FISH PASSAGE CENTER

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MEMORANDUM

TO: Steve Richards, WDFW

FROM: Michele DeHart

DATE: August 23, 2016

RE: Estimates of juvenile survival for subyearling fall Chinook from Ringold Springs Hatchery, 2016

In 2016, Ringold Springs Hatchery released approximately 3,057 PIT-tagged subyearling fall Chinook juveniles from two different rearing ponds, a 5-acre pond and a 9-acre pond. Of these, 913 were released from the 5-acre pond, beginning on June 23rd and 2,144 were released from the 9-acre pond, beginning on June 29th. Releases from both ponds were volitional. The hatchery outfall at Ringold Springs Hatchery is equipped with a PIT-tag detection system (RRH), allowing for PIT-detections of fish as they are entering the mainstem Columbia River. Detections at RRH allows for more accurate estimates of fish travel times, as it is an indicator of when each detected fish exits the hatchery facility and begins its out-migration through the Columbia River. In addition, detections at RRH can be used to obtain estimates of pond survival (i.e., survival from the time tagged fish are placed into the pond to when fish begin to out-migrate), as well as survival from the hatchery outfall (RRH) to McNary Dam.

You requested the Fish Passage Center staff to estimate survival of these PIT-tagged Ringold Springs Hatchery subyearling Chinook. Concern was expressed as to whether the 3,000 PIT-tag release total was adequate to accurately estimate survival of these fish to McNary Dam, as well as whether separate survivals could be estimated for each of the two release groups (5-acre versus 9-acre). In response to your request, the Fish Passage Center has estimated survival of subyearling fall Chinook juveniles released from Ringold Springs Hatchery in June 2016. Along with estimating survivals, we are also providing estimates of passage timing at McNary Dam (MCN) and fish travel times to

MCN for each of the two releases (5-acre pond vs. 9-acre pond) along with estimates for the combined releases.

Travel Time and Passage Timing:

We estimated minimum, median, and maximum fish travel times from detection at RRH to McNary Dam for each of the two release groups, as well as for the combined release (Table 1). Also provided are estimates of the 95% confidence limits around the estimated median travel time. In addition, we estimated the 10%, 50%, and 90% passage dates of Ringold Springs Hatchery subyearling fall Chinook juveniles at McNary Dam for each of two releases, as well as for the combined release (Table 2). Figure 1 is provided as an illustration of the arrival timing (at MCN) for each of the two release groups, along with the arrival timing of the combined release in 2016.

Table 1. Ringold Springs Hatchery subyearling Fall Chinook Travel Times from detection at RRH to McNary Dam, 2016.

Release Group	Travel Time (Days)			95% Confidence Limits	
	Min	Med	Max	Lower	Upper
5-Acre	2.1	4.7	11.3	4.1	5.5
9-Acre	1.4	3.6	15.2	3.3	4.4
Combined	1.4	4.2	15.2	3.7	4.6

Table 2. Estimated 10%, 50%, and 90% passage dates of Ringold Springs Hatchery subyearling fall Chinook at McNary Dam, 2016.

Release Group	10% Passage Date	50% Passage Date	90% Passage Date
5-Acre	28-June	1-July	2-July
9-Acre	3-July	4-July	10-July
Combined	29-June	3-July	7-July

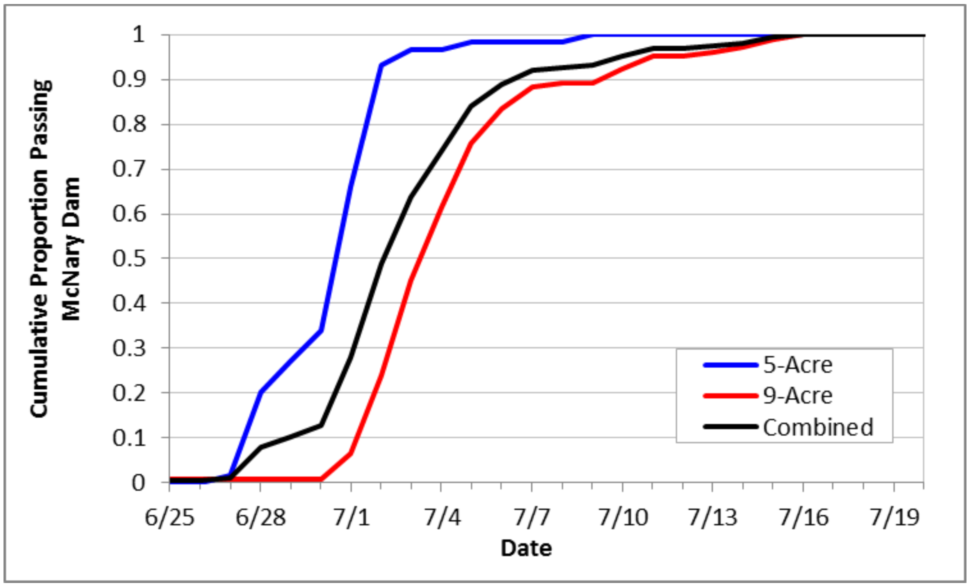

Figure 1. Cumulative passage timing of Ringold Springs Hatchery subyearling fall Chinook to McNary Dam, 2016.

Juvenile Survival

We also estimated juvenile survival for each of the two release groups (5-acre vs. 9-acre), along with survival for the combined release. To estimate juvenile survival, we developed a 5-digit capture history for each PIT-tagged fish. This 5-digit capture history included the following: 1) release, 2) detection at the hatchery outfall (RRH), 3) detection at McNary Dam, 4) detection at John Day Dam, and 5) detection at Bonneville Dam. Using these capture histories, single mark-release mark-recapture survival estimates were generated using the 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).

By including detections at RRH, we were able to obtain estimates of pond survival (i.e., survival from the time tagged fish are placed into the pond to the time fish actively begin to out-migrate). Furthermore, we were able to estimate survival from the hatchery outfall (RRH) to McNary Dam. These two survivals (Pond-to-Outfall and Outfall-to-MCN) were then combined to estimate survival from release into the pond to MCN (herein referred to as Pond-to-MCN survival). Variance estimates for the product of the two survivals were generated using the delta method (Burnham et al. 1987). Using this methodology, estimates of individual reach survivals (e.g., Pond-to-Outfall or Outfall-to-MCN) can exceed 100%. However, individual reach estimates are often negatively correlated with adjacent reaches. Therefore, when estimating overall reach survivals (e.g., Pond-to-MCN), we allow individual reach survival estimates to exceed 100%. An overall reach survival (e.g., Pond-to-MCN) estimate was considered unreliable when its point estimate exceeded 100% or its coefficient of variation exceeded 25%.

For the 5-acre release group, we were able to reliably estimate Pond-to-MCN survival, which was 0.43 (95% CI: 0.17-0.70) (Table 3). However, the estimate of Pond-to-MCN survival for the 9-acre release group was unreliable. In fact, both the Outfall-to-MCN and Pond-to-MCN were above 1.0 for this group. When both release groups were combined, we were able to reliably estimate Pond-to-MCN survival, which was 0.62 (95% CI: 0.28-0.97) (Table 3). While the survival estimates for the 5-acre release and the combined release were deemed reliable, confidence intervals for these survival estimates are very wide, which leads to the question of how useful these estimates are to management decisions. Finally, detection probabilities at MCN were fairly low for all three groups (5-acre, 9-acre, and Combined). The 9-acre release group had a detection probability of (0.047) while the 5-acre release group had a detection probability of (0.148) (Table 3). The detection probability for the two groups combined was 0.086.

Table 3. Estimated Pond-to-Outfall, Outfall-to-MCN, and Pond-to-MCN survivals for Ringold Springs Hatchery subyearling fall Chinook juveniles released in migration year 2016.

Release Group	Tags Released	Pond-to-Outfall (95% CI)	Outfall-to-MCN (95% CI)	Pond-to-MCN (95% CI)	MCN Detection Probability
5-Acre	913	0.91 (0.90-0.93)	0.48 (0.19-0.76)	0.43 (0.17-0.70)	0.148
9-Acre	2,144	0.89 (0.86-0.93)	1.17 (0.07-2.26)[A]	1.04 (0.06-2.02)[A]	0.047
Combined	3,057	0.90 (0.88-0.92)	0.69 (0.33-1.06)	0.62 (0.28-0.97)	0.086

[A] Based on criteria outlined above, these survival estimates were deemed unreliable but are still being reported for illustrative purposes.

Discussion

Several factors can affect detection probabilities at the bypass systems, including: 1) spill operations (both proportion spill and Temporary Spillway Weir (TSW) operations), 2) river flows, and 3) fish migration behavior. The higher the probability of fish passing in spill the lower the detection probability will be at the juvenile bypass PIT-tag detection systems. The 2016 Fish Operations Plan (FOP) calls for summer spill (June 16-August 31) of 50% of the total river flow at MCN. This 50% spill operation results in the majority of fish passing MCN via the spillway and, thus, avoiding detection in the juvenile bypass PIT-tag detection system.

River flows and detectability are also significantly linked. River flows are linked to passage timing and migration speed as well as determining the exposure to spill. In some years the percentage of spill can even be higher than planned levels, based on the fact that the powerhouse turbine capacity at MCN is relatively small compared to the total river flow and high levels of uncontrolled spill that can take place. This can be a significant contributing factor to the detection probability at the juvenile bypass PIT-tag detection system.

Fish migration behavior could be an important factor affecting the detection probability of juvenile migrants. While there isn’t an abundance of information available on the cross-sectional distribution of subyearling fall Chinook migrants in the MCN pool, Daube et al. (1989) found that subyearling fall Chinook from the Hanford Reach prefer shallower shoreline areas. As these subyearling Chinook out-migrate from the Hanford Reach into the Mid-Columbia, past the confluence with the Snake River, it is possible that this preference for shoreline areas may make them more likely to move along the Washington shore. Since the spillway at MCN is on the Washington side, it is possible that fish swimming along the Washington shore could be more likely to pass in spill and, therefore, not be detected by the juvenile bypass PIT-tag detection system.

Confounding our understanding of the impact of these factors on PIT-tag detections is the fact that we were able to get a reliable survival estimate from a release group of just over 900 PIT-tagged fish (5-acre release), while a tag group more than twice that size yielded an unreliable survival estimate (9-acre release). Given the differences in detection probabilities between the two release groups, we investigated what, of the above mentioned factors, may have also differed between the two groups in 2016.

According to the 2016 FOP, the TSWs at MCN were to be removed on June 8th, which means that the TSWs were not in operation during the periods when Ringold Springs subyearling Chinook passed MCN. Therefore, TSW operations could not have affected detection probabilities between the two release groups and can be eliminated as a factor. Additionally, both release groups experienced an average MCN spill proportion of approximately 0.501 (Figure 2), which means that while spill proportion plays a significant role in the overall detection probability, it likely had little impact on the differences in detection probabilities between the two release groups.

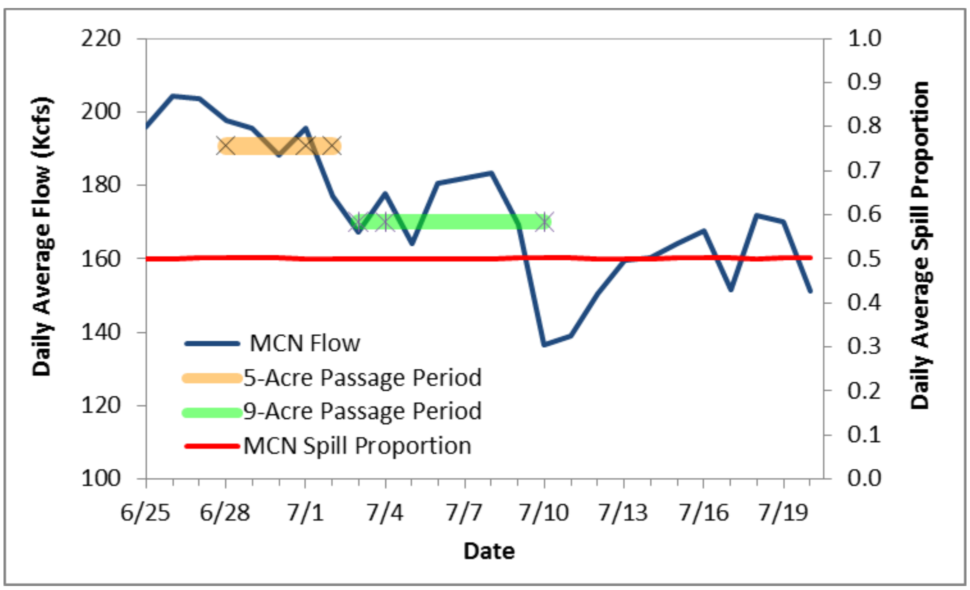

Figure 2. Daily average flow volume (Kcfs) and spill proportion at McNary Dam during Ringold Springs subyearling fall Chinook passage. Colored horizontal bars represent the average flows experiences by the 5-acre and 9-acre release groups during their respective passage periods (i.e., period between 10% and 90% passage dates). Symbols within these bars represent estimated 10%, 50%, and 90% passage dates.

The two release groups did experience different flows during their respective MCN passage periods (i.e., the time between the 10% and 90% passage dates), despite the fact that these passage periods were only separated by a few days. The 5-acre release group experienced an average flow at MCN of approximately 191 Kcfs while the 9-acre release group experienced an average flow of 170 Kcfs (Figure 2).

In addition to changes in flows, there was also a change in turbine operations at MCN between the passage periods for the 5-acre and 9-acre releases. During periods of warm temperatures at MCN, the Fish Passage Plan (FPP) calls for a modification in turbine unit priorities in order to minimize thermal stress on juvenile salmonids. Under normal conditions, Unit 1 has first priority followed by Units 14-2 (in descending order). Unit 1 is located closest to the Oregon shore and Unit 14 is located closest to the spillway (near the middle the project) (Figure 3). During this warm water operation, units 2, 4, 6, 8, 10, 12, 14, 3, 5, 7, 9, 11, and 13 are stopped (in successive order). Which and how many units are stopped are dependent on total flows at the time this operation is implemented. For example, at total flows of 170 Kcfs (as was experienced by the 9-acre group), total powerhouse flow would be approximately 80 Kcfs (assuming 50% spill and 5 Kcfs miscellaneous flow). Assuming each turbine unit has a capacity of ~16.5 Kcfs, only about 5 units would be in operation. Under the normal operation, these five units would be Units 1, 14, 13, 12, and 11. However, under the high temperature operation, Units 12 and 14 would be stopped while Units 7 and 9 would be turned on. This effectively means that a portion of powerhouse flows would be shifted to the northernmost portion of the powerhouse (Units 12 and 14) to a more central location (Units 7 and 9) (see Figure 3 for reference).

Shifting turbine unit operations from the northernmost region of the powerhouse to a more central region of the powerhouse would only add to the lower probability of powerhouse passage for Upper Columbia subyearling Chinook, thus reducing detection probabilities further. Coincidently, in 2016, MCN switched to the high temperature turbine operations on July 2nd, about the same time that the 9-acre release first arrived at MCN but after most of the 5-acre release had already passed.

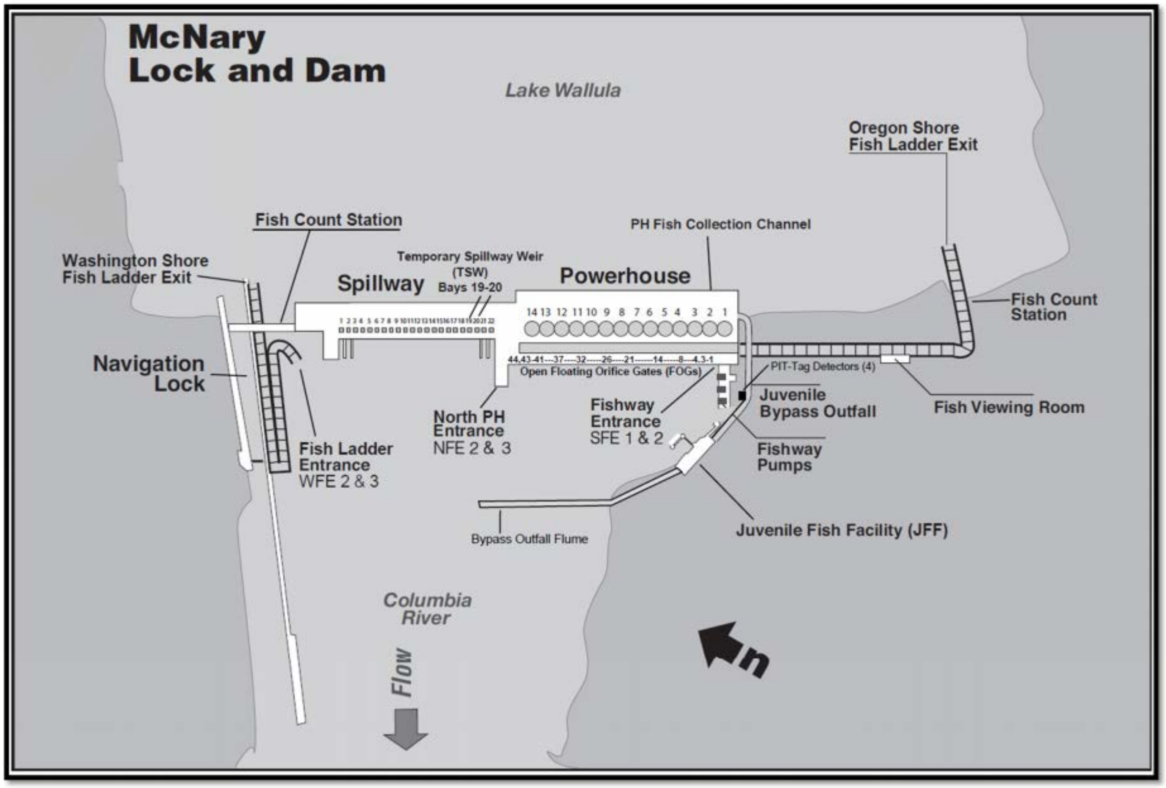

Figure 3. Map of McNary Dam Lock and Dam with locations of turbine units and spill bays. Extracted from 2016 Fish Passage Plan.

There is also the possibility that temperature differentials between water from the Snake River and Columbia River, at their confluence, may have added to the possibility of more fish from 9-acre release group passing via spill. In a study on behavioral thermoregulation of subyearling Chinook, Tiffan et al. (2009) found that subyearling Chinook from the Snake River appeared to select a depth and temperature combination that increased their exposure to optimal temperatures in the 16-20°C range. While this study did not specifically address horizontal movement to avoid suboptimal temperatures and was limited to Snake River subyearling Chinook above the Lower Granite Dam Pool, results from Tiffan et al. (2009) suggest the possibility that subyearling Chinook may avoid warmer temperatures by remaining in the cooler Columbia River water after its confluence with the Snake River. This behavior, if it is occurring, may contribute to the reduced detection probabilities that have been observed for subyearling Chinook migrants from the Hanford Reach and Upper Columbia River, as the cooler Columbia River water would be more likely to flow along the Washington shore and, therefore, make up a larger proportion of spill at MCN.

During the passage period for the 5-acre release group, temperatures in the Columbia River (as measured at the USGS gauge in Pasco, WA, 4.8 miles above the confluence with the Snake River) averaged 18.4°C while Snake River temperatures (as measured at the Ice Harbor Dam tailrace) averaged 18.7°C. For the 9-acre release group, average Columbia River temperatures were 18.6°C while Snake River temperatures were

19.4°C. While all of these temperatures were within the optimal range suggested by Tiffan et al. (2009) (16-20°C), the differential between the Columbia River and Snake River temperatures were larger for the 9-acre release group than the 5-acre release group. With this larger temperature differential, it is possible that fish from the 9-acre release group were more likely to stay in the cooler Columbia River water and, therefore, more likely to pass in spill, thus reducing their probability of detection at the juvenile bypass PIT-tag detection system at MCN.

Conclusions

This is not the first time we have observed low detection probabilities at MCN, particularly for Upper and Mid-Columbia fish that out-migrate during the summer period when flows are particularly low. Low detection probabilities and high standard errors in migration year 2015 resulted in unreliable estimates of survival (Release-to-MCN) for subyearling fall Chinook from Priest Rapids Hatchery and subyearling summer Chinook from Wells Hatchery (FPC 2016). It is possible that the high temperature turbine operations at MCN and/or temperature differentials between the Columbia and Snake Rivers at their confluence could have had an impact on these 2015 estimates as well.

It is difficult to determine whether the number of PIT-tags released in 2016 for each release group would be sufficient to obtain reliable survival estimates in future years, as this depends largely on detection probabilities at and below MCN. Based on the results from the 5-acre release group (~900 tags), it appears that reliable estimates of survival to MCN are possible when detection probabilities at MCN were approximately 0.15. However, as was observed with the 9-acre release group, approximately 2,000 tags were not enough to estimate survival to MCN when detection probabilities at MCN dropped to approximately 0.05. It appears that a combination of low flows, fish behavior, and changes in turbine operations may have all contributed to the precipitous drop in detection probabilities for the 9-acre release group.

One point worth repeating is the relatively wide confidence intervals for the Outfall-to-MCN and Pond-to-MCN survivals that we were able to estimate (5-Acre and Combined) (Table 3). Two ways to reduce the bounds of these confidence intervals (i.e., increase precision) would be to increase the number of tags that were released and/or increase detection probabilities at downstream projects. Since detection probabilities are outside our control, tag numbers may be the only factor that could be manipulated to increase the precision of these survival estimates. Consequently, in order to assure the development of reliable survival estimates with smaller confidence bounds, we recommend exploring the ability to increase PIT-tag numbers for future years.

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