A Statistical Model of Central Valley Chinook Incorporating Uncertainty

Grant Agreement 08WRGR0013

Final Report

Prepared for CALFED

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The objectives of the supplemental funds for the Statistical Model of Central Valley Chinook Incorporating Uncertainty were to understand how the OBAN (Oncorhynchus Bayesian Analysis) model could be improved through technical review and evaluation of other models in the Delta (Task 1), through additional data (Task 2), and through evaluation of alternative management approaches (Task 3). A description of each of the task objectives, the degree to which those objectives were met, and a summary of the results from the task are described below. We conclude with a short section describing the importance of the work completed under the supplemental funds for the CALFED Science Program.

Tasks

Task 1: Model technical review and public presentation

The objectives of the first task were to: 1) provide an opportunity for the scientific community in the Bay-Delta and elsewhere to critique the OBAN model; and 2) to evaluate linkages to other models in the Bay-Delta that could expand the OBAN model.

Summary of Results

Noble Hendrix gave presentations to the Bay-Delta community (e.g., Biennial CALFED Science Conference in 2010, Presentation to NMFS Biologists in June 2010) as well as to technical audiences outside of the Bay-Delta community (Quantitative Seminar Series at University of Washington School of Aquatic and Fisheries Sciences, November 2010). Over the time period of the contract, such presentations provided an opportunity for scientists to gain familiarity with the OBAN modeling framework. Comments received on the winter OBAN model were incorporated into the model structure where appropriate, and the model structure was improved through the iterative process of model review and subsequent alteration.

During the period of June – December 2011, Dr. Hendrix and Mr. Nightengale completed a Technical Memorandum evaluating the Delta Passage Model (DPM) constructed by Cramer Fish Sciences (Multiple Central Valley Chinook Model Evaluation). . The review of the DPM provided insight into Cramer Fish Sciences' approach to modeling the complexities of the Delta and the potential for the DPM and OBAN to be viewed as competing models. While both models are focused on winter Chinook, they have different objectives (the DPM is an outmigrant smolt model whereas OBAN is a full life-cycle). Instead it was determined that there was some functionality to the DPM that would benefit OBAN; namely the Delta portion of the model was described in greater spatial detail in the DPM. Overall, the DPM was found to have a nice user interface that made evaluation of the components easy to follow. Unfortunately, some DPM model assumptions were not well supported by the available data, and we provided additional sources of information that could improve the DPM as part of the Technical Memorandum. Although the Delta Passage Model provides some improvement in the spatial treatment of the Delta relative to OBAN, the functions used to route fish and calculate survival among the spatially explicit representation of the Delta may require some revision in order to be consistent with current scientific expertise of the system. Still, reviewing the model provided insight into the need for greater spatial detail in the OBAN model to take advantage of acoustic tagging studies that have been conducted in the Delta (see Task 2).

Ultimately, the potential for linking OBAN to a spatially explicit population dynamics model for the Delta is appealing, although the spatially explicit model will likely not be the DPM.

Task 2: Incorporate additional information into the model structure

The OBAN model is a statistical model that is fit to indices of abundance data; therefore, incorporating additional indices of abundance has the potential to improve model performance. There were two data sets that were evaluated to determine if they could improve the statistical inference of the OBAN model: 1) abundance indices at Chipps Island, which provides a key site due to its location at the end of the Delta but before the Gulf of the Farallones; and 2) mortality and movement information collected from acoustic tagged late fall Chinook.

Summary of Results

Incorporating Chipps Island data into the winter OBAN model. To assess the value of juvenile abundance data collected at Chipps Island by the USFWS, we incorporated these data into an OBAN model. The OBAN model with Chipps data was compared to a previous OBAN model that lacked these data. The modeling results indicated the sensitivity of the OBAN model to indices of abundance for evaluating population dynamics in the ocean versus in the Delta.

Incorporating acoustic survey data into the winter OBAN model. The proposal identified acoustic tagging studies as potential sources of additional data to augment the abundance indices used in previous versions of the OBAN models. We reviewed the work based on tagging hatchery smolts from Coleman National Fish Hatchery and monitoring them through an array of passive acoustic receivers set throughout the Bay-Delta ecosystem. The goal of using these data was to identify the migratory pathways and estimate survival rates along those pathways for inclusion into the OBAN modeling framework.

We reviewed many of the studies involved with the acoustic tagging work (e.g., Perry and Skalski 2008, Perry and Skalski 2009, and Perry 2010, among others) in the evaluation of the Delta Passage Model (Task 1). We decided not to attempt to include the acoustic tag data for two reasons:

1) Given the spatially explicit nature of the data, we would need to reconstruct the OBAN model. The utility of these data are tied to having a more explicit representation of the Delta, and one needs to model the relative survival among different routes explicitly. The level of work required to construct a new OBAN model was beyond the current scope, so we proposed to build a Delta specific model as part of a proposal with the University of Washington for the 2011 PSP.
2) We could have tried to use an overall survival estimate from the acoustic data to "pin down" the survival through the lower Sacramento and Delta, but this has some issues too. The size differences between acoustically tagged fish and winter run smolts may have caused different behavior by the acoustic tagged fish relative to winter run fish. These differences may provide counter-intuitive results that are likely based on these size differenences. For example, highly channelized reaches provided higher survival for acoustic tagged fish than reaches with greater channel complexity. The hypothesis to explain this result is that the acoustic tagged fish are using migratory corridors to leave the system as fast as possible, thus these types of reaches are

well-suited to moving rapidly. They may not be so great for fish trying to find a place to grow bigger before heading out, such as winter run.

The current Chipps Island indices of abundance have several important assumptions that caused us to use caution evaluating the OBAN model that incorporated them. The evaluations of these data were detailed in the Technical Memorandum for Task 2 (Evaluating Chipps Island data with the winter run OBAN model). While Chipps Island does provide an important location for collecting salmonid data, the current abundance estimates at Chipps Island do not appear to be consistent with previously used data sets (escapement estimates and juvenile abundance estimates at Red Bluff Diversion Dam). This result could have been due to the use of size at time criteria for partitioning Chinook smolts, or due to the assumptions in the expansion factors used to calculate abundance from catch. Efforts by USFWS to use genetic race identification and more precise expansion of catch to abundance could provide higher quality data in the future for inclusion into the OBAN and other modeling efforts, however.

Task 3: Exploration of Active Adaptive Management

One useful aspect of models is the ability to simulate future observations by making assumptions about the structure of the system. We used the OBAN model to simulate future data sets depending upon the type of management approach (no adaptive management, passive adaptive management, and active adaptive management).

Adaptive management assumes that the management process can be used learn about the natural system being investigated. The process of identifying competing hypotheses, formalizing those hypotheses into specific models, and collecting data to test which of the competing models is best supported by the available data is the process of passive adaptive management. In contrast, active adaptive management is the process by which specific objectives are identified by stakeholders, and management actions are tied to achieving those objectives *apriori*. In contrast, the default management approach is often to stick with the status quo until faced with some set of circumstances that require a reactionary alteration (i.e., threat of extinction). We described the last type as no adaptive management. We assessed the precision in estimates of a biological quantity of interest by using data collected under each of these three management approaches. The biological quantity of interest was the carrying capacity of spawning habitat below Keswick Dam; therefore, we simulated future data sets of winter run adult escapement and juvenile counts at Red Bluff Diversion Dam under each of the 3 management approaches.

Summary of Results

The simulations provided insight into how management can be used to learn about important biological relationships, such as capacity limitations. We simulated 50 trajectories of data collected under no, passive, and active adaptive management approaches over 50 years. Management was able to modify the levels of fresh water exports depending upon the juvenile abundances at RBDD and modify the level of harvest depending upon the number of 2 year old returns. Each 50 year time series was then analyzed using a Beverton Holt stock recruitment model to estimate the productivity and capacity in the spawning reach below Keswick Dam. Of the three management approaches, the active adaptive management approach provided estimates of capacity that were least the biased and had the smallest 95% probability

intervals. The passive adaptive framework provided less precise estimates of capacity, whereas no adaptive management provided the least precise estimates of capacity and in several cases (7 of 50 data sets) was unable to provide a capacity estimate. The results of this analysis suggests that adaptive management may have an important role in helping to structure management decisions in the Bay-Delta, particularly for biological reference points such as carrying capacity. These results support a rather contrarian idea that periods of high abundances of winter run may be the time to reduce harvest and reduce exports, if one is interested in learning about capacity. Such a proposal may run counter to the "share the pain and share the gain" approach that is being practiced.

Relevance to the CALFED Science Program

The work proposed in the supplemental request had an objective of enhancing the understanding and improving the overall reliability of the OBAN statistical models so they can be more effectively and efficiently used for evaluating potential management and restoration options. There has been substantial progress on this goal from January 2010 to December 2011. For example, the OBAN model has become one of the tools being used to evaluate the proposed project under the Bay Delta Conservation Plan. The OBAN model was selected for this purpose due to familiarity with the modeling tool and its growing acceptance among the Bay-Delta science community as a useful model.

Other goals of developing the OBAN statistical models were 1) to understand how management actions are likely to affect the populations of winter and spring run Chinook, 2) how the data collection methods may provide observations of those populations, and 3) how the management process may improve or hinder learning about key biological uncertainties. These objectives have been met to varying degrees over the 2010 – 2011 period of this funding proposal. This project has confirmed previously obtained results that winter run population dynamics are affected by temperature in the spawning reaches, flows in the mainstem Sacramento, export levels in the Delta, and harvest in the ocean. These relationships have been known for some time. This project did identify wind-stress curl in the Gulf of Farallones as a factor that is likely affecting winter run as well as other races of Chinook in the Central Valley. Finally, this project has made some improvements in quantifying the uncertainty in projected population abundances through use of Bayesian estimation techniques and subsequent forecasts.

There has been some progress made toward objective 2 through the evaluation of Chipps Island data. While the existing Chipps Island indices of abundance appear to conflict with other sources of data in the winter run life-cycle, Chipps Island remains one of the important data collection points in the Bay-Delta ecosystem. Further use of data within the Delta will likely require more precise identification of the run than the size at length criteria currently in use. With such improvements, it is possible that the Chipps trawl data as well as information from the CVP and SWP salvage may provide important indices of abundance that can be used in the OBAN modeling framework.

Finally, there has been some progress made toward understanding how the management process affects data that could be collected in the future. Our results indicate that there is value in developing management approaches that are either passively or actively adaptive. In the analysis we conducted, the no adaptive management approach provided little new information on the biological parameter of interest

after an additional 50 years of data collection. This result is one that most scientists and managers would like to avoid, i.e., no improvement in understanding after an additional 50 years of data. The alternative is to formalize an active or passive adaptive management approach in the Central Valley to ensure that there is an overall improvement in learning over time. While this analysis was relatively simple in nature, it highlights the importance of explicitly integrating active or passive adaptive management into the management framework as soon as possible.

Budget Summary

From July to December 31 2010, approximately $52,000 was invoiced to the CALFED grant for work completed primarily on Tasks 1 through 3. Work during the reporting period was completed primarily by Dr. Hendrix and Mr. Tim Nightengale. The budget was expended by December 31, 2011 at the close of the contract.

Literature Cited

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