Independent Review of the 2008 NMFS Analytical Framework for its OCAP Biological Opinion

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CALFED Science Review Panel

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I. Introduction and Background

This is the first report of the Review Panel[1] (Panel) convened by the CALFED Science Program to review the Biological Opinion (BO) on the Long-Term Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) expected in 2009. The BO assesses the effects of the continued operations of the CVP and SWP on listed Sacramento River winter-run Chinook salmon (*O. tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), Central California Coast steelhead (*O. mykiss*), Southern Oregon/Northern California Coast coho salmon (*O. tshawytscha*), Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*), and Southern Resident killer whales (*Orcinus orca*). This review was voluntary and was initiated at the request of the National Marine Fisheries Service's (NMFS) Sacramento Office.

The initial BO on the CVP/SWP OCAP was issued by the NMFS, Southwest Region, in October 2004. That BO was reviewed by an earlier CALFED review panel and two reviewers (Dr. Thomas McMahon and Dr. Jean-Jacques Maguire) from the Center for Independent Experts (CIE) at the University of Miami. These reviews were then reviewed by a team of NMFS scientists assembled from NMFS Science Centers. All reviews are available on the CALFED web site for OCAP reviews: http://www.science.calwater.ca.gov/events/reviews/review_ocap.html.

NMFS is in the process of revising the 2004 BO and requested a review of the analytical framework (AF) for the 2009 BO as the BO is being prepared. The AF specifies the technical analyses that NMFS will use to produce the BO. This Panel was convened and given a two-part charge:

(1) Evaluate and comment on the AF.
(2) Review the draft BO.

This report relates to the first charge: a review of the AF. Four specific questions for review of the NMFS' AF were posed to the Panel:

1. Does the analytical approach fully address the concerns described in the independent peer review reports of the NMFS 2004 OCAP biological opinion (CALFED Science Program, January 3, 2006; McMahon and Maguire, Center for Independent Experts; January 2006; and NMFS Science Center, May 25, 2006)?

2. Does the AF fully incorporate the framework presented by Lindley et al. (2007), "Framework for Assessing Viability of Threatened and Endangered Chinook and Steelhead in the Sacramento-San Joaquin Basin?"

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[1] Disclosure: Dr. Rose is also a member of the U.S. Fish and Wildlife Service (USFWS) review panel on their ecological effects analysis. Dr. Smith was also a member of the USFWS OCAP Delta Smelt Actions Evaluation Team.

3. Does the analytical approach fully explain how the exposure, response, and risk to listed individuals, populations, and diversity groups resulting from project operations will be assessed?

4. Does the analytical approach describe a method that allows evaluation of combined project operations effects on the listed species?

We first summarize the review process (Section II). We then make a summary statement concerning the merits of the AF and offer suggestions for next steps (Section III). Section IV is the panel's responses to the four questions. Finally, we list our major technical comments. We emphasize this is a review of the AF planned for the BO that relies heavily on the information and model results presented in the Biological Assessment (BA) prepared by the U.S. Bureau of Reclamation and the California Department of Water Resources. Our focus is on the AF itself and the scientific basis and validity of how the information (most of which is found in the BA but also from other sources) will be used in the AF. We were not charged with, nor had the time, to systematically review the BA, which will be used as an information source in the AF. A separate report is planned to address the second charge to the Panel of reviewing the BO itself, including details of the information used in analyses.

II. Review Process

The Panel initially met in Sacramento on August 5, 2008. Prior to this meeting, a draft document prepared by NMFS describing the AF was circulated to the Panel. NMFS staff also gave presentations at the meeting (see OCAP website cited above), and engaged the Panel in discussion.

At the meeting, the Panel determined that more details about the AF would help the review process and enable the Panel to provide more useful comments. The Panel requested that NMFS provide a mock analysis illustrating how two different actions would be analyzed using the AF to illustrate to the Panel how the AF would use the available information. The Panel also suggested that NMFS prepare a summary of how the AF addresses the comments of the four previous reviews.

NMFS provided the requested supplemental information. The Panel received the mock analysis on August 8, 2008 (Appendix A), and received a summary of NMFS' responses to reviewers on September 16, 2008 (Appendix B).

The Panel and NMFS staff had a conference call on August 29, 2008, after the mock analysis was reviewed by the Panel. During this conference call, the charge to the Panel was further refined. The four questions were not changed, but the Panel was provided access to a draft of the recently revised BA in order to better answer the questions. Providing the most useful review is a challenge because of the severe time constraints in the preparation of the BO, the relatively small size of this Panel, and the large amount of information involved with the analyses. The Panel met briefly again

during the CALFED Science Conference on October 23, 2008 to distill everyone's comments and to continue Panel discussions about the AF.

The Panel had some difficulty in conducting this review. We strongly support NMFS in seeking peer-review and feedback on the AF before it develops the BO. However, it was a challenge for the Panel to work with a draft document that did not include many of the details of how the analyses will actually be done. Some of our comments arise because of lack of details, and not because of problems with the AF. We offer comments in the hopes of providing guidance to improve the science underlying the AF, and thus the BO. Because of the generality of the AF described, we cannot be assured that our comments are comprehensive; important issues can arise with the details of the analyses not apparent in a general description.

III. Summary Statement

The Panel endorses the AF described by NMFS as a significant step in the right direction towards a comprehensive and transparent analysis of the effects of project operations on listed species of concern. The preparation of the AF does address one of the major comments from the earlier reviews. When fully implemented, the AF will enable a much clearer roadmap of the data, assumptions, and logic of the effects analysis that will underlie the decisions in the BO on whether the projects will jeopardize or conserve the listed species. The Panel cannot fully endorse the AF at this time because issues may arise in the implementation of the AF that are not apparent in the general description provided to the Panel, and because the last few steps in the AF are unclear. The lack of details and incomplete last steps prevented the Panel from making straightforward "yes" responses to the four questions posed to the Panel.

The Panel strongly encourages the continued development of the AF into the next phase of implementation. We recommend: (a) clear documentation of the logic used in selecting which effects are potentially important and which are ultimately quantified, (b) further extension of the existing AF to relate individual effects to population responses and then to species risks, so the AF culminates in a table similar to Table 1 from Lindley et al. (2007), (c) more specific definition of baseline conditions and evaluation of the CALSIM-II simulated scenarios for their realism, (d) development of a bookkeeping method to keep track of the uncertainties and conservatism of assumptions (protective of the species) associated with the various steps in the analyses and how combining uncertainties and assumptions from the multiple individual steps might affect a final overall assessment of jeopardy or no jeopardy, and (e) some formatting and organization details to improve clarity.

The Panel recommends that NMFS continue with the current AF and move towards the details of implementing and formulating a theoretically sound method for relating individual and stage-specific effects to population responses and species risks. The Panel suggests NMFS use a "vertical" analysis at this point (i.e., take a few examples like in the mock analysis and truly fill out the values and get the analyses all the way

through to the end). Further, the Panel recommends a standing committee, or group of advisors, or Panel similar to this (acknowledging the self-serving aspects of a Panel recommending a panel) to provide rapid feedback as findings and conclusions become apparent from the vertical analysis and perhaps help with population responses and species risks. The USFWS seems to have used this approach successfully in the development of their effects analysis for delta smelt. The Panel does not know the expertise or availability of everyone working on the BO but if technical questions or time constraints arise, the Panel suggests that NMFS should ensure the team has easy access to expertise in salmon life history, biology and population dynamics. Conducting this analysis is challenging and having a small group of advisors for quick feedback should be helpful. Some of these suggestions may be obvious but the Panel would be remiss if we did not at least mention them.

IV. Panel Responses to Questions

1. Does the analytical approach fully address the concerns described in the independent peer review reports of the NMFS 2004 OCAP biological opinion?

The Panel's answer is a qualified "yes". The AF directly addresses the overarching issue in the CALFED review of the need for an analytical framework, and represents significant progress towards addressing two other overarching issues: need for a conceptual framework and a life cycle approach. The current AF does not completely address all possible aspects of these issues, mostly due to its general description and the lack of sufficient detail in the final few steps. The pieces are now nearly all present for a comprehensive and defensible analysis of the effects of operations on the listed species of concern. The AF should also make use of other tools available, such as the conceptual models in the Delta Regional Ecosystem Restoration Implementation Plan (CALFED 2007), which would help with completing a conceptual framework that nicely integrates with the AF. The Panel urges continued development of the AF as described by the NMFS, with careful attention to the details of how the results tables, as provided in the mock analyses, are filled out, and integrated with life cycle information that will be presented in other sections of the BO. The missing piece is how to relate individual and stage effects to population responses, which can then be related to species risks.

As an aside, the Panel adds that the AF, and the analyses presented in the revised BA upon which the AF heavily relies, represents a sincere effort to address many of the comments in the previous reviews. We are not at this point commenting on how well the analyses were done, but are encouraged by the richer suite of analyses available for this BO. It is very clear and encouraging that the comments of the earlier reviews were carefully considered by NMFS as they proceeded with the new BO.

2. Does the AF fully incorporate the framework presented by Lindley et al. (2007)?

The Panel's answer is "almost yes." We believe that the AF can eventually fully incorporate the Lindley et al. framework but there are several key steps that are either undefined or missing in the current version of the AF. The steps from the response analyses (critical habitat and listed species) to the risk analysis are not described in any detail. In particular, determining effects on individuals within life stages seems doable, but then how to scale those individual effects to population responses and relate the population responses to species risks as listed in Table 1 in Lindley et al. are not specified in the AF. The general conceptual model for assessing species risk and reaching a jeopardy or no jeopardy conclusion is given in Figure 1 of the AF. The decision-making approach is defined in Tables 2 and 3 of the AF. How these tables will be used to rationalize a jeopardy or no-jeopardy decision was not clear. The Panel offers some suggested approaches in Comment 1.

3. Does the analytical approach fully explain how the exposure, response, and risk to listed individuals, populations, and diversity groups resulting from project operations will be assessed?

The Panel's answer is no, not in its current form. There are several major steps that are not described in any detail. The middle of the AF (determining effects on individuals and life stages) appears doable and tractable. The AF lays out a nice structure for identifying the temporal and spatial impact of operations on individuals in particular life stages. However, the AF needs to be strengthened in its beginning and ending steps. The beginning needs to lay out the life cycle and possible effects of operations, from which a shorter list of effects will emerge when the practicality of doing the analysis and expectations of the likely magnitude of effects are factored in. The life cycle and ecology of the species will be covered in other sections of the BO, and the critical habitat analysis that involves defining of the primary constituent elements (PCEs) also forces life cycle thinking. The Panel wants to be sure that there is a high level of integration among these pieces. As mentioned above, the AF needs a clear way at the end to get from individual effects through population and species responses, culminating in the information needed as input to Table 1 in Lindley et al. or a similarly constructed table.

4. Does the analytical approach describe a method that allows evaluation of combined project operations effects on the listed species?

The Panel's answer is that the AF has the potential to succeed and is a major step in the right direction, but in the form provided to the Panel, is missing several steps. When fully fleshed out with details, the AF should be able to provide a defensible and systematic analysis of the effects of operations on salmon species. Not all effects can be quantified, but they should in the AF, at a minimum, be acknowledged in the analysis. How well the AF will perform with the species other than the salmon species is less clear. For example, the AF may default to many blank entries and unknowns for steelhead to

the point that the use of the AF may be uninformative. The killer whales analysis will require information on their bioenergetics and foraging behavior in the marine environment. The Panel is aware such information is being collected but it was not clear how this would meld with the AF. The AF also did not discuss in detail how to deal with missing information and sparse analysis. For example, will information be used from other species? How will conservatism be built into the analysis? If the final BO does not deal effectively with these issues, it will be difficult to have confidence in its conclusion.

V. Major Technical Comments

Comment 1—"The Final Steps"

The AF does not clearly state the details of how the key final steps in the analysis — extending individual effects to population responses and then to species risks — will be accomplished. The AF uses the Lindley et al. (2007) paper as its foundation. Lindley et al. was prepared by the Central Valley Technical Recovery Team (TRT) and applies the Viable Salmon Population (VSP) concept (McElhany et al. 2000) that outlines approaches for conservation planning of Pacific salmonids. The goal of the TRT Framework was to assess viability and ways to integrate population level assessments into ESU viability.

A key part of Lindley et al. is their table 1 (reproduced here as Table 1). Population viability was divided into low, moderate and high risks of extinction with five elements determining which category a population belonged to. Multiple populations that comprise an ESU are then assessed for their individual status, and their spatial arrangement relative to historical distributions, each other, and risk of catastrophic events in order to arrive at a ESU (species) level conclusion. A major conclusion of Lindley et al. is that Central Valley salmon exist in a small portion of their historical range and so the species are vulnerable to catastrophic disturbance.

Table 1. TRT criteria for assessing the level of risk of extinction for populations of CV salmonids. Overall risk is determined by the highest risk score for any category. Reproduced from Lindley et al. (2007). Populations risk and viability are inversely related so high risk equates to low viability.

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size > 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.
[c] Run size has declined to $\leq$ 500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline < 90% but biologically significant.
[f] See Figure 1 for assessing hatchery impacts.

The AF must go further than present status and predict how proposed operations will affect future status. In this context, the results of the AF need to be put in the context of Table 1. How will future operations affect the status of listed species? The AF assesses temporal and spatial impacts of operations on specific life stages in Boolean, qualitative, and quantitative measures.

The AF, drawing directly from the viable salmonid population (VSP) guidelines in McElhany et al. (2000), defines measures of population viability in terms of: 1) abundance, 2) population growth rate, 3) spatial structure, and 4) diversity. However, as the TRT noted in Lindley et al. (2007), "McElhany et al. (2000) did not provide quantitative criteria that would allow one to assess whether particular populations or ESUs are viable." The TRT sought a way out of this problem by developing biologically-relevant criteria that are generic to *Oncorhynchus* species. The result is Table 1 above and consequently the AF and TRT measures of viability do not have a one-to-one correspondence. In the AF, whether or not actions affect the viability measures (abundance, growth, structure, diversity) are designated yes/no and are accompanied by brief explanations. While these responses can be related the TRT categories 2-5, there are caveats that need to be considered if the AF measures are used to assess population viability by the TRT criteria-based approach. Some of the differences between the AF

and TRT approaches are illustrated in Table 2. The AF should describe how the VSP criteria will be used with the TRT categories, or similar table.

Table 2. Comparison of the AF and TRT categories.

AF category affected (yes/no)	TRT Category in Table 1	Comment
Abundance	2. Population size	AF considers a qualitative increase or decrease in abundance while the TRT assessment considered abundance in terms of the impact on inbreeding, which decreases genetic diversity.
Population growth rate (productivity)	3. Population decline	AF considers qualitative changes in growth rate while the TRT considered a categorical ranking of population decline over 2 generations.
Spatial structure	4. Catastrophe	AF considers spatial structure in terms of whether or not an action limits the spatial range of the habitat. The TRT considered spatial structure in terms of the relationship between the ESU spatial structure and specific large-scale events such as volcanic eruptions, wildfires and droughts.
Diversity	5. Hatchery influence plus life-history diversity	The AF considers genetic diversity and phenotypic (life-history) diversity such as run timing. The TRT considered genetic diversity associated with hatchery influence but did not explicitly consider life-history diversity.

Life stage impacts in many instances are made qualitatively from inferences and limited information. It appears the AF has not established a procedure for how to use qualitative information in assessing how an action will fit into the TRT category states. This issue is important and needs further discussion if NMFS' final product is a risk table like Table 1.

The AF will also generate some quantitative estimates of operations effects on life stage vital rates. The measures are developed by linking models of changes in the environment with changes in life stage growth, reproduction, or survival. A model exists for effects of temperature and water withdrawals on early life history stages. In the Mock analysis, the effects of actions were expressed in terms of % increase in mortality at a specific life stage (e.g. 5% increase in egg mortality).

The step from a suite of individual and life stage-specific responses that are Boolean, qualitative, or quantitative to the population response is very challenging. In an

ideal world, there would be a full life cycle, spatially-explicit population model that everyone believes and all important impacts would be quantified with confidence so that predicted population dynamics would be viewed in absolute terms of numbers. We simply do not know enough to do this uniformly and consistently across the entire spatial distribution, across species of concern, and across all impacts. The careful use of the SALMOD and IOS salmon modeling results from the BA is strongly encouraged by the Panel, although these models should be evaluated for their appropriateness and realism for the specific scenarios of the BO.

So how do we get from qualitative and quantitative stage-specific changes in vital rates to population responses? There are several possible approaches. The Panel discusses two possible approaches below, although neither has been sufficiently vetted. We offer these as starting points that need further thought and review. The Panel did not have the time to completely work out the details of these approaches but offer them in their unbaked form to encourage similar thinking about the "final steps." Even if these cannot be implemented, perhaps they will encourage thinking about the process. The approaches are spawner-recruit modeling and life table analysis. There are also other models that could be adapted, such as the Dennis extinction model (Dennis et al. 1991) and other simple population viability analysis (PVA) models (Beissinger and McCullough 2002; Holmes 2004). We focus on the spawner-recruit and life table because they seem relatively easy to adapt to the AF.

Short-term declines with a spawner-recruit model

One approach is to use expected short-term declines in the populations, coupled with their spatial diversity. We suggest that population decline (Category 3 in Table 1) can be expressed as a probability statement. To modify Table 1, we suggest expressing population decline of 10%/yr as a probability statement that specifically fits into the three levels of risk in Table 1:

- for low risk, the probability of short term decline is less than p_1
- for medium risk, the probability of short term decline is greater than $p_1$but less than p_2
- for high risk, the probability of short term decline is greater than p_2

We define the ratio R of the population from one year or cohort to the next year or cohort:

$$R = \frac{N_{t+1}}{N_t} \tag{1}$$

where N_t is a random variable of population sizes at years or cohorts t and $t + 1$. We can then define R^* as the TRT criterion for a decline in population level. Using the 10% decline from Table 1, $R^* = 0.9$ and $\log(R^*) = -0.105$. The probability of a decline greater than R^* for the low, medium, and high risk states can then be calculated (Table 3).

Table 3. Definitions of risk based on probabilities of short term population decline. R* is a threshold level of decline.

Risk level	Probability statement
Low	$\Pr\left(\log R < \log R^*\right) < p_1$
Medium	$p_1 < \Pr\left(\log R < \log R^*\right) < p_2$
High	$\Pr\left(\log R < \log R^*\right) > p_2$

Judgment is used to define values for p_1 and p_2 (e.g., we might set $p_1 = 0.2$ and $p_2 = 0.8$). The ratio R can be estimated from a full life-cycle model or from a spawner-recruit equation that uses inputs from life stage survivals reported in the BA and from other sources.

When a full life cycle model is not available, the population decline could be approximated by a density independent spawner-recruit equation

$$R = \frac{N_{t+1}}{N_t} = \exp\left(\log F - \sum_j a_j - \sum_j \Delta a_j - \sum_j \varepsilon_j \right) \tag{2}$$

where N_t is the spawner population size at cohort t and N_{t+1} is spawner size at cohort $t + 1$, F is fecundity, a_j is the baseline mortality rates for each life stage j, Δa_j are the variations in the mortality rates as a result of actions in each life stage and ε_j is a normally distributed (or some appropriate distribution) variation in the mortality rate for each life stage.

If a historical baseline is not available then we suggest assuming that the population is sustainable prior to the actions (i.e., stable). In effect, by assuming a stable population we estimate minimum impacts of the actions. Note that because eq. (2) has no density dependence the sustainable population is independent of the population level. With the assumption of a stable population prior to the implementation of actions then by definition $R = 1$ and $\Delta a_j = 0$ and so $\log F = \sum_j a_j$. When actions affect one or more life stages (i.e., $\Delta a_j \neq 0$ for some j) and then their effect on the population decline can be expressed

$$\log R = -\sum_j \Delta a_j - \sum_j \varepsilon_j \tag{3}$$

To link life-stage specific model results to the probability of decline, we require a measure of the relative effect of actions on survival (S). To illustrate the approach express the life stage models in the general form

$$S_j = \exp\left(-a_j\left(X_j\right)\right) \tag{4}$$

where a_j is the rate of mortality in life stage j and depends on the random environmental variable X_j. Define the values of the variable in the baseline and with the action as $X_{j,baseline}$ and $X_{j,action}$ then the relative effect of the action on the life-stage survival is

$$\log \frac{S_{j,action}}{S_{j,baseline}} = -a_j\left(X_{j,action}\right) + a_j\left(X_{j,baseline}\right). \tag{5}$$

If we can assume that $\log\left(S_{j,action}/S_{j,baseline}\right)$ is normally distributed with a mean $\Delta a_j = \overline{-a_j\left(X_{j,action}\right) + a_j\left(X_{j,baseline}\right)}$ and variance σ_j^2 then the distribution characterizes the fractional survival effect of the action relative to the baseline. The change in environmental factor could be estimated numerically from life-stage models run successively over a number of years with and without the action (i.e. baseline + actions vs. baseline).

Information from the life stage models is then linked to species effects through probability. That is, the probability of exceeding the rate of decline R^* is

$$\Pr\left(\log R < \log R^*\right) = \Phi\left(\frac{\log R^* - \sum_j \Delta a_j}{\sum_j \sigma_j}\right) \tag{6}$$

where Φ is the cumulative normal distribution and Δa_j and σ_j are determined from runs of the life stage survival models.

The link between population model output and the species effect with Table 3 could also be calculated directly with a life cycle model that estimates the spawner-recruit or year-to-year population trend, *R*. This approach is essentially a population viability analysis where the life cycle model generates a time series of population levels where the actions are included in the life-stage survival components. In the simplest approach, assume the year-to-year trend is normally distributed then

$$\Pr\left(\log R < \log R^*\right) = \Phi\left(\frac{\log R^* - \mu}{\sigma}\right) \tag{7}$$

where μ is the mean trend, i.e. $\mu = \log\left(N_{t+1}/N_t\right)$, and σ is its standard deviation.

Population Growth Rate and Sensitivities from Life Table

A second possible approach would be to construct density-independent life tables for the species of interest that result in matrix projection models. Life tables and matrix projection models can be organized around life stages and can easily deal with 2-3 spatial regions that allows for different vital rates for the same life stage located in different sub-regions (Hunter and Caswell 2005). The approach is very flexible and has been used for many species, and specifically for Chinook salmon (Wilson 2003). Much of the information needed to seed the life table, at least for the well-studied salmon populations, are available in the BA, and other documents. The life table then is easily converted to a matrix projection model. Stage-specific survival and durations are entered into formulas (see Caswell 2000), that convert the survivals and durations into elements of the matrix model. The POPTOOLS add-in to Excel can then be used to analyze the matrix

projection model to obtain population attributes, such as finite growth rate (λ) and elasticity. Finite growth rate is the fractional change in the population per year over the long-term, and elasticity is the sensitivity of the finite population growth rate to elements of the life table. So one could then change the survival rates in the life table, convert these to changes in the appropriate elements of the matrix model, and compute changes in population growth rate. Quantitative changes in rates from the AF can be directly input to the life table, while qualitative and Boolean impacts can be bracketed with low, medium, and high estimates. Elasticity can be used to provide information on which life stages are particularly important to affecting the population growth rate. If there are large, or many, impacts to a sensitive life stage, then this would raise the concern level.

Comment 2—Baseline

The AF does not explicitly state what will be used as the baseline conditions. The usual approach is to use a simulated case (e.g., study 6.1) as baseline and compare the other studies to this simulated baseline. Indeed, this was the approach used in the current BA and the earlier BO. Another approach is to use empirical data in recent times as the baseline. The Panel recommends that the various candidate studies presented in the BO be carefully examined for their realism, specifically the assumptions made in the many aspects of current operations now and into the future and how actions that have official ending times in the near future (e.g., EWA, VAMP) are represented. How well are actions such as the permanent barriers operated in the South Delta, an intertie between the California Aqueduct and the Delta-Mendota Canal, the Freeport Regional Water Project (FRWP), changes in the operation of the Red Bluff Diversion Dam (RBDD), the Sacramento River Water Reliability Project, the Alternative Intake Project for CCWD, the operational elements of the American River Flow Management Standard, and others represented in the simulated scenarios? The Panel assumes reasonable assumptions were made as the scenarios look towards the future; it is the details of these reasonable assumptions that need to be fully understood in order for proper interpretation of the simulated results and their use in the AF.

The alternative approach of using empirical data (observed values of abundances and other measures) to define baseline conditions may be tempting but is generally problematic. The idea of using data, rather than simulated conditions, for defining baseline is attractive, as using data seems intuitive and data are likely closer to actual conditions. However, in this ecosystem the use of data can also be problematic. Any historical record with sufficient number of observations to determine a baseline will necessarily have to include data from periods that included trends or portions of cycles in the populations of interest, and an ecosystem that experienced different operations (e.g., X2 standards) and a variety of ecosystem changes (e.g., food web changes from invasive species). If model results are used for both baseline and future conditions, then the difference between the two sets of model results is straightforwardly interpreted as an estimate of expected changes between present and future conditions. The difference between model results for baseline and future conditions approximately corrects for model errors because these errors can be assumed to be similar in the baseline and future

simulations. Using empirical data as a baseline is problematic if the period of record includes major ecological or operational changes, or the current-conditions model results do not agree well with the empirical baseline. In this case, the difference between the model results for future conditions and observations represents not just the expected change between present and future conditions, but also this difference between empirical and simulated current conditions (i.e., baseline data and model mismatch).

The specific definition of the baseline to be used for the BO was not spelled out in the AF, and the Panel suggests that careful thought be given to the selection of baseline conditions (either simulated or data). How baseline is defined will greatly influence interpretation of the comparative analyses that appear throughout the AF.

Comment 3—Uncertainty

Uncertainty is always an issue with analyses such as those outlined in the AF, especially when information is taken from a variety of sources. How uncertainty will, and will not, be dealt with needs to be part of the AF. Some simple things can be done to help understand the uncertainty, such as including measures of fit when statistical models are used and showing plots of the relationships and variables in raw form and for any summarized variables (e.g., means) that are used in analyses. The review of the BO (second charge to this Panel) will likely involve an examination of the details of the analyses and their uncertainty. The AF would greatly help this process by documenting uncertainties as much as possible as an integral step in the analysis.

There are many forms of uncertainty in the analyses anticipated for the BO. Uncertainties in the analysis are not just due to unexplained variance from a regression analysis. Uncertainty can also arise from ignored effects, mis-estimated effects from unknown biases in the laboratory or field data, and assumptions made in other analyses that are used as inputs to the AF. Decisions were made by people in their analyses (e.g., dropping points as outliers, transformations, which data sets used to estimate parameters of IOS and SALMOD) that can lead to uncertainty that is unknown to the end user. For example, the use of population models can be valuable but the predicted responses may include density-dependent effects that are realistic but whose magnitude is unknown, and these results are then used with analyses that assumed density-independence. The life cycle models in the BA also make other, potentially influential assumptions, such as that pre-spawning mortality is fixed and independent of environmental conditions and that ocean mortality is constant over years. Spring Chinook experience high summer mortality prior to spawning that will likely increase with warming in the Central Valley. Ocean survival of salmon stocks varies on multiple time scales (decadal, interannual and monthly), and climate change may affect ocean survival and migration patterns. These are uncertainties in the assumptions and formulations of the model and are often referred to as structural uncertainties to distinguish them from parameter or input uncertainties. Furthermore, population models are not currently available for other runs of interest (spring Chinook, fall Chinook, and late fall Chinook). These runs have different life-history strategies and experience different environmental conditions than what is

experienced by winter Chinook. Therefore, while the overall structure of the winter Chinook model can be adapted to the other runs, it is not, at this time, sufficient for projecting environmental effects to the population level for the other runs. Some caution is needed in how the modeled population responses are used because of assumptions made within the model (e.g., density-dependence, constant ocean mortality), and because of unevenness of the availability of similar, consistently generated predictions across all populations and species.

Another type of uncertainty involves the assumptions underlying other analyses. For example, how will the possibility of a near-term drought period be handled? Use of the historical water patterns in CALSIM-II is great. But how well does taking averages over the 1922-2000 simulated conditions represent possible operations effects in the exceptionally rare but bad years and how well does it capture the possibility of the rare but possible sequence of bad years in the very near future? The CALSIM-II simulation of the historical record has been well documented; we would like to see how these events and possibilities are represented in the AF in the context of the biology and life history of the listed species.

Uncertainty also arises from the analyses that feed information to the AF having undergone different levels of scrutiny and review. Use of some "off-the-shelf" results is a necessity, but careful use of their results is strongly encouraged. CALSIM-II is not perfect but its performance and weaknesses are well known. On the other hand, it appears that SALMOD has been scrutinized less and not been published in peer-reviewed literature. The Panel recommends that the key analyses that feed into the AF be carefully vetted so that the assumptions and uncertainties of specific results that are then used in the AF be well understood.

Ultimately, the design of the TRT table (similar to Table 1) will help with uncertainty because the multiple categories in the table try to cover the possible short-term and long-term species responses. It is too easy to arrive at the table at the end of the analysis having carried along too little information on uncertainties with the multiple steps of the analysis.

Given the numerous factors contributing to uncertainty, the difficulty of performing quantitative assessments of many of them, the complex logical structure of the overall analysis, and the demanding schedule for producing a BO, rigorous uncertainty quantification cannot be performed. However, the degree of confidence associated with any decision can be discussed if uncertainties and assumptions are documented as NMFS proceeds through the AF.

Comment 4—Climate Change Analyses

Much of the analysis relies on CALSIM-II simulations of possible operations scenarios (called studies in the BA). Some assessment of the realism of defined scenarios is needed to ensure appropriate interpretation of the resulting analyses.

Eventually, the idea of the future Delta being discussed in efforts such as DRMS (California DWR and DFG 2008), the Delta Vision (California Resources Agency 2008), the Bay-Delta Conservation Plan (California DWR 2008), and other future-looking studies (Lund et al. 2008), should be incorporated at some level into the interpretation part of the AF. These are possible changes in the Delta ecosystem into the future.

An important issue cited in the previous reviews of the 2004 BO was failure to incorporate considerations of future climate change into the analysis. This criticism has validity, because the certainty of continued anthropogenic climate change raises questions about the validity of using historical river flows to represent future conditions, as done with the CALSIM-II simulations of 1922 to 2000. Because of climate change, future hydrology will tend to stray outside of the envelope of its past behaviors.

The AF is general enough that if the appropriate information were provided, the AF should be applicable to including future conditions that include assumed climate changes. The Panel used this opportunity to closely examine how climate change was incorporated into the BA, to inform NMFS as to the usability of the results in their BO.

In general, the methods, models, and assumptions used in the consideration of climate change reported in the BA are state-of-the-art, and can be said to represent "best available" information and practices. Nonetheless, there are limitations, which should be borne in mind when using the climate change studies results as inputs to the AF. These limitations, while potentially significant, are typical of today's climate change studies, and therefore do not constitute inadequacies or suggest a need to revise the climate change analyses. Furthermore, many of these are acknowledged in the BA itself (e.g., Section 5); we repeat them here to ensure that they receive adequate attention in the AF and BO.

A key element of the climate change modeling in the BA was modeling of the operations of the California water infrastructure. This was performed using CALSIM-II. The basic logical flow of CALSIM-II is as follows: a fundamental input is unimpaired river flows at multiple above-dam locations, which in this case were produced by a sequence of models simulating future climate and hydrology. CALSIM then simulates water deliveries, reservoir levels, carry-over storage, etc., assuming that impaired (below-dam flows) are constrained by environmental requirements such as minimum flow rates. In the climate change scenarios reported in the BA, these specific quantitative constraints were assumed to be the same in the future as they are today. This is reasonable, since no guidance as to other possible constraints was provided. On the other hand, this approach does not consider the possibility that quantitatively different constrains will be needed in a future climate environment. The assumptions of no change in demand for water and no change in flood-control rules between the historical period and 2030, in particular, are questionable. There are also a variety of planned or proposed infrastructure changes (e.g., the California Aqueduct and the Delta-Mendota Canal, Freeport Regional Water Project (FRWP), changes in the operation of the Red Bluff Diversion Dam (RBDD), the Sacramento River Water Reliability Project, the Alternative Intake Project for CCWD) that question the "continue as today" assumptions. Further, there are efforts related to

how the Delta might change in the next decades (e.g., Lund et al. 2008), which include some configurations much different from today's configuration. The "continue as today" assumptions are defended in the BA more on the grounds that it is difficult to know what else to assume. These assumptions may be reasonable, but they introduce significant uncertainty into any subsequent analysis and conclusions. It seems very likely that the future water demands, flood control, and many other operational aspects, will differ from those that are in place today. Sensitivity studies illustrating the uncertainty introduced by these "continue as today" assumptions would be helpful for determining the robustness of the future climate change results, and the conclusions drawn from them.

The approach of basing analyses on a limited number of climate projections that essentially span the range of the full set of available climate projections is reasonable, and it would be impractical to perform a full analysis on a larger set of projections. However, although this approach illustrates the range of possible outcomes, it does not allow rigorous quantification of uncertainties. To do that would require, first, analysis of a larger suite of scenarios, and, more importantly, assessment of the relative likelihood of the different scenarios. Thus, the climate change analysis in the BA is a sensitivity study, not a probabilistic assessment.

All the climate-based modeling described in the BA is based upon coarse-resolution global climate projections that have been "downscaled" (translated to a fine spatial grid) using an approach known as Bias Correction/Spatial Downscaling (BCSD). This approach essentially adds spatial detail to projected surface temperatures and precipitation, based on historical observations of these quantities. This approach is widely used and has proven skill. However, a limitation of this and related approaches is that it cannot represent a "snow-albedo feedback," in which warming causes loss of snow cover, which in turn amplifies warming because a bare surface is darker than a snow-covered surface and absorbs more sunlight. Omission of this effect apparently can reduce substantially the changes in river flow timing that result from a greater proportion of precipitation falling as rain and from snow melt occurring earlier. Estimates based on climate projections downscaled using BCSD typically estimate that these effects shift the timing of river flows to about 2 weeks earlier; similar results downscaled using dynamical models that explicitly represent the snow-albedo feedback indicate a shift of about 4 weeks. Hence this shift may be significantly underestimated in the BA and subsequent analyses.

The BCSD approach has additional limitations as well; perhaps the most important of these involves the bias correction (error removal) applied to future climate projections. The BCSD method assumes that a bias correction developed based on comparing model simulations of the historical period to observations applies to future-climate projections as well (i.e., the method assumes that model biases are invariant under climate change). There is no way to assess the validity of this assumption.

The BA considers single sea-level rise scenario (1 foot increase by 2030); this choice was dictated by availability of existing model results for CVP and SWP operations and Delta hydrodynamics. As noted in the BA, consideration of a single sea-level rise

value does not fully illustrate the range of possible effects of sea-level rise. Furthermore, as acknowledged in the BA, using the same sea level rise value with different climate change scenarios introduces a degree of internal inconsistency. In reality, each climate change scenario should have its own unique value of sea-level rise.

There are several noteworthy aspects to the water-temperature modeling in the climate change scenarios, and seemingly ignoring any possible sediment effects. Effects of changing air temperatures on inputs to the Reclamation water temperature model were handled simplistically (Appendix R, p. 48). As noted in the BA, the simplifying assumptions would seem to act in the direction of overestimating effects of increasing air temperatures on water temperatures. Expected changes in ocean temperatures are predicted by climate models, and are therefore incorporated into all the results that are calculated based upon climate model output (e.g. impaired and unimpaired river flow rates). However, increasing ocean temperatures may have direct impacts on listed species; these are of unknown importance, and it was not clear to the Panel how these would be accounted for in the AF or BO. The presence of sediment may affect salmon, and climate change could influence future sedimentation rates through changes in vegetation, soil moisture, and the frequency and magnitude of extreme precipitation events. The BA does not consider possible future changes in sedimentation, so any effect of changes in sediment loading on listed species are ignored.

The Panel emphasizes that the climate change modeling included in the BA is state-of-the-art but that there are many required assumptions that should be understood in order to ensure proper interpretation of the results. The climate change scenarios are the best available but not without limitations.

Comment 5—Clarity and presentation

There are several ways to increase the transparency of analyses emerging from the AF. The AF described to the Panel ended with a section 7.0 entitled "Key Aspects and Tools of NMFS' Analyses", which included a list of models used in the BO as bulleted points. Obviously, NMFS has more information about how these tools and models will be used than was included in the draft AF provided to the Panel. We recommend a flow chart type approach, whereby the inputs and outputs (including their spatial and temporal scales) of each analysis are shown. The flow charts would show what was used from the CALSIM-II simulations (e.g., monthly water temperatures, annual X2, seasonal exports), how this information was combined with output from other analyses (e.g., monthly water temperatures converted to daily water temperatures), and how they all lead to biological models whose outputs are ultimately entries in the tables (e.g., SALMOD, egg mortality, qualitative statements). Accompanying these flowcharts would be "hidden" but accessible tables and appendices that include commentary and quantitative information about the uncertainties at each of the steps in the flowchart.

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Appendix A. Mock analyses prepared by NMFS a the request of the Panel.

Mock Analyses Following the NMFS Analytical Approach for the OCAP Consultation
August 8, 2008

Mock Analysis #1

Identify the action: OCAP, releasing flows below Shasta Dam
Deconstruct the Action:

- Temperature Compliance Point (TCP) of 56ºF at Balls Ferry[2]
    - Adaptive management process via Sacramento River Temperature Task Group to move the TCP
- RBDD: open September 15 to May 15, closed May 15 through September 15
- Flows to contractors
- Reduce releases to install ACID Dam in April
- Flood flows/releases of up to 100,000 cfs at Bend Bridge
- Spring Creek dilution flows

Identify the Action Area

- Upper Sacramento River (Keswick Dam downstream to RBDD)
- Mid Sacramento River (RBDD downstream to Sacramento)
- Delta

Assess Species Exposure

- March through May 15
- TCP at Balls Ferry
- TCP moved upstream of Balls Ferry: CalSim II modeling results are input into Reclamation's temperature model, and its results are input into the Sacramento River Water Quality Model. linked to instream temperature results to determine under what circumstances the TCP at Balls Ferry is not met. Information that could be used to determine the circumstances include water year type, time of year, frequency of exceedance, duration of exceedance, reservoir storage, cold water pool, air temperatures
- TCP moved downstream of Balls Ferry
- Species exposed (life history stages):
    - Sacramento River winter-run Chinook salmon (adult immigration, holding, and spawning)
    - Central Valley spring-run Chinook salmon (adult immigration, yearling juvenile rearing)
    - Central Valley steelhead (post-spawn adults, juvenile rearing)
    - Southern DPS of North American green sturgeon (adult immigration, spawning)

Assess Species Response

- Adult immigration response: Delay in adults accessing cooler water (~1-1.5 hours)
- Holding response: Crowding (density dependent)
    - Agonistic behavior
    - Infections and disease
    - Unnecessary energy expenditure
- Spawning response:
    - None—The preferred habitat is high upstream anyway
    - Less spawning area
        - Superimposition of redds (density dependent)
        - Fewer redds (females decide not to spawn)
    - Spawning that occurs between Balls Ferry and new TCP prior its new location

[2] Highlights are what we focused on in this vertical analysis. (Note from Panel: This footnote and the highlighting were done by NMFS as part of the mock analysis.)

Mock Analysis #1 - continued

Assess Risk to Individuals

Risk	Tools to Assess Risk	In BA?
Prespawn mortality resulting from reduced spawning habitat and increased competition	USFWS (2003) provides flow vs. weighted usable area vs. spawner relationship (IFIM) for carrying capacity. Use data in document to evaluate reduction in spawning area based on moving the TCP upstream	Yes
Reduced fecundity resulting from less energy reserves	Literature	No
Increased egg mortality from disturbance of redd from redd superimposition	Literature to determine rates of superimposition and mortality that results from superimposition Field observations of redd superimposition Inferences from habitat availability and spawning population size	No
Direct mortality of eggs from elevated temperatures	Salmon Mortality Model assumes a temperature threshold of 56˚F and fixed spawning distribution. Outputs will provide the percent mortality of eggs.	Yes
Sublethal effects to eggs subjected to increased temperatures during incubation	Literature to determine types and extent of effects	No

Assess Risk to Population (VSP Parameters Affected)

- Consider status of species in the action area
- Abundance (Yes: reducing number of fry produced, which can reduce the number of returning adults)
- Population growth rate (Yes: likely decreased cohort replacement rate, *i.e*., population is not replacing itself)
- Spatial structure (Yes: constricting/limiting spawning area)
- Diversity (Yes: decreased fecundity and constricting spawning habitat availability appears to be causing a behavioral change in selecting spawning sites further upstream)

Assess Risk to Species (VSP Parameters Affected)

- Status of the Species considerations: Same as for risk to population because species is comprised of one population
- Add consideration of cumulative effects, which would include future effects of climate change. NMFS assumes the following (not in any specific order):
    1. All scenarios will lead to less cold water available for summer temperature control (e.g., less snow pack, snow melt earlier in the year, more dry/critically dry water years)
    2. The 2 wetter scenarios will result in greater precipitation occurring during the winter months, however, no increase in reservoir storage or cold water pool.
    3. Based on Appendix R, page 11, Figure 7, air temperature in the action area is projected to increase by 2-3˚F when comparing the 2000-2040 time period to the 1971-2000 time period.
    4. Therefore, we assume a 1˚F water temperature increase by 2030 (OCAP time period). This would result in:
        a. moving the TCP upstream, or
        b. additional cold water releases from Shasta Reservoir to maintain the TCP.
    5. Based on the climate change modeling ("sensitivity analysis") results from the BA (page 11-67, figure 11-58), average egg mortality will increase from 5% resulting from effects of Project operations, to an average of 10% egg mortality, after considering the effects of climate change, for all water year types.
- In summary, the effect of moving the TCP upstream during March through May 15 on adult winter-run Chinook salmon immigration, holding, and spawning is likely to result in a reduction in abundance, population growth, spatial structure, and diversity of the species. There is a pattern of Reclamation moving the TCP upstream every year in the last 15 or so years, and our analysis shows that this pattern will likely continue in the foreseeable future. The analysis shows that the effects of this particular activity may result in the continued survival of the species [effective population >500 adults (Lindley *et al*. 2007)], but will preclude its recovery by consistently reducing the species productivity and distribution.

Mock Analysis #1 - continued

Location/ Habitat (Life Stage)	Temporal Consideration	Stressor	Response Analysis Method	Response	Probable Fitness Reduction	VSP Parameters Affected
Upper Sac R. (Adult immigration, holding, & spawning)	March – May 15	Higher water temperature resulting from moving the TCP upstream	Literature, BA model results, inferences, field observations	Prespawn mortality, egg mortality, sublethal effects on eggs and fry	Average of 5% egg & alevin mortality across all water year types, assuming fixed spawning distribution, additional 5% egg mortality when considering climate change	Abundance, Population growth rate, Spatial structure, Diversity

Mock Analysis #2

Identify the action: Pumping from the Delta pumping facilities
Deconstruct the Action:

- CVP and SWP are pumping water from the Delta[3]
- Cleaning operations
- Pumping occurs all year round
- Predators in Clifton Court Forebay and the salvage release sites

Identify the Action Area

- CVP and SWP rivers up to their respective dams
- Delta, particularly the central and south Delta

Assess Species Exposure

- October through June
- Tidal dispersion into Georgiana Slough and DCC (when open) move fish into the central Delta
- Reverse Old and Middle flows draw fish towards the pumps from the central Delta and San Joaquin River
- Species exposed (life history stages): Sacramento River winter-run Chinook salmon (smolts and adults)
  Central Valley spring-run Chinook salmon (smolts and adults)
  Central Valley steelhead (smolts and adults)
  Southern DPS of North American green sturgeon (juveniles and adults)

Assess Species Response

- Prescreen loss (i.e., loss across Clifton Court Forebay through predation)
- Herbicide treatment of Clifton Court Forebay
- Entrainment at the pumps (includes disorientation, injury, and mortality from holding, handling, trucking)
- Crowding
- Predation at all 4 of the salvage release sites
- Feeding
- Migration delays
  - altered migration route from the mainstem Sacramento River through the central Delta, back to the mainstem
  - delay resulting from fish entering the central delta and through the fish facility back to the release site
- Water temperature acclimation/shock/adjustment (potential changes in the fish facilities, truck, release sites, *etc.*)

Assess Risk to Individuals

Risk	Tools to Assess Risk	In BA?
Prescreen loss (mortality) at Clifton Court Forebay	Calculation (82% from most recent DWR studies)	No
Prescreen loss (mortality) at CVP facility	Calculation (unknown, but 15% for salmon inferred from GCID)	No
Mortality in the fish facilities associated with salvage (via holding, handling, trucking)	Modeled from historical numbers	Yes
Mortality from primary louver cleaning (fish lost through the canals), which occurs 1-3 times daily (2 hours exposure per cleaning), depending on debris load	Reclamation (2005; salmon loss estimate)	No
Mortality from secondary louver cleaning (fish lost through the canals), which occurs 1 time daily (49.3 minutes exposure)	Reclamation (2005; salmon loss estimate)	No
Predation in the fish facilities and at the release sites	Inferences, anecdotal information, observations, new study (pending reports)	No
Sublethal effects resulting from reverse flows, including crowding within the fish facilities; reduced growth from reduced feeding resulting from increased temperatures and contaminants exposure; delays in migration resulting in mortality; increased exposure to contaminants, predators, poor water quality, agricultural barriers result in increased stress; osmoregulation; temperature shock	Inferences, anecdotal information, literature, VAMP studies on survival, considering average difference in travel time through the Delta for Sacramento vs. San Joaquin fish; Reclamation's studies on stress in holding tanks	No
Mortality from herbicide treatments in Clifton Court forebay	BA page 13-50 assumes 100% are "taken" within Clifton Court Forebay. NMFS assumed this means 100% mortality.	Yes

[3] Highlights are what we focused on in this vertical analysis. (Note from Panel: This footnote and the highlighting were done by NMFS as part of the mock analysis.)

Mock Analysis #2 - continued

Assess Risk to Population (VSP Parameters Affected)

- Consider status of species in the action area
- Abundance (Yes: reducing number of smolts entering the ocean, which can reduce the number of returning adults)
- Population growth rate (Yes: likely decreased cohort replacement rate, *i.e.*, population is not replacing itself)
- Spatial structure (No: Habitat is being modified, but the structure of individual steelhead populations will not change resulting from pumping, straying rates not altered by this action)
- Diversity (Yes: Habitat changing/being modified by reverse flows; exotic species introduction altering abundance and behavior; sublethal effects modifying behavior and delaying run timing, favoring some emigration patterns over others)

Assess Risk to Species (VSP Parameters Affected)

- Status of the Species considerations: All populations could be incrementally affected because steelhead smolts from all diversity groups enter the Delta
- Add consideration of cumulative effects, which would include future effects of climate change. NMFS assumes the following (not in any specific order):
    1. Climate change resulting in a 1-foot sea level rise would have more influence on the effects of Project operations at the pumps than the air temperature and precipitation pattern considerations.
    2. Based on OCAP BA pages 9-96 through 9-100, Table 9-22, approximately 5% less pumping, on average, would likely result in less entrainment and subsequent effects at the pumps.
    3. Based on OCAP BA pages 9-96 through 9-100, Table 9-22, an increase in reverse flow through the Old and Middle Rivers would likely result in more smolts drawn into the Central and South Delta and result in increased indirect/sublethal effects.
    4. The location of X2 will move upstream/to the east, and if/when it reaches Collinsville (the Antioch release site), osmoregulation of the salvaged fish will be compromised when they are trucked from freshwater to brackish/salt water before the fish are physiologically ready.
- In summary, although the abundance of the CV steelhead species is unknown, the effect of pumping will likely result in reduced abundance, population growth rate, and modified diversity.

Location/Habitat (Life Stage)	Temporal Consideration	Stressor	Response Analysis Method	Response	Probable Fitness Reduction	VSP Parameters Affected
Central and South Delta (smolt)	October through June	Pumping	Modeling, calculations, inferences, anecdotal information, literature, BA	Mortality, sublethal effects	Please advise from tools above.	Abundance, population growth rate, diversity

Appendix B. NMFS' summary responses to reviewers' comments prepared at the reuaets of the Panel.

NOAA's National Marine Fisheries Service's
Responses to Peer Review Recommendations of the October 22, 2004, Biological Opinion
On the Central Valley Project and State Water Project Operations Criteria and Plan

September 3, 2008

California Bay-Delta Authority, January 3, 2006

Overarching Issues:

1. Need for a conceptual framework
2. Analytical framework
3. Life cycle approach

NMFS' analytical approach document to the peer reviewers and presentations during the peer review public workshop addressed the above three issues in a "tell me" fashion. The follow-up mock analyses were examples of "show me."

Specific Technical Issues:

Issue 1 – Too coarse of a temporal resolution in the analytical and numerical modeling related to temperature.

The various models and time step include the following, as provided in the OCAP BA page 9-4:

Model	Model Time Step	Simulation Period (Water Year)
CalSim-II	Monthly	1922-2003
DSM2	15 minute	1976-1991
Reclamation Temperature	Monthly	1922-2003
SRWQM	6 hour	1922-2003
Feather River Model	1 hour	1922-1994
Reclamation Mortality	Daily	1922-2003
SALMOD	Weekly	1922-2003
IOS	Daily	1923-2002

Additional details are provided in Chapter 9.

The OCAP Temperature Modeling Workshop report (http://www.science.calwater.ca.gov/pdf/workshops/workshop_tmm_final_report_4-1-08.pdf) discusses the course time step on pages 6-7.

Issue 2 – Unclear and sometimes inconsistent use of water temperature metrics for thermal criteria.

Water temperatures are still calculated with monthly averages.

Sub-monthly temperature results from the Sacramento River Water Quality Monitoring for the upper Sacramento, Trinity, and Clear Creek reaches were developed to approximately diurnal temperature variability. Historical temperature observations are provided as complementary information in addition to the monthly and mean daily (using 6-hour meteorology) temperature results (OCAP BA appendix H, page 6).

Issue 3 – Too narrow treatment of temperature effects.

Not addressed in OCAP BA.

The report from the OCAP Temperature Modeling Workshop (http://www.science.calwater.ca.gov/pdf/workshops/workshop_tmm_final_report_4-1-08.pdf) discusses sublethal effects on pages 11-14.

Issue 4 – Reliance on a questionable LSalmon-2 temperature-egg mortality model.

The BA/Reclamation is still using LSalmon-2 temperature-egg mortality, but has added the Cramer IOS model (Chapter 9) for another tool to evaluate effects on winter-run Chinook salmon.

The report from the OCAP Temperature Modeling Workshop (http://www.science.calwater.ca.gov/pdf/workshops/workshop_tmm_final_report_4-1-08.pdf) discusses temperature and models on pages 13-14.

Issue 5 – Incomplete documentation of how other models (e.g., Decision tree, fish allocation) were used in the analysis.

NMFS' analytical approach and mock analyses provide examples of the analytical framework, conceptual framework, and life history model used in the analysis. The new draft biological opinion will provide the details necessary to address/incorporate the recommendation.

Issue 6 – Other than ecologically-based metrics used to evaluate the significance of the impacts of specific effects.

Not addressed in OCAP BA.

The new draft biological opinion will include consideration of the relative importance of different life history stages to the long term survival and recovery of the species. We will also utilize the VSP concept in order to address population scale effects of the action.

Issue 7 – Questionable calculations used to combine individual effects into cumulative impacts.

Not addressed in OCAP BA.

See response to issue 6. We plan on using life-stage equivalents so that all effects are on a "level playing field."

Issue 8 – Lack of a comprehensive population approach to jeopardy assessment.

Not addressed in OCAP BA.

Analytical framework provides a new structure, including the viable salmonid population (VSP) concept (McElhany *et al.* 2000). Panel comments will provide additional advice.

Issue 9 – Too little attention paid to effects and impacts on life history and population structure.

Not addressed in OCAP BA.

We will utilize the VSP concept (McElhany *et al.* 2000, Lindley *et al*. 2007) in the analysis, which includes various spatial scales, ranging from individuals to ESUs/DPSs.

Issue 10 – Little discussion of the potential effects of smolt migratory behavior and predatory fish on juvenile survival.

Predation is the primary mechanism of mortality associated with the loss of fish at the Delta export pumps. In the 2008 OCAP BA, predator-related mortality due to the introduction of non-native warm water species is discussed in Chapter 4 (pages 4-23 through 4-25) and Chapter 6 (pages 6-58 through 6-61). In addition, although not explicitly stated, predation-related mortality is included in the IOS salmon life-cycle model (Appendix N).

The new draft biological opinion will explore the interaction between predatory fish and salmon survival as it changes with project operations. We will describe trends in predatory fish species populations (*e.g.*, striped bass, largemouth bass, smallmouth bass, and Sacramento pikeminnow) and the likelihood of those populations expanding under future climate change scenarios.

Issue 11 – Too little explicit, quantitative treatment of uncertainty.

Sensitivity and uncertainty analyses of modeling are provided in the 2008 OCAP BA (appendices W and X). Each of the 10 models used in the BA have a certain level of uncertainty associated with them (*e.g.*, Appendices D, F, H, and J).

Various types of uncertainty associated with fisheries management will be explicitly stated in the new draft biological opinion. For example, the 2008 OCAP BA page 1-2 discusses the "institutional uncertainty" of "the CVPIA specified that the dams and reservoirs of the CVP should now be used 'first, for river regulation, improvement of navigation, and flood control; second, for irrigation and

domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement.'"

Issue 12 – Unclear connection between the analyses and the findings in the BO.

Not addressed in OCAP BA.

The new draft biological opinion will receive multiple and rigorous internal review, in addition to peer review to "ensure" that it is biologically and legally defensible/sound.

Issue 13 – Too little consideration given to the potential negative effects of hatcheries in the integration and synthesis.

Consideration of the risks associated with hatchery raised mitigation fish provided in the OCAP BA p.11-97 through 11-103, although it falls short in addressing all hatchery effects from all CVP and SWP hatcheries.

NMFS requested information regarding the effects of hatchery fish from the CVP mitigation hatcheries [*e.g.*, Livingston Stone National Fish Hatchery (NFH), Coleman NFH, Nimbus Hatchery], as the BA largely only addresses effects of Feather River Hatchery fish.

Issue 14 – Questionable use of surrogates in some situations.

Surrogates are only used to represent spring-run Chinook yearlings that are migrating out of Deer, Mill and Antelope Creek during the fall and winter because they are indistinguishable from other salmon races. The alternative would be to quantify the level of incidental take on Chinook salmon in general, rather than target a limit for specific races. Surrogates are not used to represent spring-run fry that emigrate from Butte Creek in the spring. Recent studies by Kimmerer (2008), Newman (2008), and Hanson (2008), support the use of uniquely marked hatchery late-fall Chinook salmon smolts as surrogates because they are released at approximately the same time and size as yearlings that are leaving the tributaries.

The uncertainty of using surrogate hatchery fish is that their behavior is not assumed to be the same as wild fish. We acknowledge that this should be explicitly stated in the new draft biological opinion.

Issue 15 – Inadequate accounting for fluctuations in ocean conditions that effect salmon survival.

Consideration of variable ocean conditions is provided in OCAP BA p.11-95 to 11-97, but not incorporated into the current status of the species.

Issue 16 – Too little attention devoted to effects of future global climate change.

Climate change and sea level rise sensitivity analysis modeling methods are provided in the OCAP BA, p.9-28 through 9-29.

Climate change results are provided in OCAP BA p.9-95 through 9-98.

Upstream effects resulting from climate change are provided in the OCAP BA p.11-85 through 11-95.

OCAP BA appendix R is dedicated to the sensitivity of future CVP and SWP operations to potential climate change and associated sea level rise.

See Mock Analysis #1 on page 3 for an example of how we intend to use the climate change (temperature) information in our analyses.