June	0.373	0.281	0.465
2000	19-June	0.210	0.168	0.253
2001	20-June	0.211	0.166	0.257
2002	17-June	0.449	0.395	0.503
2003	17-June	0.456	0.406	0.506
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 4.** 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	June 16-24	0.568	0.458	0.679
1998	June 13-25	0.840	0.639	0.940
1999	June 14-23	0.757	0.679	0.836
2000	June 15-27	0.666	0.577	0.755
2001	June 11-19	0.746	0.670	0.794
2002	June 11-19	0.697	0.627	0.767
2003	June 12-20	0.633	0.590	0.677
2004	June 14-22	0.775	0.689	0.861
2005	June 09-17	0.655	0.573	0.729
2006	June 12-20	0.671	0.577	0.765
2007	June 13-21	0.686	0.564	0.808
2008	June 12-20	0.646	0.485	0.807
2009	June 11-19	0.626	0.510	0.742
2010	June 9-17	0.647	0.514	0.780
2011*	June 15-23	0.820	0.452	0.962

\*2011 survival estimate is preliminary and taken from 2011 Priest Rapids Hatchery Report (posted to FPC website on November 2, 2011). Final estimate of survival will be available in 2011 FPC Annual Report (due out in draft form in June 2012).

To put some 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.

Survival estimates from the tagging at RIS are for the RIS to MCN reach (Tables 5 through 8). These fish 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). Among the groups that the FPC Annual Report provides estimates of RIS-MCN survival for are: 1) hatchery and wild yearling Chinook (Table 5), 2) hatchery and wild steelhead (Table 6), and 3) hatchery and wild subyearling Chinook (Table 7). In addition, the FPC Annual Report provides annual estimates of survival for hatchery and wild sockeye (RIS-John Day Dam), along with the environmental variables these sockeye juveniles were expected to experience upon their out-migration (Table 8). Analyses of these groups for migration year 2011 have not been done yet. However, they will be available in the 2011 FPC Annual Report, which will be available in draft form in June 2012.

**Table 5.** 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 the in the analysis. These data were taken from the 2010 FPC Annual Report (Appendix H, Table H-8).

<b>Migration Year</b>	<b>Release Dates</b>	<b>Median FTT (days)</b>	<b>Survival (RIS-MCN)</b>	<b>Survival Variance</b>	<b>WTT (days)</b>	<b>Avg. Spill Percent</b>	<b>Avg. Temp. (°C)</b>
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

**Table 6.** 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 2010 FPC Annual Report (Appendix H, Table H-9).

<b>Migration Year</b>	<b>Release Dates</b>	<b>Median FTT (days)</b>	<b>Survival (RIS-MCN)</b>	<b>Survival Variance</b>	<b>WTT (days)</b>	<b>Avg. Spill Percent</b>	<b>Avg. Temp. (°C)</b>
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

**Table 7.** 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 2010 FPC Annual Report (Appendix H, Table H-10).

<b>Migration Year</b>	<b>Release Dates</b>	<b>Median FTT (days)</b>	<b>Survival (RIS-MCN)</b>	<b>Survival Variance</b>	<b>WTT (days)</b>	<b>Avg. Spill Percent</b>	<b>Avg. Temp. (°C)</b>
2000	6/20-7/3	21.8	0.560	0.00745	7.7	12.4	17.1
2000	7/4-7/17	20.9	0.783	0.01696	8.1	29.0	18.4
2000	7/18-7/31	18.7	0.616	0.00604	8.1	29.2	19.4
2000	8/1-8/14	11.1	0.630	0.00720	8.7	27.1	19.5
2001	6/20-7/3	32.7	0.285	0.00528	14.6	18.4	18.0
2001	7/4-7/17	25.6	0.400	0.00104	15.6	18.4	19.1
2001	7/18-7/31	23.7	0.252	0.00098	15.0	10.1	19.5
2001	8/1-8/14	18.8	0.258	0.00197	13.2	1.2	19.4
2001	8/15-8/31	16.1	0.129	0.00213	14.4	2.0	19.1
2002	6/20-7/3	12.2	0.777	0.01298	4.9	44.9	15.7
2002	7/4-7/17	11.7	0.797	0.00480	6.0	36.5	17.5
2002	7/18-7/31	16.3	0.758	0.00299	7.9	28.9	18.8
2002	8/1-8/14	11.6	0.621	0.00413	8.7	25.0	19.2
2003	6/20-7/3	11.7	0.618	0.01143	8.4	25.8	17.0
2003	7/4-7/17	12.0	0.464	0.00254	9.0	29.0	18.9
2003	7/18-7/31	8.4	0.276	0.00455	9.7	28.6	20.1
2003	8/1-8/14	9.5	0.293	0.00783	10.2	21.7	20.6
2004	6/20-7/3	13.0	0.441	0.03558	8.1	27.9	17.8
2004	7/4-7/17	12.8	0.222	0.00170	9.8	27.9	18.8
2004	7/18-7/31	11.1	0.188	0.00453	10.6	28.0	20.0
2005	7/4-7/17	10.9	0.354	0.02450	7.2	45.7	18.3
2006	6/20-7/3	13.2	0.560	0.02813	6.5	30.7	17.4
2006	7/4-7/17	11.6	0.338	0.00519	7.2	24.8	18.8
2006	8/1-8/14	21.0	0.203	0.01606	9.9	16.2	20.1
2007	6/20-7/3	23.5	0.308	0.01622	7.3	26.0	17.6
2007	7/4-7/17	17.7	0.473	0.01169	7.4	25.3	18.7
2007	7/18-7/31	11.9	0.444	0.00793	7.9	25.1	19.3
2008	6/20-7/3	10.1	0.285	0.00343	5.0	37.3	15.6
2008	7/4-7/17	13.1	0.671	0.05265	7.6	28.9	17.6
2009	7/18-7/31	34.7	0.219	0.00299	11.5	33.4	19.9
2010	7/4-7/17	19.7	0.544	0.05876	8.6	29.2	20.8
2010	7/18-7/31	17.7	0.891	0.09442	9.9	31.6	21.4
2010	8/1-8/14	20.8	0.508	0.04084	11.4	33.2	20.4

**Table 8.** Estimates of survival and fish travel time for hatchery and wild sockeye in the reach from Rock Island Dam to John Day Dam and the environmental covariates used in the analysis. These data were taken from the 2010 FPC Annual Report (Appendix H, Table H-11).

<b>Migration Year</b>	<b>Release Dates</b>	<b>Median FTT (days)</b>	<b>Survival (RIS-JDA)</b>	<b>Survival Variance</b>	<b>WTT (days)</b>	<b>Avg. Spill Percent</b>
1998	4/15-5/26	16.2	0.55	0.007	8.9	41.0
1999	4/15-5/26	11.4	0.50	0.004	9.2	39.9
2000	4/15-5/26	11.6			9.9	41.0
2001	4/15-5/26	23.3	0.25	0.006	20.5	22.6
2002	4/15-5/26	10.9	0.33	0.004	10.6	39.2
2004	4/15-5/26	10.9	0.4	0.015	12.6	35.3
2005	4/15-5/26	11.0	0.42	0.034	12.3	34.6
2006	4/15-5/26	10.2	0.88	0.023	8.4	35.0
2007	4/15-5/26	10.1	0.56	0.007	10.2	25.4
2008	4/15-5/26	7.3	0.77	0.035	9.9	26.4
2009	4/15-5/26	12.3	0.59	0.011	10.2	25.9
2010	4/15-5/26	19.3	0.81	0.025	11.9	27.1

### **Survival Estimates from CSS Annual Reports:**

In recent years, the Comparative Survival Study (CSS) has provided analyses of PIT-tagged hatchery and wild Upper Columbia Chinook and steelhead juveniles. Wild Chinook and steelhead smolts are trapped and PIT-tagged with screw traps in the Wenatchee, Methow, and Entiat rivers. These smolt traps are typically in operation for several months, during which time fish are collected, PIT-tagged, and released. This long period of tagging, along with the lack of juvenile PIT-tag detection sites between the release sites and MCN, makes estimating survival from release to MCN problematic.

The lack of juvenile PIT-tag detection in the Upper Columbia also affects survival estimation for hatchery groups. However, because the various Upper Columbia hatchery groups release smolts over a shorter period (when compared to wild groups), survival estimates from release to MCN are more reasonable. The Upper Columbia hatchery groups that the CSS has been working with include: 1) hatchery Chinook that are reared at Cle Elum Hatchery and released from three acclimation facilities on the Yakima River (Jack Creek, Easton Pond, and Clark Flat) and 2) hatchery steelhead that are reared throughout the Eastbank Hatchery Complex and released into the Chiwawa River and/or Nason Creek. Below, we have compiled juvenile survival estimates for these hatchery groups (Tables 9 and 10). These survival estimates are for the release to MCN reach.



**Table 9.** Survival estimates of Cle Elum Hatchery yearling spring Chinook released from Jack Creek, Easton Pond, and Clark Flat acclimation ponds in the Yakima river. These data were compiled from analyses done for the 2011 CSS Annual Report.

Migration Year	Release Dates *	Survival (Rel-MCN)	95% Confidence Limits	
			Lower	Upper
2000	3/15-6/2	0.358	0.337	0.381
2001	3/15-6/6	0.232	0.227	0.237
2002	3/15-5/24	0.298	0.289	0.306
2003	3/14-5/15	0.300	0.290	0.308
2004	3/15-4/30	0.199	0.189	0.211
2005	3/9-4/27	0.145	0.138	0.152
2006	3/15-5/15	0.254	0.243	0.265
2007	3/15-5/15	0.317	0.307	0.326
2008	3/15-5/14	0.296	0.281	0.312
2009	3/16-5/14	0.393	0.379	0.409
2010	3/15-5/14	0.312	0.297	0.330

\* Release dates shown are for entire volitional release. PIT-tag release date for these fish was entered as the start date for volitional releases.

**Table 10.** Survival estimates of Eastbank Hatchery Complex steelhead released into the Wenatchee River basin. These data were compiled from analyses done for the 2011 CSS Annual Report.

Migration Year	Release Site(s) *	PIT-Tag Release Date(s)	Survival (Rel-MCN)	95% Confidence Limits	
				Lower	Upper
2003	NASONC	4/15-5/1	0.403	0.384	0.427
2004	NASONC	4/19	0.307	0.280	0.342
2005	NASONC	5/4	0.423	0.400	0.449
2006	NASONC, CHIWAR	5/1-5/2	0.419	0.392	0.451
2007	NASONC, CHIWAR	5/1-5/7	0.438	0.389	0.498
2008	NASONC, CHIWAR	5/5-5/6	0.528	0.483	0.579
2009	NASONC, CHIWAR	5/4-5/8	0.489	0.442	0.545
2010	NASONC	5/3-5/4	0.501	0.433	0.599

\* Release site codes are as follows: NASONC = Nason Creek and CHIWAR = Chiwawa River.