SCHOOL OF AQUATIC & FISHERY SCIENCES
COLUMBIA BASIN RESEARCH

UNIVERSITY OF WASHINGTON

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Dear John,

RE: Statistical Review of McCann (February 2008) Presentation, "Importance of spill juvenile hydro-system survival and SARs"

Overview

The analysis of spill survival relationships was based largely on the use of an information-theoretic approach (Burnham and Anderson 2002) which has become popular in recent years. This approach to analysis is relatively new and still evolving. Not everyone agrees on exactly how to use it or interpret it, or on its utility (Guthery et al. 2005). Nevertheless, common sense should prevail when analyzing any data. There are a few fundamental concerns with the spill analyses which I wish to summarize.

1. In the analysis of inriver juvenile survival, only three covariates were considered:
    a. Average spill proportion
    b. Water particle travel time
    c. Inseason group release order

    Other variables such as water temperature, turbidity, etc., also known to affect survival were not considered. A thorough analysis should have used a wider range of potential covariates.

2. The so-called "relative weight of evidence" for the individual variables is a term formulated by the presenter. Burnham and Anderson (2002), developers of the concept, call it "relative variable importance" (RVI). It expresses the relative strength of the covariates to each other and has no absolute meaning. The value of RVI depends on the models considered and is very sensitive to the set of models analyzed.

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3. In the first section on inriver survivals, the calculation of the RVI appears to be correct. A balanced set of models with each variable represented an equal number of times was used. In the last section on SARs, however, the calculation of RVI values seems to be incorrect. It appears from the presentation that all or most of the models compared included average spill proportion as a variable. If this is the case, the RVI for that variable will have a value at or near 1 regardless of its importance, simply because of the nature of the models compared. In this situation, the RVI values are not reasonable.

Consequently, the relative weight of evidence as applied in the presentation is an unfortunate misinterpretation of information-theoretic analyses (Burnham and Anderson 2002). Furthermore, it appears the model comparisons performed in the latter half of the presentation were misformulated, resulting in the spill proportion appearing more important than it really is.

Specific Comments on the Presentation

Review comments are provided according to the three main sections of the presentation.

A. Juvenile salmon reach survival analyses

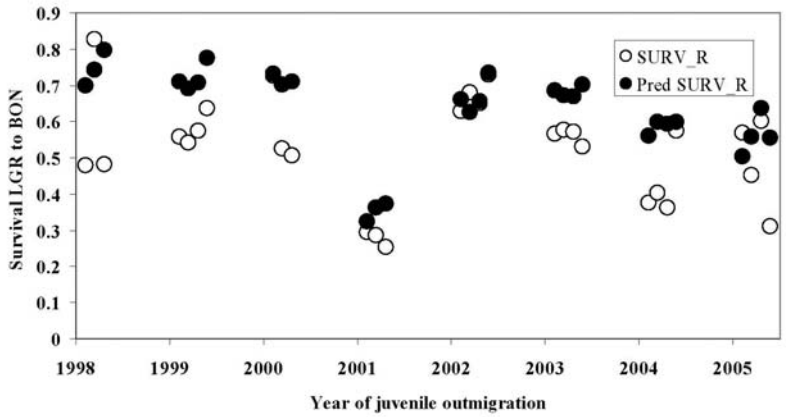
1. Overall, the analyses found average spill proportions to be a useful predictor of spring/summer Chinook salmon smolt inriver survival. However, for steelhead, average spill proportions were no more useful than the other two covariates (water particle travel time and date of group release).

2. The model selection procedure was appropriate with a balanced design of alternative models for the three covariates considered. Of greater concern, however, is that only three covariates were considered in the analyses. Other variables such as water temperature and turbidity, known to affect inriver survival, were not considered. If the goal is to investigate spill–survival relationships, the best way to find it is to exclude alternative explanations.

3. The model averaging approach of Burnham and Anderson (2002) should be based on only "reasonable" models. This means *biologically* and *quantitatively reasonable* models. Unfortunately, "reasonable" is in the eye of the beholder. The author appears to have averaged all models tested. The other approach would consider only models with delta AIC_c of 10 or less from the best model. The consummate model would then change.

4. The fitted model for inriver survival of yearling Chinook salmon seems to possess systematic bias. For the majority of years, predictions exceed observed values.

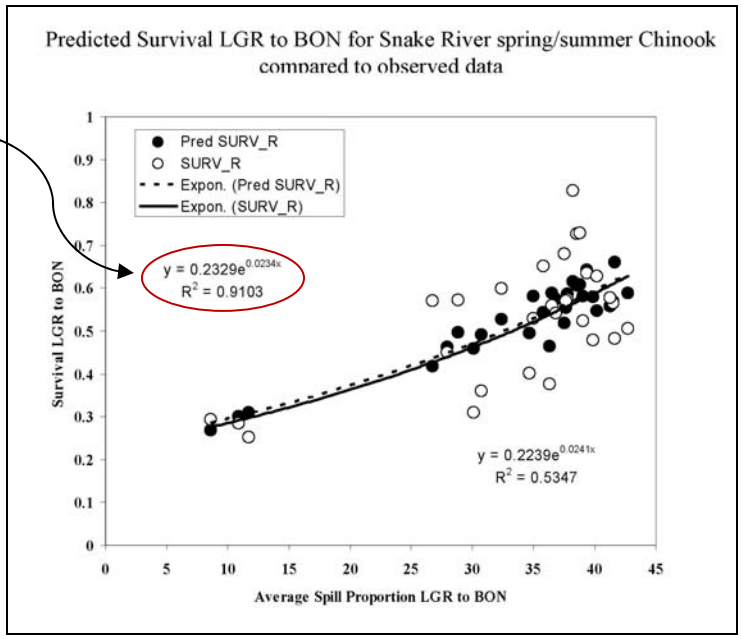
SURV_R compared to Predicted SURV_R (survival from Lower Granite Dam to Bonneville Dam), for Snake River yearling spring/summer Chinook (R^2 = 0.5198).



5. There is a contradiction in the regression results. The multivariate final models have smaller R^2 values than the univariate models with only average spill proportions (Chinook salmon: Model average, R^2 = 0.5198, univariate = 0.5347; steelhead: Model average, R^2 = 0.534, univariate = 0.5467). The R^2 expresses the proportion of variability explained by the regression model. In classical multiple regression, R^2 values increase monotonically as the number of variables increases.

6. In the univariate regression of ln survival against average spill proportion, the author also included a regression of the predicted values (black dots) against spill and obtained high R^2 values. For example, for yearling Chinook salmon, R^2 = 0.9103; steelhead, R^2 = 0.8301). In short, the author used spill to predict survival and then used the predictions to refit the spill model. The resulting conclusion that spill is a good predictor is circular in logic, and thus cannot be supported.

These values are nonsensical and should be ignored.



7. The "weight of evidence" for the various covariates is a term of the author's creation. Burnham and Anderson (2002:168-169) call the quantity the "relative variable importance" (RVI) and state the larger the quantity, the more important the variable is *relative* to the other variables considered. High values do not imply high *absolute* importance. Their values depend on what models were examined. For steelhead, for example, the RVI for average spill proportion is 0.98 while 0.96 for WTT; thus, the average spill proportion is

$$\frac{0.98}{0.96} = 1.0208$$

or 2% more important than WTT. Any other interpretation of RVI is not acceptable.

Weight of evidence for each variable in explaining ln SURV_R for Snake River spring/summer Chinook and steelhead.

	Relative Weight of Evidence for each variable by Species	
Variable	Spr/Smr Chinook	Steelhead
AvgSpillProp	0.97	0.98
WTT	0.85	0.96
Date_Grp	0.28	1.00

B. Juvenile salmon reach survival and relationship to adult returns

1. The presentation uses a creative way of ranking years by oceanographic conditions. However, transforming the four continuous oceanographic variables into a single categorical variable is fraught with problems. Bishop et al. (1975:301) suggests such approaches may be useful as a preliminary step for detecting interactions but the consummate analysis should use the continuous values to avoid loss of information. There are other concerns as well.

    a. The choice to subdivide the ocean data into thirds is arbitrary.

    b. The ranking weights the four oceanographic variables equally, which may or may not be correct if they are correlated—in which case, methods such as principal component analysis would be more appropriate.

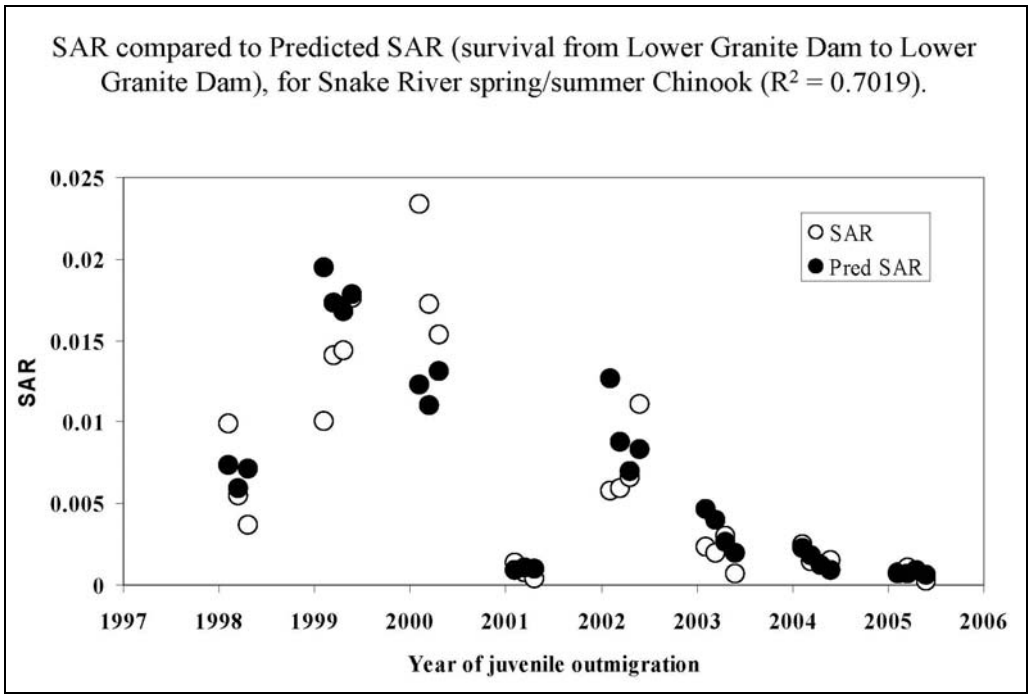
    c. The classification of years into good, moderate, and poor is again arbitrary but also inconsistent. Using the values good (3), moderate (2), and poor (1), as specified in the presentation, the various classifications can be given an overall score. The overall scores indicate contradictions in classification. For example, there are two oceanographic conditions with a score of 9, one classified as a good year, the other as moderate. There are two oceanographic conditions with a score of 7, one classified as moderate, the other as poor.

Summarizing the logic used to classify each year

Good (3)	Moderate (2)	Poor (1)	Overall Category	Overall Score
3	1	0	good	**11**
3	0	1	good	**10**
2	2	0	good	**10**
2	1	1	good	**9**
1	**2**	1	moderate	**8**
1	**3**	0	moderate	**9**
0	**3**	1	moderate	**7**
2	0	2	moderate	**8**
1	0	**3**	poor	**6**
0	1	**3**	poor	**5**
0	2	**2**	poor	**6**
1	1	**2**	poor	**7**

All of these factors suggest a more rigorous and objective handling of oceanographic conditions is required.

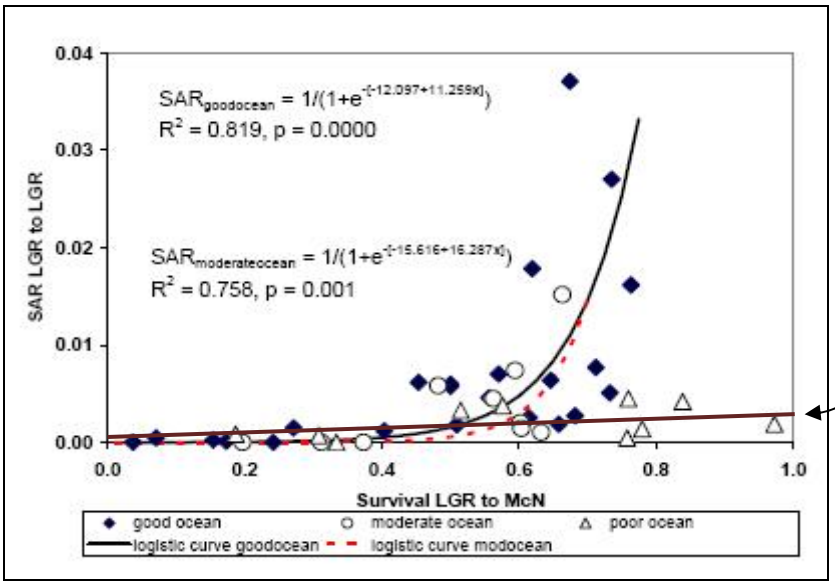
2. The analyses use an inappropriate scale for the observations. Because oceanographic conditions are measured at an annual scale, use of the biweekly release groups is pseudo-replication. Accordingly, the author has four years of poor oceanographic conditions, two years moderate and five years of good on which to base these analyses. All releases within the same year share the same oceanographic conditions, so they are not independent observations but repeated measures.



Thus, analyses should have been based on the 11 yearly observations or adjusted for subsampling. Note in the above figure, SARs within a year are clustered, illustrating their lack of independence within a year, particularly for yearling Chinook salmon.

3. Note that while SAR curves were generated for "good ocean" and "moderate ocean" data, they were not produced for poor ocean conditions. For both yearling Chinook salmon and steelhead, their data indicate SARs are unaffected by inriver survival during poor ocean years. Under any inriver conditions, SARs are at or near zero under poor ocean conditions.

Steelhead



Poor ocean

According to the author, poor ocean conditions occurred during 4 of the last 11 years (1995-1997, 2004), i.e., 36.4% of the time.

B. Relationship between SAR (and SOA) and both inriver and ocean variables

1. The relative variable importance (RVI) results in this section share the same interpretation problem mentioned in the previous section (see comment A7). Again, high values do not imply high absolute importance. The higher the value, the more important this variable is relative to the other variables considered.

Weight of evidence for each variable in explaining variability in adult return data for Snake River spring/summer Chinook and steelhead.

	Relative Weight of Evidence for each variable by Species and Reach			
Variable	Yearling Chinook lnSAR	Yearling Chinook lnSOA	Steelhead lnSAR	Steelhead lnSOA
AvgSpillProp	0.996	0.999	1.000	0.991
May_PDO	0.999	0.999	0.431	0.981
Date_Grp	0.588	0.593	0.985	0.423
Sep_PDO	0.946	0.736	0.178	0.062
WTT	0.258	0.430	0.483	0.375
Apr_Upwell	0.191	0.455	0.081	0.349
Oct_Upwell			0.016	0.130

This time, however, there is also a fundamental analysis flaw. Burnham and Anderson (2002:169) state when assessing the relative importance of variables, it is necessary to achieve a balance in the number of models that contain each variable. It appears that all or at least perhaps most of the models analyzed included the variable for average proportion spill.

Model selection results for **lnSARs** of Snake River steelhead versus environmental variables; Average Spill Proportion, Water Travel Time (days), Date at Lower Granite, April Upwelling, May and Sept. PDO. Smolt migration years were 1998-2005.

Variables in Models	AICc	delta AICc	weight
AvgSpillProp,Date_grp	59.921	0	0.254
AvgSpillProp,Date_grp,May_PDO	60.399	0.478	0.200
AvgSpillProp,WTT,Date_grp	60.873	0.952	0.158
AvgSpillProp,WTT,Date_grp,May_PDO	61.297	1.376	0.128
AvgSpillProp,WTT,Date_grp,May_PDO,Sep_PDO	62.778	2.857	0.061
AvgSpillProp,WTT,Date_grp,Apr_Upwell	63.146	3.225	0.051
AvgSpillProp,Date_grp,Sep_PDO	63.191	3.27	0.050
AvgSpillProp,WTT,Date_grp,Sep_PDO	63.451	3.53	0.044
AvgSpillProp,WTT,Date_grp,Apr_Upwell,May_PDO	65.12	5.199	0.019
AvgSpillProp,WTT,Date_grp,May_PDO,Sep_PDO,Oct_Upwell	65.931	6.01	0.013

By design, then, this action will always result in that variable having an RVI value at or near 1, as reported. As such, the results reported are of little value.

2. In plotting percent fish passing in spill vs. percent spill, the spill efficiency curves that are usually expressed in terms of the ratio

$$\frac{\text{proportion of fish passage}}{\text{proportion of spill}} = \frac{p_F}{p_S}$$

are instead being expressed as an odds ratio,

$$\frac{\left(\dfrac{p_F}{1-p_F}\right)}{\left(\dfrac{p_S}{1-p_S}\right)},$$

which may not be familiar to most people. Note, therefore, an odds ratio of 4:1 does not mean a spill efficiency of 4:1.

Literature Cited

Bishop, Y. M. M., S. E. Fienberg, and P. W. Holland. 1975. Discrete multivariate analysis: Theory and practice. The MIT Press, Cambridge, MA.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference. Springer-Verlag, New York, New York, USA.

Guthery, F. S., L. A. Brennan, M. J. Peterson, and J. J. Lusk. 2005. Information theory in wildlife science: Critique and viewpoint. Journal of Wildlife Management 69:457-465.

I hope this review will be of some help. If we can be of any further assistance, please call.

Sincerely,

John R. Skalski
Professor of Biological Statistics