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MEMORANDUM

TO: Doug Taki, Shoshone Bannock Tribe
Richie Graves (NOAA)

FROM: Michele DeHart

DATE: August 6, 2008

RE: Response to NOAA Memorandum: "Initial Critique of Fish Passage Center's July 14, 2008 Memorandum from Michele DeHart to Liz Hamilton re: Sockeye adult returns in 2008"

In response to your request the FPC staff reviewed the subject NOAA document (attached), which critiques the July 14th memorandum from FPC to Liz Hamilton, NSIA. In addition, as a courtesy, this response is being provided to Ritchie Graves, NOAA in response to the NOAA critique. The Fish Passage Center reviewed and re-analyzed the July 14th memorandum analyses, and conducted additional analyses, in order to fully address all of NOAAs comments and concerns.

The critique establishes NOAA's agreement with the main points in the FPC summary that:

- sockeye returns in 2008 are the highest that have occurred in decades,
- in-river survival rates of sockeye in 2006 and 2007, the juvenile migration years that comprise the 2008 returns, were relatively high,
- increasing the number of juveniles that enter the ocean should positively effect the number of returning adults, and
- sockeye hatchery programs may increase abundance.

However, NOAA raises concerns regarding some of the analyses. The NOAA memorandum does not dispute the characterization of historical juvenile migration conditions in terms of flow, water travel time, and average percent spill, nor does it dispute the measured biological responses of fish travel time or in-river survival rates. Although NOAA raises general concerns in their critique regarding the effects of juvenile outmigration conditions, they do not offer an alternative analysis or data that discounts the impact of high levels of spill and flow on increased survival of juvenile sockeye and the resulting increase in adult returns. After addressing all of NOAA's comments and re-analyzing the data in the July 14th memorandum, **we found no technical basis for modifying the original conclusions. In fact, the additional analyses further confirm and strengthen our previous conclusions that:**

- **The increased returns of Mid-Columbia sockeye adults in 2008 are likely due to a combination of good in-river conditions (e.g., shorter water transit times and increased spill at JDA and MCN), shorter fish travel times, increased juvenile reach survivals, and increased hatchery output in migration year 2006 and 2007.**
- **The increased returns of Snake River sockeye adults in 2008 are likely due to a combination of good in-river conditions (e.g., shorter water transit times, higher average percent spill), shorter fish travel times, increased juvenile reach survivals, and a decrease in the proportion transported in migration years 2006 and 2007.**

The FPC has carefully considered the NOAA comments and addresses each one in the following discussion. The NOAA comments are repeated in **bold print.**

The memo fails to consider how variability in ocean productivity may have affected the number of returning adults and instead seeks to attribute the variance in returns primarily to in-river operations.

The July 14th memorandum was a response to a specific data request to respond to five specific questions, including: 1) "What are the impacts of the Court-ordered spill program on the Sockeye that are returning this year?", 2) "…what year did these fish out-migrate?", 3) "What time of year did they migrate?", 4) "Does spill help sockeye?", and 5) "Are any of them barged or trucked?". The data request did not ask how variability in ocean productivity may have affected the number of returning adults. Subsequently, the FPC received a request from the Bonneville Power Administration (BPA) to address questions regarding ocean conditions and their influence on the 2008 adult sockeye returns and the FPC provided a response to this request on July 21st. In their comments, NOAA recognized this response (in a footnote), which addresses ocean conditions (attached). But despite its public availability on July 21st, NOAA did not substantively incorporate the content of the July 21st ocean conditions memorandum in their July 24th critique.

Although NOAA has raised the question of ocean conditions in their critique, they do not address several compelling points. First, if good ocean conditions were the primary reason for increased sockeye returns to the Snake River, similar increased returns should be evident for other sockeye populations along the northwest coast (Peterman et al. 1998, Mueter et al. 2002). The NOAA critique does not present any evidence that other sockeye populations are experiencing similarly large increases in adult returns. Second, the NOAA critique does not reconcile the facts that years of good ocean conditions have occurred in the recent past, but those good ocean years have not resulted in increased adult returns of sockeye when in-river passage conditions were poor and the majority of sockeye were transported as smolts. For example, Scheuerell and Williams (2005) concluded that ocean years 1998-2003 were conducive to high productivity of Snake River spring/summer Chinook. Similarly, the NOAA Northwest Fisheries Science Center's (NWFSC) Ocean Indicators group estimated that 1999-2002 were all good ocean years, with 2001 estimated to be the best ocean year in terms of overall ranking of the ocean indicators across all ocean years examined (http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm). If ocean conditions were the primary factor, then one would expect that the adult sockeye returns to the Snake River in 1999-2003 would have been high, but this did not occur. And despite the NWFSC identifying 2001 as having the highest overall ranking in terms of good ocean conditions, returns from migration year 2001 (55 at LGR in 2002 and 11 at LGR in 2003) were poor. But in terms of the juvenile migration, 2001 was characterized by low juvenile reach survivals, low flow, low percent spill, long water travel times, and the highest proportion of the population transported.

NOAA addresses sockeye transportation in Williams et al. (2005). They note that information on the effects of transportation on Snake River sockeye salmon is quite limited. The small size of this population precludes a rigorous transportation study on this population. Based on the currently available information, Williams et al. (2005) state that:

> "As with Chinook salmon, most untagged sockeye salmon smolts were collected and transported to below Bonneville Dam. Nonetheless, few adult sockeye salmon returned to Lower Granite Dam from 1990 to 2003. The median annual return was 13 (range 3 to 282). Low numbers of returning adults suggest that transportation provides little if any benefit to Snake River sockeye salmon. Moreover, based on PIT-tag data, the alternative of in-river migration looks poor."

However, in-river survival estimates in 2006 and 2007 (geometric mean = 0.73) were substantially higher than in-river survival estimates during the 1998-2005 migration years (geometric mean = 0.52), and were also likely higher than the 1990-1997 migration years analyzed in Williams et al. (2005). In addition, other migration years with comparable in-river conditions to 2006 and 2007 resulted in relatively high reach survivals and adult returns (e.g., migration year 1998, which returned as adults in 1999 and 2000; migration year 2003, returned as adults in 2004 and 2005).

Several recent analyses for Snake River spring/summer Chinook and steelhead address the effects of juvenile outmigration conditions on subsequent adult returns, while accounting for varying ocean conditions. These analyses show that juvenile passage conditions such as spill and water travel time, in conjunction with ocean conditions, affect adult returns of Chinook and steelhead (Zabel 2007, McCann et al. http://www.fpc.org/documents/misc_reports/13-08.pdf). It is important to note that a recent NOAA analysis (ICBTRT and Zabel 2007) found that one of the factors influencing first year ocean survival in Snake River spring Chinook was water travel time. Given that this relationship between in-river conditions and adult returns/ocean survival exists for Chinook and steelhead, there is no basis to assume that it does not apply for sockeye in a similar manner.

There is nothing in the FPC analysis that disputes the importance of ocean conditions. The FPC and NOAA both agree that juvenile fish must survive the in-river migration corridor in order to benefit from good ocean conditions. But the NOAA critique does not include data or analysis that discounts the importance of juvenile migration conditions to adult returns.

The [FPC] memo failed to consider many factors in the freshwater environment that are likely to influence sockeye adult returns to the Columbia River Basin, including:

The total number of juveniles (not just hatchery output) that started migrating to the ocean.

In response to the NOAA concern regarding the number of migrating sockeye smolts, the FPC reviewed annual estimates of the number of wild, hatchery, and total (wild plus hatchery) sockeye smolts arriving at Lower Granite Dam, as estimated by NOAA Fisheries in a document entitled, "Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin." In that memo, NOAA estimates the number of wild, hatchery, and total sockeye smolts arriving at Lower Granite Dam. Table 1 below shows these annual estimates.

The number of wild sockeye smolts arriving at LGR in 2006 was estimated by NOAA to be 13,500, an increase of 7,933 and 7,501 from 2005 and 2004, respectively. However, NOAA estimates that wild sockeye smolts arriving at Lower Granite Dam in 2007 declined from 2006 by 9,305, to 4,195 in 2007. Although the estimated population of wild sockeye arriving at Lower Granite increased by nearly 8,000 smolts from 2004/2005 to 2006, there was a 9,000 fish decline in 2007. The NOAA estimates for hatchery smolts arriving at Lower Granite increased in 2007, however, past years (e.g., 1999, 2002, and 2003) had hatchery smolt estimates that were larger than 2006, without similar increases in adult returns to those documented in 2008. In addition, the total number of smolts outmigrating in 2006 was similar to previous years (e.g., 1999, 2002, and 2003). These NOAA estimates indicate that neither differences in the number of wild fish nor the total number of wild and hatchery fish outmigrating in 2006 and 2007 are sufficient to explain the magnitude of increase (a 20-fold increase over the 10-year average) in the 2008 adult sockeye return to Lower Granite Dam.

Table 1. Estimated number of sockeye smolts arriving at Lower Granite Dam (From NOAA memo: "Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin".

Migration Year	Wild	Hatchery	Total	% wild
1998	2,400	26,600	29,000	8.2%
1999		61,300	61,300	
2000	237	14,927	15,164	1.5%
2001	988	14,621	15,309	6.4%
2002	790	58,801	59,591	1.3%
2003	1,000	54,304	55,304	1.8%
2004	5,999	23,785	29,784	20%
2005	5,567	21,517	27,084	20%
2006	13,500	31,534	45,034	29%
2007	4,195	89,096	93,291	4.5%

The survival of juvenile sockeye through the free-flowing river reaches prior to entering the mainstem Snake and Columbia Rivers.

On October 29, 2007, in response to a data request, the FPC posted a memo on the web site that estimated juvenile survival of hatchery Snake River sockeye smolts and pre-smolts through the free-flowing river reaches (i.e., release to Lower Granite Dam). These survival estimates are for hatchery sockeye released at Alturas Lake and Redfish Lake and are summarized below in Table 2. Based on the weighted average survivals, the survival through the free-flowing river reach (release to LGR) in 2006 is well within the range of survivals seen since 1994, with two years (1994 and 2005) having higher survival estimates through this reach.

Table 2. Survival of PIT-tagged sockeye smolts and pre-smolts from release (Alturas and Redfish Lake) to Lower Granite Dam. Weighted average survival based on numbers of PIT-tags released for each age group.

Migration Year	Smolts		Pre-Smolts		Weighted Average Survival
	Num. Rel.	Survival	Num. Rel.	Survival	
1994	717	0.55	N/A	N/A	0.55
1995	1,480	0.13	2,728	0.02	0.06
1996	2,078	0.48	5,977	0.11	0.21
1997	67	N/A	1,930	0.10	0.10
1998	2,516	0.78	10,622	0.11	0.24
1999	1,061	0.47	5,425	0.13	0.19
2000	1,244	0.43	3,111	0.19	0.26
2001	2,987	0.27	N/A	N/A	0.27
2002	3,842	0.35	N/A	N/A	0.35
2003	2,272	0.37	5,522	0.08	0.16
2004	2,759	0.41	1,519	0.10	0.30
2005	4,254	0.50	2,029	0.24	0.42
2006	2,000	0.55	2,019	0.24	0.39
2007	2,856	0.43	2,032	0.19	0.33

Other environmental factors that likely affect the survival of juveniles migrating through the mainstem Snake and Columbia Rivers (temperature, turbidity, fish condition, recent installation of surface passage routes, etc.) are not included in the FPC analysis.

To address the NOAA comment, FPC staff have investigated the effect of temperature and turbidity on juvenile Snake River sockeye reach survival (LGR-MCN). A weighted regression analysis was conducted (weighted by the inverse variance of survival) as was presented in the original memo. There was no statistical association between average temperature and juvenile reach survival ($R^2 = 0.00$, $p = 0.74$, Table 5). Similarly, there was no statistical association between average turbidity and juvenile reach survival ($R^2 = 0.09$, $p = 0.22$, Table 5). A summary of the average temperature and turbidity conditions that juveniles experienced during their out-migration is presented in Table 3. As indicated in this summary and in Table 3, there has been very little variation in average temperature over the past 10 years.

Table 3. Juvenile reach survivals (LGR-MCN) and average temperature and turbidity experienced by PIT-tagged sockeye juveniles with first time detects at LGR or LGS. Survival estimate to MCN was not possible in migration year 2004 due to a large proportion of PIT-tagged individuals being transported in that year.

Migration Year	Average Temp. (°C)	Average Turbidity (FNU)	Juvenile Survival (LGR-MCN)
1998	13.8	2.2	0.60
1999	12.3	2.5	0.63
2000	13.9	3.2	0.64
2001	14.4	4.6	0.26
2002	12.3	4.4	0.50
2003	12.5	3.7	0.71
2004	13.2	3.8	N/A
2005	13.8	3.1	0.45
2006	13.6	2.4	0.86
2007	13.9	4.0	0.62

The FPC is not aware of reliable fish condition data dating back to 1998 that could be used to evaluate the effect of fish condition on juvenile reach survival. However, in their 2008 Biological Opinion, NOAA Fisheries states that "despite changes in configuration and operations in the hydrosystem, rates of descaling and mortality are higher for sockeye than for other species, although the reason for this discrepancy is unknown" (Section 8.4.3.1). This NOAA conclusion indicates that it is unlikely that improvements in fish condition can explain the magnitude of increase in adult returns in 2008. Improvements in fish condition and reduced rates of descaling may provide part of the explanation for the higher juvenile reach survival for sockeye that has been observed in years where the average percent spill was higher. A higher spill percent would effectively reduce the proportion of juveniles encountering the juvenile bypass system and the turbines, and thus reduce potential descaling and mortality.

Finally, although we did not specifically evaluate the installation of surface passage routes in the original memo, the effects of these surface passage routes would have been incorporated in the other in-river variables (e.g., fish travel time). For example, an RSW was installed at LGR in 2002. Prior to that time, we estimate average fish travel time from LGR to MCN to be 9.18 days (1998-2001). After the installation of the RSW, average fish travel time decreased to 8.42 days (2002-2007). Both of these periods (prior to installation and after installation) include years where there was little to no voluntary spring spill in the Snake River (2001 and 2005).

The memo fails to provide any analysis of Smolt to Adult Returns (SAR).

As indicated earlier, the memorandum was a response to a specific request about juvenile survival, transportation, and outmigration conditions. Life cycle analysis was not the objective of the memorandum. In fact, the FPC analysis (July 21) recognized that inadequate numbers of marked fish and low population numbers hinders life cycle analysis. NOAA recognizes this in their 2008 Biological Opinion

On average only about 7,500 sockeye juveniles were PIT-tagged each year (range: 2,294-16,522) over the ten years we analyzed. Furthermore, since 1998, only 31 PIT-tagged Snake River sockeye adults have been detected at either Bonneville or Lower Granite Dam. Coincidently, almost half (14) of these were detected in 2008. The FPC maintains that there are too few PIT-tagged sockeye adults to thoroughly evaluate sockeye SARs.

However, in order to address the NOAA concern regarding sockeye SARs, the FPC staff reviewed the NOAA 2008 Biological Opinion. The Biological Opinion provides SAR estimates for Snake River sockeye (Section 8.4.2.1):

> "Williams et al. (2005) reported that between 1990 and 2001, two adults returned from 478 juveniles transported and only one adult returned from 3,925 PIT-tagged fish that migrated in-river (SARs of 0.4% vs. 0.03%, respectively). As with Chinook salmon, most untagged sockeye salmon smolts were transported to below Bonneville Dam. Nonetheless, few adult sockeye salmon returned to Lower Granite Dam in the last decade."

The significance of water travel time (WTT) vs. reach survival regressions used in the memo for Snake River fish are currently driven by a single data point – 2001 – when essentially no spill occurred in the Snake River and substantially reduced spill occurred in the Lower Columbia. Thus, a much higher percentage of juveniles passed dams through the turbines than was the case in any of the other years included in the analysis. This is a serious oversight which should be remedied by providing an analysis of the data without 2001.

There is simply no logical basis for removing 2001 from our analysis, or any other analysis. The reach survival and fish travel time estimates in 2001 properly reflect the management decisions that were made by the Action Agencies (i.e., the termination of, and severe reductions in spill) and the environmental conditions experienced (long water travel times) during the juvenile outmigration in 2001. The NOAA critique may longingly wish that 2001 did not happen, but it did actually happen and the results were real. Migration year 2001 clearly illustrates the inadequacy of passage mitigation measures that were in place during that year. An extensive passage monitoring program was in place in 2001. Migration year 2001 provides an important example of how juvenile reach survivals can be affected by a lack of spill for fish passage at dams and a lack of flow for migration through reservoirs. In contrast with the NOAA comment that data from 2001 should be ignored, both the NOAA Biological Opinion analysis and the TRT analysis for recovery include data from 2001. There is simply no credible scientific or technical basis for excluding migration year 2001 from any juvenile or adult analysis.

It is true that, due to a lack of spill in 2001, more juveniles would have passed through the turbines than in any other year. However, we estimated that 95% of the juvenile Snake River sockeye population would have been transported, leaving only 5% of the population susceptible to higher turbine passage. Despite this high transportation proportion in 2001, and good ocean conditions, the sockeye adult returns to Lower Granite Dam in 2002 and 2003 were low (55 and

11, respectively). This simply validates the importance of spill to overall juvenile reach survival, particularly those migrating in-river.

For example, of the years we analyzed, 2001 was the lowest flow year, followed by 2007 and 2000. Despite the low flows in 2000 and 2007, reach survivals in these years were much higher than that seen in 2001. One potential explanation for this is the fact that 2000 and 2007 both had a higher average percent spill (46.1 and 38.3, respectively) while 2001 had extremely low average percent spill (1.2).

Fish travel times and water travel times of Snake River sockeye are not well correlated (R^2 = 0.226, un-weighted). The memo fails to note this fact or to provide a mechanistic explanation for how fish survival and water transit time might be correlated, absent a correlation between fish survival and fish travel time.

As was the subject of the data request, the FPC memorandum simply presents the facts regarding outmigration conditions and the measured responses in terms of survival and fish travel time. However, given sockeye life history and the fact that they spend over a year in lake/reservoir-like environments and migrate through that lake/reservoir-like environment, orienting to river outlets and to the ocean, there should be no surprise that they are well adapted to move through lake/reservoir environments quickly and absent the water velocities required by Chinook and steelhead. Considering their life history characteristics, there is no reason to expect a higher correlation between WTT and FTT for Snake River sockeye juveniles. It is quite possible that sockeye are better adapted to actively migrate through slow-moving lakes/reservoirs than are Chinook and steelhead, who rear as juveniles in faster moving rivers and streams. Thus, steelhead and Chinook are likely more apt to passively migrate through the hydrosystem at rates similar to the ambient water velocity, whereas sockeye would likely be more active migrants in slow moving reservoirs. In fact, the NOAA 2008 Biological Opinion acknowledges this possibility and cites research that has demonstrated that Mid-Columbia sockeye migrate faster through the hydrosystem than do yearling and sub-yearling Chinook (Section 8.4.3.1). It is possible that that sockeye juvenile survival maybe more affected by spill for fish passage and proportion of fish transported.

The memo fails to recognize other actions being taken in Canada (besides hatchery releases of fry) to increase productivity of Okanogan River sockeye salmon – especially improved management of flows to protect redds.

We do not discount that actions taken in Canada to increase productivity of the Okanogan River may have had an impact on the substantial returns of sockeye adults to the Mid-Columbia region. However, it is important to note that the juvenile reach survival (RIS to JDA) in 2006 for Mid-Columbia River sockeye was the highest among the years we analyzed. Our reach survivals are from sockeye juveniles that are collected, PIT-tagged, and released at Rock Island Dam. Furthermore, the reach survival in 2007 was extremely close to that seen in 1998 and 1999, prior to these efforts in the Okanogan River. Therefore, it is unlikely that the efforts on the Okanogan River basin were significant enough to lead to the high reach survivals in 2006 and 2007.

The memo fails to provide any data supporting the claim that more adults returned because transport rates were lower than usual. No Okanogan River or Lake Wenatchee sockeye salmon have been transported for years.

Contrary to NOAA's assertion, substantial numbers of sockeye, with the vast majority likely originating from the Mid-Columbia, have been transported from McNary Dam in recent years (35,395 sockeye transported in 2000 and 132,208 transported in 2001). These transport numbers constituted 59% and 93% of the number of sockeye collected at McNary, respectively.

With regard to Snake River transportation, we provided data on the proportion of the population arriving at Lower Granite Dam that was transported, 1998-2007. We observed that migration years 2006 and 2007 had some of the lowest estimates of the proportion of juvenile sockeye transported over this time period. The average proportion transported during 1998-2005 (average = 77%) was 37% higher than the average proportion transported during 2006 and 2007 (average = 56%). In 2007 and 2008, adult returns to Lower Granite were well above the 10-year average of 42 adult sockeye (55 in 2007 and over 859 as of August 4, 2008). The concurrence of these estimates provide one line of indirect evidence that the lower transportation proportions may have contributed to the observed increase in adult returns. A second line of indirect evidence is the fact that descaling rates for sockeye collected in the bypass/transportation systems are high, suggesting that the screening and collection process, with subsequent loading onto a barge, is far from benign to juvenile sockeye. A third line of indirect evidence is the conclusion of Williams et al. (2005) that "low numbers of returning adults suggest that transportation provides little if any benefit to Snake River sockeye salmon."

The memo fails to provide a figure relating average spill to the survival of sockeye detected at RIS, as was done for sockeye detected at LGR.

As discussed in the FPC memorandum, there was little variation in average percent spill between the years analyzed and, therefore, average percent spill had little effect on juvenile reach survival for Mid-Columbia sockeye (weighted regression[1], $R^2 = 0.00$, $p = 0.98$, Table 4). Since spill has not varied, there would be no reason to expect that an effect of spill could be detected. This can not be interpreted as evidence that no relationship exists between average spill and sockeye survival. If spill in the upper Columbia reach actually varied, it is probable that a relationship could be detected.

The memo fails to investigate the extremely high survival rates estimated for 2006 out-migrants. Changes in survival of this magnitude are surprising. Therefore, these data should be carefully reviewed to ensure that are not spurious.

Upon receiving NOAA's critique, we have reviewed our analyses in detail and have found no evidence that the higher survivals in 2006 are "spurious." Contrary to the NOAA comment and given the fact that the survival estimates calculated by NOAA for the reach (LGR-MCN) survivals for steelhead and yearling Chinook in 2006 and 2007 were among the highest on record

[1] The FPC memo posted on July 14, 2008 incorrectly identifies the regression analyses for Mid-Columbia sockeye as weighted regressions. The regression results presented in the original memo for Mid-Columbia River sockeye are not weighted. However, we provide these weighted regression results in our answer to comment number 9.

(Ferguson,NOAA on Aug. 31, 2007), the sockeye survival estimates are not surprising. The methods for calculating survival are standard, and there is no reason to expect that the sockeye survival estimates are less realistic than the Chinook or steelhead survival estimates.

The memo fails to describe how the regressions were "weighted" in this analysis or to provide any assessment of how sensitive these analyses are to the "window" of time used to select which fish are included in the analysis.

The weighted regressions for Snake River sockeye were weighted by the inverse variance of the survival estimates. In order to fully address NOAA's comments, we have re-run all regression analyses for Mid-Columbia and Snake River sockeye and provide the results below.

Mid-Columbia River Sockeye
The following are results (Table 4) of regressions weighted by the inverse variance of the survival estimates. Lack of data precluded similar regression analyses for temperature and turbidity data for the Mid-Columbia.

The weighted regression analyses indicates a negative association between water transit time and reach survival (RIS-JDA) for Mid-Columbia sockeye, although this relationship was not statistically significant at the $\alpha = 0.10$ level (Table 4, Figure 1, $p = 0.127$). However, the sign of the estimated coefficient suggests that as water transit time decreased, reach survival increased. We did not find a statistically significant association between the average percent spill and fish travel time or between average percent spill and reach survival for juvenile Mid-Columbia sockeye (Table 4). However, it is important to note that there was little contrast in the spill percentages across years, making the examination of spill effects difficult.

Table 4. Results from weighted regression analyses for Mid-Columbia River sockeye. Each environmental variable was regressed against juvenile reach survival (RIS-JDA). Statistically significant variables are in bold ($\alpha = 0.05$) and italics ($\alpha = 0.1$).

Environmental Variable	Untransformed survival			Log-transformed survival		
	Adjusted R^2	F statistic (df = 1,6)	P value	Adjusted R^2	F statistic (df = 1,6)	P value
WTT	0.24	3.15	0.127	0.45	6.62	**0.042**
FTT	0.00	0.81	0.402	0.04	1.27	0.302
Avg. Percent Spill	0.00	0.001	0.982	0.00	0.03	0.863

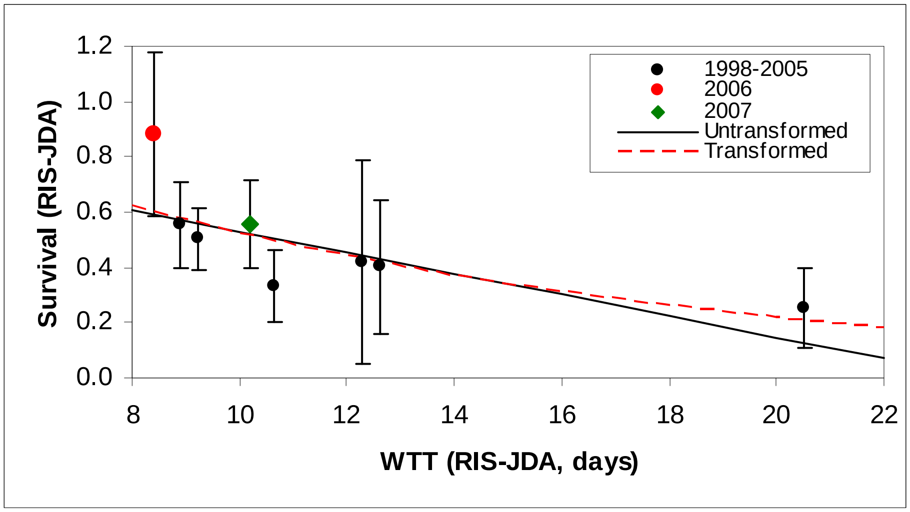

Figure 1. Weighted regressions of water transit time and juvenile reach survival (RIS-JDA) of PIT-tagged Mid-Columbia River sockeye juveniles releases at RIS.

To further address NOAA's comments, a logarithmic transformation was employed for modeling the survival data, where the mean and variance estimates are often positively correlated, in order to reduce heteroscedasticity (Burnham et al. 1987:211-212). By definition, using a log-transformation of survival assumes that survival is lognormally distributed. There is both empirical evidence and a theoretical basis for assuming that a lognormal distribution is a reasonable approximation for characterizing variability in survival rates (Peterman 1981, Hilborn and Walters 1992:264-266). Since our overall reach survival estimates are the product of shorter reach survival estimates, it is a good general practice to log-transform these overall reach survival estimates ($Ln(Surv_{RIS\text{-}JDA})$) prior to performing regressions of survival versus candidate covariates. In order to do this with weighted regression, it is necessary to calculate the variance of a log-transformed variable. For lognormally distributed random variables, the variance of log (x) is (Blumenfeld 2001):

$$Var[\log(x)] = \log(1 + [cv(x)]^2)$$

Weighted regression analyses of the log-transformed survival estimates revealed a statistically significant association between water travel time and juvenile reach survival ($R^2 = 0.45$, $p = 0.042$, Table 4, figure 1). As with the un-transformed analyses, there was no statistical association between percent spill and reach survival (Table 4).

The findings presented in the July 14th memorandum are supported and confirmed by these recent analyses. These more detailed analysis indicate that water travel time appears to have an effect on juvenile reach survivals of Mid-Columbia River sockeye, with decreased water transit times resulting in higher reach survivals.

Snake River Sockeye
In order to fully address NOAA's comments we have reanalyzed the weighted regression analyses (weighted by the inverse variance of survival) (Table 5, Untransformed survival). We have also conducted additional weighted regression analyses per NOAA's request (e.g., temperature, turbidity, and fish travel time). These re-analyses resulted in slight changes to the test statistics for the relationship between percent spill and survival and water travel time and survival.

Table 5. Results from weighted regression analyses for Snake River sockeye. Each environmental variable was regressed against juvenile reach survival (LGR-MCN). Statistically significant variables are in bold (α = 0.05) and italics (α = 0.1).

Environmental Variable	Untransformed survival			Log-transformed survival		
	Adjusted R^2	F statistic (df = 1,7)	P value	Adjusted R^2	F statistic (df = 1,7)	P value
WTT	0.24	3.45	0.105	0.28	4.16	*0.081*
FTT	0.48	8.39	**0.023**	0.51	9.20	**0.019**
Avg. Percent Spill	0.35	5.38	*0.054*	0.53	10.15	**0.015**
Avg. Temp.	0.00	0.12	0.737	0.00	0.106	0.754
Avg. Turbidity	0.09	1.79	0.223	0.165	2.58	0.153

This most recent weighted regression analysis revealed a positive association between average percent spill and reach survival ($R^2 = 0.35$) that was statistically significant at the α = 0.10 level (p = 0.054) (Table 5, Figure 2). In addition, a weighted regression also revealed a negative association between water transit time and juvenile survival ($R^2 = 0.24$), although this relationship was not statistically significant at the α = 0.10 level (p = 0.105) (Table 5, Figure 3). Finally, the weighted regression analysis of fish travel time (FTT) versus reach survival of Snake River juvenile sockeye showed a negative association between fish travel time and juvenile reach survival ($R^2 = 0.48$, p = 0.02, Table 5, Figure 4). As FTT increased, juvenile reach survival decreased. As presented in our response to comment #2C above, the weighted regression analyses of the effect of temperature and turbidity versus reach survival revealed no statistically significant associations (Table 5).

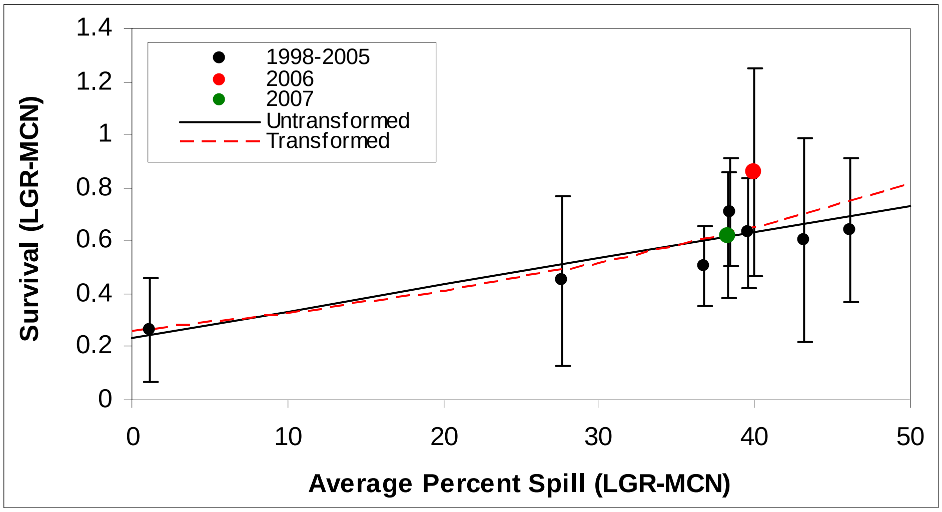

Figure 2. Weighted regressions of average percent spill and juvenile reach survival (LGR-MCN) of PIT-tagged Snake River sockeye released above Lower Granite Dam.

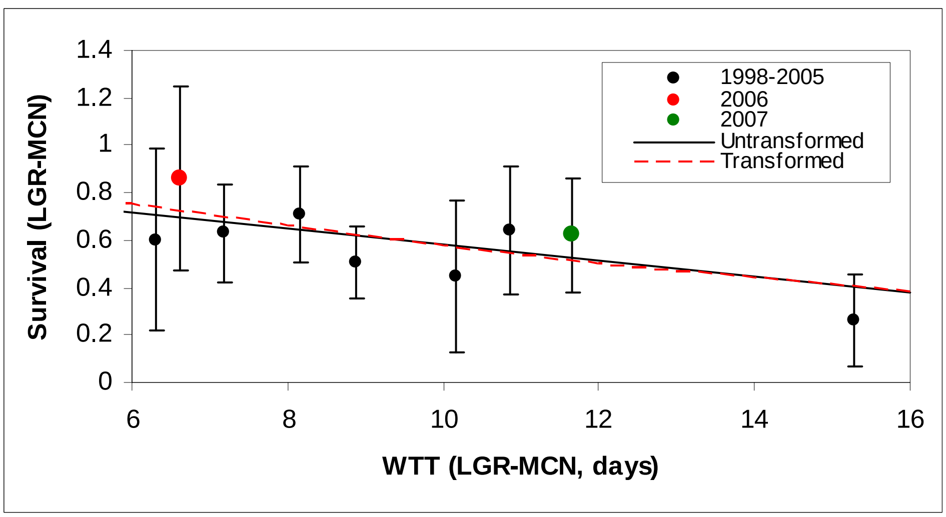

Figure 3. Weighted regressions of water transit time and juvenile reach survival (LGR-MCN) of PIT-tagged Snake River sockeye released above Lower Granite Dam.

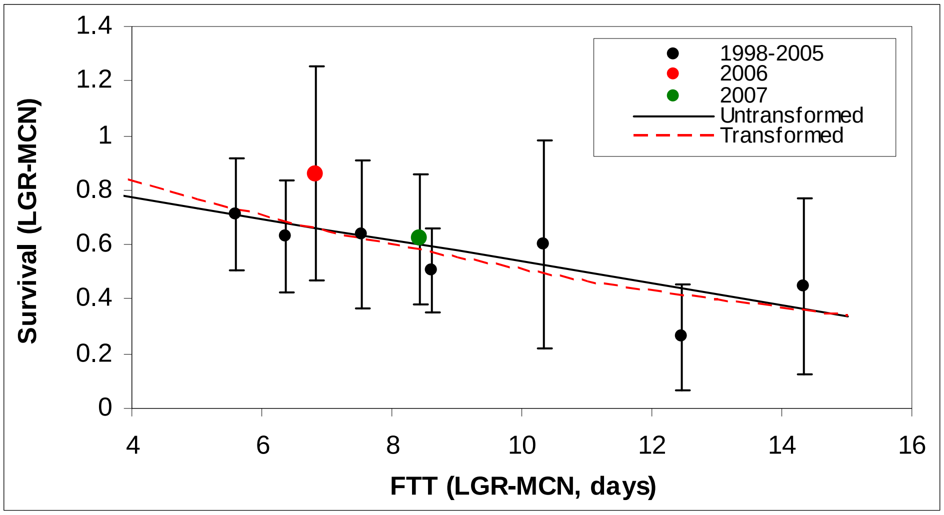

Figure 4. Weighted regressions of fish travel time and juvenile reach survival (LGR-MCN) of PIT-tagged Snake River sockeye released above Lower Granite Dam.

As with the Mid-Columbia sockeye, we performed the same weighted regression analyses on log-transformed reach survivals (Ln($Surv_{LGR-MCN}$)). These weighted regressions were weighted on the variance of the log-transformed survival estimates (Equation 1). The weighted regression analyses of the transformed survival estimates resulted in similar results as those for untransformed survival estimates. At the α =0.05 level, both average percent spill and fish travel time were found to have a statistically significant associations with juvenile reach survival (p = 0.015 and 0.019, respectively) (Table 5). Also, at the α = 0.10 level, there was a statistically significant association between water transit time and juvenile reach survival (p = 0.081) (Table 5).

Overall, these regression analyses all support our original conclusions: average percent spill, water transit time, and fish travel time all showed strong associations with juvenile reach survival for Snake River sockeye.

As discussed in the June 14th memo, the "window" of time used in the analyses represented a trade off between adequate sample sizes and estimating environmental variables. We made a significant attempt to minimize this window as much as possible, while still allowing for an sufficient number of PIT-tagged juveniles for our survival analysis.

This memo contains many statements like "strong" and "likely" that are NOT supported with statistical results (i.e., significant p-values).

In order to address NOAA's comments we repeated the weighted regression analyses to describe the relationship between the environmental variables and juvenile reach survivals. Subsequently, we report the statistical results of these analyses for Mid-Columbia (Table 4) and Snake River (Table 5) sockeye. In both the Snake and Mid-Columbia reaches, we found statistically significant associations between environmental variables and reach survival. We have also reported p-values and test statistics of these regression analyses (Tables 4 and 5). These statistical results confirm the original conclusions that in-river migration conditions such as spill and water transit time contributed to increased juvenile survival and the resulting adult returns.

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UNITED STATES DEPARTMENT OF COMMERCE
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July 24, 2008

MEMORANDUM FOR: Bruce Suzumoto

FROM: Ritchie Graves

SUBJECT: Initial Critique of Fish Passage Center's July 14, 2008 MMemorandum from Michelle DeHart to Liz Hamilton re: Sockeye adult returns in 2008.

NOAA Fisheries agrees with several points made in the FPC Memo:

- Sockeye returns in 2008 were substantially better than those that have occurred for many decades.
- Inriver survival estimates for juvenile sockeye were relatively high in 2006 and 2007.
- Increasing the number of juvenile sockeye smolts that enter the ocean in good condition should (on average) positively affect the number of adults returning.
- Sockeye hatchery programs may effectively address some limiting factors by increasing abundance (supplementation) and spatial distribution (reintroduction).

However, the memo suffers from several important short-comings. These include, but are not limited to, the following:

- Ocean productivity substantially influences the recruitment of Chinook and coho salmon stocks,[1] and is, therefore, likely an important determinant of sockeye recruitment as well. The memo fails to consider how variability in ocean productivity may have affected the number of returning adults and instead seeks to attribute the variance in returns primarily to in-river operations.[2] Such attribution is not reasonable nor supportable given the likely magnitude of ocean productivity effects.
- The memo fails to consider many factors in the freshwater environment that are likely to influence the number of adults returning to the Columbia River Basin. These factors include:

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[1] See: http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm

[2] A more recent Fish Passage Center memo dated July 21, 2008 does acknowledge that "ocean conditions are important for adult returns."

- The total number of juveniles (not just the number of hatchery produced fish) that started migrating to the ocean
- The survival of these fish through free-flowing river reaches prior to entering the mainstem Snake and Columbia Rivers[3]
- Other factors besides flow and spill levels that likely affect survival of juveniles migrating through the mainstem Snake and Columbia Rivers (temperature, turbidity, fish condition, recent installation of surface passage routes, etc.)

- The memo fails to provide any analysis of Smolt to Adult Returns (SAR) – a glaring omission considering that the apparent goal of the memo is to describe factors which likely contributed to the larger than expected returns of sockeye salmon in 2008.
- The significance of Water Transit Time (WTT) vs Reach Survival regressions used in the memo for Snake River fish are entirely driven by a single data point – 2001 – when essentially no spill occurred in the Snake River and substantially reduced spill occurred in the lower Columbia River. Thus, a much higher percentage of juveniles passed dams via turbines at the mainstem federal hydroelectric projects than was the case in any of the other years included in this analysis. This is a serious oversight which should be remedied by providing an analysis of the data without 2001. Such an analyses would show essentially no relationship (low R^2, highly insignificant) without 2001.
- Fish travel times and water travel times of Snake River sockeye (regression of unweighted data presented in table 4) are not well correlated ($R^2 = .226$). The memo fails to note this fact or to provide a mechanistic explanation for how fish survival and water transit times might be correlated, absent a correlation between fish survival and fish travel time.
- The memo fails to recognize other actions being taken in Canada (besides hatchery releases of fry) to increase the productivity of Okanogan River sockeye salmon – especially improved management of flows to protect redds.
- The memo fails to provide any data supporting the claim that more adults returned because transport rates were lower than usual. No Okanogan River or Lake Wenatchee sockeye salmon have been transported for years. Also, starting in 2006, essentially all (ca. 97%) of PIT-tagged SR sockeye salmon have been diverted back to the river. So few have been transported that we would not expect to observe any PIT-tagged adults that were transported as juveniles.
- The memo fails to provide a figure relating average spill to the survival of sockeye detected at RIS as was done for sockeye detected at Lower Granite Dam. The analysis should be consistent for the two groups of fish being examined.
- The memo fails to investigate the extremely high survival rates estimated for the 2006 outmigrations (88% from RIS to JDA for Columbia River populations and 86% for Snake

[3] Only 26% to 47% of the juvenile fish migrating from Redfish Lake typically survive to Lower Granite Dam. In only one year, 1998 did fish survive at rates outside this range (73%). (NMFS unpublished data - 1996 to 2005).

River sockeye). The next highest reported values for these fish are 56% (2007) and 71% (2003), respectively, differences of about 57% and 21%. Similar magnitudes of difference were not observed in survival estimates for other spring migrating species in these years. Changes in survival of this magnitude are surprising. Therefore, these data should be carefully reviewed to ensure that they are not spurious.

- The memo fails to describe how the regressions were "weighted" in this analysis or to provide any assessment of how sensitive these analyses are to the "window" of time used to select which fish are included in the analysis.
- The memo contains many statements like "strong" or "likely" that are NOT supported with statistical results (i.e., significant P-values or high R^2 values). In fact, P-values are not reported for any of the analyses, leaving the reader unable to assess which, if any, of the relationships are statistically significant.

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MEMORANDUM

TO: Scott Bettin, BPA

FROM: Michele DeHart

DATE: July 21, 2008

RE: Adult sockeye return and ocean conditions

In response to your request the FPC staff considered ocean conditions and adult returns. Sockeye mark group data is limited and therefore extensive lifecycle analysis such as that conducted on Chinook and steelhead is not possible. Ocean conditions are important for adult returns. However, out migration conditions that result in high juvenile survival and fast travel time, for optimum ocean entry, are critical in order for juvenile fish to benefit from good ocean conditions.

Analysis of Steelhead and Chinook migration and adult return data, which incorporates ocean conditions, indicates that adult return is related to juvenile migration conditions. The FPC has conducted an analysis on Chinook and steelhead which incorporates ocean conditions, juvenile migration characteristics, juvenile migration conditions and adult returns. The analysis is available on the FPC web site. This analysis of Chinook and steelhead indicates that juvenile passage conditions and specifically increased spill is related to increased adult returns. Sockeye population numbers are extremely depressed so the numbers of marked fish are small. Therefore, a similar analysis on sockeye is not possible at this time. Other analyses such as the multiple linear regression conducted in CSS Ten Year Report (Schaller et al. 2007; Chapter 5) indicates that SARs of Snake River wild spring/summer Chinook were positively correlated with faster water travel time experienced during the smolt migration, cooler phases of the PDO index and stronger downwelling in the fall during first year of ocean residence. Similarly, the Interior Columbia Technical Recovery Team and R. Zabel (2007) analyzed first year ocean survival for Snake River spring/summer Chinook and steelhead and upper Columbia spring Chinook; again, first year ocean survival was significantly related to water travel time experienced by juveniles, spring upwelling or fall downwelling and cooler phases of the PDO.

Good ocean conditions have occurred in past years (1998-2002), but not all of these good ocean years resulted in high returns of sockeye adults.
Our analysis for Chinook and steelhead indicate that 1998 through 2002 were all good ocean years. However, past years with good ocean conditions, in which migration conditions were less favorable and included a higher proportion of sockeye transported (e.g., MY 2001) did not result in high returns of sockeye adults to the Snake River (2003).

The last recent high return of sockeye to the Snake River occurred in 2000, the juvenile migration year of this adult return was 1998 which was a high flow, high spill year. In 2000, 299 adult sockeye were counted at Lower Granite Dam. Most of these individuals would have out-migrated in 1998. Based on our analysis, juveniles out-migrating in 1998 would have experienced the lowest water travel time (and subsequently highest average flow) and second highest average spill percent among the years we analyzed and good ocean conditions.

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