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TO: **Jay Hesse, NPT**

FROM: **Jerry McCann**

DATE: **October 16, 2014**

RE: **Power Analysis for fall Chinook marking in Snake River**

In response to your request the Comparative Survival Study (CSS) conducted a power analysis of the mark group sizes proposed for fall Chinook PIT-tagging above Lower Granite Dam. Based on this analysis, the proposed release of 40,400 subyearling fall Chinook in the Snake River above Lower Granite Dam should result in a power of 0.83 to detect a 50% difference in Smolt-to-Adult Return Rates (SARs) of transported and in-river study groups. The details of the power analysis are provided below.

The CSS has previously conducted power analyses of sample sizes needed to detect differences in SARs for spring/summer Chinook and steelhead in the CSS 2008 Annual Report (Berggren et al. 2008) based on the methods described in Snedecor and Cochran (1989). Through those analyses, the CSS determined 8,455 juvenile fish at Lower Granite Dam in each study category were necessary in order to have a 0.9 probability of detecting a significant difference in transport (T_x) and in-river (C_0) SARs, given a lower SAR of 1.0% and assuming a 50% difference in SARs (i.e., the higher SAR was 1.5%). The test was a one-tailed and compared the lower SAR to the higher SAR at an alpha level of 0.05.

To determine the sample sizes needed for fall Chinook, we first summarized SAR estimates for subyearling fall Chinook mark groups reported in recent CSS Annual Reports (Tuomikoski et al. 2012). SAR data for fall Chinook from the years 2006 to 2011 were used for determining a range of juvenile survivals and proportions of fish that were available in each study category as well as the range of SARs by study category. Fall Chinook SARs were lower than the 1% minimum used to establish goals for spring/summer Chinook and steelhead in the CSS. Estimated SARs for subyearling fall Chinook averaged about 0.5%. To reflect the lower SARs observed in fall Chinook, the CSS set the lower SAR level for the power analysis at 0.5% while still maintaining a difference of 50% (i.e., the higher SAR was 0.75%). Given the lower SAR for fall Chinook, we determined that 17,088 smolts at Lower Granite Dam in each study category were necessary to achieve a power of 0.9 (Figure 1).

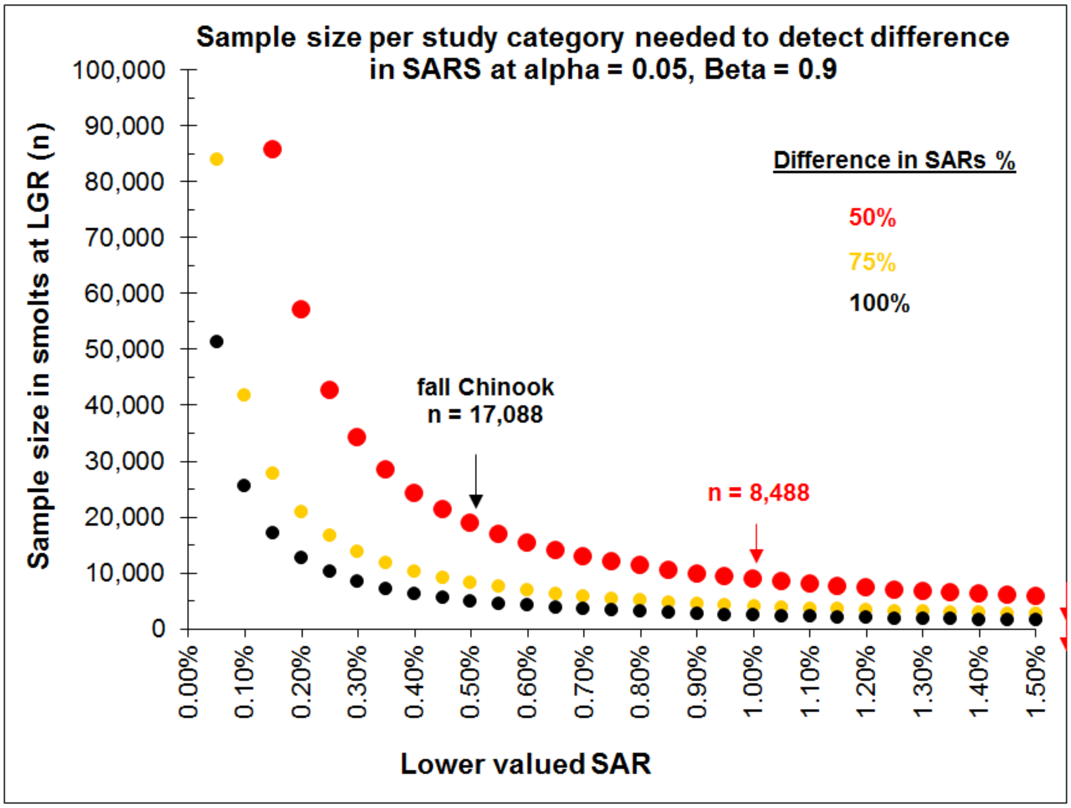

Figure 1. Sample size required per study category at Lower Granite Dam to achieve power of 0.9 at alpha of 0.05 for various differences in SARs. For spring/summer Chinook and steelhead the target SAR was 1% with a difference of 50%, while for subyearling fall Chinook a lower target SAR of 0.5% was used.

Our analyses show that three main factors influence the power of the test.

- The Lower Granite Dam population of PIT-tagged smolts in each study category needs to be sufficiently large.
- The relative difference between transport and in-river SARs needs to have large contrast. In this case we assumed a difference of 50% (i.e., the higher valued SAR = 0.75) similar to Berggren et al. 2008.
- Finally the magnitude of the SARs being compared has to be large.

The only portion of this that can be controlled *a priori* is the sample size.

An additional factor that can influence the number of fish in each study category is pre-assignment proportions for transport versus return-to-river. These pre-assignment proportions give directives on the routing of fish that are collected. Under previous fall Chinook transportation studies, 45% were pre-assigned to transport and 55% were pre-assigned to return-to-river, resulting in 56% of the release in the transport and in-river groups at Lower Granite Dam. We simulated changing the proportion transported and found that using the CSS pre-assignment proportions of 70% transport and 30% return to river, or 70/30, would result in about 66% of the release in the transport and in-river groups. Table 1 shows simulation results for subyearling fall Chinook released at Captain John Rapids in 2010. Simulations across multiple years found similar increases over a range of detection probabilities. Changing the percent pre-assigned to the transport category effectively reduce the release numbers required to achieve a given sample size per category by providing more fish the chance to be transported and thus included in the T_x group. The in-river (C_0) category did not change regardless of the pre-assignment proportion, since undetected fish from either transport or in-river pre-assigned groups that are undetected at the transport dams become part of the C_0 sample.

Table 1. Simulated effect of increasing the percentage of PIT-tag release of fall Chinook pre-assigned to the transport category on the resulting LGR populations of T_x and C_0 and subsequent power analysis. The simulation was based on the conditions (survival, detection probabilities at transport dams) experienced by the 2010 release of subyearling fall Chinook released at Captain John Rapids and assumed a 0.5 SAR for the T_x group and a 0.75 SAR for the C_0 group. The original PIT-tag release was 37,822.

Simulated Release Num.	Pre-assignment pcts. (T/R)	Resulting LGR Pop. T_x group	Resulting LGR Pop. C_0 group	Power (Beta)	Comment
50,000	(45/55)	9,973	18,129	0.82	Pre-assignments in original release
50,000	(50/50)	11,081	18,129	0.84	
50,000	(55/45)	12,189	18,129	0.86	
50,000	(60/40)	13,297	18,129	0.87	
50,000	(65/35)	14,405	18,129	0.89	
50,000	(70/30)	15,513	18,129	0.90	CSS proposed pct. transport/in-river
50,000	(75/25)	16,621	18,129	0.91	

Based on our analysis, the sample size of 40,400 fish currently budgeted for 2015 marking, should provide a power of 0.83 to detect a difference in SAR of 50% given a minimum SAR of 0.5%. A release of 40,400 fish with a 70/30 transport/in-river pre-assignment proportion is expected to result in approximately 13,300 smolts in each study category at LGR. We also estimate that for a release number of 50,000 fish, as originally proposed, the corresponding power, given the same assumptions, would have been 0.89. And to achieve the power of 0.9, 51,780 fish would need to be released (see Table 2).

Table 2. Power associated with different sample sizes at Lower Granite Dam for subyearling fall Chinook based on a 66% release to LGR study sample survival/efficiency conversion. Alpha was set at 0.05 and the lower SAR(1) was assumed to be 0.5% compared to a SAR(2) of 0.75%. Release number was calculated as two times the smolt sample size per study category divided by 0.66 (the simulated average conversion efficiency).

Release N	Smolt sample size (T_x, C_0)	SAR (1)	SAR (2)	Power (Beta)	Comment
Various	8,488	0.005	0.0075	0.90	Spring/summer Chinook & steelhead
40,400	13,330	0.005	0.0075	0.83	2015 release using preloaded tags
50,000	16,500	0.005	0.0075	0.89	CSS original release proposal
51,780	17,088	0.005	0.0075	0.90	Release needed to for power of 0.9

A comparison of fall Chinook SARs by study category reported in the CSS confirm that existing methods for determining power are consistent with results from the analysis of transport versus in-river SARs. The CSS reported 14 statistically significant differences between transport and in-river SARs for fall Chinook. The *post hoc* theoretical power computations (i.e., not valid to apply power to results but applied here to see if power calculations correspond to observed significant differences) would have had a minimum power of 0.7 for 13 out of 14 significantly different PIT-tag group comparisons. Differences in SARs were often greater than the value of 50% that was used in the power analysis. Sample sizes from existing SAR study groups, in most cases, were not as high as 17,088, identified in our power analysis. In those cases where sample sizes were lower than 17,088 and TIRs were significant, the relative differences in SARs were greater than 50%. Relative differences in SARs for fall Chinook were variable and ranged from 0 to 330%, with the average at 70%. These results confirm that the analytical approach appears appropriate to capture the power of detecting a significant difference in SARs.

References

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