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MEMORANDUM

TO: Russ Kiefer

Michele DeHart

FROM: Michele DeHart

DATE: July 18, 2006

RE: Low spring Chinook rack returns at Dworshak Hatchery relative to Rapid River Hatchery

In response to your request to investigate the observed below-average adult spring Chinook conversion rates observed at Dworshak National Fish Hatchery (DWORNF) relative to Rapid River Hatchery (RAPH) for the 2006 return year, we analyzed adult PIT-tag data from Bonneville (BON), McNary (MCN), and Lower Granite (LGR) dams for the 2006 migration season (3 March to 20 June 2006). The BON-LGR conversion rates were approximately 20% lower for DWORNF adults compared to RAPH adults in 2006; more importantly, DWORNF conversion rates were approximately 17% lower than the average experienced by this hatchery group over the last five years (2001-2005), whereas RAPH conversion rates were typical of earlier years (**Table 1**).

In order to determine possible causes for the below-average conversion rate seen for DWORNF fish relative to RAPH, we considered patterns in run timing and upstream-passage success for these two hatchery groups in relation to in-river migration conditions (e.g., flow and harvest). Secondarily, considering previous work on the association between juvenile outmigration experience (i.e., in-river vs. barged) and inter-dam 'dropout' rates for returning adults (i.e., the inverse of conversion rates), we evaluated the role of smolt transportation in the observed 2006 DWORNF-RAPH return pattern. To draw inference on possible explanations for these patterns, we effectively treated RAPH fish as a control group in our analysis.

Based on observed detections of adult spring Chinook salmon (i.e., including jacks) at Bonneville Dam, both RAPH (n = 121) and DWORNF (n = 161) fish initiated their upstream migrations within a similar timeframe during the spring of 2006 (**Figure 1**). The mean BON arrival date for DWORNF spring Chinook was 10-May (range: 24-April to 10-June) whereas for RAPH fish it was 8-May (24-April to 22-May). It is worth noting that DWORNF salmon had a more skewed distribution of arrival dates than RAPH fish, with several fish appearing in late May and early June.

Table 1. Conversion rates for PIT-tagged adult Chinook salmon between Bonneville and Lower Granite dams for DWORNF and RAPH fish. 2006 values are presented in bold-faced font for display purposes.

Year	DWORNF	RAPH
2002	0.63	0.72
2003	0.75	0.79
2004	0.82	0.84
2005	0.75	0.80
2006	**0.57**	**0.77**
2002-5 Mean	0.74	0.79
(SD)	(0.08)	(0.05)

In contrast to the arrival timing distributions, there were clear differences in upstream travel times (BON to LGR) and migration patterns for these two groups of fish. First, DWORNF salmon (mean travel time: 20 days) took approximately 5 days longer than did RAPH fish (mean travel time: 15 days) to make their upstream migrations. This disparity was likely due to long delays and fallback events between BON and MCN dams; a closer look at first and last detections at BON for individual fish confirms this suggestion. In fact, 11 (out of 161 total) DWORNF Chinook salmon were first observed passing BON early in the season and detected at this same project 10–40 days later. Seven of these 11 individuals (4.3% of all DWORNF BON detects) never arrived at LGR. This 'confused' migration and associated fallback behavior has also been documented in previous years using radio telemetry methods (e.g., Keefer et al. 2006). In contrast to DWORNF, extensive delays and fallback behavior was not observed for any RAPH salmon during 2006.

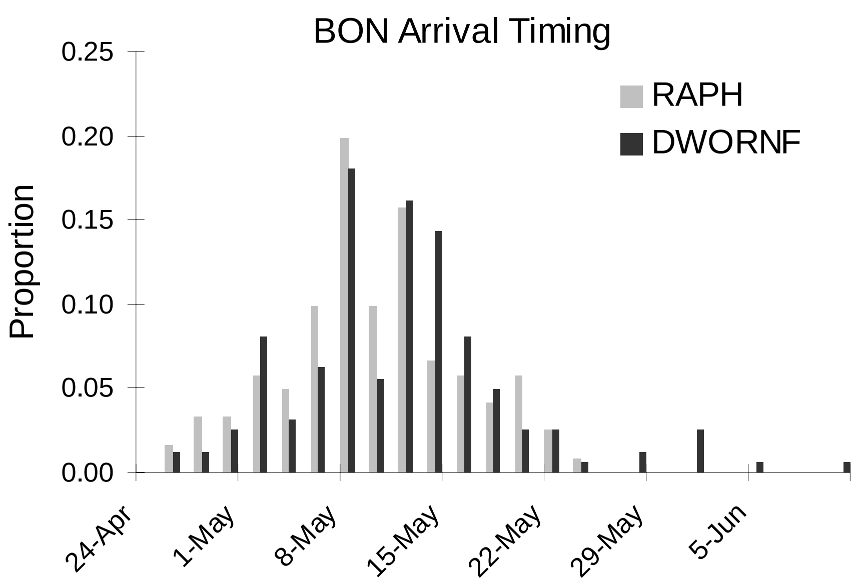

Figure 1. Histogram of 2006 Bonneville Dam arrival times for upstream-migrating spring Chinook salmon originating at Dworshak (DWORNF, black bars) and Rapid River (RAPH, gray bars) hatcheries.

Given the known effects of environmental conditions and harvest on upstream migration success, we considered the potential role of these factors in explaining the observed disparity in migration patterns and conversion rates. The 2006 spring migration season was characterized by relatively high and variable flows across the Basin. As a result, uncontrolled spill occurred at nearly all projects after 2 April and continued across the migration period. Water temperature conditions (as indexed at BON) were consistent with previous years, at ± 1°C of the 10-year average. Finally, due to the late arrival of the spring Chinook run, harvest in the Zone 6 gillnet fishery was modest (M. Matylewich, CRITFC, personal communication); only half of all tribal permit quotas were filled prior to their expiration. With the exception of flow and spill patterns, environmental conditions relating to upstream migration success were not atypical of what has been observed over the last several years. Given the similar migration timings of DWORNF and RAPH fish, however, both salmon groups were exposed to the same environmental and harvest conditions. Thus, it is unlikely that the disparity in rack returns was a result of differential exposure to anomalous in-river migration conditions.

In accordance with previous suggestions that juvenile transportation can affect the natal site imprinting of smolts and influence subsequent straying and fallback behavior of returning adults (Pascual et al. 1995; Chapman et al. 1997), we evaluated the possibility that the below-average 2006 return could be explained by juvenile transport history. To evaluate this hypothesis, we analyzed the juvenile outmigration history of returning adults and tested for an effect of transportation. First, we tested whether the successful passage of adults from BON to LGR (conditioned on being detected at BON; success: detected at LGR, failure: not detected at LGR) was independent of juvenile transport history (groups: in-river, transported from LGR, transported from LGS or other downstream dams) using a χ^2-test test, for both hatchery groups (**Table 2**). Second, to determine whether 2006 results was part of a larger pattern, we also tested for a relationship between BON-LGR conversion rates (**Table 1**) and juvenile outmigration experience (% of returning adults that outmigrated as in-river smolts; **Table 3**) using linear regression and data from the last 5 years for these two stocks.

Table 2. Contingency table (count-by-category) of successful/failed upstream migration (i.e., detected subsequently at LGR) of adult salmon detected at BON as a function of juvenile transport history (LGR = transported from LGR; LGSdown = at LGS, LMN, or MCN) for the 2006 return year for DWORNF and RAPH salmon.

Hatchery	Out-migration history	Successful	Failed
DWORNF	In-river	44	22
	$\text{Transported}_{\text{LGR}}$	16	31
	$\text{Transported}_{\text{LGSdown}}$	31	17
RAPH	In-river	31	3
	$\text{Transported}_{\text{LGR}}$	51	18
	$\text{Transported}_{\text{LGSdown}}$	13	5

Based on our analysis, it appears that there is an association between transport history and upstream migration success for DWORNF (χ^2-test, P = 0.001) but not RAPH salmon (P = 0.104) during the 2006 migration season (**Table 2**). For DWORNF, significantly more adults of in-river smolt origin made a successful upstream migration than would be expected by chance alone, whereas the reverse pattern was seen for adults that were transported (from LGR) as smolts. Among DWORNF, there was no difference for observed and expected passage success (or failure) for smolts transported in the combined LGSdown group or for any RAPH group. Based on 2006 adults alone, it appears that there is an effect of juvenile transportation history on adult conversion rates for DWORNF but not RAPH. When considered across years, this pattern is even more striking (**Figure 2**). DWORNF conversion rates increased steeply as a function of the percentage of detected, returning adults that outmigrated as in-river smolts (linear regression, $P = 0.078$); while there was also a positive relationship for RAPH salmon, it was weaker and not statistically significant ($P = 0.123$). For both groups of fish, returning adults detected in 2006 were comprised of the lowest in-river smolt percentage of the five-year record (**Table 3**).

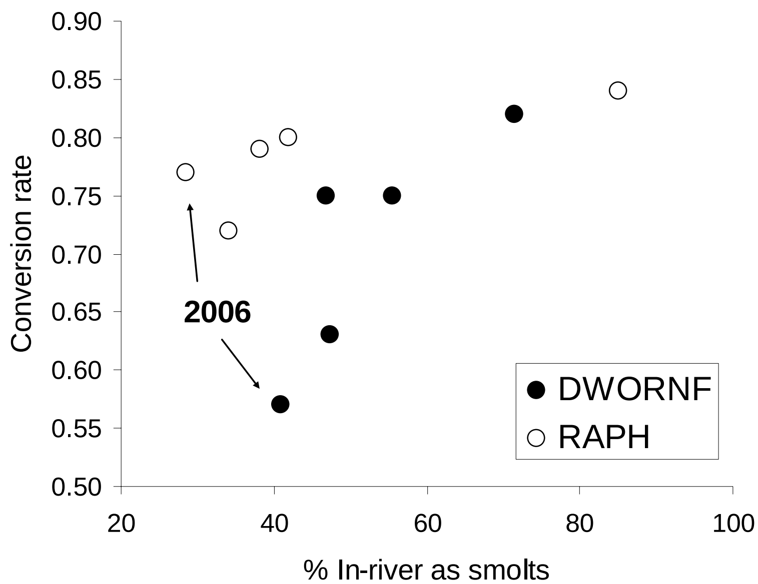

Figure 2. Scatterplot of BON-LGR conversion rates as a function of the percent of returning adults that made their outmigration as in-river (versus transported) smolts.

Both 2006 and multi-year analyses indicate that the upstream migration success of returning adults is related to juvenile outmigration experience for DWORNF fish and less so for RAPH-origin salmon. Considering earlier work on the effects of juvenile transportation on adult homing ability and the fact that RAPH smolts travel further in-river (~200 km) than do DWORNF smolts when imprinting is thought to occur (i.e., during the parr-to-smolt transition), these findings are not surprising. Ultimately, our analysis suggests that the observed disparity in rack returns at DWORNF relative to RAPH may be a result of juvenile transportation, rather than environmental conditions or harvest efforts.

Table 3. Juvenile outmigration experience ('Inriver' includes fish bypassed and returned to river; '$Trans_{LGR}$' = collected at LGR and transported; '$TRANS_{down}$' = collected at LGS, LMN, or MCN and transported) of adults returning in years 2002-2006. 2006 values are presented in bold-faced font for display purposes.

Site	Year	Outmigration experience (%)		
		In-river	$Trans_{LGR}$	$Trans_{LGSdown}$
DWORNF	2002	47.4	32.8	19.8
	2003	46.9	30.9	22.2
	2004	71.5	13.3	15.2
	2005	55.4	25.7	18.8
	2006	**40.9**	**28.7**	**30.5**
	2002-5 mean	55.3	25.7	19.0
RAPH	2002	34.0	45.1	20.9
	2003	38.3	47.1	14.6
	2004	85.0	9.3	5.7
	2005	41.9	42.9	15.2
	2006	**28.5**	**56.1**	**15.4**
	2002-5 mean	49.8	36.1	14.1

References cited

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