Approach and Scope of New Work

Models of complex systems like the Bay-Delta may be enhanced by an iterative process of model construction, evaluation, and modification. Given the January 1, 2009 completion date, we are concerned that there will be little opportunity for such an iterative process. Without such opportunities for "hands on" evaluation of the Statistical Models, there is a high probability that they will be constructed and forgotten. If additional time can be devoted to the current project for this iterative model development process, there are also opportunities to incorporate ongoing studies funded by CALFED and other agencies into the parameter estimates of the Statistical Models. There is an existing mechanism for incorporating information from empirical studies into the Statistical Models (Figure 1, Task 6) through Bayesian updating of parameter estimates. In addition, the decision analysis task (Figure 1, Task 8) in the Statistical Model proposal may be improved to incorporate an active adaptive management framework (e.g., Walters 1986).

The objectives of the new scope of work are to:

1) Make the models more useful to the Bay Delta community
2) Incorporate results of recently completed, or expected to be completed, empirical studies into the models

3) Improve the evaluation of management alternatives by incorporating the process of feedback policy design (adaptive management) into the models (i.e., use the models as a tool for learning about the population dynamics and how management may influence that learning process).

Task 1: Model Technical Review and Public Presentation

Models can only aid in understanding if they are used. Carl Walters (1986) has stated that, "When you... recognize modeling as a very human way of groping for understanding, it should be obvious who will benefit most from it: those who engage in it directly." The goal of the first task is to get the Statistical Models into the hands of as many interested parties as possible. Further, previous approaches to modeling Chinook salmon on the Columbia River may provide some insight into how to accomplish this task. Some key lessons learned from the Plan for Analyzing and Testing Hypotheses (PATH) identified by Marmorek and Peters (2001) were:

> *(1) build trust through independent technical facilitation and multiple levels of peer review (agency scientists, independent participating scientists and an external Scientific Review Panel); (2) clarify critical uncertainties by developing common data sets, detailed sensitivity analyses, and thorough retrospective analyses of the weight of evidence for key alternative hypotheses; (3) clarify advice to decision makers by using an integrated life cycle model and decision analysis framework to evaluate the robustness of potential recovery actions under alternative states of nature; (4) involve key senior scientists with access to decision makers; (5) work closely with policy makers to clearly communicate analyses in non-technical terms and provide input into the creation of management alternatives; and (6) recognize the trade-off between collaboration and timely completion of assignments.*

Task 1.1 Technical Model Review

To address the first two points raised by Marmorek and Peters (2001), technical personnel need to have a chance to review the models, identify shortcomings, and see those shortcomings addressed. This process is imperative if there is to be any confidence in the models and their subsequent forecasts.

Workshops lasting 1 to 2 days will be conducted for each model to evaluate the technical aspects of models and receive review comments. Following the workshops, the models will be modified to improve their technical merit. A technical memorandum describing comments received and modifications to the model structure to address those comments will be completed as a deliverable.

Task 1.2 Multiple CV Chinook Model Evaluation

Multiple competing models may cause confusion rather than facilitate understanding of a system under study. For example, competition between the Columbia River Salmon Passage Model (CRiSP; Anderson et al. 1996) and Fish Leaving Under Several Hypotheses (FLUSH; Wilson 1994) created confusion in factors affecting Chinook salmon passage on the Columbia River. Additional analysis of these models for decision making was eventually required through the Plan for Analyzing and Testing Hypotheses (PATH; Peters and Marmorek 2001). Models of

winter run Chinook salmon have been developed, and a spring run model is currently under construction by SP Cramer for the California Department of Water Resources. In the hopes of avoiding the CRiSP – FLUSH scenario in the Bay-Delta, we propose to engage the technical teams currently developing population models for winter and spring run Chinook in a series of workshops to develop a consensus on the modeling approaches.

Two technical workshops lasting 1 to 2 days will be conducted for each Chinook run to evaluate the technical underpinnings of the alternative population models being constructed by SP Cramer and DWR. A technical memorandum evaluating the SP Cramer and DWR models relative to the Statistical Models will be completed as the deliverable.

Task 1.3 Public Engagement of CV Chinook Models

To improve the usefulness of the models, stakeholders, policy managers, decision makers, and other interested members of the public need to be exposed to the models and have the opportunity to have their questions addressed. Development of simplified Statistical Models that can be used by individuals who do not have a strong quantitative background was the goal in the original proposal (Figure 1, Task 9 Web-based Interactive Model); however, engaging and educating the public in using the simplified Models will require interaction. The importance of connecting with policy and decision makers was also identified by Marmorek and Peters (2001) in items 4 and 5 listed above. We propose to conduct workshops that present the simplified Models in non-technical terms for managers and stake holders.

A one day workshop will be conducted for each Chinook run to introduce the models and provide the opportunity to game with a simplified version of the model. The simplified versions of the Models will also be made available on the web-page (Figure 1, Task 9) for online interaction.

Task 2: Incorporate Additional Information into the Model Structure

In the framework for the Statistical Models, there is a quantitative mechanism for incorporation of information from empirical studies (namely through the use of informative priors). Data from recently completed (or ongoing) empirical studies may provide important contributions to reducing uncertainty in specific life history stage parameters by either a) improving the information that can be provided from an existing data source, or b) providing direct estimates of particular Model parameters through empirical studies.

Two studies, among others that may provide information valuable to winter and spring run Statistical Models are:

- Studies to estimate the abundance of winter and spring run Chinook salmon migrating past Chipps Island. This study, lead by Pat Brandes U.S. Fish and Wildlife Service, uses genetic samples of Chinook captured in the Chipps Island trawls and estimates of gear efficiency to expand trawl counts to estimated abundances of winter and spring run Chinook. These abundance estimates are at a critical location within the Bay-Delta and would reflect the effects of stressors within the Delta. The abundance estimates from Brandes' study may be incorporated into the Statistical Models providing another time series from which to estimate the population dynamics (Figure 1, Tasks 2 and 3).

- Studies to evaluate the proportion of the outmigrating smolt population using specific migration routes and the mortality rates associated with specific routes. Acoustic tagging of hatchery smolts from Coleman National Fish Hatchery will be monitored through an array of passive acoustic receivers being maintained by large consortium of agencies (http://californiafishtracking.ucdavis.edu/index.html). Data from this study may identify the migratory pathways and estimate survival rates along those pathways. Because the smolts used in the acoustic study are late fall and fall run Chinook, the results of the study may have to be evaluated with caution when applying them to spring run Chinook, and may not be suitable for application to winter run. Still, such estimates could potentially help reduce the uncertainty in the spring run lower Sacramento and Delta survival rates in the spring run Statistical Model (Figure 1, Task 2).

Task 3: Exploration of Active Adaptive Management

Adaptive management is an important approach to management in the CALFED science program evaluation, and in salmon recovery planning in general (e.g., NMFS 2007). Forecast modeling can be used to design actively adaptive management programs, and the specific design matrices in an actively adaptive program can be evaluated prior to implementation through model simulations (Hilborn and Walters 1992). In particular, forecasts of the winter and spring run Chinook Statistical Models can be used to "game" with specific active adaptive management decision matrices to: 1) compare adaptive designs with static decision rules for reaching recovery goals of the population; 2) provide an opportunity for learning about the system by including the influence of management on the types of future data that are likely to be collected; and 3) evaluate the time frame over which learning (reducing uncertainty in competing hypotheses) may take place.

Although there may be many benefits to using an adaptive management framework (e.g., NMFS 2007), the question remains as to what rates of learning can be expected in different management designs. As an example of how the Statistical Models could be used to evaluate active adaptive management in the Delta, a hypothetical application is presented: habitat limitation in the spawning population size of winter run Chinook.

Historical run sizes of winter run Chinook were notably higher than current levels (Botsford and Brittnacher 1998); however, there has also been a change in the spawning habitat. Winter run Chinook are confined to spawning in specific locations below Keswick Dam (CDFG 2004). The distribution of spawners in the reaches below Keswick Dam has been variable and there are a couple factors (among others) that may influence the spawning distribution: improved passage at the Anderson Cottonwood Irrigation District (ACID) Dam, and temperature releases from Keswick Dam. Given the goal of naturally producing 110,000 winter run Chinook in the upper Sacramento River as part of the Anadromous Fish Restoration Plan (AFRP, USFWS 2001), there are two (oversimplified) competing hypotheses: spawning habitat will be limiting versus spawning habitat will not be limiting.

There are several courses of policy making at this point in order to resolve these two hypotheses: remain with the status quo and attempt to discern whether the spawning habitat is limiting (passive adaptive management), try a series of random alterations to the spawning channel (trial and error adaptive policy), or develop a set of experiments that would balance learning about the

influence of habitat limitation while balancing the conservation status of winter run Chinook (active adaptive management) (Hilborn and Walters 1992). Experiments in this hypothetical example might consist of manipulating the 56°F compliance point through management of the temperature control device at Shasta Dam (e.g., Jellys Ferry in 2002 and Balls Ferry in 2003, CDFG 2004). The active adaptive approach has the requirement of considerably more modeling and evaluation of stock response to experiments; however, it may also have the highest potential for identifying which of the two hypotheses is correct (Walters 1986). Furthermore, by performing simulation experiments with the winter run Chinook Statistical Model, an estimate of the time required to identify which of the two hypotheses was correct could be calculated (e.g., Walters 1986 Chapter 7).

We propose to hold a meeting to identify particular questions that may be amenable to implementing an active adaptive management approach with the winter and spring run Chinook Statistical Models. A technical memorandum describing the details of the workshop, the questions amenable to testing, the subsequent model runs, and comparisons among policy options will be completed as the deliverable.

Table 2.Table of tasks for supplemental funding of A Statistical Model of Central Valley Chinook Incorporating Uncertainty.

Task	Name	Personnel	Description	Deliverable	Budget
1.1	***Technical Model Review***	Hendrix, Noble Hilborn, Ray Greene, Correigh, Beechie, Tim DeVries, Paul Reiser, Dudley Loftus, Michael Nightengale, Tim Olson, Alan Programmer	Technical review of models and subsequent modification of model structures to address comments	Memo describing comments received and modifications to address those comments for winter and spring run models	$63,684
1.2	***Multiple CV Chinook Model Evaluation***	Hendrix, Noble Hilborn, Ray Greene, Correigh, Beechie, Tim Programmer	Technical workshops with developers of other winter and spring run models (SP Cramer and Associates) to evaluate alternative models	Memo describing the underpinnings of each of the alternative models and potential mechanisms for reconciling differences among models	$28,342
1.3	***Public Engagement of CV Chinook Models***	Hendrix, Noble Hilborn, Ray Greene, Correigh Beechie, Tim Programmer	Public workshops to introduce statistical models in a non-technical manner using simplified versions of statistical models	Production of simplified models for distribution via web page	$33,794
2	***Incorporate Additional Information into the Modeling Structure***	Hendrix, Noble Hilborn, Ray Greene, Correigh, Beechie, Tim Programmer Reiser, Dudley DeVries, Paul	Evaluate ongoing or recently completed empirical studies for information that may reduce uncertainty in model parameters	Memo describing the manner in which the additional information was used in the model structure	$46,911
3	***Exploration of Active Adaptive Management***	Hendrix, Noble Hilborn, Ray Greene, Correigh, Beechie, Tim DeVries, Paul Reiser, Dudley Loftus, Michael Nightengale, Tim Olson, Alan Programmer	Identify particular questions about winter and spring run that may be amenable to adaptive management approaches, run simulations with the statistical models to evaluate the potential for active adaptive management	Memo describing the questions addressed, the active adaptive management approach, and the results of simulating active adaptive management with the statistical models	$86,783
4	***Report Preparation and Project Management***	Hendrix, Noble R2 Staff Programmer	Prepare semiannual reports for CBDA, correspond with CBDA and respond to comments	Semiannual progress reports to CBDA, final report to CBDA	$36,928