MEMORANDUM

TO: Tom Iverson,
Confederated Tribes and Bands of the Yakama Nation

FROM: Michele DeHart, FPC

DATE: June 13, 2019

RE: CSS Model Analyses of CRSO EIS alternatives

Subsequent to our telephone conversation discussion of questions regarding Comparative Survival Study (CSS) modelling analyses of the Federal CRSO alternatives, The Fish Passage Center with the CSS Oversight Committee has developed answers to the following questions.

What has the CSS submitted to the federal agencies relative to CRSO EIS alternatives?
The CSS Oversight Committee and the Fish Passage Center submitted predicted survivals at various life stages, including smolt-to-adult return of salmon and steelhead for each of the CRSO EIS alternatives and the No Action Alternative developed by the federal agencies. The analyses submitted to the federal agencies are based upon a suite of statistical models developed over the past two decades by the CSS Oversight Committee. These analyses include the CSS cohort models developed and conducted since 2011 and the Life-cycle model, which began in 2013. The development of these models and the model analyses have been reviewed annually by the Independent Scientific Advisory Board (ISAB) of the Northwest Power and Conservation Council (NPCC).

What is the modelling approach utilized in CSS analyses?
The CSS analyses utilize an empirical statistical modelling approach. This is a very common and wide spread approach in ecological modelling analyses and predictive modelling. (Shenk and Franklin 2001, Ford 2000). CSS model analyses are empirical because they are based upon direct observations, of salmon survival and migration rates and rely on long time-series’ of data.
CSS models are statistical because they characterize the relationships between the sets of variables that best describe the variation in the empirical data, making few assumptions about the underlying processes. Unlike mechanistic models, a statistical model is not dependent upon specific definition of each of the underlying processes that result in the relationships among variables. A statistical model describes the relationships among variables that best explains the variation in the data and effectively makes no assumptions about those relationships.

Why did the CSS pursue statistical modelling approaches?
Statistical models, as opposed to mechanistic modelling approaches, are inherently more successful for predictive purposes because they are not reliant on a large number of parameters and relationships describing the underlying mechanistic processes. (Shmueli 2010) There are many underlying processes that affect upstream and downstream migration and survival of salmon and steelhead. A mechanistic model would require detailed, accurate data and defined mathematical relationships for each of these underlying processes across a wide range of conditions. In the absence of detailed data on the relationships explaining each of these underlying processes, assumptions have to be imposed. The statistical model approach was utilized to avoid the necessity of making assumptions where detailed data are not available. In addition, the statistical modelling approach avoids the problems of over-parameterization, which can result in poor predictive capability (Burnham and Anderson 2002).

What is over-parametrization?
An over-parameterized model is one that has more parameters than can be estimated from the available data or more parameters than are necessary to explain the variation in the data, leading to greater uncertainty. In many mechanistic models, because the data required to estimate specific parameters are not available, some parameters are assumed. Over-parameterization typically results in poor predictive performance, especially in situations where conditions are outside the range of historical observations (e.g., increased spill levels beyond those observed historically) (Breiman 2001) (Everitt 2010).

How were the CSS models developed?
The CSS models are based upon retrospective analyses of three data sets: the long time-series run-reconstruction data set (1956 - 2009), the PIT tag data set (1998 - 2015), and the Grande Ronde tributary abundance and production data sets (1992 - 2009). The CSS models were developed through the Comparative Survival Study project, which is a joint project of the Idaho Department of Fish and Game, the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the Columbia River Inter-tribal Fish Commission, the US Fish and Wildlife Service, and the Fish Passage Center. The process used to develop the statistical models used in the CSS analyses began with workshops held in 2011 and 2013, to consult with regional, national, and international experts in statistical modelling of salmon and steelhead life cycle dynamics. Through these workshops, the CSS conducted research and presented results that identified the most important variables affecting survival at various salmon and steelhead life stages (Marmorek & Hall 2013, Marmorek 2011). Retrospective analyses of these historical data sets were conducted to identify the most important variables affecting life cycle survival, smolt to adult return rates, and identify the best fitting model for the existing data. The best fitting models, the ones that matched the data most closely and avoided over-parameterization, identified water transit time (flow), proportion of river spilled (PITPH), and ocean conditions as
the most important variables affecting smolt to adult return rates. The best fitting models were identified by using Akaike’s Information Criteria (AIC) scores, a ranking method that guards against over-parameterization. Based upon retrospective analyses in 2013, a life cycle model was developed to integrate multiple, interacting populations of salmonids into a common assessment framework. The life cycle model is based on a population model that is statistically fit to empirical juvenile and adult abundance data, as well as time series’ of environmental variables. The statistical fitting results provide a detailed perspective of spatial and temporal variability in SAR estimates, including results on a population-specific level, as well as well as separating overall survival into freshwater and ocean components. The CSS models have continued to be developed and refined over time based upon annual ISAB, agency, and public regional reviews.

The on-going process of CSS model development and analyses is included in the CSS Annual Reports, which are reviewed by the ISAB each year. For ease of reference, Chapter 2 of the 2017 CSS Annual Report is attached, to provide detailed model documentation of the life cycle model (Appendix A). Responses to ISAB review comments and recommendations are appended to each annual report. In addition, the CSS Cohort models and corroborating analyses are described in detail in a document submitted to the ISAB and provided to the region on May 7, 2017 attached here as Appendix B for ease of reference. The model descriptions and model coefficients are identified in the attached detailed appendices for ease of reference.

What are the assumptions inherent in the CSS models?
The primary assumption in the CSS statistical modelling is that the relationships among variables that have been defined by decades of data and observations to date, which are described by mathematical coefficients, will be fundamentally the same in the future. Again, after adhering to standard parametric best practices, the empirical statistical modelling approach adopted by the CSS makes no assumptions about underlying processes.

What are the inputs to the CSS statistical models?
For the Cohort models, the input variables include water transit time, proportion of river spilled (PITPH), date of juvenile release at Lower Granite Dam, and ocean conditions. Similarly, for the Life-cycle model, the input variables include water transit time, proportion of river spilled at each project (PITPH), ocean conditions, and the proportion transported.

What are the fish performance metrics generated by the CSS model analyses?
The CSS models generate predictions of smolt-to-adult return rates, adult abundance, juvenile fish survival, juvenile fish travel time, ocean survival, and Transport:In-river ratios (TIR).

How are CSS model results validated?
CSS model predictions of juvenile fish travel time, juvenile survival, and smolt-to-adult return rates have been compared to actual estimates from monitoring data. Model predictions have closely matched the monitoring data estimates.

Are the CSS models available to the public? Can the public run the CSS models?
Yes, all CSS model coefficients are available to the public. These models are described in the CSS Annual Reports and are reviewed annually by the Independent Scientific Advisory Board. These model coefficients have been summarized in the attached appendices. Any member of the public with some basic knowledge of math could run CSS models utilizing the model coefficients described in the attached appendix. The CSS project is a monitoring project that measures salmon and steelhead performance across their life cycles. The CSS project utilizes empirical statistical models to understand the patterns of juvenile and adult salmon and steelhead survival in the Columbia River Basin. The overall objective of the CSS is to provide analyses to the fishery management agencies and the region to assist them in addressing prevailing salmon and steelhead management questions, and these models provide useful tools for accomplishing this objective.

What kind of software and hardware is necessary to run CSS models?
CSS models do not have any unique software or hardware requirements. The CSS utilizes standard, publicly-available software packages to estimate model coefficients including MARK, R, JAGS, OpenBUGS, and AD Model Builder. As described above, once these coefficients have been estimated, any member of the public with some basic knowledge of math could run the CSS models, using these model coefficients and the equations within or outside of the programs listed above.

What are the most important findings from CSS model analyses?
1. The CSS model analyses have identified water transit time and spill, and the presence of removable spillway weir and temporary spillway weirs for steelhead, as the most important variables affecting smolt to adult return rates for Snake River salmon and steelhead.
2. The CSS model analyses have defined the relationship between smolt-to-adult return rates (SARs) and juvenile route of passage through the hydrosystem, with higher SARs associated with higher proportions of juvenile fish passing through spillways.
3. CSS model analyses have confirmed the relationship between spill, water travel time, and smolt-to-adult return rate with three independent data sets: the run-reconstruction data sets, the PIT tag data sets, and tributary production and abundance data sets.
4. CSS model analyses have demonstrated that levels of direct and delayed mortality are related to powerhouse passage effects.
5. CSS model analyses have provided support and validation of the regional 2-6% SAR goal for specific populations of spring chinook and some steelhead populations.
6. The CSS has generated and managed numerous, long time-series’ of data, including fish travel time, juvenile survival, ocean survival, smolt-to-adult return rates, Transport: In-river Ratios for Columbia and Snake river salmon and steelhead populations, which are all available to the public.
References


Shmueli, G. To explain or to predict. 2010 Statistical Science. Vol. 25. No. 3. 299-310
Appendix A

Chapter 2 of the 2017 CSS Annual Report
Appendix B
Documentation of Experimental Spill Management: Models, Hypotheses, Study Design and Response to the ISAB
May 12, 2017
(Corrected June 2019)