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: Michael Gallinat, WDFW

FROM: Michele DeHart

DATE: 11/21/2017

SUBJECT: Tucannon River Spring Chinook

In response to your request, The Fish Passage Center (FPC) has evaluated the PIT tag data available for Tucannon River spring Chinook. We have provided summaries of available PIT tag records, detections, juvenile survival, and SARs for migration years 1999-2017. However, due to the limited extent of tagging groups and detections below McNary Dam, this analysis is not comprehensive and our findings should be considered preliminary. Our key observations are as follows:

- Due to the limited tagging/detection data available for Tucannon River spring Chinook, comprehensive answers to population level questions will be difficult to answer definitively. We recommend drafting a formal study design, complete with a full power analysis to determine the types of questions needing answers, expected effect sizes, and the subsequent tagging effort required to achieve these goals.
- Since 2005 sufficient numbers of PIT-tagged hatchery fish have been deployed at Tucannon Hatchery to estimate juvenile survival from release to Lower Monumental and Lower Monumental to McNary Dam, with the exceptions of migrations years 2006 and 2015, where only release to Lower Monumental Dam was estimable.
- From 2005-2017, Tucannon Hatchery spring Chinook survival from release to Lower Monumental Dam ranged from 25-69%, while survival from Lower Monumental Dam to McNary Dam ranged from 68-95%.
- From 2006-2017 wild Tucannon River spring Chinook survival from release to Lower Monumental Dam ranged from 24-86%, while survival from Lower Monumental Dam to McNary Dam ranged from 58-93%

- Detections were insufficient to estimate juvenile survival for any reach below McNary Dam for both wild and hatchery raised Spring Chinook originating in the Tucannon River.
- Insufficient data are available from the Tucannon River marking to quantitatively evaluate differential SARs between transported and in-river migrants.
- In all years since 2006, SARs (Rel-BOA) for Tucannon Hatchery spring Chinook (0.0-0.9%) were lower than those for wild Tucannon River spring Chinook (0.1-2.5%).
- SARs for Tucannon Hatchery spring Chinook (LMN-BOA) generally tracked the LGR-BOA SARs for hatchery spring Chinook stocks originating above LGR. This suggests that SARs for these two groups respond to similar experiences (i.e., in-river conditions below LMN, estuary, and ocean conditions).
- In all years, SARs (LMN-BOA) for Tucannon River Hatchery spring Chinook were lower than LGR-BOA SARs for hatchery spring Chinook stocks originating above Lower Granite Dam.
- Wild Tucannon River spring Chinook tend to out-migrate earlier than hatchery raised spring Chinook.
- Several of our findings suggest that the Tucannon Hatchery spring Chinook group are less robust than wild Tucannon spring Chinook.
    - In 8 of the 12 years where we have estimates for both, the Rel-LMN survival for Tucannon Hatchery spring Chinook was lower than that for the wild Tucannon River fish, even though the estimate for wild fish would include overwintering mortality that is not applicable to the hatchery group.
    - In all years, the Rel-BOA SARs for Tucannon Hatchery spring Chinook were lower than those for wild Tucannon River spring Chinook, even though the SAR for the wild fish would include overwintering mortality that is not applicable to the hatchery group.
    - In all years, the LMN-BOA SARs for Tucannon Hatchery Chinook were lower than the LGR-BOA SARs for up-river groups, even though the LMN-BOA reach is shorter than the LGR-BOA reach

Summarizing Available PIT-tag Data and Juvenile Timing

To investigate the availability of PIT-tags in the Tucannon River Basin for estimation of juvenile survival and/or SARs, FPC staff queried the PTAGIS database for all PIT-tagged spring Chinook juveniles released into the Tucannon River from migration years 1999 to 2017. For all the years where there were sufficient tagging numbers, we estimated juvenile timing at Lower Monumental Dam (LMN), based on the date of first detection at that site. Separate timing estimates were generated for wild and hatchery spring Chinook juveniles.

To assess travel time, we calculated the median number of days between detections at LMN and MCN for each Tucannon hatchery fish. This was then compared with travel times in the same reach for hatchery fish originating above Lower Granite Dam as well as wild Tucannon River spring Chinook.

Juvenile Survival

We estimated juvenile survivals and their associated variance estimates in the reach from Release to Lower Monumental Dam (Rel-LMN) for PIT-tagged spring Chinook originating in

the Tucannon River during migration years 2005-2017. Capture histories were created using the occasions: 1.) tagging in Tucannon River, 2.) detection at Lower Monumental Dam (LMN), 3.) detection at McNary Dam (MCN), and 4.) detection at either John Day Dam (JDA), Bonneville Dam (BON), or the estuary trawl. Using these capture histories, single mark recapture survival estimates were generated using Cormack-Jolly-Seber (CJS) methodology, as described by Burnham et al. (1987) with Program MARK (software available free from Colorado State University). (White and Burnham 1999). This methodology generated estimates of survival for two individual reaches: 1) Rel-LMN, and 2) LMN-MCN.

For context, we compared reach survival for LMN-MCN of Tucannon hatchery raised spring Chinook with those of hatchery spring Chinook originating above LGR for migration years 2005-2016.

Smolt-to-Adult Rates (SARs)

Release to Bonneville Dam (Rel-BOA)

We calculated SAR as the number of adults detected at Bonneville Dam (BOA) divided by the number of smolts marked and released in Tucannon River for a given migration year. Separate estimates were conducted for hatchery and wild Tucannon River spring Chinook. It is important to note that the SAR estimates for wild fish includes fish that were tagged and released in the fall and winter prior to out-migration. Therefore, these SAR estimates include any overwintering mortality prior to out-migration. The SARs for hatchery fish do not include this level of overwintering morality, as hatchery fish are volitionally released in the spring. Confidence intervals were estimated using the Clopper Pearson binomial confidence interval methodology (Clopper and Pearson 1934). SAR calculations included jacks for both wild and hatchery raised fish for migration years 2005-2015.

Lower Monumental to Bonneville Dam (LMN-BOA)

In addition, we estimated SARs from LMN to BOA for hatchery and wild Tucannon River spring Chinook. We do not provide confidence intervals for these LMN to BOA SARs. These SAR estimates were based on an estimated juvenile population at LMN and the number of adults detected at BOA. The estimated juvenile population at LMN was based on the release number and the juvenile survival from release to LMN. SAR calculations included jacks for both wild and hatchery raised fish for migration years 2005-2015.

Results:

Summarizing Available PIT-tag Data and Juvenile Timing

PIT-tag numbers for Tucannon River spring Chinook were sparse and intermittent since 1999, with sufficient tagging numbers for estimation of juvenile timing, reach survival (Rel-LMN, and LMN-MCN), and SARs beginning in 2005 for hatchery fish, and 2007 for wild fish. Summaries of juvenile spring Chinook PIT-tag numbers for these years are presented in Figure 1. Annual tagging numbers ranged from 1,986-24,976 for hatchery Chinook, and between 163-5,407 tags for wild Chinook.

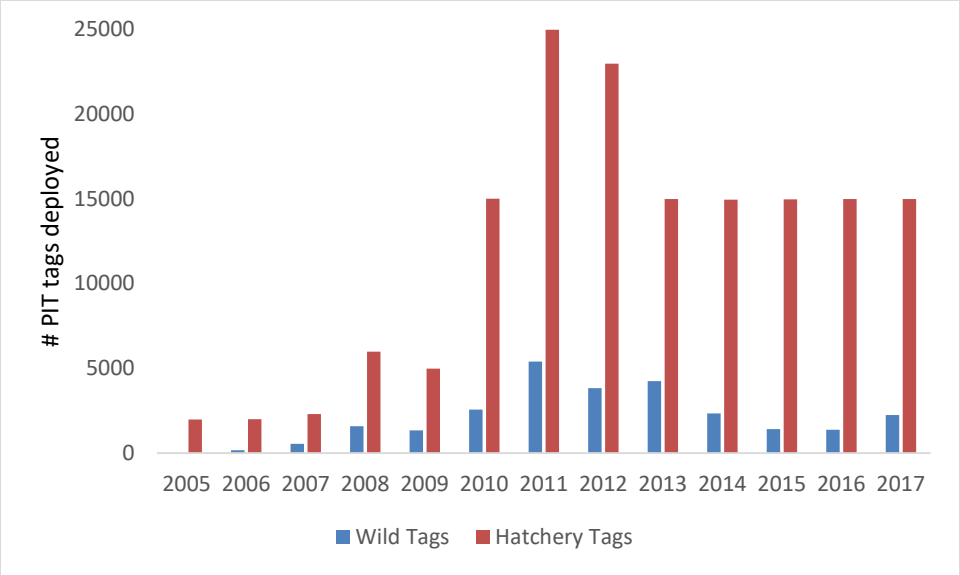

Figure 1: Number of PIT tags deployed in Tucannon River, migration years 2005-2017

Juvenile timing of wild and hatchery spring Chinook at LMN are summarized for years 2006-2017 in Table 1 and Figures 2 and 3. In general, wild spring Chinook reach Lower Monumental Dam slightly earlier than the hatchery releases. This could be partially attributable to a small proportion of wild spring Chinook beginning downstream migration significantly earlier than the bulk of the population (Nov-Dec vs Apr-May), but also because hatchery fish downstream movement is restricted by their date of release. The difference in emigration timing results in as much as 9% of the wild population passing Lower Monumental Dam prior to the beginning of spring spill. For comparison, 0% of the hatchery population are detected passing LMN prior to the start of spring spill. In addition, a higher proportion of wild fish generally pass LMN before transportation begins, when compared to those raised in Tucannon hatchery. Fish passing LMN prior to transport made up between 45-100% of the wild population, and between 1-94% of the hatchery population for migration years 2006-2017 (Table 2).

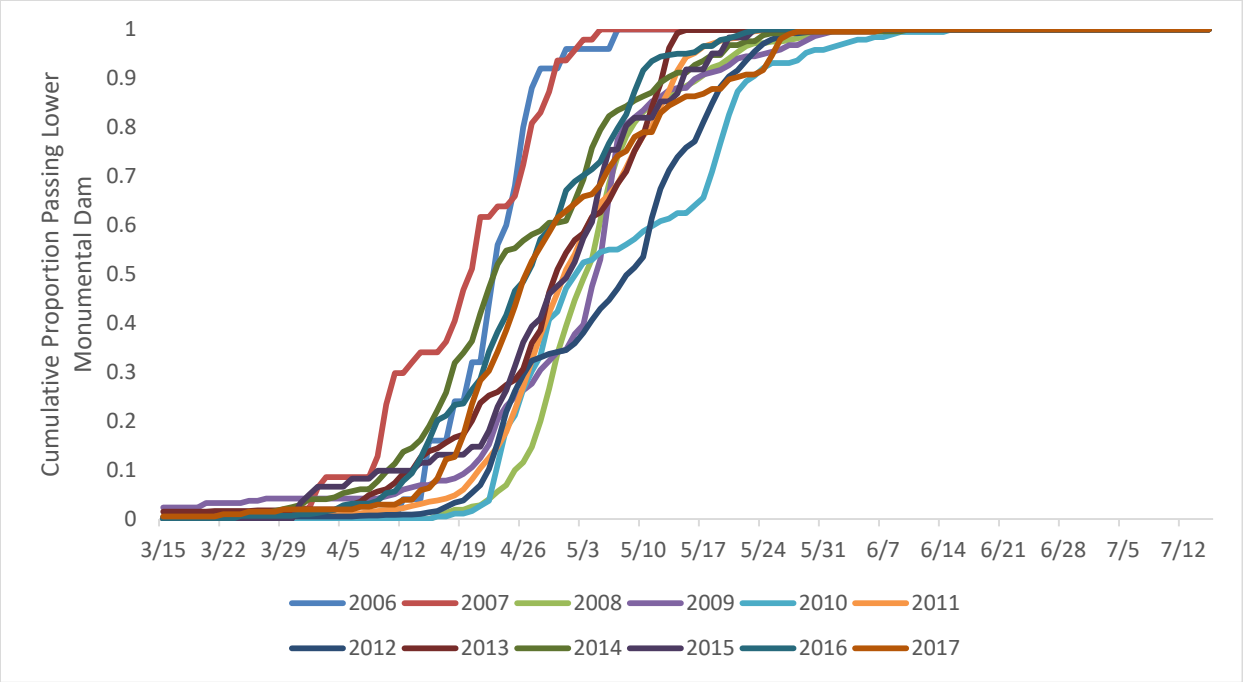

Figure 2: Cumulative proportion of PIT tagged wild Tucannon River spring Chinook detected at Lower Monumental Dam 2006-2017

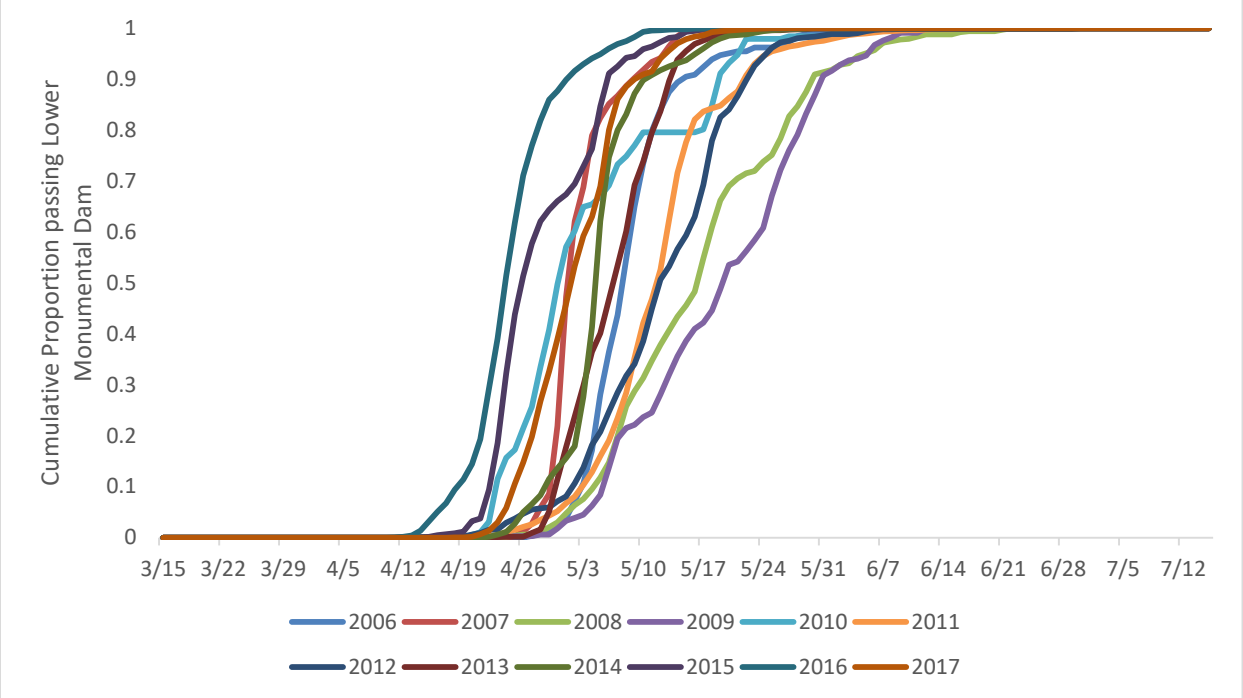

Figure 3: Cumulative proportion of PIT tagged hatchery raised Tucannon River spring Chinook detected at Lower Monumental Dam 2006-2017

Table 1: Date at which 10-50-90% of wild and hatchery raised Tucannon River spring Chinook were detected at Lower Monumental Dam

	Wild			Hatchery		
	10%	50%	90%	10%	50%	90%
2006	4/15	4/23	4/28	5/3	5/8	5/15
2007	4/9	4/20	4/30	4/30	5/2	5/9
2008	4/25	5/4	5/17	5/5	5/17	5/30
2009	4/20	5/5	5/17	5/6	5/20	5/31
2010	4/18	5/3	5/23	4/23	5/1	5/19
2011	4/21	5/1	5/14	5/3	5/12	5/22
2012	4/22	5/9	5/20	5/2	5/12	5/23
2013	4/14	4/30	5/13	4/30	5/7	5/14
2014	4/11	4/23	5/13	4/29	5/5	5/11
2015	4/14	5/2	5/15	4/23	4/26	5/6
2016	4/14	4/27	5/10	4/19	4/24	5/2
2017	4/17	4/27	5/21	4/25	5/2	5/9

Table 2. Estimated proportions of PIT-tagged hatchery and wild Tucannon spring Chinook passing Lower Monumental Dam prior to the start of voluntary spring spill (April 3rd) and the initiation of transportation at that project, 2005-2017

		Hatchery		Wild	
Migration Year	**Initiation of Transportation at LMN**	**Prop. Passing Prior to Spill**	**Prop. Passing Prior to Transportation**	**Prop. Passing Prior to Spill**	**Prop. Passing Prior to Transportation**
2005	04/03	0.0	0.0	-	-
2006	04/28	0.0	0.01	0.0	0.92
2007	05/12	0.0	0.94	0.09	1.0
2008	05/13	0.0	0.41	0.0	0.87
2009	05/09	0.0	0.22	0.04	0.82
2010	05/05	0.0	0.67	0.0	0.54
2011	05/09	0.0	0.35	0.01	0.75
2012	05/06	0.0	0.25	0.01	0.45
2013	05/08	0.0	0.18	0.02	0.71
2014	05/02	0.0	0.69	0.04	0.65
2015	05/02	0.0	0.92	0.07	0.52
2016	05/02	0.0	0.53	0.02	0.69
2017	05/02	0.0	0.35	0.02	0.64

Travel times between LMN-MCN varied between wild and hatchery spring Chinook originating in Tucannon River, but did not show consistent differences among the years for which data are available (Figure 4). Travel times in migration years 2007 and 2008 appeared anomalous for wild Tucannon River fish, but this may be explained by low sample size and lack of detections at McNary dam.

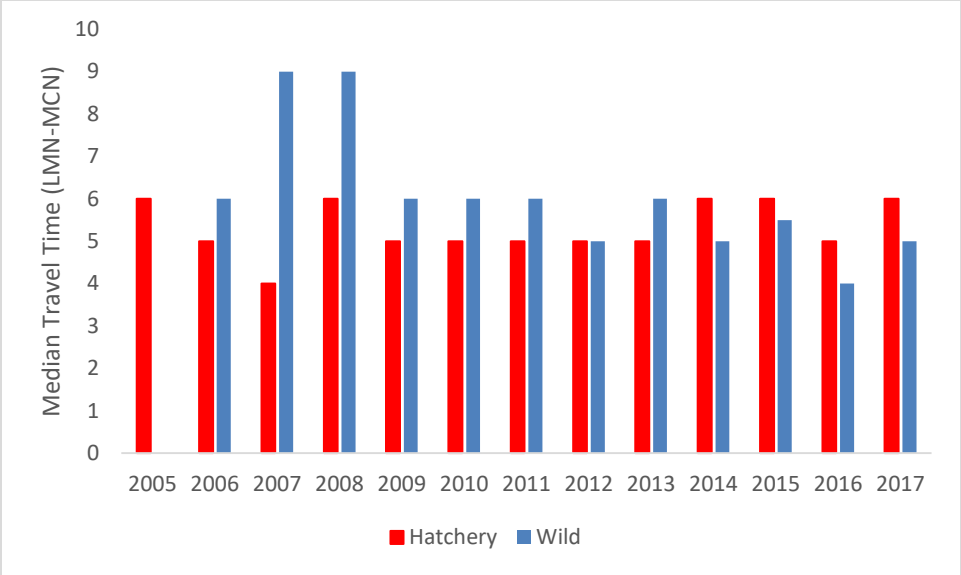

Figure 4: Median travel time (days) for wild and hatchery Tucannon River fish between Lower Monumental and McNary Dams

When comparing LMN-MCN travel times for Tucannon Hatchery spring Chinook to hatchery spring Chinook originating above LGR, the median travel time of Tucannon Hatchery fish were consistently longer (Figure 5). These differences varied by year, but on average, the Tucannon Hatchery fishes median travel time was 34% longer than Snake River Chinook from 2005-2017. This may be simply a function of their recent migration start date relative to the upstream stocks, of which, only efficient downstream migrators remain. Observations of historical smolt monitoring data indicate that early in the migration period juvenile migrants travel at a slower rate and migrate faster as their migration continues downstream.

Arrival at Lower Monumental Dam also varied by year and hatchery, but overall, between 2005 and 2017, there was no consistent difference in migration timing between Tucannon hatchery and Snake River (above LGR) hatcheries as it pertained to arrival at LMN (Figure 6).

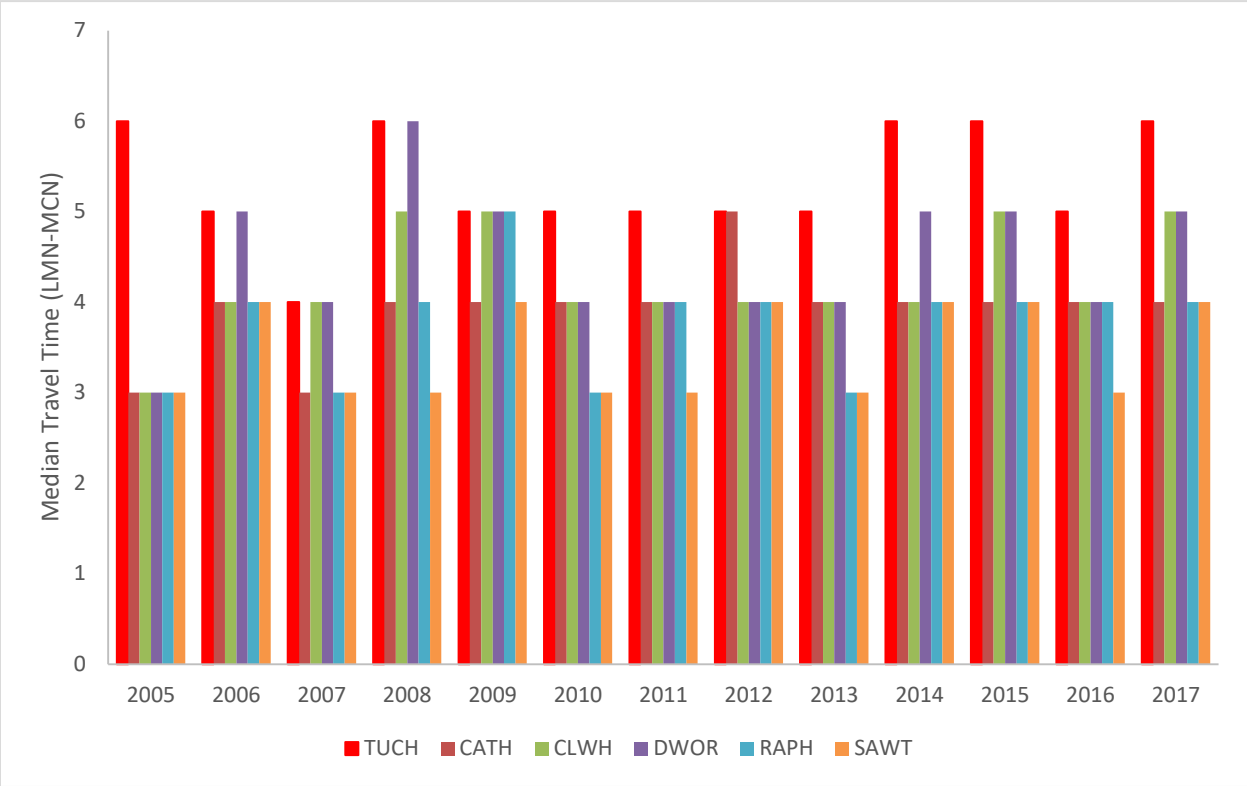

Figure 5: Median travel time (days) between Lower Monumental and McNary Dams for hatchery spring Chinook from Tucannon, Dworshak, Rapid River, Clearwater, Catherine Creek, and Sawtooth hatcheries.

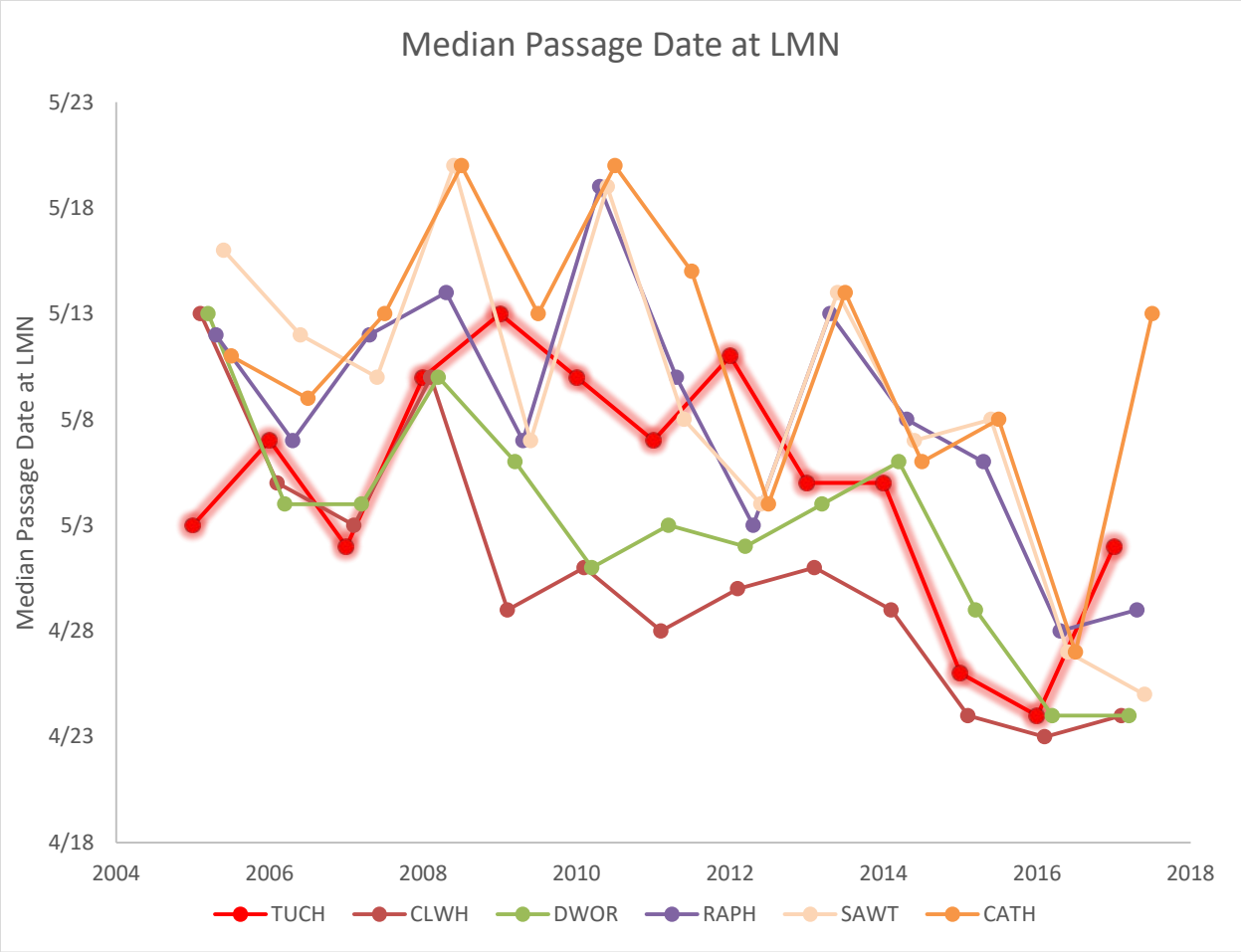

Figure 6: Median date of passage at Lower Monumental Dam for Tucannon, Clearwater, Dworshak, Rapid River, Sawtooth, and Catherine Creek hatchery spring Chinook

Juvenile Survival

Due to relatively low detection numbers we were only able to estimate juvenile reach survival for migration years 2005-2017 for hatchery Tucannon River spring Chinook and 2006-2017 for wild Tucannon River spring Chinook. Estimates of survival from release to Lower Monumental Dam (Rel-LMN), and Lower Monumental Dam to McNary Dam (LMN-MCN) for hatchery and wild spring Chinook from 2005-2017 are provided in Table 3. For the reach Rel-LMN, survival ranged from 0.25-0.69 for hatchery reared fish, while wild fish ranged from 0.24-0.86. Survival estimates from LMN-MCN ranged from 0.65-0.95 for hatchery fish, and 0.58-0.95 for wild tagged fish.

In addition, reach survival (LMN-MCN) for Tucannon River hatchery fish was not substantially different from hatchery spring Chinook originating above Lower Granite Dam (Figure 7).

Table 3 Estimated juvenile survival and 95% confidence intervals from release to Lower Monumental Dam (Rel-LMN) and Lower Monumental to McNary (LMN-MCN) for both Wild and Hatchery spring Chinook originating in Tucannon River.

	Rel-LMN		LMN-MCN	
Year	Hatchery	Wild	Hatchery	Wild
2005	0.48(0.41-0.55)		0.84(0.52-0.96)	
2006	0.45(0.39-0.50)	0.38(0.27-0.50)		
2007	0.69(0.61-0.76)	0.86(0.43-0.98)	0.93(0.60-0.99)	0.70(0.44-0.88)
2008	0.67(0.59-0.74)	0.84(0.70-0.92)	0.76(0.61-0.87)	0.71(0.56-0.83)
2009	0.57(0.47-0.66)	0.60(0.52-0.67)	0.68(0.51-0.82)	0.95(0.27-1.00)
2010	0.65(0.49-0.77)	0.69(0.58-0.79)	0.87(0.51-0.98)	0.81(0.61-0.92)
2011	0.62(0.59-0.65)	0.68(0.64-0.71)	0.65(0.59-0.71)	0.77(0.69-0.84)
2012	0.25(0.23-0.28)	0.77(0.72-0.82)	0.88(0.68-0.96)	0.93(0.65-0.99)
2013	0.56(0.52-0.61)	0.82(0.73-0.88)	0.79(0.68-0.87)	0.80(0.66-0.89)
2014	0.65(0.61-0.68)	0.39(0.32-0.45)	0.80(0.72-0.87)	0.58(0.43-0.72)
2015	0.58(0.50-0.66)	0.24(0.17-0.33)		
2016	0.68(0.66-0.71)	0.75(0.63-0.85)	0.95(0.82-0.99)	0.68(0.5-0.82)
2017	0.67(0.61-0.72)	0.34(0.28-0.41)	0.86(0.68-0.95)	0.88(0.31-0.99)

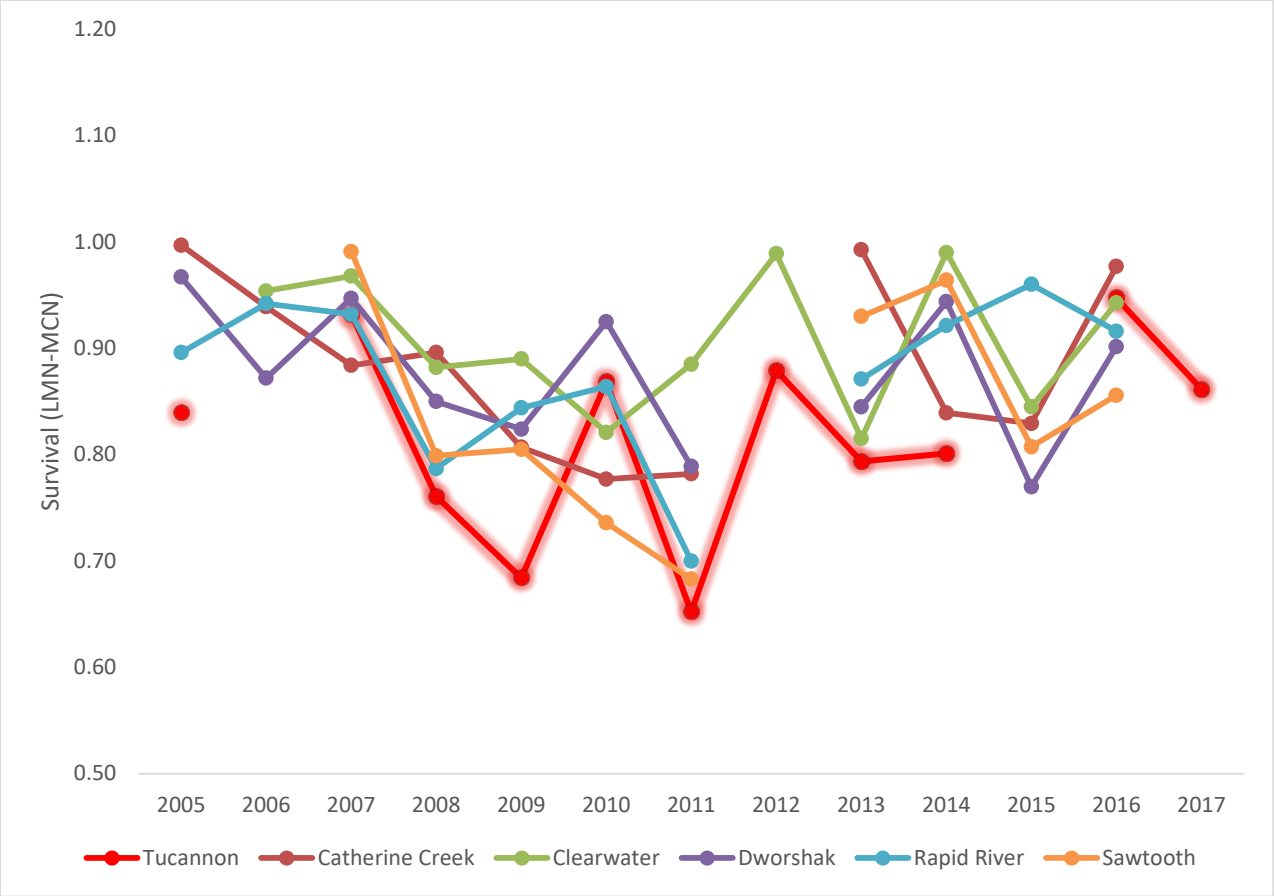

Figure 7: Estimated juvenile survival LMN-MCN for hatchery spring Chinook from Tucannon River hatchery, Dworshak hatchery, Catherine Creek hatchery, Rapid River hatchery, and Clearwater hatchery

Smolt-to-Adult Rates (SARs)

Release to Bonneville Dam (Rel-BOA)

Similar to juvenile survival estimates, our ability to estimate SARs (Rel-BOA) was limited to migration years where tagging numbers were sufficient. Furthermore, we provide estimates of SARs through migration year 2015. However, these should be considered preliminary, as they only include 2-salt detections at BOA through Oct. 27th, 2017. Rel-BOA SAR estimates varied by year and between hatchery and wild cohorts. SAR's for hatchery spring Chinook ranged from 0-0.9% between 2005 and 2015. SAR's for wild Chinook tagged in Tucannon River ranged from 0.1-2.5% between migration years 2006 and 2015 (Table 4).

Table 4: SARs (% Rel-BON) for wild and hatchery raised spring Chinook originating in Tucannon River for migration years 2005-2015. LL and UL represent the 90% confidence interval limits for these SAR estimates.

	Hatchery			Wild		
Year	SAR(%)	90% CI LL	90% CI UL	SAR(%)	90% CI LL	90% CI UL
2005	0.0	0.0	0.2	-	-	-
2006	0.05	0.0	0.2	0.90	0.0	4.2
2007	0.26	0.1	0.5	1.98	1.1	3.3
2008	0.85	0.7	1.1	2.52	1.9	3.3
2009	0.26	0.2	0.4	1.56	1.0	2.2
2010	0.52	0.4	0.6	0.51	0.3	0.8
2011	0.15	0.1	0.2	0.33	0.2	0.5
2012	0.11	0.1	0.2	0.44	0.3	0.7
2013	0.21	0.1	0.3	0.94	0.7	1.2
2014	0.23	0.2	0.3	0.09	0.0	0.3
2015	0.16	0.1	0.2	0.07	0.0	0.3

Lower Monumental to Bonneville Dam (LMN-BOA)

We were able to estimate LMN-BOA SARs for Tucannon Hatchery spring Chinook for migration years 2005-2015, and Tucannon River wild spring Chinook for years 2006-2017. Over these years, LMN-BOA SARs ranged from 0.0-1.3% for hatchery fish, and 0.22-3.0% for wild fish (Table 5). For comparison we plotted SARs for wild Tucannon River spring Chinook against the Lower Granite to Bonneville (LGR-BOA) SARs from Snake River wild spring Chinook MPGs that originated above Lower Granite Dam (Figure 4). In general, SARs for these populations varied by year and group, but the SAR estimates for Tucannon river wild spring Chinook did not differ significantly from the above Lower Granite MPGs. We also plotted Tucannon Hatchery spring Chinook SARs (LMN-BOA) against the Lower Granite to Bonneville (LGR-BOA) SARs from Snake River hatchery spring Chinook groups that originated above Lower Granite Dam (Figure 5) (McCann et al., 2017). In this comparison Tucannon Hatchery spring Chinook SARs (LMN-BOA) were consistently lower than the LGR-BOA SARs for the in river migrating hatchery groups originating from above LGR. And, while the LMN-BOA SARs for Tucannon Hatchery spring Chinook were lower, they generally tracked the LGR-BOA SARs from the upriver groups. This suggests that the SARs of the two groups (Tucannon River and Upriver groups) are affected by some shared experiences. For example, both groups experience largely the same in-river conditions after LMN and similar ocean conditions.

Table 5: SAR's (%) (LMN-BON) for wild and hatchery raised Tucannon River spring Chinook

	Hatchery	***Wild***
2005	0.00	-
2006	0.11	2.38
2007	0.38	2.29
2008	1.27	3.00
2009	0.46	2.61
2010	0.80	0.73
2011	0.24	0.49
2012	0.45	0.57
2013	0.37	1.16
2014	0.35	0.22
2015	0.28	0.29

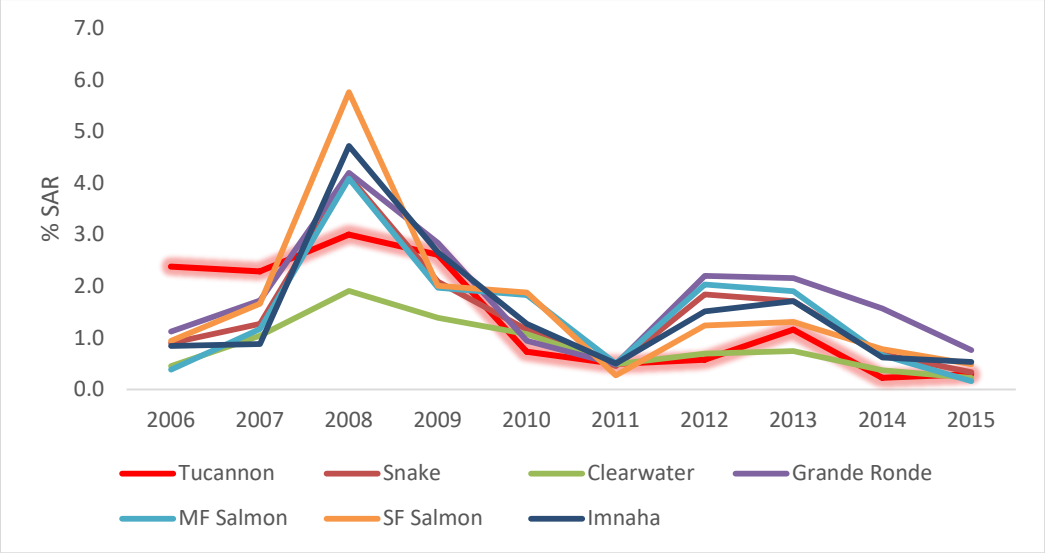

Figure 8: Estimated LMN-BOA SARs for Tucannon wild spring Chinook and LGR-BOA SARs for Snake River, Clearwater River, Grande Ronde River, Middle Fork Salmon River, South Fork Salmon River, and Imnaha River wild spring Chinook

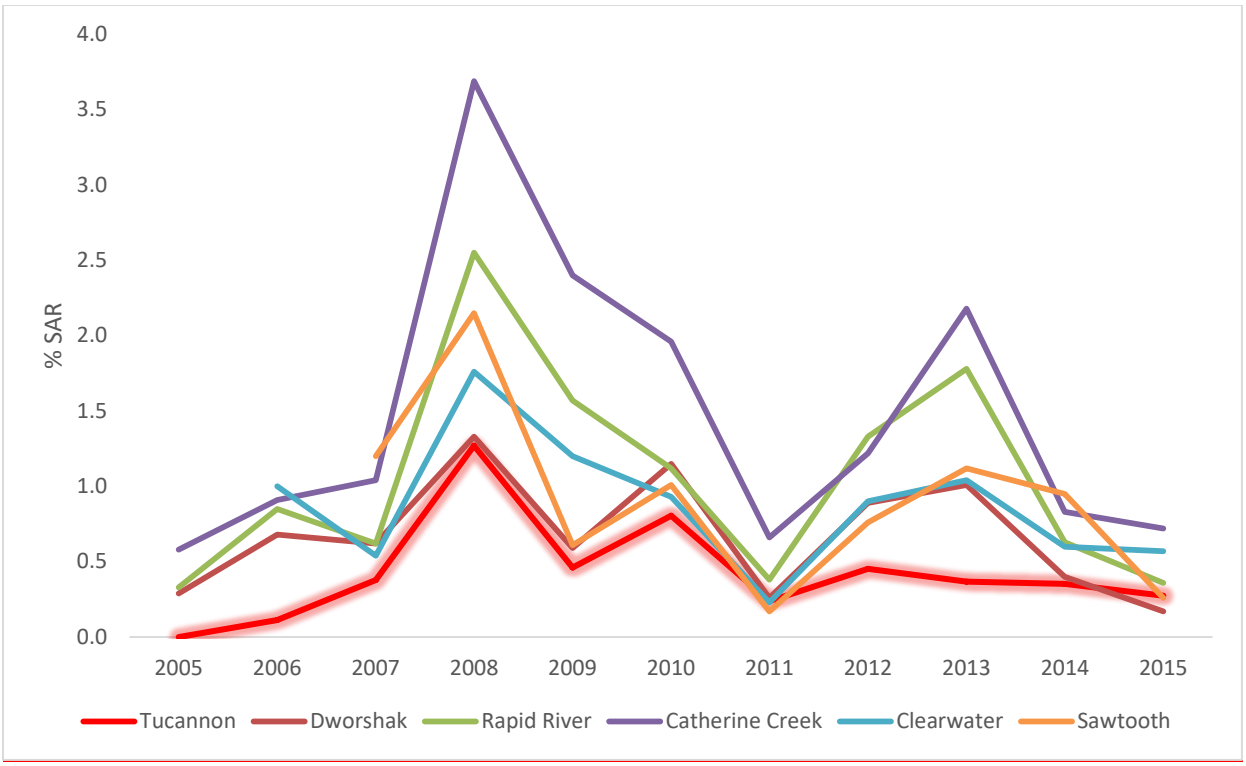

Figure 9: Estimated LMN-BOA SARs for Tucannon Hatchery spring Chinook and LGR-BOA SARs for Dworshak, Rapid River, and Catherine Creek Hatchery spring Chinook

Discussion:

There were sufficient data to analyze juvenile survival from release into the Tucannon River to Lower Monumental Dam for migration years 2005-2017 for hatchery raised fish and 2006-2017 for wild fish. Most years between 2005 and 2017 also had sufficient tagging numbers data to estimate juvenile survival between LMN and MCN. However, tagging numbers and down-stream detections were insufficient to provide consistent estimates for the reaches below McNary in the years of available data.

Evaluating the effect of transport on SARs of Tucannon River origin fish is not possible with the available data. The default action for PIT-tagged fish that are detected at transportation facilities is for them to be returned to the river. To evaluate the effect of transportation on SARs, some portion of the PIT-tagged population needs to be transported. The only way to assure that a portion of the PIT-tagged population makes it into a barge is to pre-assign some portion of the PIT-tags for Monitor Mode (i.e., transport if detected at transportation site when transportation is occurring). Prior to migration year 2015, we are unaware of any such pre-assignments for wild or hatchery Tucannon River spring Chinook. In migration year 2015, the Comparative Survival Study (CSS) began pre-assigning wild Tucannon River spring Chinook for a pilot study. The default pre-assignment for these fish is for 70% to be randomly pre-assigned for Monitor Mode. These pre-assignments were done in 2016 and 2017 as well. Even with the pre-assignments in the last three years, the number of PIT-tagged fish that have ended up being transported from LMN is generally low. For example, in 2015, 2016, and 2017, 15, 59 and 42 PIT-tagged wild spring Chinook have been transported from LMN, respectively. With these low numbers of transported PIT-tagged fish, it is unlikely that we will be able to evaluate differentials in SARs between transport and in-river cohorts. We recommend drafting a formal study design, complete with full power analysis to determine the types of questions needing answers, expected effect sizes, and the subsequent tagging effort required to achieve these goals.

Finally, we found some evidence that the Tucannon Hatchery spring Chinook do not perform as well as Tucannon wild spring Chinook. First, in eight of the twelve years (67%) where we have estimates of Rel-LMN survival for both Tucannon Hatchery spring Chinook and wild Tucannon River spring Chinook, the point estimate for the wild fish was higher than that for the hatchery group. This is counter to what one would expect, given that the survival estimate for the wild fish includes overwintering mortality while that for the hatchery fish does not. There is also a marked difference in migration timing between hatchery and wild fish originating in Tucannon River, as measured by the arrival timing at Lower Monumental Dam. Wild Tucannon River spring Chinook, on average, arrive earlier, and survive at a higher rate between Tucannon River and Lower Monumental Dam, even when including overwinter mortality. Additionally, in all years of available data, SAR (LMN-BOA) estimates are consistently lower for Tucannon Hatchery spring Chinook than hatchery fish originating above Lower Granite Dam. This pattern was not apparent for the wild Tucannon River spring Chinook when compared to MPGs originating upstream of Lower Granite Dam.

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