FISH PASSAGE CENTER

1827 NE 44th Avenue, Suite 240, Portland, OR 97213
Phone: (503) 230-4099 Fax: (503) 230-7559
http://www.fpc.org/
e-mail us at fpcstaff@fpc.org

MEMORANDUM

TO: Ed Bowles, ODFW
Guy Norman, WDFW
Rob Lothrop, CRITFC

FROM: Michele DeHart

DATE: February 16, 2006

RE: COMPASS model discussion

On Monday February 13, 2006 state, federal and tribal staff that attended COMPASS meeting held on February 6, 2006 had a telephone conference call to discuss their impressions, comments concerns regarding the development of the COMPASS model to date. Two letters have been sent from the fish managers describing some concerns about the model and its intended use. Those are attached for reference. Those participating in the call were:

Charlie Petrosky	IDFG
Kristen Ryding	WDFW
Margaret Filardo	FPC
Steve Haeseker	USFWS
Earl Weber	CRITFC
Rick Kruger	ODFW
Paul Wilson	USFWS

The discussion participants did not arrive at any conclusions, but the discussion was informative and thoughtful. Complete review will not be possible until the model is completed and validated against empirical information. In addition, the specific intended application of the model is not completely clear. The following points are provided for your consideration in future discussions of the COMPASS model and the intended use of the model in the remand process to determine success in meeting the gap and for in-season passage management.

- The COMPASS model is complex, highly parametized, and requires many parameters and assumptions, much like the previous SIMPASS and CRISP models. The

COMPASS model portends to include two additions that were not included in the previous models: delayed mortality and some treatment of variance around input parameters.

- The comments provided by CRITFC in the development of the COMPASS model distill a primary concern regarding the COMPASS model and it's use, expressing that "..caution should be exercised in the planning phase to prevent the development of a model that implies precision the underlying data can't support." This point is illustrated by recent model results for the McNary to Bonneville reach in which predicted model results differed from actual estimates.
- A model as a tool for developing hypotheses about potential fish responses to potential operational changes within a decision analytic framework is useful. However, the COMPASS model appears to be intended to stand alone as the definitive tool to determine in-season management of fish passage measures, specifically flow and spill levels, and to determine which suite of mitigation measures fill the BIOP "gap" determined by NOAA. Whether the available data is adequate to support the complexity of COMPASS for in season decisions for passage management is questionable.
- One fundamental issue is the context in which the COMPASS model output will be used. A decision analytic framework has not been identified. There are several categories of technical information that are generally considered in natural resource management decisions; analysis of risks, analysis of costs/benefits, natural resource modeling, existing monitoring data and stakeholder preferences. The COMPASS model or a simpler model could be used within a multiple criteria decision analysis framework in the modeling category. However, a decision analysis framework is necessary to fully integrate and evaluate these categories of technical information.

The conference call participants have participated in meetings of the model dam passage/data, reservoir mortality/calibration, and latent mortality sub-committees. There was a wide scope of concerns and impressions from the group regarding the development and potential application of the COMPASS model thus far. There was no overall conclusion from the group at this point. Brief descriptions of the points raised in the discussion follow.

Earl Weber described concerns regarding the reservoir mortality component of the model. He has provided Rich Zabel, NOAA with his concerns in writing. Earl provided his written concerns to the group and those are attached. Earl expressed concern that the lower Columbia reach in particular appeared problematic in the model since the predicted survival from the COMPASS model did not match the actual observed survival for the McNary to Bonneville reach. Earl is considering submitting an alternative approach for the reservoir component.

Paul Wilson explained that the latent/delayed mortality component of the COMPASS model is actually separate and has not been brought into the model at this point. The latent mortality group is developing hypothesis that they will submit to NOAA. Their understanding is that the COMPASS model will be able to incorporate various alternative hypotheses regarding delayed mortality.

The group discussed some of the general concerns regarding the model. Specifically that the COMPASS model is highly complex and "data hungry" with various stages of estimation implemented on little actual data. Some of the technical concerns that have been discussed include:

1. There appear to be four independent stages of estimation, each with very different assumptions, and levels of certainty and quality in the data. Additionally, because these stages are being treated independently, the covariance structure and errors between the data sets are being lost and/or misallocated. Presently, the CRiSP model is being used to estimate the historical dam survivals. This first stage of estimation is based on the current parameters utilized by CRiSP, and may not reflect the results of the few studies that have been conducted on dam survival. The second stage of estimation divides out these estimates of dam survival from the observed reach survival rates to arrive at estimates of reservoir survival. Because there are few studies on dam survival, most of these reservoir survival estimates utilize assumed dam survivals in years and projects where no studies were conducted. Because observed dam survivals, as well as survival rates for specific routes, can and have varied considerably across years and within seasons, the assumed dam survival rates at projects in years without studies do not appear to be tenable. The third stage of estimation is to model the estimated reservoir survivals as functions of various environmental variables. Again, because most of these reservoir survival estimates are largely "made up" based on non-tenable estimates of dam survival in non-studied years and within-season periods, the true sample size for investigating these relationships is greatly over inflated. The fourth stage of estimation has been referred to as "calibration," whereby the migration rates and variability of the arrival distributions are manipulated within COMPASS. It is unclear exactly how these manipulations are conducted or what objective functions or data are used to determine fit. Because the covariance structure and errors between the various data sets is broken by the independent treatment of the estimation stages used in COMPASS, it is likely that the relative strengths/weaknesses of the various data sets is not being accounted for properly and estimation errors are being misallocated.
2. As mentioned above, the COMPASS model appears to be creating data that do not exist and treating those data the same as data which have more of an empirical basis. The vast majority of the dam survival studies only report seasonal survival estimates. Therefore the only reservoir survival estimates that could have empirical support would be seasonal estimates of reservoir survival based on the empirical seasonal dam survival estimates and the empirical seasonal reach survival estimates. Empirical within-season dam survival estimates do not exist for the vast majority of the studies that have been conducted, and therefore the within-season reservoir survival estimates based on within-season dam survival estimates lack an empirical basis and are largely "made up." This is especially true for the cases where seasonal dam survival estimates do not even exist for project/year combinations. Subsequent to the creation of these artificial data, the data are all treated the same, regardless of whether there is an empirical basis or not.
3. There is no weight-of-evidence framework for judging the relative strength of evidence for alternative survival hypotheses or alternative models of in-river passage survival.

While COMPASS developers have expressed a willingness to incorporate alternative hypotheses, the process for evaluating the relative strengths of those hypotheses based on available empirical data has not been formally established. Additionally, a process for evaluating the historical predictive performance of COMPASS relative to other candidate models has not been established. Without a weight-of-evidence framework for evaluating alternative hypotheses or models, it will be difficult to assess the level of certainty that should be placed in prospective forecasts based on those alternative hypotheses and/or models.

4. The time steps used in COMPASS (daily time steps) are not supported by either the PIT-tag data or the dam survival data. The temporal resolution for the PIT-tag data used to date is a week. The temporal resolution of the dam survival data is a season. Breaking these data into a finer temporal resolution than that which exists for the available data does not appear to be scientifically valid or justified.
5. The assumption of population mixing at the dams violates the NMFS assertions of size-dependent collection efficiency, as expressed in the NMFS 2004 Effects Memo. In the Effects Memo, NMFS conducted analyses which concluded that small spring-summer Chinook smolts have a greater tendency to be collected than large spring-summer Chinook smolts. If this assertion is true, then the COMPASS and SIMPAS model assumptions of population mixing, whereby the probability of a fish (regardless of its size) experiencing spill, turbine, or collection is only determined by spill passage efficiency and fish guidance efficiency, is violated. That is, smaller fish would have a greater tendency to be collected and transported or bypassed than large fish, and therefore the smaller-sized members of the populations would be more likely to not experience spillway passage due to incomplete mixing at the dams.
6. Contrary to the assertions in the COMPASS manual, the COMPASS model is highly complex. Depending how one counts them, there are 60-80 parameters that require estimates for the COMPASS model to run. With this level of complexity in a highly data-hungry model, it will be difficult to assess which assumptions are being violated or reasons for lack-of-fit to empirical data. This COMPASS exercise does not advance the recommendations for a much simpler model, expressed by many reviewers of the complex models that have historically been used in the Region (Carpenter et al. 1998-PATH Scientific Review Panel Conclusions, and the ISAB review of the All-H Analyzer).
7. The rejection of data based on ad-hoc criteria does not seem to be appropriate. The COMPASS model documentation describes the developers' approach for rejecting data based on the estimated standard error of the estimates. Given that this model is so data-hungry, rejection of any available data does not seem justified. Instead, the estimation approaches utilized should account for the differences in estimate precision. By this, estimates with low precision would not influence the resulting relationships as much as estimates with high precision. Statistical methods for adopting this approach are readily available, and would be preferable to utilizing ad-hoc criteria or thresholds for precision (e.g., inverse-variance weighted regression).
8. The COMPASS model developers propose to adopt only one "best fit" reservoir survival relationship, ignoring model uncertainty. As stated in the COMPASS

documentation, preliminary investigations several alternative forms of reservoir survival functions achieved nearly the same level of fit. However, only one representation of the reservoir survival model is proposed to be carried forward. This approach ignores model uncertainty, whereby alternative models which achieve nearly the same level of fit are ignored. Reporting the results of only one model, when several others are nearly as likely, overstates the certainty in the predictions based on that model. Again, some sort of weight-of-evidence approach is warranted, where the level of evidence for the various alternative models is assessed, and this uncertainty is carried forward in the reporting of prospective forecasts.

9. There appears to be substantial bias in the lower river reservoir survival estimates generated by COMPASS for spring-summer Chinook. The COMPASS documentation has presented graphs depicting the COMPASS estimates of reservoir survival versus "observed" estimates of reservoir survival, and the COMPASS estimates are much greater than the "observed" estimates when the "observed" estimates are low. An important clarification of this information is that the "observed" values are not observed, but simply reservoir survival estimates generated by dividing PIT-tag reach survival estimates by CRiSP estimates of dam survival. Nevertheless, there is a substantial departure between the COMPASS model predictions and the reservoir survival values used in the fitting. Given the high complexity of COMPASS, it is unclear how one could ever resolve the reason for this disparity.
10. It is still unclear how or whether the COMPASS "gap" analyses will be consistent with or use the same assumptions and input data as the Framework analysis assigning proportion of total mortality to the hydrosystem and other Hs. It would seem that there needs to be some level of interaction between these two groups to ensure that the sets of input data that have been considered, the assumptions that have been used, and the approaches that have been taken are all mutually consistent.

Passage Model Design Considerations
Earl Weber
Columbia River Inter-Tribal Fish Commission
January 23, 2006

Background

NMFS has formed several collaborative working groups to assist in the development new Biological Opinion for listed Salmon stocks. One of working groups is developing a new passage model to replace a series of models used in the past. To date the effort has focused on the passage survival of Snake River spring/summer Chinook and, although other stocks could be assessed, it is doubtful that will happen in the near future because time constraints. This document examines some biological relationships and lists some precepts that may be useful in the development of the passage model.

Passage model applications

The most immediate use of the passage model under development will be to estimate the increase in survival thought to be possible through various management actions that presumably will be delineated in a forthcoming RPA (Reasonable and Prudent Alternative). Therefore, the group is being asked to develop an analytical tool before knowing what exactly will be analyzed. However, management actions will likely fall into several categories represented in former management proposals, namely flow augmentation, spill augmentation of some sort, and dam breaching. A forth category, temperature modification is usually associated with summer rather than spring migrants. Thus the first precept is that the eventual model should have the capability to address the survival increases associated with flow, spill, dam breaching and temperature management, if need be.

Note that the estimated survival increases will be used to determine the degree to which the management actions associate with the RPA will fill the “gap” identified within the “framework” working group. Note also that the passage model will address only direct survival increases and delayed mortality associated with transportation and expressed as the “D” statistic. The model will not estimate any potential reductions in “latent mortality” experienced by fish migrating inriver as identified by the post Bonneville mortality working group. Substantial levels of mortality attributable to the hydro system have been identified by several authors (Deriso et al 2001; Schaller et al. 1999; FPC/CSS 2004). Although passage models traditionally have not addressed reductions in latent mortality, previous modeling efforts assumed reductions in latent mortality proportionate to the estimated reductions in direct mainstem mortality estimates.

Data sources and limitations

The development of the passage model is employing mainstem survival data estimated on a weekly basis from PIT tags, for years 1998 through 2005. The data set that has been developed separates the mainstem into two reaches, Lower Granite Dam to McNary Dam, and McNary Dam to Bonneville Dam. However, because there are too few fish surviving through the entire reach, estimates in the lower reach include fish from the Upper Columbia River that have joined their Snake River counterparts in McNary Pool.

Flow data originate with the U. S. Army Corps of Engineers. Rather than use flow directly, however, this approach uses estimated water travel time for several reasons:

1. Using flow to explain variability in system survival is complicated because there are two flows, one in the Snake and one in the Columbia River, and they are not highly correlated. Using water travel time eliminates this problem.
2. The underlying assumption behind this approach is that fish survival depends on travel time (duration) rather than flow per se.
3. Water travel time (and velocity) depend on the reservoir volume, not just the flow, because of differences in cross sectional area.
4. Alternative variables, such as flow or mortality per mile, do not comport with changes in survival following impoundment or, what changes in survival would be expected following breaching.

Water travel times are estimated using the replacement method (the time require for a given inflow to fill a given reservoir) and thus should be viewed as an indices rather that empirical estimates.

Also, fish travel time could be used instead of water travel time but that would add another layer of complexity against the wishes of previous reviewers who have argued for less complexity. Also, because water travel time is readily converted from flow data, the 60 year flow record can be used to provide a probability distribution of water travel times that can be used to represent long term annual environment variability, as proposed herein, for stochastic simulations. The relationship between weekly estimates of water travel time and fish travel time are shown in Figure I.

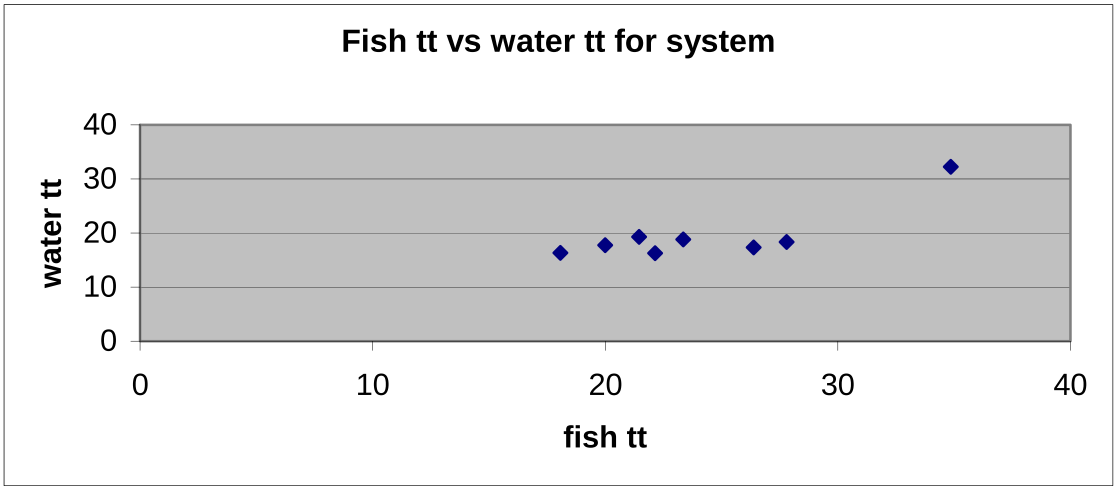

Figure 1. Relation of fish travel time and water travel time for the hydrosystem.
Annual estimates of both water travel time and fish travel time were estimated by weighting weekly estimates by the number of fish tagged during that week.

[Reservoir volumes are provided by the U. S. Army Corps of Engineers. The 60-year record of flows at all projects is available through Bonneville Power Administration and the Northwest Power and Conservation Council.]

Reservoir survival

Passage models, now and in the past, typically estimate the mortality associated with each dam as a preliminary step. Then, given an estimate of system survival, the dam survival is backed out leaving an estimate of system (total) reservoir survival. Water travel time may also be used to allocate reservoir survival among the reservoirs. [This allocation is necessary to simulate transport operations in which inter-dam mortality affects the number of fish collected.]

Weekly estimates of survival, water travel time and temperature were each weighted by the number of fish tagged during the week to provide annual estimates. The relationship between survival and water travel time is shown in Figure 2.

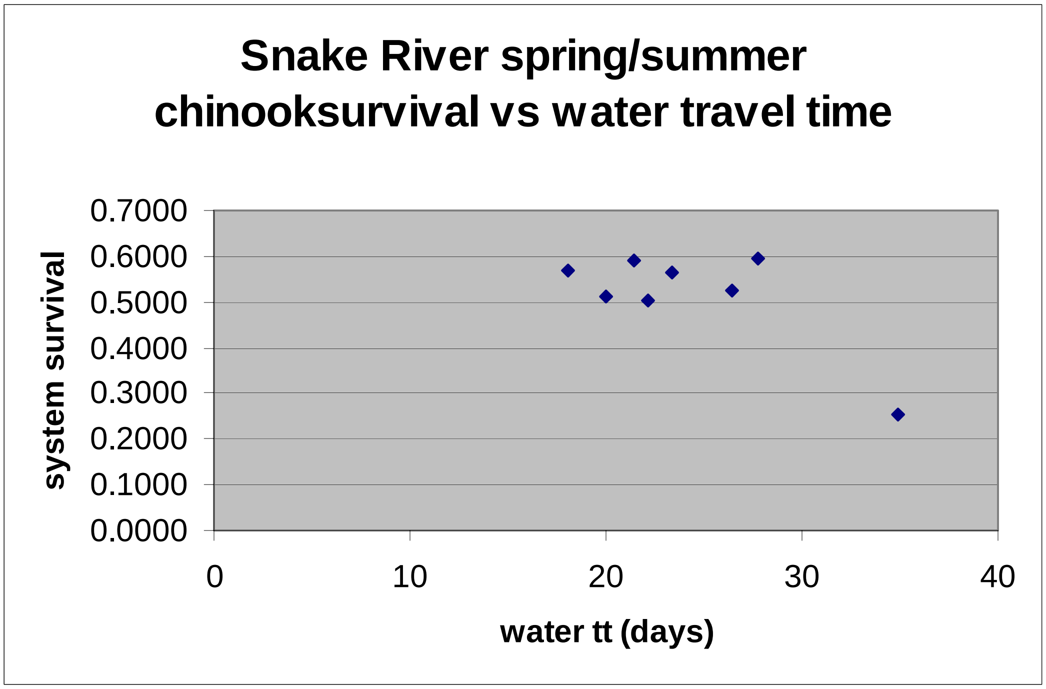

Figure 2. Relationship between mainstem survival and water travel time for Snake River spring/summer Chinook for years 1998 through 2005.

The eventual relationship will be influenced by the 2001 migration year (lower right). This relationship indicates that in years of poor flow (high water travel times) fish survive at relatively low levels.

The relationship between survival and temperature is shown in Figure 3.

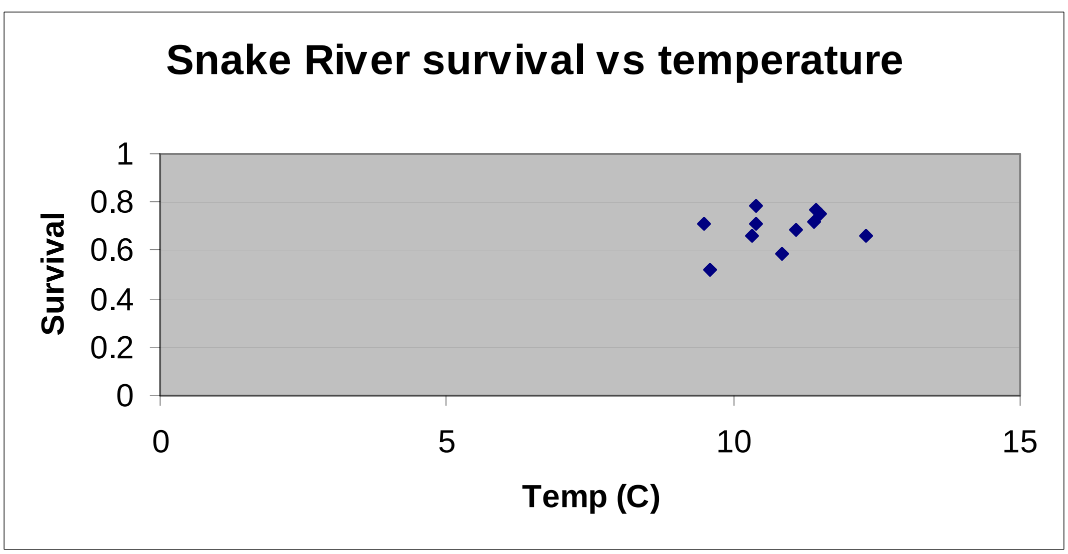

Figure 3. Relationship between survival and temperature for Snake River spring/summer Chinook, for years 1998 through 2005.

Unlike the relationship with flow, temperature effects appear to be more random in nature. This result was not unexpected because temperature appears to be an environmental cue for the fish that vary their migration timing to fit the temperature window. Because of the apparent lack of predictive value, and because temperature modification is unlikely to be proposed as a management action for spring migrants, it is tentatively proposed that temperature not be used as a model variable.

Note that spill is assumed to affect dam survival rather than reservoir survival. Thus in prospective simulations, spill actions, including the effects of Removable Spillway Weirs if they are part of the RPA, would result in an increase in dam, not reservoir survival. If spill actions, or any other actions such as dam breaching, seem likely to reduce latent mortality, such reductions can be simulated as described previously.

Discussion

The considerations discussed herein are intended to guide passage model development and are not intended as a proposed model at this point. This approach, or any other, should be considered tentative until its specific uses are identified. This approach is aimed at guiding the development of a fairly uncomplicated simulation tool for assessing the potential survival increases associated with management actions that are likely to be proposed. While more complex models can certainly be developed, their use may not be justified, particularly in light of past review comments urging simplicity. For example, temperature may affect fish behavior and survival in a manner that is too complex for a model in which temperature management actions, such as cold-water releases, are not anticipated. See attached McCann document for a discussion on temperature and fish survival.

Model complexity, in a broader sense, may be severely constrained simply due to data limitations. The data set for dam passage is incomplete and what data are available have been collected under a narrow range of conditions. This affects model accuracy because reservoir survival is the residual after the assumed dam effects have been backed out. In short, because data are not available for all dams, during all years, under all conditions, even partitioning dam survival from reservoir survival should not be assumed to be highly accurate.

Inriver survival estimates are problematic also. As noted previously, inriver survival estimates for Snake River spring/summer Chinook include Chinook from Columbia River stocks in the lower reach because of low sample sizes and poor survival. For three years, 1995 through 1998, no estimates at all are available for the lower reach even though estimates in the upper reach are. In all years data in the lower reach require more aggregation so that fewer blocks exist relative to the upper (Snake River) reach.

For these reasons, caution should be exercised during the planning phase to prevent the development of a model that implies precision the underlying data can't support. Some members of the working group have suggested a time step of one day or less. This would seem to be unrealistic given that the data set in use is arranged in weekly tag release groups and those are frequently aggregated into larger time steps to provide adequate sample sizes. For example, there is currently interest in limiting transportation to only that part of the migration season where a benefit is likely. However, the only preliminary assessment to determine when transport should begin uses data from quartiles not weeks or days.

Thus the argument can be made that assessments of this sort should be conducted with conventional spreadsheets and statistical programs and reserving passage models as fairly straightforward simulation tools. If a large, complex model that few can use or even understand is developed, there is a very real risk of repeating past mistakes and developing a black box that divides the region on important passage issues instead of uniting it.