TO: Andrew Kolosseus, Washington Department of Ecology
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FROM: Steven L. Haeseker, USFWS and CSS Oversight Committee member

DATE: June 2, 2008

RE: Response to comments made by John Skalski regarding CSS Study presentation

As part of the TMDL process reviewing forebay gas monitors, the Adaptive Management Team (AMT) requested that the Comparative Survival Study (CSS) authors present the results of their recent Ten-Year Retrospective Summary Report (Schaller et al. 2007) in regard to the effects of spill on smolt migration and survival rates. The CSS retrospective report was coauthored by fifteen scientists from the Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, Columbia River Inter-Tribal Fish Commission, United States Fish and Wildlife Service, and the Fish Passage Center. The CSS Report results presented to the AMT indicated that higher levels of spill during smolt migration years 1998-2006 were associated with:

-reductions in fish travel time (faster migration rates) for both yearling Chinook and steelhead,
-reductions in instantaneous mortality rates of steelhead, and
-increased survival rates for both yearling Chinook and steelhead.

Following the presentation of the CSS results to the AMT, the Bonneville Power Administration (BPA) hired contractor John Skalski to review the AMT summary presentation. It is important to note that a draft of the CSS Report was made available for regional peer review prior to its publication on August 31, 2007. The final report addressed and provided responses to all comments that were received, including those from BPA (Schaller et al. 2007; Appendix H, pages 530-675). With this in mind, it was disappointing to find that several of the comments submitted by John Skalski duplicated the same comments that BPA submitted on the draft report, which the CSS authors previously responded to in Schaller et al. (2007, Appendix H).

The survival estimates submitted by John Skalski in his review appear to be erroneous and contradict those published by the National Marine Fisheries Service. (Williams et al. 2005). It is also perplexing to us that John Skalski criticizes the CSS for using variables capturing seasonal effects (Julian day) , when it is the same method that he himself has used in a peer-reviewed publication modeling the same types of data (Smith et al. 2002). John Skalski's review also includes several statements that are either technically inaccurate or incorrect. As mentioned above, many of the comments in the present review were previously addressed in Schaller et al. (2007) and it is disappointing that the same comments are reiterated in this review.

In sum, the review comments in no way alter the conclusions presented to the AMT that higher levels spill during 1998-2006 were associated with faster migration rates for both yearling Chinook and steelhead, reductions in instantaneous mortality rates of steelhead, and increased survival rates of both yearling Chinook and steelhead. Detailed responses to the review comments are provided below.

John Skalski comment: *An ad hoc approach to estimating the instantaneous mortality rate (Z) is used. Properly, the value of Z is based on the average lifetime* $\overline{T}$ *of the fish within the reach (both alive and dead), where* $\hat{Z} = \frac{1}{\overline{T}}$.

Response: This is the first example of John Skalski reiterating a BPA comment on the draft report that was previously addressed in Schaller et al. (2007; p. 536-537). The previous BPA comment was:

> "*Properly, the maximum likelihood estimate of Z would be based on the likelihood model* $L = \prod_{i=1}^{N} Ze^{-Zt_i}$ *and estimator* $\hat{Z} = \frac{1}{\bar{t}}$, *where* t_i *is the lifetime of the ith fish.*"

In our previous response, as well as now, we recognized that this particular estimator is not applicable in this situation because exact time-of-death data are not collected with PIT-tags. It is unclear why BPA and John Skalski continue to recommend a methodology that that they know cannot be applied. But contrary to John Skalski's comment, there are many ways to properly estimate instantaneous mortality rates, including catch curve analysis, length frequency analysis, mark-recapture experiments, fitting population models, and life-history (or meta-) analysis (Quinn and Deriso 1999; p. 357-362). Our method is an example of using mark-recapture experiments in combination with the exponential survival model to properly estimate instantaneous mortality rates.

John Skalski comment: *The CSS study uses average fish travel time* $(F\hat{T}T)$ *and reach survivals* $(\hat{S})$ *to approximate this value, i.e.,* $Z = \frac{-\ln(\hat{S})}{F\hat{T}T}$. *Th estimate of fish travel time is based on only fish that survive the reach. Hence, the Z value is biased high because the slowest fish are more likely to succumb in a reach.*

Response: Technically, this is an inaccurate description of the methods that were employed in the CSS. The CSS estimated median *FTT*, not average *FTT*. While median FTT is based on fish that survive the reach, survival is based both on fish that do and fish that do not survive the reach. Hence, it is not immediately apparent whether or not the estimator used in the CSS is biased because no technical analysis or simulation results were provided by John Skalski to support his conjecture.

Other methods for estimating instantaneous mortality rates using exact recovery time data (i.e., the type of data available and used within the CSS) include Gulland (1955) and Hearn et al. (1987). By comparing the instantaneous mortality rate estimates using these methods with those used in the CSS, it is apparent that the various estimation approaches

result in similar values (Table 1). Additionally, simulation studies using the fish travel time model of Zabel and Anderson (1997) in combination with the exponential survival model used in the CSS indicate that the CSS estimator has negligible bias, with simulated estimates typically within 3% of their true values (S.L. Haeseker, unpublished data). These two lines of evidence indicate that the instantaneous mortality rate estimator used in the CSS has little, if any, apparent bias.

Table 1. Estimates of instantaneous mortality rates of steelhead (STH) and yearling Chinook (CHN) using the CSS estimator (CSS), the Gulland (1955) estimator (GUL), and the Hearn et al. (1987) estimator (HSH).

Species	Release dates	Year	Reach	GUL	CSS	HSH
STH	May 22-28	1999	LGR-MCN	0.027	0.033	0.030
STH	May 8-14	2005	LGR-MCN	0.057	0.048	0.045
CHN	April 22-28	1998	LGR-MCN	0.018	0.022	0.020
CHN	April 29-May 5	2005	LGR-MCN	0.029	0.037	0.035

John Skalski comment: *From the ROSTER results (http://www.cbr.washington.edu/trends/roster.php), there is not a simple inverse relationship between survival and fish travel time as seen below for the yearling Chinook salmon in the McNary-to-Bonneville reach.*

Response: It is perplexing why John Skalski submits *annual* estimates of survival and fish travel time when the CSS analyzed *weekly* estimates of survival and fish travel time. The estimates submitted by John Skalski are obviously collected at an inappropriate temporal scale for make comparisons with the CSS results. To be clear, the CSS analyses use the exponential survival model to characterize the relationships between median fish travel time, instantaneous mortality, and survival for *weekly* release cohorts. The CSS methods and analyses deliberately avoid using the type of season-wide averages submitted by John Skalski, as averaging can obscure important within-year variation in migration rates, instantaneous mortality rates, and survival rates.

The exponential survival model used within the CSS describes a linear relationship between the natural log of survival (S), instantaneous mortality (Z), and median fish travel time (FTT):

$$\log(\hat{S}) = -Z \cdot F\hat{T}T \qquad \text{(Eqn. 1)}$$

Analogous to techniques of catch curve analysis (Quinn and Deriso 1999; p. 319-323), Equation 1 is of the form of a linear regression with slope = Z and intercept = 0. One way to examine whether the exponential survival model is appropriate for characterizing the relationship between weekly estimates of log(S) and FTT is to conduct randomization tests for the significance of the slope estimate (Manly 1997; p. 148-149). For both yearling Chinook (Table 2) and steelhead (Table 3), there is strong evidence of a linear relationship between weekly estimates of log(S) and FTT, with the slope (Z) characterizing the instantaneous mortality rate. Additionally, as was presented to the AMT, there is evidence that weekly estimates of instantaneous mortality increase over the season. By merely presenting annual estimates of survival and travel time, John

Skalski misses these patterns of within-year variability. Also, the survival estimates submitted by John Skalski in his review appear to be erroneous and contradict those published by the National Marine Fisheries Service (Williams et al. 2005) (Table 4). It is unclear why the estimates submitted by John Skalski differ from the estimates published by NMFS by such a wide margin.

Table 2. Linear regression estimates of the instantaneous mortality rate for weekly release cohorts of wild yearling Chinook from Lower Granite Dam to McNary Dam, 1998-2007. The * denotes that there were too few observations (n = 4) to conduct a randomization test for the first weekly release cohort.

Release dates	Z (slope)	*P* -value
4/1-4/7	0.014	*
4/8-4/14	0.019	0.026
4/15-4/21	0.023	0.036
4/22-4/28	0.028	0.017
4/29-5/5	0.033	0.030
5/6-5/12	0.036	0.008
5/13-5/19	0.040	0.028
5/20-5/26	0.054	0.039

Table 3. Linear regression estimates of the instantaneous mortality rate for weekly release cohorts of wild and hatchery steelhead from Lower Granite Dam to McNary Dam, 1998-2007.

Release dates	Z (slope)	*P* -value
4/17-4/23	0.036	0.008
4/24-4/30	0.061	0.005
5/1-5/7	0.071	0.013
5/8-5/14	0.074	0.029
5/15-5/21	0.094	0.006
5/22-5/28	0.106	0.010

Table 4. Estimates of survival from McNary Dam to Bonneville Dam for yearling Chinook and steelhead during 2000, 2002 and 2003 presented by John Skalski versus those published by the National Marine Fisheries Service (NMFS, Williams et al. 2005). Percent differences between the estimates are also provided.

	Yearling Chinook			Steelhead		
Year	NMFS	Skalski	% difference	NMFS	Skalski	% difference
2000	0.640	0.92	44%	0.580	0.56	-3%
2002	0.763	0.95	25%	0.488	0.61	25%
2003	0.728	0.76	4%	0.510	0.64	25%

John Skalski comment: *Because the CSS estimates of Z are based on reach survivals (S) and fish travel times (FTT), separate analyses of Z, S, and FTT are not independent. In particular, survivals within a season are relatively stable while fish travel times show marked seasonal trends. Using a ratio of this information in the form of the Z value [Eq. (1)] induces seasonal patterns in Z. In part, the trends in Z are nothing more than the inverse trends in fish travel times which are misinterpreted as trends in survival.*

Response: This is the second example of John Skalski reiterating a BPA comment on the draft report that was previously addressed in Schaller et al. (2007; p. 22-31, 54-55). The previous BPA comment was:

> *"survivals within a season are relatively stable while travel times show marked seasonal trends. Using the ratios of this information, Z values are calculated and seasonal trends are (mis)interpreted as survival processes. In fact, the trends in Z are nothing more than inverse trends in travel times misinterpreted or misconstrued as survival effects."*

First, the CSS reported that during 1998-2006 weekly survival rates within a season varied by up to 39 percentage points for both wild Chinook and steelhead, and up to 32 percentage points for hatchery Chinook (Schaller et al. 2007; p. 22). John Skalski himself has published papers showing that within-years, weekly survival rates during 1995-1998 varied by up to 49 percentage points for yearling Chinook and 76 percentage points for steelhead (Muir et al. 2001). Table 5 below demonstrates the high degree of within-year variation in weekly survival rates that John Skalski has published (Muir et al. 2001). We would not characterize this level of variation as being relatively stable and it unclear how John Skalski could reasonably characterize this high level of within-year variation as being "*relatively stable*." Second, variation in *Z* primarily reflects variation in survival rates (r^2 = 0.49-0.58) followed by Julian day (r^2 = 0.35-0.36) (Schaller et al. 2007; Table 2.11, p. 55). Very little of the variation in Z was due to inverse trends in travel times (r^2 = 0.02-0.13) (Schaller et al. 2007; Table 2.11, p. 55). The statements by John Skalski are thus technically inaccurate and incorrect.

Table 5. Weekly survival estimates for hatchery and wild yearling Chinook salmon and steelhead released in the tailrace at Lower Granite Dam to McNary Dam. Data from Muir et al. (2001).

Year	species	Reach	Max. weekly survival	Min. weekly survival	Difference
1995	Chinook	LGR-MCN	0.81	0.32	0.49
1996	Chinook	LGR-MCN	0.85	0.38	0.48
1997	Chinook	LGR-MCN	0.79	0.32	0.47
1998	Chinook	LGR-MCN	0.81	0.63	0.18
1995	steelhead	LGR-MCN	0.83	0.34	0.49
1996	steelhead	LGR-MCN	0.87	0.11	0.76
1997	steelhead	LGR-MCN	0.91	0.48	0.43
1998	steelhead	LGR-MCN	0.71	0.56	0.15

John Skalski comment: *Julian day (seasonality) was included in most or all of the fitted survival and travel time models. Julian date is a surrogate for numerous factors that may have a within-season trend, including smoltification, flows, temperature, turbidity, etc. In some instances, Julian day alone does a good job of modeling the data. Using that variable in the regression models obscures the influence of the other model factors and their relevance in describing flow or spill − survival relationships. Its inclusion in the regression models also makes the predictions seem better than they really are. The degree of this problem can be measured by how correlated Julian day is with the other model variables (e.g., flow, spill, etc.).*

Response: This is the third example of John Skalski reiterating a BPA comment on the draft report that was previously addressed in Schaller et al. (2007; p. 538). The previous BPA comment was:
"Julian date is a surrogate for numerous factors that may have a within-season trend including smoltification, flows, temperature, turbidity, etc. If the purpose of the regression analyses is to describe environmental and hydrosystem factors affecting fish response, inclusion of Julian data obscures the results. In some instances, (e.g., Table 2.15-2.16), it does a very good job all by itself!"

As stated in our response within Schaller et al. (2007; p. 538), the use of Julian day as a covariate to capture seasonal effects is a common modeling strategy with these data (Berggren and Filardo 1993, Smith et al. 2002, Williams et al. 2005). However, these possible seasonal effects (smoltification, photoperiod, fish length/size, predator abundance/activity) are those which are *not* already captured by the other variables examined (flows, temperature, turbidity). It is unclear why John Skalski believes using Julian day *"obscures the influence of other variables"* and *"makes the predictions seem better than they really are*" when he himself has published papers using Julian day in regression models of these same types of data (Smith et al. 2002). His position on using Julian day is inconsistent and untenable.

John Skalski comment: *In summary, the presentation is a restatement of last year's CSS ten-year retrospective summary report. Many of the review comments at that time were not taken into account in this new presentation. While models predicting smolt survival as a function of environmental and operational covariates would be very helpful, the CSS analysis is statistically inadequate for this purpose at this time. Shifting the focus from survival (S) to instantaneous mortality rates (Z), as presented, results only in confusion and should be avoided.*

Response: As was requested by the AMT, the CSS has provided a summary of its retrospective report findings on the effects of spill levels on juvenile travel time, instantaneous mortality rates and survival rates. In Schaller et al. (2007; Appendix H), the CSS provided written responses to all the comments that BPA submitted on the draft report. Despite addressing all of those comments, three were repeated in John Skalski's submission, reflecting his apparent failure to read our responses.

Prior to the CSS retrospective report, the most extensive analysis of the effects of environmental and management factors on smolt survival was Smith et al. (2002), with John Skalski as a co-author. In that work, the authors were able to account for 12% and

20% of the variation in survival rates of yearling Chinook and steelhead, respectively. As a result of the CSS analyses presented in Schaller et al. (2007), the CSS authors have accounted for 63% and 80% of the variation in survival rates of yearling Chinook and steelhead, respectively. This represents a 4-5 fold improvement in the proportion of variation in survival rates explained, using the instantaneous mortality rate approach that was described to the AMT and presented in Schaller et al. (2007). The high degree of accuracy in these results speak for themselves, and along with the responses written above, demonstrate that John Skalski's characterization of this work as being *"statistically inadequate"* and resulting "*only in confusion,"* is without merit and baseless.

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