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Date: January 3, 2006

To: Rodney McInnis
Regional Administrator
Southwest Regional Office
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213

From: Johnnie Moore, Ph.D
Lead Scientist

Subject: Biological Opinion - Independent OCAP Review

Enclosed is the final report from the expert panel convened by the California Bay Delta Authority (CBDA) Science Program to examine the use of best available science in your October 2004, Biological Opinion (BO) on the Long-Term Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP). Also enclosed is the panel's written response to the comments you provided on December 20, 2005, on their draft report.

The panel's analysis and conclusions were based mainly on the review of the BO and supporting Biological Assessment (BA), other documents provided by National Marine Fisheries Service (NMFS) and the U.S. Bureau of Reclamation, and material presented by NMFS staff at the October 12-13, 2005, workshop. When finalizing their report, the panel members also considered your December 20, 2005, comments on an earlier draft.

As you will see in the report, the panel members unanimously concluded that the scientific information used in the BO was not the best available. The report identifies the reasons for this conclusion and specific suggestions for improvements. The panel also recognized the complexity of the issues involved and the rather short timeline NMFS had to prepare the BO.

As the next steps in the review process, the CBDA Science Program will post the panel's final report and this transmittal letter, your December 20, 2005, comment letter, and the panel's draft report on which you based the comments. Links to background material that were included in the review will also be on the website.

Dr. Randy Brown, who is the Science Program lead in facilitating this review, will arrange a public meeting to conclude the review. During this meeting, Jim Lichatowich, the panel chair, will present the panel's major findings and their rationale. (Other panel members will also be there to the extent possible). The public will have an opportunity to ask questions during the meeting. Dr. Brown will work with NMFS staff to identify a meeting date. If you believe it helpful, he can try to arrange a meeting the same day between some of the panel members and NMFS and possibly other appropriate agency staff to discuss where to go next with the scientific problems identified in the review.

I would like to commend NMFS for its willingness to open this important document to peer review. I believe the review will help make for a stronger science base in future biological opinions and assessments. The review has also identified areas of scientific uncertainty that can be addressed by new biological studies and modeling, perhaps in part through future Science Program research activities. Finally, the panel has asked me to express its appreciation to your staff for their help in the review; in particular to Bruce Oppenheim.

If you have any questions, please contact Dr. Brown directly at brown.randall@comcast.net, or at (916) 961-5449.

Attachment

cc: Mike Aceituno
Joe Grindstaff

Report

of the

Technical Review Panel

Review of the Biological Opinion of the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan

For

Johnnie Moore

Lead Scientist

California Bay-Delta Authority

December 2005

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Executive Summary

Background and Charge

Over the last 150 years, the Sacramento River has been engineered into a massive water delivery system, which includes various dams that have blocked access to much of the historical habitat of anadromous salmonids. Development of the basin's water resources has, in effect, unintentionally initiated a large-scale ecological experiment. The experiment examines whether the historical habitat templates, and their associated salmon and steelhead production systems, can be relocated below the migration barriers. This undertaking has, so far, put at risk of extinction three of the basin's four evolutionary significant units (ESUs): winter-run and spring-run Chinook salmon and steelhead in the Sacramento River are listed as endangered or threatened under the Federal Endangered Species Act (ESA).

This is the report of the Technical Review Panel (Panel) convened by the CALFED Bay-Delta 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). The OCAP BO was issued by the National Marine Fisheries Service (NMFS), Southwest Region. The BO assesses the effects of the continued operations of the CVP and SWP on listed Chinook salmon and steelhead in the Sacramento River, and on coho salmon in the Trinity River. This review was initiated at the request of the National Marine Fisheries Service's Sacramento Office.

The Panel's basic charge is to determine whether NMFS used the best available scientific and commercial information in developing the BO. According to our charge:

> "The Technical Review Panel's Charge is to evaluate and comment on the technical information, models, analyses, results and assumptions that formed the basis for the assessment of the proposed long-term water operations of the projects described. … For example, the panelists should review how NMFS assessed the individual responses of fish to certain effects (i.e., flows, water temperatures, diversions, etc.) and whether NMFS missed best available information on how fish are likely to respond to those impacts."

Accordingly, the Panel considered whether the best available scientific information (including models and analyses) was discussed or cited in the BO, and how NMFS took this information into account in reaching its decisions.

The charge to the Panel included two important restrictions on the content of the review. First, we were not asked whether NMFS made the proper determination regarding jeopardy. Therefore, we do not address that question in this report.

Second, we were also not asked whether NMFS properly considered the effects of baseline conditions in assessing jeopardy. All analyses in the BO were based upon the incremental impacts due to the proposed operations of the projects, rather than the impacts of baseline plus project operations. The Panel understands that there was a rationale for this approach (i.e., baseline does not cause jeopardy; hence the incremental effects are evaluated by themselves).

But the Panel would feel remiss without at least mentioning that this is a critical assumption and that from a purely scientific view, populations may not respond linearly to progressively increasing losses of individuals.

Findings

The Panel is unanimous in its finding that the scientific information used in the BO is not the best available. As salient examples, NMFS ignored the potential effects of climate change in their analyses in the BO, and NMFS used a temperature-mortality model (LSalmon-2) that does not produce credible estimates of temperature-induced mortality. Other important factors, such as variable ocean conditions or the risks associated with hatchery-released fish, are described in parts of the BO, but how these factors were related to the conclusions regarding jeopardy were unclear to the Panel.

The Panel identified three overarching issues, which if addressed, would improve the presentation of the analyses in the BO. Specifically, the BO would have benefited:

1) from a clearly articulated conceptual model
2) from an analytical framework (based on the conceptual model) for the various data analyses, statistical models, and analytical tools that were used
3) by placing its analyses in the context of an explicitly defined life cycle approach.

In addition, the Panel identified 15 specific technical issues in the BO. These technical issues are described in detail in the body of this report; we highlight the major issues below.

1) **Global climate change was not considered.**
   The BO assumes that the climate and hydrologic regime during the last century will persist into the future. The Panel does not believe that global climate change (e.g., temperature warming), and the consequent temperature and hydrological changes, received adequate treatment in the BO. This deficiency resulted in an important uncertainty being ignored that could affect the characterization of the risk to the ESUs.

2) **Variability in ocean productivity, and its affect on fish production, was not incorporated into the analyses.**
   The current status of the listed populations is, in part, an outcome of recent favorable ocean conditions. What will the status of listed populations be under less favorable conditions that may occur in the near future? By not including variability of ocean conditions in its analysis, the BO does not adequately address whether or not the listed populations are sufficiently large to survive a period of poor ocean conditions.

3) **Unknowns or uncertainty were either not adequately incorporated into the analyses, or their incorporation was not clearly explained.**
   In some cases, uncertainties were simply ignored or their consideration was deferred to other future analyses or other in-progress biological opinions. For example, Table 9

in the BO (page 193) summarizes the effects of the proposed project on the listed ESUs, but Table 9 fails to list eleven additional effects mentioned in the text of the BO. Ignoring or deferring the consideration of these effects in analyses does not give the listed species the required benefit of the doubt.

4) **Some models and analyses appeared to be flawed.**
The application of monthly temperature models to anadromous fish studies is a point of concern. Of particular concern is the adoption, with little discussion, by NMFS of these monthly results both for assessing potential impacts and for setting thermal criteria. In addition, the data used to develop relationships between water temperature and salmon gamete, egg, and alevin mortality was not the best available.

5) **Greater consideration should be given to genetic and spatial diversity in the ESUs.**
Too little consideration was given to the genetic and spatial diversity aspects of the ESUs. The Central Valley Technical Recovery Team (CVTRT) noted that the “dependent” populations of spring Chinook and steelhead occupy marginally suitable habitats that either depend on migrants from the nearby streams or operate as a metapopulation in which each stream is not individually viable, but the group persists. These dependent populations are a valuable resource because they exist in marginal environments, may contain valuable genetic attributes (e.g., higher temperature tolerance), and may serve as links with other populations in ways that increase the viability and resiliency of the ESUs over long time scales. The BO did not adequately treat the genetic and spatial diversity aspects in their analysis.

To guide us in our evaluation, NMFS posed seven questions for the review that addressed issues they felt were important. We were advised that we could reformulate these questions. We decided that the salient issues covered by the original seven questions could be covered with four questions. The four questions overlap somewhat among themselves in their coverage of the important issues. The reformulated four questions, and a summary of our responses to them, are listed below:

1) **Are the technical data, tools, and analyses used in the BO (e.g., modeling, calculations, qualitative assessments) able to determine impacts to individuals and to populations of listed ESUs?**

NMFS’ dependence on using existing off-the-shelf models, especially for quantitative analyses, resulted in less quantitative results and more qualitative-based assessments than is desirable. The Panel appreciates the constant tension between the desire to use a systematic approach versus the uneven availability of information among species and among river systems. However, we are of the opinion that, even with the time constraints and desire to be systematic, there are several areas where the data and analyses used by NMFS could have been improved.

2) **Were risks and uncertainties adequately considered and treated in the BO? What risks, uncertainties, and limitations were not addressed?**

Characterizing uncertainty is an important step in assessing risk, and ultimately in understanding the strengths and weaknesses of regulatory and management decisions. Uncertainty can take a number of forms (Francis and Shotton 1997). Uncertainty arises from natural variability; missing, inaccurate, or imprecise data; necessity for simplifying assumptions for analyses and models; and how agencies communicate and interact. Regardless of the form, characterizing uncertainty is an important step in assessing risk, and ultimately in properly understanding the basis of regulatory and management decisions.

The Panel determined that more explicit treatment of uncertainty would greatly improve the scientific underpinnings of the BO. Some of the uncertainties of concern to the Panel were addressed more fully at the October 12-13, 2005 workshop at the University of California at Davis than in the BO, which suggests that uncertainties may have been considered but not documented in the BO. The Panel concluded that the BO would benefit from better documentation of key uncertainties and a clear description of how they were incorporated into the final decision analysis. Furthermore, we suggest that, when possible, the BO should treat the major uncertainties in a more quantitative manner.

3) **In the absence of available information to establish probable responses to impacts (e.g., steelhead losses at the CWP and SVP pumps, spring-run Chinook salmon survival and reproduction above Red Bluff Diversion Dam), were reasonable scenarios developed to identify the likely effects of the proposed projects on the fish species of interest? Were comparisons made to other species with similar impacts?**

At the October 12-13, 2005 workshop, the Panel was given a handout[1] that highlighted some of the guidelines used in preparing biological opinions. A key point appeared on page 10 of the handout, under the section heading entitled "Providing the Benefit of the Doubt to Listed Populations." The text stated that the Services should conduct their analyses to avoid making a Type II error (i.e., avoid making the mistake of concluding that there was no effect on listed species or their habitat when in fact there was an effect). In other words, the BO should give the listed species the benefit of the doubt. This guideline of giving the species the benefit of the doubt was used as a criterion when we evaluated the BO, especially when we addressed question (3).

The BO ignored or understated several factors that are expected to have measurable effects on the listed salmon and steelhead populations. Where there was insufficient information to develop a quantitative estimate of an effect, the BO frequently appeared to ignore the unquantified effect, or to not clearly explain how the unquantified effects were incorporated into the overall integration and synthesis. Potentially important effects were apparently not included in the

[1]A package containing pages 8-10 of material copied from another source was given to the Panel by Penny Ruvelas of NOAA Fisheries at the October 12-13 Workshop. The header on the handout was entitled "Background paper on assessment framework for jeopardy analysis."

synthesis, or there was no explicit explanation as to how they were included in the final analysis. For example, it was unclear to the Panel exactly how the following issues were incorporated in the analyses or final synthesis: the effect of hatcheries, mortality of subyearling Chinook on route to and within the Delta, the effects of global climate change, and the effects of Red Bluff Diversion Dam on adult and juvenile passage. The failure to explicitly explain how known or anticipated effects were incorporated into the synthesis of effects is inconsistent with the guideline to provide “the benefit of the doubt to the listed species.”

4) **Where information was limiting or unavailable (e.g., the abundance of steelhead), did the BO provide evidence or make reasonable assumptions regarding the probable responses of listed ESUs to proposed project operations? Of particular concern are the potential effects besides direct mortality (e.g., changes in fecundity and growth rates of individuals, genetic diversity, access to specific spawning and rearing areas)?**

The effect of the proposed projects focused on population abundance (numbers of individuals), and effects on life history traits and population structure were essentially ignored or simply noted in the BO. Several potential pathways for the proposed project to affect life history and population structure, which may affect the determination of jeopardy, were noted by the Panel. These pathways include: changes in temperature and water routing affecting juvenile fish growth and survival in the floodplains and the Delta; disproportionate harvest of older age classes affecting population age-structure and total egg production; supplementation of wild stocks with hatchery stocks reducing genetic fitness; and operations of diversion dams affecting the movements of fish into marginal, but evolutionary significant, habitats. Additional quantitative or qualitative analysis of proposed project effects on life history traits and population structure would strengthen the science underlying the BO.

Introduction

This is a report of the Technical Review Panel (Panel) convened by the CALFED Bay-Delta 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). The OCAP BO was prepared by the National Marine Fisheries Service (NMFS), Southwest Region, and issued to the U. S. Bureau of Reclamation and the California Department of Water resources. The BO was completed and issued on October 22, 2004.The BO assesses the effects of the continued operations of the CVP and SWP on listed Chinook salmon and steelhead in the Sacramento River, and on coho salmon in the Trinity River. The review was initiated at the request of the National Marine Fisheries Service's Sacramento Office.

The Panel

The CALFED Bay-Delta Program convened a panel consisting of six members:

Dr. Jim Anderson
Research Associate Professor
School of Aquatic and Fishery Sciences
Box 358218
University of Washington, Seattle WA 98195
Areas of Expertise: Salmon ecology, ecosystem modeling
Other Professional Activities:

- Member of the NOAA Central Valley Chinook and Steelhead Technical Recovery Team
- Member of the CALFED Environmental Water Account Review Panel
- Over one hundred publications in aquatic science

Dr. Mike Deas
Principal
Watercourse Engineering, Inc
133 D Street, Suite F
Davis, CA 95616
Areas of Expertise: Numerical flow model modeling, temperature modeling
Other Professional Activities:

- Chair, Peer Review Panel of Water Temperature Objectives Used as Evaluation Criteria for the Tuolumne, Merced, and San Joaquin River Water Temperature Modeling and Analysis Project
- Coauthor of Review of Water Temperature Modeling - Central Valley, prepared for the Bay Delta Modeling Forum
- Steering Committee Member, California Water and Environmental Modeling Forum

Dr. Al Giorgi
Senior Fisheries Scientist
BioAnalysts, Inc.
Redmond, WA

Areas of Expertise: Fish passage, water management, salmon ecology
Other Professional Activities:

- Technical analyst and advisor to the Bonneville Power Administration, and the Northwest Power and Conservation Council regarding salmon passage, water management and salmon survival in the Columbia Basin
- NRC committee member (2003-2004): Effects of water withdrawals and flow on salmon in the Columbia River

Mr. Jim Lichatowich (Chairperson of the Technical Review Panel)
Fisheries Biologist
Alder Fork Consulting
Columbia City, OR. 97018
Areas of Expertise: Salmon management, salmon ecology and life history
Other Professional Activities:

- Member (10 years), Independent Science Advisory Board for the Columbia River salmon recovery program
- Vice-chair (4 years), Independent Multidisciplinary Science Team for Oregon's salmon recovery program
- Chair (2 years), Independent Science Team for the review of the salmon recovery program of the city of Portland, Oregon
- Chair, Technical Review Team for the Battle Creek Salmon Restoration Program
- Author *Salmon without Rivers: A History of the Pacific Salmon Crisis*

Dr. Kenneth Rose
Professor
Coastal Fisheries Institute and Department of Oceanography and Coastal Sciences
Louisiana State University
Baton Rouge, LA 70803
Areas of Expertise: Fish population dynamics, mathematical and simulation modeling
Other Professional Activities:

- Fellow of the American Association for the Advancement of Science
- Member of the Independent Science Board (ISB) and the Environmental Water Account Review Panel of the CALFED Bay-Delta Restoration Program.
- Member of the Reef Fish Stock Assessment Panel of the Gulf of Mexico Fisheries Management Council

Dr. John Williams
Independent consultant
875 Linden Lane, Davis, CA 95616
Area of Expertise: Salmon biology, fluvial geomorphology
Other Professional Activities:

- Author, CALFED-funded monograph on Central Valley salmon (in review)
- Member, NOAA Fisheries Technical Recovery Team for Central Valley Chinook salmon and steelhead
- Chair, geomorphology and riparian issues work team, Comprehensive Assessment and Monitoring Program (CMARP) of the CALFED Bay-Delta Program

- Special Master, Lower American River, EDF versus EBMUD

Panel Charge

The Panel's basic charge is to determine whether NMFS used the best available scientific and commercial information in developing the BO. According to our charge:

> "The Technical Review Panel's Charge is to evaluate and comment on the technical information, models, analyses, results and assumptions that formed the basis for the assessment of the proposed long-term water operations of the projects described. … For example, the panelists should review how NMFS assessed the individual responses of fish to certain effects (i.e., flows, water temperatures, diversions, etc.) and whether NMFS missed best available information on how fish are likely to respond to those impacts."

The full charge is reproduced in Appendix A. Accordingly, the Panel considered whether the best available scientific information (including models and analyses) was discussed or cited in the BO, and how NMFS took this information into account in reaching its decisions. In conducting its review, the Panel was instructed to "focus on the technical aspects" of the BO.

The charge to the Panel included two important restrictions on the content of the review. First, we were not asked whether NMFS made the proper determination regarding jeopardy. Therefore, we do not address that question in this report.

Second, we were also not asked whether NMFS properly considered the effects of baseline conditions in assessing jeopardy. All analyses in the BO were based upon the incremental impacts due to the proposed operations of the projects, rather than the impacts of baseline plus project operations. For example, suppose the proposed operations resulted in an increase of 12,000 fish lost at the pumps, and that under baseline about 50,000 fish would be killed by the pumps. The BO evaluated whether the incremental increase of 12,000 fish would cause jeopardy or not, not whether the predicted total loss of 62,000 fish would cause jeopardy. The Panel understands that the rationale for this approach was that baseline does not cause jeopardy; hence the effects of the proposed projects are evaluated as incremental effects. But the Panel would feel remiss without at least mentioning that this is a critical assumption and, that from a purely scientific view, populations may not respond linearly to progressively increasing losses of individuals.

To guide us in our evaluation, NMFS posed seven questions for the review that addressed issues they felt were important. We were advised that we could reformulate these questions. We decided that the salient issues covered by the original seven questions could be covered with four questions. The reformulated four questions are:

1) **Are the technical data, tools, and analyses used in the BO (e.g., modeling, calculations, qualitative assessments) able to determine impacts to individuals and to populations of listed ESUs?**

2) **Were risks and uncertainties adequately considered and treated in the BO? What risks, uncertainties, and limitations were not addressed?**

3) **In the absence of available information to establish probable responses to impacts (e.g., steelhead losses at the CWP and SVP pumps, spring-run Chinook salmon survival and reproduction above Red Bluff Diversion Dam), were reasonable scenarios developed to identify the likely effects of the proposed projects on the fish species of interest? Were comparisons made to other species with similar impacts?**

4) **Where information was limiting or unavailable (e.g., the abundance of steelhead), did the BO provide evidence or make reasonable assumptions regarding the probable responses of listed ESUs to proposed project operations? Of particular concern are the potential effects besides direct mortality (e.g., changes in fecundity and growth rates of individuals, genetic diversity, access to specific spawning and rearing areas)?**

To assist the Panel in its review, CALFED organized a workshop held on October 12-13, 2005 at the University of California at Davis. The Panel heard presentations on the BO, and had the opportunity to ask questions related to the Panel's charge and about the information considered and used in the preparation of the BO.

The Panel recognizes that the preparation of the BO was a complicated task that involves large projects in a complex and highly engineered ecosystem. We would like to thank NMFS for their openness and cooperative participation, especially that of Bruce Oppenheim, Penny Ruvelas, and Mike Tucker. The open exchange of information was critical to the Panel's deliberations and effectiveness.

This report will focus on the general issues related to the use of "the best scientific and commercial data available", and will only delve into the specifics and details to illustrate the general issues. Our report has six major parts: Executive Summary, Introduction, Background, Review of the Biological Opinion, Concluding Remarks, and Appendices. Appendix A reproduces the Panel's charge, and Appendix B is an example analysis of Delta routing and survival of smolts. As much as possible, we use the term effect to refer to the direct consequences of the proposed project on the environment (e.g., changes in temperature, flow) or on individual fish (e.g., growth rate), and use the term impact for when the consequences of effects are expressed at higher-levels (e.g., population abundance).

Background

Over the last 150 years the Sacramento River has been engineered into a massive water delivery system, which includes various dams that have blocked access to much of the historical habitat of anadromous salmonids. Storage dams, which are key parts of the engineered system, block 95 percent of the historical salmon and steelhead habitat. The remaining habitat below the dams "... is managed for multiple fish species and lacks the suitability to maintain natural populations" (BO page 82). This statement quoted from the BO is underscored by the listing under the Federal Endangered Species Act (ESA) of the Sacramento River winter-run and spring-run Chinook salmon and steelhead.

Development of the basin's water resources has, in effect, unintentionally initiated a large scale ecological experiment. The experiment examines whether the historical habitat templates, and their associated salmon and steelhead production systems, can be relocated below the migration barriers. The migratory pathways to the ocean have also been altered by the levee construction to reclaim wetlands and to modify river channels, the introduction of non-native predators, flow manipulation and water diversion related to human activities and needs, and pollutants. The experiment is, in effect, asking the question: can the habitat templates that once existed above the dams be sufficiently recreated below them and throughout the migratory pathways to ensure the persistence of the native populations of salmon and steelhead? Variations of this experiment are being carried out throughout the southern part of the salmon's range in the Pacific Northwest (e.g., Columbia River system).

The BO satisfies provisions of the Federal ESA. Preparation of a BO is a demanding task, and is especially challenging in the Sacramento River system due to the complexity of the proposed projects and the ecosystem. The Panel appreciates the time constraints imposed on NMFS as part of the ESA process. The NMFS generally uses what information is provided in the Biological Assessment (Bureau of Reclamation 2004), but NMFS is also mandated to use the best available scientific and commercial information, ranging from juried professional journals to anecdotal and oral information. NMFS can also request more information than is contained in the Biological Assessment, and can request that additional analyses be performed by the project agencies.

Definition of "Best" and "Available"

The Panel was charged with determining if the best scientific information and methods were used in preparing the BO. We interpreted this charge as including whether the relevant information that was discussed in the BO was also taken into account in reaching conclusions regarding jeopardy. This charge requires working definitions of "best" and "available."

We interpreted "best" in terms of the normal scientific criteria: empirical support, consistency with information and theory generally accepted by leading scientists, relevance to the issue at hand, and professional reputation of the author.

Based on guidance provided at the workshop by Penny Ruvelas of NOAA Fisheries, we take "available" to mean information that NMFS biologists working in the Central Valley could reasonably be expected to be aware of, or could be expected to find with reasonable effort. This includes articles in major or regional journals; books published by major presses; reports by the National Research Council, by the other offices of NOAA Fisheries and other State and Federal agencies, and by major advisory committees that deal with management of Pacific salmon; and material presented at scientific meetings that are commonly attended by Central Valley salmon biologists (e.g., CALFED science conferences, Interagency Ecological Program and Modeling Forum annual meetings). Grey literature and unpublished reports by other state and federal agencies that deal with salmon in other geographic areas whose information was not widely reported in scientific journals would not be considered available.

We interpreted "using the best available scientific information" in terms of the following statements (from NRC 2004-a):

1) The agencies may not manipulate their decisions by unreasonably relying on some sources to the exclusion of others;
2) The agencies may not disregard scientifically superior evidence;
3) Relatively minor flaws in scientific data do not render the data unreliable;
4) The agencies must use the best data available, not the best data possible;
5) The agencies must rely on even inconclusive or uncertain information is that is the best available at the time of the decision;
6) The agencies cannot insist on conclusive data to make a decision;
7) The agencies are not required to conduct independent research to improve the pool of available data.

Jeopardy Analysis Guidelines

In addition to definitions of "best" and "available", we also used the guidelines provided in the ESA Section 7 Consultation Handbook (USFWS 1998) as a basis for performing our review. The ESA Handbook defines an action that jeopardizes a species as an action that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild. The ESA Handbook outlines important issues and topics that a BO should consider. We have extracted some key words and phrases from the Handbook, and have listed them below in outline form.

1. In determining jeopardy, the biologist considers:
    a. the species status
    b. the status of the baseline
    c. the effects of the proposed actions
    d. the cumulative effects of other anticipated actions

Based on this information the biologist attempts to determine if the proposed action is likely to reduce the probability of both survival and recovery of the species (See BO page 90).

2. The conditions under which a species can survive are characterized by:
    a. a sufficiently large population
    b. with all necessary age classes
    c. that is genetically heterogeneous

d. with sexually mature individuals producing viable offspring

3. This population exists in an environment that provides for the completion of the entire life cycle (i.e., the BO must consider the life cycle of the species).

4. Jeopardy analysis frames survival in terms of:
    a. species reproduction
    b. numbers
    c. distribution in the wild

The definitions of “best” and “available,” the guidelines for jeopardy analysis, the Panel’s general charge, and the four questions were the context within which the Panel carried out its review.

Review of the Biological Opinion

Overarching Issues

The Panel believes there are overarching issues related to the preparation of the BO that need to addressed first in order to provide a context for our more specific comments on the 15 technical issues. The three overarching issues are: the conceptual framework, an analytical framework, and a life cycle approach.

A conceptual framework is a comprehensive description of processes and inter-relationships based on theory, fact, and data. Although a conceptual framework can be useful in characterizing conditions and formulating hypothesis, it is not a quantitative tool. Based on the conceptual framework, decisions can be made concerning appropriate statistical, analytical, and numerical models that may be applicable for the subsequent quantitative analysis of a system. Because large systems are often complex, there is generally not a single analytical model that adequately treats all of the processes of interest. Often a suite of models and assumptions is developed that represent the system of interest. This suite of models is termed an analytical framework, and is invaluable in identifying critical shared information and connections among the various models, potential impacts of identified actions, and in assessing uncertainty. The life cycle approach is a way of identifying potential relationships between various actions and activities and the specific life stages of salmon and steelhead affected. As such, the life cycle approach forms part of a conceptual model for formulating an analytical framework (i.e., identifying the appropriate statistical, analytical, or numerical models to quantitatively and comprehensively assess the impacts of proposed actions).

Conceptual Framework

The Panel believes that there was an underlying conceptual framework in the BO, but that the conceptual framework was not explicitly identified and was, in our opinion, rather obscure. The framework had to be assembled by the reader due to its piecemeal and fragmented presentation in the BO. The BO's underlying conceptual framework should have been explicitly and clearly described, and brought to the forefront of the BO.

A conceptual framework is an important part of scientific evaluations like biological opinions. In the case of this BO, the conceptual framework would provide a set of scientific theories, hypotheses, principles, and assumptions, which describe how the salmonid-producing ecosystem functions. The conceptual framework aids in the interpretation of information, statement of the problems to be addressed, and identification of appropriate solutions (ISG 2000). Salmon at River's End (Bottom et al. 2005[2]), a report by NMFS biologists, argues that the foundation of traditional salmon management resulted in a conceptual framework characterized by "production thinking." Production thinking is a point of view that "... measured success by the output on natural resources (e.g., pounds or numbers of salmon, angler-days of use, etc.)" and that "emphasized short-term changes in the abundance of salmon, which were defined arbitrarily as any geographic unit of management interest (e.g., river basin, state, or nation)". As an

[2] The final publication for Bottom et al. was 2005, but the information was available from NMFS in draft form in 2001.

alternative, Bottom et al. (2005) argued for what they call "population thinking," a more ecologically and evolutionarily oriented point of view compared to production thinking (Table 1).

To the extent that the Panel was able to discern, the conceptual framework underlying the analyses in the BO is closer to production thinking than to population thinking. This contributed to some of the technical issues that our review identified, such as not giving enough attention to the spatial distribution of spring-run Chinook or to the diversity in life history patterns.

Table 1. Comparison of production thinking and population thinking in salmon biology and management. This table is reproduced from Table 2 in Bottom et al. (2005). The bottom two rows are stated as specific to estuaries, but it is straightforward to generalize them to be applicable to upstream habitats.

	Production Thinking	**Population Thinking**
Goals	Efficiency, production	Resilience, reproduction
Population Units	Arbitrarily defined	Biologically defined
Time Frame	Short	Evolutionary
Objectives	Control survival and abundance	Conserve local populations and life-history diversity
Estuary Function	Corridor for a single, homogenous group of salmon	Nursery area for many self-sustaining populations
Estuary Management	Control predators, promote rapid salmon out-migration	Protect habitats of diverse life-history types

<u>Life Cycle Approach</u>

The Panel believes that Bottom et al. (2005) and ISG (2000) present the beginnings of a useful conceptual framework that leads to a life cycle approach. A clearly articulated conceptual framework, coupled with a life cycle approach, is consistent with the guidelines stated in the ESA Section 7 Consultation Handbook. In our opinion, fully embracing this type of approach would have yielded a more transparent and coherent BO.

The BO describes in sufficient detail the general life history strategies of the listed species; however, it was not evident that all the relevant life history stages, and the linkages among them, were adequately treated in analyses. To explore the completeness of the analyses reported in the BO, we developed a life cycle impacts matrix (Table 2). The rows indicate habitats and the associated life stages from egg deposition through maturation and spawning. The columns indicate, by life stage, possible actions associated with the proposed projects (SWP and CVP), possible harvest and hatcheries effects, and possible effects of short and long-term environmental variation.

Table 2. Life cycle impacts matrix indicating potential major impacts on salmon habitats and life history stages. Qualitative and quantitative analysis of impacts, as reported in the BO, are indicated by L1 and L2 followed by the representative pages (p#) where the analysis is found in the BO. Potential impacts identified by the Panel which were not discussed in the BO indicated by L0. Actions not applicable to habitats and/or the associated life stages are shaded in gray.

<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th></tr>
<tr><th></th><th>Habitat
(life stage)</th><th>SWP/CVP Effects on Flow and Water Routing</th><th>SWP/CVP Dams and Land use</th><th>SWP/CVP Effects on Temperature</th><th>Hatchery</th><th>Harvest</th><th>Environmental Variation and Climate Change</th></tr>
<tr><td>1</td><td>Tributaries and Mainstem redds (Egg)</td><td>Flow changes dewaters eggs (L2 p103) (Table 9, 10), distribute gravel & may cause redd superimposition (L1 p132)</td><td>Increase sedimentation buries eggs (L1 p70)</td><td>High temperature decreases egg survival (L2 p94) (Table 9, 10)</td><td>Artificial production increases numbers of natural spawners. (L1 p72)</td><td>Sports fishing in habitat reduces egg viability. (L1 p85)</td><td>Warming decreases egg viability and incubation time. (L0)</td></tr>
<tr><td>2</td><td>Tributaries and Mainstem (Fry)</td><td rowspan="2">Flow fluctuations strand fish (L1 p 198)

Irrigation withdrawal entrain fish (L1 p157)

Agricultural return degrades water quality (L1 p82)</td><td rowspan="2">Floodplain controls fragment habitat (L1 p70

Reduces sources of large woody debris (L1 p69)

Increase predator habitat (L1 p70)</td><td rowspan="3">Water project induced variations in temperature can alter growth and predation rates. Effects may be beneficial with temperature control. (L2 p94).

High temperatures can increase fish disease (L1 p51)</td><td rowspan="2">Increased competition for food between wild and hatchery fish (L1 p58)</td><td>[shaded]</td><td rowspan="3">Climate Warming increases fry/smolt growth rates and predator activity. (L0)

High summer temperatures from climate warming may increase fish disease & mortality. (L0)

Ecosystem response to environmental change. (L0)</td></tr>
<tr><td>3</td><td>Migration corridor (Fry/Smolt)</td><td>[shaded]</td></tr>
<tr><td>4</td><td>Delta (Smolt)</td><td>Delta Cross Channel diverts fish. (L2 p149)

Delta pumps entrain fish (L2 p139)

Interior Delta mortality (L2 p190)(Table 9,10)</td><td>Evasive species present growth & provide predator habitat (L1 p84)</td><td></td><td>[shaded]</td></tr>
</table>

	A	B	C	D	E	F	G
	Habitat (*life stage*)	**SWP/CVP Effects on Flow and Water Routing**	**SWP/CVP Dams and Land use**	**SWP/CVP Effects on Temperature**	**Hatchery**	**Harvest**	**Environmental Variation and Climate Change**
5	Estuary/ Ocean (*Adult*)				Hatchery production increases fishing pressure on wild fish **(L1 p71)**	Harvest affects age structure. **(L1 p73)** Harvest regulation increased abundance **(L1 p88)**	Inter-annual and decadal variations in ocean productivity alter survival and migration routes of fish **(L1 p75)**
6	Delta (*Adult*)	Reduced flows may increase straying. **(L1 p150)**	DCC ops. delay migration and increase straying **(L1 p208)**		Offsite hatchery releases stray to natural populations **(L1 p60)**		**(L0)**
7	Migration corridor (*pre-spawn Adult*)	Depleted flows & agricultural returns block and delay migration **(L1 p82)**	Floodplain bypasses & diversion dams delay or block upstream migration. **(L1 p68 p82)**	Temperature variations alter survival & egg viability and may block upstream migration. **(L2 p125)**		Sport fishing catch and release increases prespawning mortality of steelhead (**L2 p84**)	Droughts and climate warming increase prespawning mortality and may block upstream migration. **(L1 p75)**
8	Tributary/ Mainstem (*Spawner*)	Flow variations alter spawning UWA **(L2 p162)**. Depleted flow reduce gravel & large wood debris recruitment **(L2 p194)**	Reservoir dams block access to spawning areas **(L2 p194)**	Temperature variations may alter spawning timing. **(L0)**	Mixed wild hatchery spawning homogenize stocks & reduce genetic diversity **(L2 p132, p192)**		Droughts and climate alter spawning timing. **(L0)** Drought reduces reservoir releases that benefit fish. **(L1 p75)**

Examples of locations in the BO that discussed specific life stages or interactions are indicted in the matrix cells by page numbers. We then evaluated the extent to which the BO treated each issue or interaction, assigning each treatment to one of three levels of analysis and quantification:

- Level 0 (L0). – Issues or interactions were not discussed in detail.
- Level 1 (L1). – Issues or interactions were discussed qualitatively but impacts were not quantitatively evaluated in terms such as changes in population or survival.
- Level 2 (L2). – Issues or interactions were evaluated with data and models and quantified in terms such as population change, survival change, or change in habitat area.

While the impacts matrix shown in Table 2 is only an example designed to illustrate benefits of the life cycle approach, the matrix does reveal several aspects of the analyses underlying the BO. First, most impacts in the BO were treated qualitatively (L1 level of analysis). In these cases, the potential impacts were discussed and the relative impacts were deemed insignificant or were not further evaluated. Second, interactions that were assessed quantitatively (denoted as level L2) were often evaluated with models that had different levels of detail. For example, the impacts of temperature on egg mortality were treated with linked models; the output of a model simulating the monthly water temperatures was used as input to a model of the temperature-dependence of egg mortality (BO pages 94-95). Other models were simple impact estimates. For example, hooking mortality, based on a study indicating 12% of hooked fish die, was expanded to an impact by assuming 30% of Central Valley steelhead was hooked and thus hooking mortality resulted in 3.6% mortality (BO, page 85). This type of impact matrix helps illustrate how the proposed projects and the environment affect fish in a broader ecosystem context. It can also be useful for organizing the analysis and presenting information in a more holistic and biologically-meaningful format. Connecting effects of actions within the cells in the matrix to a life cycle approach requires an analytical framework that can deal with both quantitative and qualitative measures of individual life stage impacts. In Appendix B, we illustrate using the example of smolt survival in the delta, how a quantitative analysis for a particular cell can be formulated and expressed in a life cycle context.

Analytical Framework

The Sacramento River system, and the associated water resource facilities, forms a very large and complex set of reservoirs and river reaches, which ultimately flow into the Pacific Ocean through the Delta. Because the system is so complex, an analysis of the effects of project operations, such as those examined in the BO, would benefit from an explicit analytical framework. The Panel believes that NMFS used an underlying analytical framework in the BO, but it was not explicitly identified or described and was, in our opinion, rather obscure. An explicitly described analytical framework would characterize the various components of the system, and, to the extent practicable, permit important processes and impacts to be quantified. The basis for the analytical framework is a clearly articulated conceptual framework and a life cycle approach. The analytical framework itself consists of the models, analytical tools, and assumptions used in the assessment, and how these models and tools relate to each other in terms of shared information and overlapping assumptions. General information on conceptual and analytical frameworks is described in USEPA (2000, 2003) and CALFED (1999).

An explicitly defined analytical framework would assist in: (a) ensuring the proper questions are assessed using appropriately configured models, (b) determining that the temporal and spatial resolution of the various models is consistent with the scales of the problem, (c) defining the data gaps, and overlapping assumptions and parameter values among the various models, (d) ensuring analyses are performed in a consistent manner using the same information pool, and that competing assumptions are clearly articulated, (e) providing a framework for incorporating uncertainty into calculations and for propagating the uncertainty through the models to allow assessment of overall risk, and (f) ensuring documentation of the various models and analyses, and accurate conveyance of assumptions and results to decision makers.

The Panel will not specify any preferred numerical models, statistical relationships, or analytical models that should be used in the BO, other than providing examples of specific models to illustrate the type of models that could be used. However, the formal construction of an analytical framework that relates these quantitative tools and assumptions to one another is a central part of the overall analysis. Important in this approach is the understanding that the models need not be directly integrated, but rather that the relationships, data sharing, and other key attributes should be clearly defined. An analytical framework allows for the flow of information to be followed and the implications, or consequences, of one model on subsequent models to be clearly understood. Finally, coupling of the analytical framework and the conceptual model provides a means for testing and, as necessary, updating the conceptual model during analyses. An example of an analytical framework is illustrated by the smolt survival analysis presented in Appendix B, wherein multiple survival relationships (or models) represent the routing of fish through the Delta.

Specific Technical Issues

The Panel identified 15 specific issues or areas in the BO, which if addressed, would improve the scientific basis and synthesis of information used in the BO. The issues are organized into three general categories: Flow and Temperature Related Effects and Analyses, Population Level Performance Indices, and Important Factors that were Inadequately Treated. For each issue, we identify which of the four reformulated questions is addressed. The 15 issues are:

<u>Flow and Temperature Related Effects and Analyses:</u>
Issue 1 – Too coarse of a temporal resolution in the analytical and numerical modeling related to temperature. (Questions 1 and 2)

Issue 2 – Unclear and sometimes inconsistent use of water temperature metrics for thermal criteria. (Questions 1 and 2)

Issue 3 – Too narrow treatment of temperature effects. (Questions 1, 2, 3, and 4)

Issue 4 – Reliance on a questionable LSalmon-2 temperature-egg mortality model. (Questions 1 and 2)

<u>Population Level Performance Indices:</u>

*Issue 5 – Other than ecologically-based metrics used to evaluate the significance of the impacts of specific effects. (*Questions 1, 2, and 3*)*

Issue 6 – Questionable calculations used to combine individual effects into cumulative impacts. (Question 1)

Issue 7 – Lack of a comprehensive population approach to jeopardy assessment. (Questions 1 and 2)

Issue 8 – Too little attention paid to effects and impacts on life history and population structure. (Questions 2, 3, and 4)

<u>Important Factors that were Inadequately Treated:</u>
Issue 9 – Little discussion of the potential effects of smolt migratory behavior and predatory fish on juvenile survival. (Questions 1, 2, 3 and 4)

Issue 10 – Too little explicit, quantitative treatment of uncertainty. (Question 2)

Issue 11 – Unclear connection between the analyses and the findings in the BO. (Questions 2 and 3)

Issue 12 - Too little consideration given to the potential negative effects of hatcheries in the integration and synthesis. (Questions 2 and 3)

Issue 13: Questionable use of surrogates in some situations. (Questions 1, 2, and 3)

Issue 14 –Inadequate accounting for fluctuations in ocean conditions that effect salmon survival. (Question 3)

Issue 15 – Too little attention devoted to effects of future global climate change. (Questions 2, 3, and 4)

Each of the issues is discussed below in two parts: a statement of the issue and suggested approaches for addressing the issue.

<u>Flow and Temperature Related Effects and Analyses</u>

Issue 1 – Too coarse of a temporal resolution in the analytical and numerical modeling related to temperature. **(**Questions 1 and 2**)**

***Statement*:** The Panel thought that monthly output for water temperature could be used, but additional information was presently available that should have been used to assess the implications of using a coarse monthly time step. The Panel agrees that using a series of nested models, in which the outputs of one model become the inputs to the next model, is a reasonable and viable approach for assessing the effects of the proposed project on water temperature and early life stage mortality. NMFS clearly recognized that the monthly output of the CALSIM II was coarse. As part of the Incidental Take statement (BO Term and Condition 6.d., page 220), NMFS required the Bureau of Reclamation to “develop guidelines for use of the current temperature model to analyze information produced by the model in combination with measured temperature profiles to evaluate seasonal risks of cold water management.” The monthly time step models that were used in the BO have been developed and applied for over thirty years in Bureau of Reclamation studies in the Central Valley. The Bureau of Reclamation was the lead agency in the preparation of the Biological Assessment. The Bureau of Reclamation is a well informed and educated model user, and the models used enable a relatively similar approach to be applied across the Sacramento River system.

However, despite these advantages, the application of monthly temperature models to anadromous fish studies is still a point of concern for the Panel. Of particular concern is the adoption, with little discussion, by NMFS of these monthly results in both assessing potential impacts and setting thermal criteria. One common thread to water temperature conditions in the Central Valley systems is variability. Long river reaches provide an opportunity for waters to heat appreciably during the warmer periods of the year. Diurnal temperature variation can be appreciable, as can the response of river systems to warm and cool spells, seasonal conditions, and tributary inputs. The spring and fall periods can experience appreciable differences in minimum, mean, and maximum daily temperatures. The spring and fall periods are also some of the most critical time periods in terms of water flow and temperature management for the salmon species of concern. Analyses only based on monthly temperature are difficult to interpret, especially in the context of whether the results are conservative (i.e., protective of the species). For example, one use of the monthly predictions was as input to an egg mortality model, in which temperature-related mortality is a non-linear transformation of temperature, so variation of temperature around the monthly value may have significant and asymmetrical effects.

Approach: Extensive field data collection efforts related to water temperature have been performed in the Sacramento River system. The advent of inexpensive remote logging thermistors has made available sub-daily temperature (e.g., hourly) observations in critical river reaches where salmon and steelhead reside. Furthermore, models that operate on sub-daily time steps have been applied to the Sacramento River (Deas et al 1997; Watercourse 2002), Clear Creek (Fellos 2000), the Feather River (Cook and Orlob 2000; Deas et al. 1997), and the Stanislaus River and lower San Joaquin River (AD and RMA 2002). The Panel realizes that use of these models is not simple and the models have not been used to date to address specific BO issues. However, the Panel believes that examination of existing field data and modeling results may offer appreciable insight about short term variability (e.g., daily, sub-daily) in temperature at important locations in the system.

The Panel is encouraged by NMFS’s requiring more detailed modeling in the future, but the Panel felt that some relatively simple analyses using presently available data could have been done for this BO. A relatively quick exercise would involve a detailed examination of field observations to construct exceedance plots or probability distributions of water temperatures at varying temporal scales (e.g., hourly and daily) for each month of the year. These data could then be superimposed on the simulated average monthly temperatures to provide insight into potential variation in water temperatures that may be experienced within a particular month. This information could then be used to discern implications of thermal conditions on target species.

For example, in larger river reaches, such as the Sacramento River below Keswick Dam, the use of monthly temperature data may be more applicable than smaller river systems because the large flow volumes and generally constant temperature release from Shasta Reservoir moderate daily and seasonal influences on water temperature. On smaller systems, or where flow releases are modest (e.g., Clear Creek, Stanislaus River), simulated average monthly temperatures most likely under represent the wide range of potential thermal conditions that salmon and steelhead experience.

Issue 2 – Unclear and sometimes inconsistent use of water temperature metrics for thermal criteria. (Questions 1 and 2)

Statement: The water temperature metrics used in the BO are not always clearly defined, different metrics are used across river systems, and their relationship to monthly predicted water temperatures is unclear. For example, temperature metrics reported in the BO are instantaneous maximum temperatures for the Feather River, daily mean temperatures for the Clear Creek, and instantaneous maximum temperatures for the Sacramento River, with the caveat that the Bureau of Reclamation consults with NOAA Fisheries to exceed this temperature in response to certain conditions (e.g., insufficient cold water, extreme ambient air temperatures, high downstream tributary flows of warm water). Furthermore, temperature criteria used in the BO vary for similar life histories on different river systems (e.g., 60^{o}F from June 1 through September 15 for over-summering steelhead in Clear Creek versus 65^{o}F from June 1 through November 30 for over-summering steelhead in the Stanislaus River).

For decades, resource managers have been attempting to characterize temperature criteria to assist in management of various salmon species among the river systems in California and in other regions. New technology has lead to relatively inexpensive and accurate measurement of water temperatures at fine spatial and temporal scales. Accompanying this availability of fine-scale water temperatures has also been improvements in the biological studies of salmon that relate to their exposure to environmental conditions (e.g., radio tracking of fish location). The ever increasing availability of fine-scale information has resulted in the continued refinement of thermal criteria for salmonids. Previously used metrics, such as mean weekly temperature, have been refined to include measures such as the 7-day average of the maximum daily temperature, daily maximum temperature, and even criteria where temperatures over a given threshold are allowable for a certain number of hours within a day.

Approach: Although attempts are made in the BO to explain some of the differences among the various stocks and streams, these differences and similarities could be made much clearer by assessing the thermal criteria on a basin scale, and by presenting the information in a single table (or tables) to permit easy comparisons. Also needed is a discussion on how the various temperature metrics that were used (e.g., maximum daily temperature) might be related to the simulated monthly average temperatures. Analyses suggested under Issue 1 would also provide useful information for better understanding and interpreting the temperature metrics.

Issue 3 – Too narrow a treatment of temperature effects. (Questions 1, 2, 3, and 4)

Statement: Some potentially important temperature effects were not clearly discussed or were not mentioned in the BO. The BO puts considerable emphasis on the effects of water temperature on a limited number of early life stages and focuses on winter-run Chinook. This is an important element to the BO, but in the opinion of the Panel, this is an incomplete view of the variety of temperature-related effects that should be examined. There are other temperature related effects that can have significant impacts on the developmental or ecological processes relevant to salmon and steelhead, and these effects can occur even within tolerated temperatures.

Three examples are the effects of temperature on emergence timing of spring-run Chinook, the shift to a resident *O. mykiss* life history, and on the spawning habitat for winter-run Chinook. The thermal inertia of reservoirs can increase the temperature in rivers downstream during fall and winter, resulting in more rapid incubation and earlier emergence of fry. On the Rogue River in Oregon, Lost Creek Dam elevated the mean daily incubation temperature of spring Chinook eggs by an average of 2.6°C, causing the mean date of fist emergence of fry to be earlier by 52 days and with the earliest spawning adults affected more than later spawning fish (Oregon Department of Fish and Wildlife 2000). The fry migration of fall-run Chinook salmon in the Sacramento River now begins about a month earlier than before Shasta Dam (Williams submitted), presumably because of warmer water in the winter (Moffett 1949). The impacts of these effects are not well-documented, but a change in emergence timing can seriously affect later survival (Miller and Brannon 1981). Cooler summer temperatures and increased summer flows have also created suitable habitat for a resident life history for *O. mykiss* in the Stanislaus and Sacramento Rivers, as well as creating spawning habitat for winter-run in the Sacramento River (Williams submitted). How these alterations affect spawning and survival is unknown. Even if these effects and their impacts cannot be quantified, the BO should more clearly recognize that the potential for these effects exists.

Approach: NMFS should assess the effects of changes in temperature on listed ESUs in a more comprehensive and systematic manner. The Panel believes that the acknowledgment, and possible inclusion, of a broader set of temperature effects in the analyses would provide a more complete ecosystem approach, and would improve the characterization of uncertainty and risk in the BO.

Issue 4 – Reliance on a questionable LSalmon-2 temperature-egg mortality model. (Questions 1 and 2)

Statement: The Panel questions whether using monthly predictions as input to the LSalmon-2 model permits accurate predictions of mortality, and whether the data used to develop the relationships in the LSalmon-2 model are representative of natural conditions. The LSalmon-2 mortality model was used to translate project-related changes in water temperature into effects on gametes, eggs, and alevins, and was a major component of the quantitative analyses used by NMFS in the BO. While the use of a series of models to generate temperatures that become the inputs to a mortality model is a reasonable approach, the specifics of the analysis performed by NMFS had three shortcomings. First, NMFS used predictions of temperature without any variation except linear interpolation between monthly means (see Issue 1). Because mortality is a non-linear function of temperature, predicted morality rates based on monthly means can under estimate stage mortality. Second, temperature at the time of spawning was taken as an index of pre-spawning temperature exposure. This approach seems unsatisfactory, particularly for spring-run Chinook, which hold over through the summer and spawn in the fall as temperatures decline. Third, and most serious, the data used to develop the relationships between temperature and mortality on eggs, alevins, and especially gametes was not the best available. According to LSalmon-2 model documentation (Bureau of Reclamation 1991), the pre-spawning egg (gamete) mortality data came from batches of eggs at Nimbus Hatchery in 1956 (Table 1 in Hinze et al. 1956). Hinze et al. (1956) is a report of the first year of operation of Nimbus Hatchery on the American River, and the report notes that severe water quality problems occurred in the American River in 1955. The poor water quality was due to the partial filling of Folsom Reservoir with relatively warm water, and from high oxygen demand and sulfides from decaying vegetation in the new reservoir. Similarly, the relationship between temperature and alevin mortality used in the model apparently was based on the opinions of hatchery managers, rather than experimental data. In addition, the Panel was also unable to reproduce the various calculations reported in the model documentation that converted the original pre-spawning egg survival as a function of temperature into daily mortality rates.

Approaches: NMFS should perform a through analysis of the data, relationships, and calculations of the LSalmon-2 model and suggest or make improvements to the model, and investigate how variation around monthly mean temperatures would affect predictions of survival. As far as we know, experimental data on mortality in early life stages from short exposures to temperature stress are not available, although there are data indicating that embryos are more tolerant of warm water in early incubation (Olson and Foster 1957). Predicting daily survival for eggs and alevins from relationships based on experimental data that used constant incubation temperatures is the best that can be done. These relationships should be developed and incorporated into the model. Some sources of data for deriving relationships between salmon egg mortality and temperature are Marine (1992), Myrick and Cech (2001), and USFWS (1999). Limited data makes modeling pre-spawning mortality of gametes more problematic. Perhaps information from temperatures in holding habitat in the Sacramento River can be used to infer whether predicted temperatures would likely affect gamete survival (see Williams, submitted).

Population Level Performance Indices

Issue 5 – Other than ecologically-based metrics used to evaluate the significance of the impacts of specific effects. (Questions 1, 2, and 3)

Statement: Evaluation of the biological significance of impacts of specific effects was sometimes based on historical losses that had varying degrees of biological foundation. For example, the BO allows a 2% take of winter-run Chinook at the Delta pumps that was based on historical levels, what was feasible for operations, and simply what was a small number. Effects of the proposed project operations were then compared to this 2% and deemed small if they were similar to or less than the 2%. In the Panel's opinion, this is too far removed from a standard based on ecological and population-level considerations. The real question is how an increase in mortality, and other effects, due to the stressor would impact the population.

Approach: Using ecologically-based benchmarks, such as comparison of increased mortality rates with mortality rates in other life stages, to assess biological significance is a preferable approach. If such ecological benchmarks cannot be reasonably quantified and established, then the BO should clearly identify the metrics used and acknowledge the limitations and assumptions inherent in the different metrics, especially those based more on historical practices and less on ecological considerations.

Issue 6 – Questionable calculations used to combine individual effects into cumulative impacts. (Question 1)

Statement: NMFS attempted to assess population level impacts of the project-related effects on individuals by incorrectly summing up percentages across effects. An example of this is Table 10 in the BO (page 194). The various percentages were summed to obtain a total effect, but some of the percentages were based on different denominators and thus cannot be simply added together. To be able to sum up effects, the percent effects should be based on the same denominator and the effects should be in the same measurement units (e.g., all expressed as the decrease in life stage survival). The Panel noted that the computed total (or combined) effects, even when appropriately combined, would likely be underestimates because they were based on the subset of effects that were examined and that were quantifiable.

Approach: Population level analyses should be performed that are based on inclusion of as many effects as possible and on proper combining of multiple effects to obtain cumulative impacts. These cumulative effects can be expressed as population level impacts (e.g., changes in λ, the finite population growth rate) by using relatively simple life table calculations (see Issue 7).

Issue 7 – Lack of a comprehensive population approach to jeopardy assessment. (Questions 1 and 2)

Statement: While the ingredients for a population level assessment were present in the BO, the Panel thought the quantitative analyses of the population level impacts were inadequate. Individual effects, or properly obtained combined effects, can be considered in terms of the fractional change in the population's finite rate of increase (λ). NMFS referred to estimates of λ in the BO, but did not attempt to relate how summed individual-level effects might affect the population growth rates. Clearly more careful analyses need to be done, but such calculations are feasible. Furthermore, multi-generational impacts, and possible compensatory and depensatory density-dependent responses, were either assessed using qualitative arguments or not discussed. In general, it is not clear to the Panel that the total effects of the proposed projects on life stage mortality and population jeopardy were properly considered.

Approach: A jeopardy assessment needs to be based on a life cycle approach that considers the combined effects of actions with uncertainties and reasonable estimates of future variability. The assessment should include mathematical analyses that can be conducted at various levels of detail, depending on the available information. Where information is sufficient, model-based population predictions can be applied. A variety of modeling approaches are available including matrix projection models, spawner-recruit models, and extinction models (Greene and Beechie 2004; Dennis et al. 1991; Holmes 2001; Holmes and Fagan 2002). The age and stage-based matrix projection models, commonly used in fisheries management, can be viewed as variants of a life table approach. Also, there are programs available that make such models easy to use and analyze, such as POPTOOLS in Excel. The Panel is not saying detailed simulation models are necessary, or which model should be used, or that density-dependence must be included. Further, the Panel recognizes that many issues can arise in the details of how any type of population-level analysis would be done. However, the BO would benefit from at least an attempt to better express the population impact of the multiple effects, and from a more detailed explanation of any potential density-dependence processes and how they might affect population dynamics.

Issue 8 – Too little attention paid to effects and impacts on life history and population structure. (Questions 2, 3, and 4)

Statement: The BO's treatment of the impacts of project operations on life history traits (e.g., growth rates, fecundity), and population structure (e.g., immigration and emigration rates) was limited. Population level indices are instructive demographic measures that could be more prominently discussed in the BO. McElhany et al. (2000) developed the concept of the viable salmonid population, and described four parameters that are central in evaluating population status and ultimately viability: abundance, population growth rate, population spatial structure, and diversity (life history and genetic). The BO focused on abundance trends and, to some extent, on population growth rates. However, population spatial structure and diversity deserve attention as well, and these may be more sensitive to proposed project operations under certain conditions of climate scenarios.

While effects on the growth rate of individuals were considered in the BO, their impacts beyond individual-level effects were not considered. For example, the BO noted the optimum temperatures for growth for Trinity River coho (page 99), and that cool water releases above Red Bluff Diversion Dam may increase the growth rate among resident trout and thereby skew the steelhead population towards non-anadromous forms (page 110). However, the significance of these possible effects was not discussed in either quantitative or qualitative terms.

Another example is how demographic impacts on steelhead populations were mentioned in the BO (page 201). After noting that project operations will affect the likelihood of steelhead population extinctions, the BO states:

> "As a result, the ESU would be rendered more vulnerable to demographic and other stochastic extinction processes by reductions in the number of populations, population abundances, ESU diversity, and spatial distribution. Based on recent status and trends, the current ESU is comprised of several populations all with high probabilities of extinction. Minor increases in the likelihood of extinction of one or more populations within such a species could have measurable impacts on the regional probability of extinction, based on the proportional relationship between local and regional probabilities of persistence in species. However, given the widespread distribution of the species, we expect that the ESU's overall probability of extinction is buffered against appreciable changes."

In this statement, a number of important issues related to life history and population structure are discussed, but are deemed to be unimportant in terms of extinction probabilities. More detailed discussion of the evidence for inferring that the effects will have little impact on extinction probability would be helpful.

General arguments that the extinction probability of spring-run Chinook would not be affected by proposed project operations are more difficult to justify based on simple qualitative arguments. The Central Valley Technical Recovery Team (CVTRT) noted that some streams appear to offer marginally suitable habitats that either depend on migrants from the nearby streams or operate as a metapopulation in which each stream is not individually viable, but the group persists. The Panel agrees with the CVTRT (Lindley et al. 2004) that these dependent populations are a valuable resource because they exist in marginal environments, may contain valuable genetic attributes, and may serve to link other populations in ways that increase ESU viability over longer time scales. Because spring-run Chinook have only three stable populations (Mill, Deer, and Butte creeks) and a number of dependent or intermittent populations (Big Chico, Antelope, Clear, Thomas, Beegum, and Stony creeks), any processes that increase spring-run Chinook mortality in the future can have significant impacts on the population demographics and therefore on the risk of extinction (Lindley et al. 2004). Furthermore, the extent of a spring-run Chinook population that historically spawned in the upper Sacramento River is now unclear, and the population may have with hybridized with a fall-run (BO page 57). Water temperatures and operations of the Red Bluff Diversion Dam continue to reduce the mainstem Sacramento River spring-run Chinook, and the proposed actions and possible global climate warming are expected to lead to its extirpation (BO page 198). In sum, it would appear that, unlike steelhead, spring-run Chinook are not widely distributed and the limited intermittent populations are under a number of threats from project operations and climate change. Thus, more detailed analysis of the demographic impacts of the proposed projects on spring-run Chinook should be performed.

Approach: The Panel appreciates the difficulties in assessing project operations on demographic properties other than mortality. However, the potential impacts on life history and spatial structure should be addressed in more detail (qualitatively if necessary) in the BO, especially in those situations when available information suggests high vulnerability of extinction to effects on individual growth rates, fecundity rates, or spatial structure. The Panel recommends treating the effects qualitatively to assess if any significant risk to the population exists. The Panel does not see any immediate means to systematically predict changes in the population spatial structure and diversity under project operations and future conditions. However, NMFS should discuss the degree of uncertainty attending these potential population impacts, and identify any vulnerable breeding units.

Specific suggested areas for more detailed analysis include: (1) how project operations may affect the diversion of juveniles in floodplains where they can grow faster, (2) evaluation of evidence to determine if young of the year juvenile salmon grow faster in the Delta than in the lower Sacramento and whether this might increase estuarine and ocean survival, and thereby partially compensate for any increased mortality within the Delta, (3) whether proposed project operations can affect growth and fecundity that are used to compute the juvenile production indices, which are the basis for assessing population status, and (4) consideration of how proposed project operations might affect the spatial structure of Clear Creek spring-run Chinook and upper Sacramento River spring-run Chinook.

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Important Factors that were Inadequately Treated

Issue 9 – Little discussion of the potential effects of smolt migratory behavior and predatory fish on juvenile survival. (Questions 1, 2, 3 and 4)

Statement: The BO identified several species of predatory fish in the Sacramento River system, but offered no clear assessment of their potential impacts on the ESUs. In the Snake-Columbia River system, predatory species (e.g., northern pikeminnow, smallmouth bass, catfish) have been identified as critical sources of mortality of juvenile salmon, particularly subyearling Chinook during the summer months (Rieman et al. 1991). The Reiman et al. (1991) study estimated that 14 % of all juvenile salmon entering the John Day Reservoir on the Columbia River were consumed by predatory fish species. Predator activity varies with prevailing water temperature. For northern pikeminnow, consumption rate increased with increasing water temperature up to some maximum (Vigg and Burley 1991). Connor et al. (2003) described a relationship where survival of the subyearling Chinook migrants in free-flowing sections of the Snake River increased with decreasing water temperature. The survival effects were primarily ascribed to the interaction between salmon migration speed and predator feeding activity, which were in turn related to water flow (water velocity) and temperature.

How proposed project operations, which affect water temperatures, will affect juvenile salmon migration dynamics and predator-related mortality is not well-treated in the BO and can be a major source of uncertainty. The Columbia River studies suggest temperature changes can have significant effects on juvenile salmon movement and resulting mortality from predation. It was unclear to the Panel whether predation on juvenile salmon by native and exotic fish species is an important source of mortality in the Sacramento River system, and the degree to which predator feeding activity may be temperature regulated. These issues become especially important under anticipated warmer than present conditions due to global climate change.

Approach: We recognize that it is impractical for the BO to construct a survival model for salmon that embraces all freshwater life stages and important mechanisms. Nevertheless, the BO could provide more detail on what is known about predatory fish species in the system, describe their population trends over recent decades, and the likelihood for their expansion under future scenarios. The BO could rely on information from other large river systems like the Columbia, and extrapolate that knowledge to the Sacramento system. If future operations foster the expansion of predatory species, this could put the salmon ESUs at increased risk. We suggest that the BO explore the likelihood of this possibility.

Issue 10 – Too little explicit, quantitative treatment of uncertainty. (Question 2)

Statement: The BO does not adequately address uncertainty and risk associated with the analyses. Uncertainty is addressed in rather general terms, and risk is not formally discussed. We encountered little documentation regarding the need to minimize type II error (error of incorrectly taking no action when action was needed). In the BO, Adaptive Management (AM) was periodically invoked as a response to emerging information, and any AM action was presumed to offset the projected impacts (e.g., barriers operation Head of Old River). Full consideration of uncertainty leads to decisions being based on risk, and a better understanding of the likely impacts of the proposed project.

Francis and Shotton (1997) describe six types of uncertainty associated with fisheries management that also apply to assessing the proposed project operations on salmon species in the Sacramento River system. These types of uncertainty are: process, observational, model, estimation, implementation, and institutional uncertainty. Process uncertainty arises from natural variability. No amount of study can reduce this uncertainty, which Fogarty et al. (1996) called irreducible and Mangel et al. (1996) described as likely very large in magnitude in ecosystems. Observational uncertainty arises from measurement and sampling errors. Model uncertainty reflects incomplete knowledge and the need to make simplifying assumptions to make models tractable. Estimation uncertainty arises from the need to assign values to parameters, and thus includes process uncertainty and observational uncertainty (chance variation and errors in measurement) and errors associated with prior analysis of the data to obtain parameter values (e.g., uncertainty associated with using regression analysis of the data to estimate a parameter). Estimation uncertainty puts severe practical limits on the complexity of models used to make predictions (Ludwig 1994). Implementation uncertainty concerns the extent to which management policies can be successfully implemented (Rosenberg and Brault 1993). In typical fisheries management, "institutional uncertainty" arises from "... problems associated with the interactions of the individuals and groups (scientist, economist, fisherman, etc.) that compose the management process" (O'Boyle 1993), and is often compounded by the lack of well-defined social, economic, and political objectives.

Approach: NMFS should place more emphasis on quantifying the degree and types of uncertainty and risk associated with the analyses and conclusions in the BO. There exist methods for examining various subsets of the sources of uncertainty (e.g., parameter estimation uncertainty using Monte Carlo methods), while for other sources simple awareness helps with the interpretation of the results and conclusions. A logical place in the BO for a more detailed discussion of uncertainty and risk would be in the synthesis chapter.

Issue 11 – Unclear connection between the analyses and the findings in the BO. (Questions 2 and 3)

Statement: The Integration and Synthesis of Effects section of the BO is a critical part of the document. In this section, all the different analyses reported in BO are brought together in a scientific synthesis to produce a coherent summation of the effects and the likely impacts of the proposed action on the listed ESUs. The handout given to the Panel at the October 12-13, 2005 workshop (see footnote 1) states that the BO should show a rational connection between the facts that were found and the conclusions reached. The Panel concludes that the synthesis and reasoning described in the BO is murky and does not present a clear, easy-to-follow connection between the results and the conclusions. We are not evaluating the jeopardy conclusion here, but are commenting on the reasoning and synthesis that connects the body of the text to whatever jeopardy conclusion is reached.

Table 9 of the BO is the core of the synthesis of effects and impacts on the populations of interest. Table 9 lists ten effects resulting from the proposed action, some of which could not be quantified. However, Table 9 fails to list at least eleven other effects of the proposed action that were mentioned in the BO (Table 3).

Table 3. Eleven effects of the proposed action mentioned in the BO that were not quantified and not included in Table 9 of the BO. RBDD = Red Bluff Diversion Dam.

	Effect	BO Page
1	The effect of hatcheries on natural populations	72, 73, 85, 165-168, 191-92
2	The effects of RBDD on adult *spring Chinook*	184
3	The effects of RBDD on juvenile salmonids	184
4	The effects of decreased and fluctuating flows below Folsom Dam	185
5	Reduced instream habitat below Goodwin Dam,	185
6	Sub-lethal effects of delays or diversion of migrants in the Delta due to flow, facility operations and impaired water quality	186
7	Increase in vulnerability in Feather River due to flow fluctuations	199
8	Sublethal effects on juvenile steelhead of elevated summer temperature in Clear Creek	104
9	The effects of changes in water quality including temperature on juvenile salmonids in the Delta	71
10	The effects of predation on juvenile salmonids at various points in their migratory corridor	74
11	The salmon mortality model only estimates mortality of early life stages. Temperature related mortality or sublethal effects on later developmental stages is unknown	95

Our Table 3 lists those effects mentioned in the BO. A comprehensive synthesis would also include effects we identified under other issues that were not discussed in the BO.

In response to a question from the Panel asking how uncertainty was supposed to be handled in the BO, Bruce Oppenheim responded with the following:

"…. Guidelines (ESA Handbook) say that in cases where there are significant data gaps there are two options: (1) extend the due date of the opinion until sufficient information is developed, or (2) develop the opinion with the available information, giving the benefit of the doubt to the species. …" In order to bridge the gaps a biologist is supposed to give evidence supporting the assumptions, such as available theory, inference form patterns, use of surrogates, or develop a series of scenarios to explain the range of possible scenarios supported with literature references. Then we have to assess the probability of how likely or unlikely an event will occur."

We interpret this guideline to mean that the effects or issues that cannot be quantified should still be integrated into the synthesis, and that the process of integration should be clearly described. The Panel did not see such a complete and transparent integration in the BO, although the presentations at the October 12-13 workshop suggest that some of the unquantified effects were given more consideration than was evident in the written text of the BO.

Approach: At a minimum, the BO should explain how the effects listed in Table 3 were taken into account, especially in the Integration and Synthesis section, and all of the effects should be listed in Table 9.

Issue 12 - Too little consideration given to the potential negative effects of hatcheries in the integration and synthesis. (Questions 2 and 3)

Statement: The effects of hatcheries were qualitatively described in the text of the BO (e.g., pages 72, 73, 85, and 165 to 168), but they were seemingly ignored in the Integration and Synthesis section, except for a comment noting that hatchery effects would be treated in a separate future consultation. Treating hatchery effects separately from the rest of the effects appears to contradict the BO (page 165):

> "Hatcheries can no longer be managed as isolated from the natural system, as their operations directly affect the viability of natural fish populations (Williams et al. 2003)."

The analyses of hatchery effects should not be isolated from the other effects addressed in the BO.

The BO notes that there are both ecological and genetic risks to naturally reproducing fish from interactions with hatchery fish (pages 165-166), and that other [than winter-run] ESUs considered in the BO, the naturally spawning populations are dominated by hatchery fish (page 192). The BO also recognizes that hatchery rearing may select for traits that are "advantageous in a hatchery setting and accompanied by a loss of fitness for natural rearing" (page 192).
The Recovery Science Review Panel (RSRP) is an expert panel that advises on overall recovery planning for Pacific salmon. In a review of hatchery effects, the RSRP reports data that suggest that fitness (as measured by relative survival) decreases by about 20% for each generation of hatchery culture (RSRP 2004). The RSRP noted that the studies reporting a loss of fitness all have shortcomings; however, the hypothesis of continuing loss of fitness seems well supported.

Approach: NMFS should use the available literature to better estimate the impacts of hatcheries for use in this BO, and should incorporate those estimates into the overall integration and synthesis of effects. While the effects of hatcheries may be scheduled for a subsequent BO, the Panel believes that it is difficult to completely assess the effects and impacts of the proposed projects in the present BO without more detailed treatment of hatchery effects. Potential sources of information are Chilcote et. al. (1986) and Chilcote (2003) (cited in the BO), and recent models such as those described in Ford (2002), Lynch and O'Hely (2001), and ISAB (2003). A more detailed treatment of hatchery effects, as recommended here, should be considered an interim measure until the more definitive information can be obtained from future consultations.

Issue 13: Questionable use of surrogates in some situations. (Questions 1, 2, and 3)

Statement: Impacts associated with the Delta pumps may be understated by using late fall Chinook as surrogates for other ESUs and life history types. Juvenile late fall-run Chinook are used as surrogates for yearling spring-run Chinook for the purpose of estimating incidental take at the Delta pumps. However, the timing of the emigration of juvenile spring-run from Mill, Deer, and Butte Creeks is highly variable and protracted (Lindley et al. 2004). Especially for Butte Creek, the large majority of individuals emigrate as fry, and it seems highly likely that once these fish reach the valley lowlands, they are committed to passing through the Delta before the heat of summer. Many juveniles emigrating from Butte Creek have been tagged, and all of the 90 marked adults recovered in the stream were tagged as fry, as were 47 of the 50 fish recovered in the ocean fishery (Paul Ward, CDFG, personal communication 2005). Accordingly, use of late fall-run fish as surrogates for fish that emigrate other than during the late fall and early winter may not provide accurate information on incidental take.

Approach: The Panel suggests using a table to identify and present what surrogates were used, assumptions associated the use of the surrogates, any support for those assumptions, and a discussion of the resulting uncertainties associated with the use of surrogates.

Issue 14 –Inadequate accounting for fluctuations in ocean conditions that affect salmon survival. (Question 3)

Statement: The BO noted the importance of ocean conditions for salmon and steelhead populations, and that marine survival of salmonids has fluctuated on a 20 to 30 year cycle in response to changing ocean conditions (page 75). The BO also noted that recent increases in the abundance of returning adult winter-run and spring-run Chinook corresponded to favorable ocean conditions, and that ocean conditions will likely change in the future. However, NMFS did not incorporate the effects of possible poorer ocean conditions in the future into their analysis. Of course there are marine-based harvest activities that will complicate any analysis that includes variable ocean conditions.

Ocean conditions are of particular concern in the assessment of the status of winter-run Chinook salmon. The BO seemed to depend heavily on the recent increase in abundance of returning adults in assessing the effects and impacts of the proposed project operations. The following text is from page 197 of the BO.

> “Given the positive indicators in the population observed over the last 8 years, it would appear that the winter-run Chinook population is recovering. While it is concerning that future Project operations are likely to result in the loss of more juveniles in each year class, NOAA Fisheries expects that adaptive management processes will reduce these increased impacts to low levels. … NOAA Fisheries reasons that these losses are not sufficient to reduce the likelihood of survival and recovery of the winter-run Chinook based on the observed and estimated recovery rates in the ESU. Recent CRRs [cohort replacement rates] in the population have been high enough that minor reductions due

to a 5% loss in juveniles would not cause the population to decline, however some reduction in the rate of ESU recovery may occur."

In discussing variation in ocean conditions and their effects on salmon populations in other documents, NMFS has cautioned against giving too much weight to short-term increases in abundance during periods of favorable ocean conditions (Federal Register: 69(113) for June 14, 2004, at p. 33114):

> "Given all these uncertainties, the [Biological Recovery Team] was reluctant to make any specific assumptions about the future behavior of the ocean-atmospheric systems or their effects on the distribution and abundance of salmon and *O. mykiss*. The BRT was concerned, however, that even under the most optimistic scenario, increases in abundance might be only temporary and could mask a failure to address underlying factors for decline. The real conservation concern for west coast salmon and *O. mykiss* is not how they perform during periods of high marine survival, but how prolonged periods of poor marine survival affect the [Viable Salmonid Population] parameters abundance, growth rate, spatial structure, and diversity. …"

We believe that the concerns of the BRT (Biological Recovery Team) are well founded, and the consequences of possibly less favorable ocean conditions in the future should have been addressed in more detail, perhaps as part of the scenarios, in the BO.

Approach: The analysis in the BO should include the effects of fluctuations in ocean productivity. Assessing ocean variability is problematic but surrogate estimates of ocean productivity derived from hatchery smolt-to-adult ratios may be sufficient to yield a reasonable estimate of the probability distribution of λ A further step would be to determine if the hatchery productivity exhibits statistically significant correlations with the Pacific Coast Chinook stocks. For an interim step, the magnitude of the effects of changing ocean conditions might be estimated from the effects of past fluctuations of ocean productivity reported in the literature. The BO should provide more information on harvest trends in recent decades. This would help associate the observed changes in adult returns with marine processes and anthropogenic effects.

Issue 15 – Too little attention devoted to effects of future global climate change. (Questions 2, 3, and 4)

Statement: The Panel did not feel that the effects of global climate change received adequate treatment in the BO, and that this deficiency leads to uncertainty regarding the analyses and proper characterization of the risk to the ESUs. Fisheries scientists have recognized the importance of considering climate change in management decisions regarding aquatic resources. In 1995, National Research Council of Canada published a compendium of symposium papers that focused on the effects of climate variability and long-term trends on numerous fish species in the northern Pacific, including northwest salmon stocks (Beamish 1995). A prominent theme was that the increasing probability for global warming could impact the distribution, productivity, and demographic structure of salmonid populations. Since then, increasing trends in water temperature (approximately one degree Celsius, spanning several recent decades) have been documented in the salmon-producing Fraser and Columbia Rivers (NRC 2004-b). In their report, the National Research Council highlighted that this alarming trend imposes increased risk on salmon stocks in those systems into the foreseeable future. Recent climate change has also been reported for the Central Valley (e.g., Cayan et al. 2001).

Approach: The Panel suggests that additional scenarios, which include potential future global climate conditions, be included in the analysis. This would better characterize the uncertainty associated with future conditions when compared to the baseline case. The Panel agreed that different water-flow year types were an appropriate way to stratify the analysis, and that use of long-term historical data was an important component of a full assessment. But we contend that the inclusion of some worst case conditions (e.g., long sequence of dry years), in concert with regionally warming temperatures, would better characterize the uncertainty in predictions and risks to the ESUs.

There is information available that could assist NMFS in formulating the additional scenarios we are suggesting. Expected changes in climate for the Central Valley have been reported in several technical and refereed papers (Dettinger and Cayan 1995; Cayan et al. 2001; Knowles and Cayan 2002; Mote 2003; Hayhoe et al. 2004; Dettinger 2005). Some of this information has also been presented in regional scientific conferences, such as at the CALFED Science Conferences. While there is disagreement among the climate models about likely effects on precipitation and other climate-related variables, there is sufficient consensus about temperature changes and enough information to bound likely changes in precipitation and other variables to warrant incorporation into some of the scenarios examined in the BO. In summary, the predicted trend is for warming, reduced snow pack in the Sierra Nevada, wetter winters with more flooding, and drier summers. The California Department of Fish and Game has good information on water temperature and temperature-related mortality among spring Chinook in Butte Creek that could inform an assessment of the effects of global climate change on spring-run Chinook.

Concluding Remarks

The Panel would like to reiterate our appreciation for the cooperation of NMFS and NOAA Fisheries in conducting this review. We understand the complexity involved in preparing the BO for proposed project operations on listed salmon and steelhead in the Sacramento River system, and the time constraints imposed by the ESA process. We hope that this review is useful for improving this and future biological assessments and opinions related to salmonids and other fish species in Central Valley.

Our review includes three overarching issues, responses to the four questions (presented in the Executive Summary only) that we reformulated as part of the original seven questions in our charge, and statements and suggested approaches for 16 technical issues. Based on this information, the Panel is unanimous in its finding that the scientific information used in the BO is not the best available.

References Cited

AD Consultants, and Resource Management Associates, Inc. (AD and RMA). 2002. Stanislaus River Modeling Report. Prepared for the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District. March.

Beamish, R.J. (editor). 1995. Climate Change and Northern Fish Populations. Canadian Special Publication of Fisheries and Aquatic Sciences 121, 739 pp.

Bureau of Reclamation. 1991. Appendices to Shasta outflow temperature control. Planning Report/Environmental Statement.

Bureau of Reclamation. 2004. Long-term Central Valley Project and State Water Project Operations Criteria and Plan: Biological Assessment.

Bottom, D.L., C.A. Simenstad, A.M. Baptista, D.A. Jay, J. Burke, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. National Marine Fisheries Service, Seattle, WA.

CALFED Bay-Delta Program (CALFED). 1999. Comprehensive Monitoring, Assessment, and Research Program (DRAFT). January 15.

Cayan, D.R., S. Kammerdiener, M.D. Dettinger, J.M. Caprio, and D.H. Peterson. 2001. Changes in the onset of spring in the western United States. Bulletin of the American Meteorological Society 82:606-623.

Chilcote, M.W. 2003. Relationship between natural productivity and the frequency of wild fish in mixed spawning populations of wild and hatchery steelhead (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 60: 1057-1067.

Chilcote, M.W., S.A. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115: 726-735.

Connor, W., H. Burge, J. Yearsley, and T. Bjornn. 2003. Influence of flow and temperature on survival of wild subyearling fall Chinook salmon in the Snake River. North America Journal of Fisheries Management 23:362-375.

Cook, C.B. and G.T. Orlob. 2000. Numerical estimation of dynamic water temperature fluctuations at compliance point Robinson Riffle: U.C. Davis Feather River Computational Model [draft]. Report to the California Department of Water Resources from the Department of Civil and Environmental Engineering, University of California, Davis.

Deas, M.L. C.L. Lowney, G. K. Meyer; C.B. Cook, J.Anderson, and M. Kirkland, 1997. Sacramento River Temperature Modeling Project. Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, University of California, Report No. 97-01.

Dennis, B., P.L. Munholland, and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

Dettinger, M.D. 2005. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science 3(1), Article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4.

Dettinger, M.C. and D.R. Cayan. 1995. Large-scale atmospheric forcing of recent trends toward early snowmelt in California. Journal of Climatology 8: 606-623.

Fellos, J.J. 2000. Flow and Temperature Relationships for Restoration of Fish Habitat in Clear Creek. Master's Thesis, Department of Civil and Environmental Engineering, University of California, Davis.

Fogarty, M.J., R.K. Mayo, L. O'Brien, F.M. Serchuk, and A.A. Rosenberg. 1996. Assessing uncertainty in exploited marine populations. Reliability Engineering and System Safety. 54:183-195.

Ford, M.J., 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology 16: 815-825.

Francis, R.I.C.C. and R. Shotton. 1997. "Risk" in fisheries management: a review. Canadian Journal of Fisheries and Aquatic Sciences 54:1699-1715.

Greene, C.M. and T.J. Beechie, 2004. Consequences of potential density-dependent mechanisms on recovery of ocean-type Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 61: 590-602.

Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J.U. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101:12422-12427.

Hinze, J.A., A.N. Culver, and G.V. Rice. 1956. Annual report of the Nimbus Salmon and Steelhead Hatchery, Fiscal year of 1955-56. California Department of Fish and Game, Inland Fisheries Administrative Report Number 56-25.

Holmes, E.E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Science 98:5072-77.

Holmes, E.E., and W.F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83:2379-2386.

Independent Scientific Advisory Board (ISAB). 2003. Review of salmon and steelhead supplementation. Northwest Power Planning Council, Portland, OR.

Independent Scientific Group (ISG). 2000. Return to the River, Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council, Doc. 2000-12.

Knowles, N. and Cayan, D. 2002. Potential impacts of climate change on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophysical Research Letters 29(18),1891, doi:10.1029/2001/GL014339

Lindley, S.T., R. Schick, B.P. May, J.J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley basin. Public review draft. NOAA Fisheries Southwest Science Center, Santa Cruz, CA.

Lynch, M., and M. O'Hely, 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics 2:363-378.

Ludwig, D. 1994. Uncertainty and fisheries management. Pages 514-528 in S.A. Levin (ed.) Frontiers in Mathmatical Biology. Spring-Verlag

Mangel, M.C. and 41 others. 1996. Prinicples for the conservation of wild living resources. Ecological Applications 6:338-362

Marine, KR. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult Chinook salmon (*Oncorhynchus tshawytscha*). Department of Wildlife and Fisheries Biology, University of California, Davis.

McElhany, P., M. Ruckleshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionary significant units. NOAA Technical Memorandum NMFS-NWAFSC-42.

Miller, R. J., and E. L. Brannon. 1981. The origin and development of life history patterns in Pacific salmonids. Pages 296-309, In: E.L. Brannon and E.O. Salo (editors), Proceedings of the Salmon and Trout Migratory Behavior Symposium. School of Fisheries, University of Washington, Seattle.

Moffett, J. 1949. The first four years of king salmon maintenance below Shasta Dam, Sacramento River, California. California Fish and Game 35:77-102.

Mote, P.W. 2003. Trends in snow water equivalent in the Pacific Northwest and their climatic causes. Geophysical Research Letters, 30, doi 10.1029/2003GL0172558.

Myrick, C.A., and J.J. Cech. 2001. Temperature effects on chinook salmon and steelhead: a review focusing on California's Central Valley populations. http://www.cwemf.org, Bay-Delta Modeling Forum.

National Research Council (NRC). 2004-a. Improving the Use of the "Best Scientific Information Available" Standard in Fisheries Management. National Academies Press, Washington, DC.

National Research Council (NRC). 2004-b. Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival. National Academies Press, Washington, DC.

O'Boyle, R. 1993. Fisheries management organizations: a study in uncertainty. Pages 423-436 in Smith, S.J., J.J. Hunt, and D. Rivard, eds., Risk evalatuion and biological referenced points for fisheries management. Canadian Special Publications in Fisheries and Aquatic Sciences 120.

Olson, P.A., and R.F. Foster. 1957. Temperature tolerances of eggs and young of Columbia River chinook salmon. Transactions of the American Fisheries Society 85: 203-207.

Oregon Department of Fish and Wildlife. 2000. Rogue Basin Fisheries Evaluation:Effects of Lost Creek dam on Spring Chinook Salmon in the Rogue River. Phase II Completion Report, Vol. 1, Portland, OR.

Rieman, B., R. Beamesderfer, S. Vigg, and T. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Recovery Science Review Panel (RSRP). 2004. Report for the meeting held August 30 to September 2, 2004. NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA.

Rosenberg, A.A. and S. Brault. 1993. Choosing a management strategy for stock rebuilding when chontrol is uncertain. Pages 243-249 in Smith, S.J., J.J. Hunt, and D. Rivard, eds., Risk evalatuion and biological referenced points for fisheries management. Canadian Special Publications in Fisheries and Aquatic Sciences 120

U.S. Environmental Protection Agency (USEPA). 2003. Guidance on Assessing Quality Systems. EPA QA/G-3, EPA/240/R-03/002, March, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 2000. Guidance for the Data Quality Objectives Process. EPA QA/G-4, EPA/600/R-96/055, August. Washington D.C.

United States Fish and Wildlife Service (USFWS). 1999. Effects of temperature on early-life survival of Sacramento River fall- and winter-run chinook salmon. ?.

United States Fish and Wildlife Service (USFWS). 1998. Endangered Species Act Consultation Handbook: Procedures for Conducting Section 7 Consultations and Conferences. March 1996, Final.

Vigg, S., and C. Burley. 1991. Temperature dependent maximum daily consumption of juvenile salmonids by northern squawfish from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48:2491-2498.

Watercourse Engineering, Inc (Watercourse). 2002. Historic Flow and Temperature Modeling of the Sacramento River – Period of Simulation: 1970-2001. Prepared for the United States Geological Survey, Biological Resources Division, Mid-continent Ecological Science Center. Fort Collins, CO.

Williams, J.G. submitted. Central Valley salmon: Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science.

Appendix A – The Panel's charge

Technical Review Panel Charge

Background

The purpose of this independent review is to evaluate and comment on the use of the best available scientific and commercial information as it pertains to the development of the 2004 National Marine Fisheries Service (NMFS) biological opinion on long-term Central Valley Project and State Water Project Operations, Criteria and Plan (OCAP).

The review will focus on the technical aspects of the NMFS biological opinion and the information provided in the OCAP biological assessment (BA). The review is not to determine if NMFS' conclusions regarding the project's potential to jeopardize the continued existence of listed Central Valley salmonids are correct. Rather, it is to evaluate the information used and whether anything was missed in the data, analyses, and results used to reach those conclusions in the opinion.

The Technical Review Panel's Charge (Review Charge) is to evaluate and comment on the technical information, models, analyses, results and assumptions that formed the basis for the assessment of the proposed long-term water operations for the projects described. The Review Panel should consider pertinent background information such as; previous NMFS biological opinions that pertain to Central Valley Project water operations (*i.e*., 1993 wWinter-run Chinook salmon opinion and the 2000 Trinity River Restoration opinion) and the Calfed adaptive management process (*i.e*., the Salmon Decision Process). Panelists should review both the data provided in the OCAP BA and the NMFS biological opinion. For example, the panelists should review how NMFS assessed the individual responses of fish to certain effects (*i.e*., flows, water temperatures, diversions, etc.) and whether NMFS missed best available information on how fish are likely to respond to those impacts.

Fundamental questions the Panel should consider include:

- Are the technical tools used in the OCAP biological opinion (*e.g.*, modeling, calculations, analytical and assessment techniques) able to determine impacts to the individuals and to the population?

- Are assumptions clearly stated and reasonable based on current scientific thinking?

- Do the data, analyses, results and conclusions presented lead one to a thorough understanding of the risks to individuals and populations from the proposed project impacts? If not, what relevant scientific information was missed that would be counter to the impact that was expected?

- Are the analytical techniques capable of determining the significance of project impacts for Endangered Species Act (ESA) purposes? If not, what additional or alternative analytical techniques are recommended? What available science do we need to best address the impacts of large-scale water projects?

- Were uncertainties considered in the opinion? If so, were they described in a way that frames the data or puts it in the proper perspective (*e.g.*, the appropriate time scale, or the likelihood that an event will happen). What uncertainties and limitations were not addressed?

- In the absence of available information to establish probable responses to impacts (*e.g.*, survival across the Delta, steelhead population estimates, steelhead losses at the Delta pumps, spring-run Chinook salmon populations above Red Bluff Diversion Dam), were reasonable scenarios developed to identify types of exposure? Were comparisons made to other species with similar impacts?

- Were relevant published and unpublished studies on listed fish species, similar species, ecological theory, and computer simulation/modeling missed?

- Was evidence provided to support the species' response to demographic changes (*e.g.*, changes in fecundity rates, changes in growth rates for individuals, and change in number of individuals that immigrate or emigrate from a population)? Was evidence provided to support the conclusions about how the proposed actions affect the species' demography?

Further Purposes of the Review

In addition to answering the fundamental questions posed above, another intended use of this review is to help ensure that best available information is used for future ESA consultations such as; early consultation components for OCAP and the South Delta Improvement Program. Reviewers are expected to address the inefficiencies in the NMFS biological opinion (*i.e.*, Did the biological opinion apply the available information in a scientifically sound manner?), but not whether or not project operations need to be reinitiated under the ESA.

The OCAP Technical Review Panel

The Review Panel will consist of scientists who will bring strong technical competence relevant to the issues associated with the effects of water project operations on anadromous salmonids. Through publications and participation on similar panels elsewhere, panel members have demonstrated the ability to deal with complex ecological issues in a balanced manner. The group will include both scientists with local expertise and scientists with relevant discipline knowledge and experience outside the Central Valley. The range of disciplines included has been determined by the complex nature of the questions the panel is being asked to address.

Individual Criteria used to select panel members

- nationally and internationally recognized;
- strong publication record and/or record of scientific leadership;
- experience with program-level reviews of resource management and complex interagency programs; and
- track record of fair and unbiased, yet constructive criticism.

Overall Criteria

- balance between local and outside experts; and
- range of expertise that spans program-wide scientific issues.

Review Format
CBDA will initially provide Review Panel members with two documents containing information related to the questions listed above. These are:

1. Long-term Central Valley Project and State Water Project Operations Criteria and Plan – Biological Assessment, including appendices. US Bureau of Reclamation. June 30, 2004.
2. Biological Opinion on the long-term Central Valley Project and State Water Project Operations Criteria and Plan. National Marine Fisheries Service. October 2004.

Other material will be provided to the Review Panel as requested during the review. All material sent to the panel, or links to it, will be posted on the CALFED website.

To facilitate the review, CBDA will convene a 2-day public workshop in the Sacramento area during mid October 2005. The workshop will consist of presentations by federal and state agency and stakeholder representatives describing the scientific information used to support conclusions in the BA and biological opinion. There will be ample time for questions and discussion among Review Panel members, presenters and CBDA or Agency staff.

By December 15, 2005, panel members will submit a report to the CBDA Contract Manager or her designee documenting their understanding of the issues.

CBDA will distribute the panel report to NMFS and post it on the CALFED website. CBDA will also request the panel chair (and other members to the extent possible) to present its finding at a public meeting in the Sacramento area – probably in January 2006.

Appendix B – An Alternative Analysis of Delta Routing and Survival of Smolts

Water operations affect the routing of fish through the Delta, and consequentially the survival of smolts. This interaction was discussed in the BO (pages 186-195), which included the results from a number of studies that estimated the losses of fish from individual factors, such as interior Delta mortality and loss at the pumps (BO Tables 9 and 10). The indirect loss in the Delta was calculated assuming the lowest indirect mortality that results in the least impact of increased Delta Pumping (Table 10 in BO). However, in the final analysis, the BO concluded that the impact of reducing Delta outflow on populations could not be quantified (page 191). The analyses reported in the BO were disconnected, and the model structure was unclear.

The Panel suggests that the information on routing and survival could be linked using simple models to demonstrate the major pathways by which the proposed operations of the water projects could affect survival over the life cycle. The example below links water routing with habitat-specific survival components to characterize survival in smolt migration, and then links this life stage element to a population response. The purpose of this analysis is to illustrate how simple models can be used in a transparent way to quantify proposed project operations on salmon survival; the specific results of this analysis are not meant to be definitive and additional analysis would be required to formulate predictions appropriate for decision-making.

The routing of juvenile salmon through the Delta (Figure B1) can be approximated by the equations below

$$
\begin{aligned}
N_{River} &= S_0\left(1-F_D\right)S_1 N_{JPE} \\
N_{Delta} &= S_0 F_D\left(1-F_P\right)S_2 N_{JPE} \\
N_{Pumps} &= S_0 F_D F_P S_3 N_{JPE}
\end{aligned}
$$

where N_{JPE} is the estimate of the number of fish that migrate downriver, N_{River} is the number of fish entering the estuary via in-river passage, N_{Delta} is the number of fish entering the estuary via Delta passage, and N_{Pumps} is the number of fish entrained in the pumps. S_{i} indicates the survival through each segment i. F_{D} is the fraction of fish entering the Delta, and F_{P} designates fraction of fish in the Delta that are diverted to the pumps.

For illustrative purposes, assume the project operations and natural conditions affect the model terms in the following ways: S_0 and S_1 are affected by river flow and water temperature; S_2 and S_3 are affected by Delta water quality, predator densities, and residence time of smolts in Delta; F_D is affected by river flow, tides and Delta Cross Channel gate operations; and F_P is affected by pump operations and inner delta water routing.

From these equations and assumptions we write the net passage survival as a fraction of the maximum survival that would occur if no Sacramento fish entered the Delta. We assume the number of fish salvaged in the pumps is insignificant and so the relative passage survival is

$$x=\frac{N_{River}+N_{Deta}}{\max N_{River}}=1-\left(1-\frac{S_2}{S_1}\right)F_{Delta}-\frac{S_2}{S_1}F_{Delta}F_{Pumps}$$

This equation provides information on the significance of alternative water operations. The relative effect of each type of diversion depends on the ratio of Delta survival to inriver survival. Figure B2 illustrates the response in terms of isopleths of relative survival as a function of diversion fractions. If Delta survival is small relative to river survival (e.g., $S_2/S_1 \sim 1/3$), then changes in diversions to the pumps have very little affect on relative survival x (i.e., the relative survival isopleths in Figure B2 are nearly vertical). However, as the river and inner Delta survivals become similar (e.g., $S_2/S_1 \sim 2/3$), the effect of diversion to the pumps becomes more important. This increasing importance is seen in Figure B2 by the increased slope of the relative survival isopleths.

The BO may contain sufficient information to determine which case is a better representation. Delta mortality studies (BO, page 190) indicate S_1 = 77% and S_2 = 5 to 67%. Assuming 30% inner Delta survival, then $S_2/S_1 = 0.39$ and we may conclude that conditions that control the fraction of fish entering the Delta, F_{Delta}, are major determinants of smolt survival through the Delta region. Furthermore, from reviewing the BA and presentations of fish tracking studies, it appears that F_{Delta} depends mostly on the operations of the Delta Cross Channel. This brief analysis may be in variance to the BO use of a best case scenario of the impact of pumping on indirect Delta mortality (Table 10 in the BO).

Linking Delta impacts to a life cycle effect.

The above smolt survival model can be incorporated into life stage matrix or simple spawner-recruit models. To briefly illustrate this step, we write the salmon life cycle in terms of a Ricker spawner-recruit model: $R = xS\exp(\mu-\beta S)$, where the number of recruits that reach maturity, *R*, depends on the number of spawners, *S*. The spawner-recruit relationship depends on the population growth rate (μ), a density dependent factor (β), and the relative smolt survival factor (x), which, as developed above, is related to water project operations. Thus, this simple approach directly links project operations to fish population dynamics.

These “back of the envelope” analyses are valuable and tractable. In particular, the Panel believes they represent an appropriate level of detail in which to link the effects of water project operations to salmon populations. As a caveat however, we note that these simple models take a production perspective that largely disregards the effects of the water projects on the salmon’s ecosystem. Therefore, we encourage the use of production-like models to explore the direct effects of water projects, but also note that, by themselves, production-based models are not sufficient for evaluating jeopardy. A comprehensive, although qualitative, consideration of the ecosystem effects, as described in Table 2 of this report, is also valuable to elaborate uncertainties and secondary issues. For example, the above model assumes that fish from river and Delta routes enter the estuary at equal sizes and therefore experience equal estuary and ocean survival. However, if Delta fish emerged large than the river fish the Delta fish might be expected to survival better in the estuary/ocean life history stage.

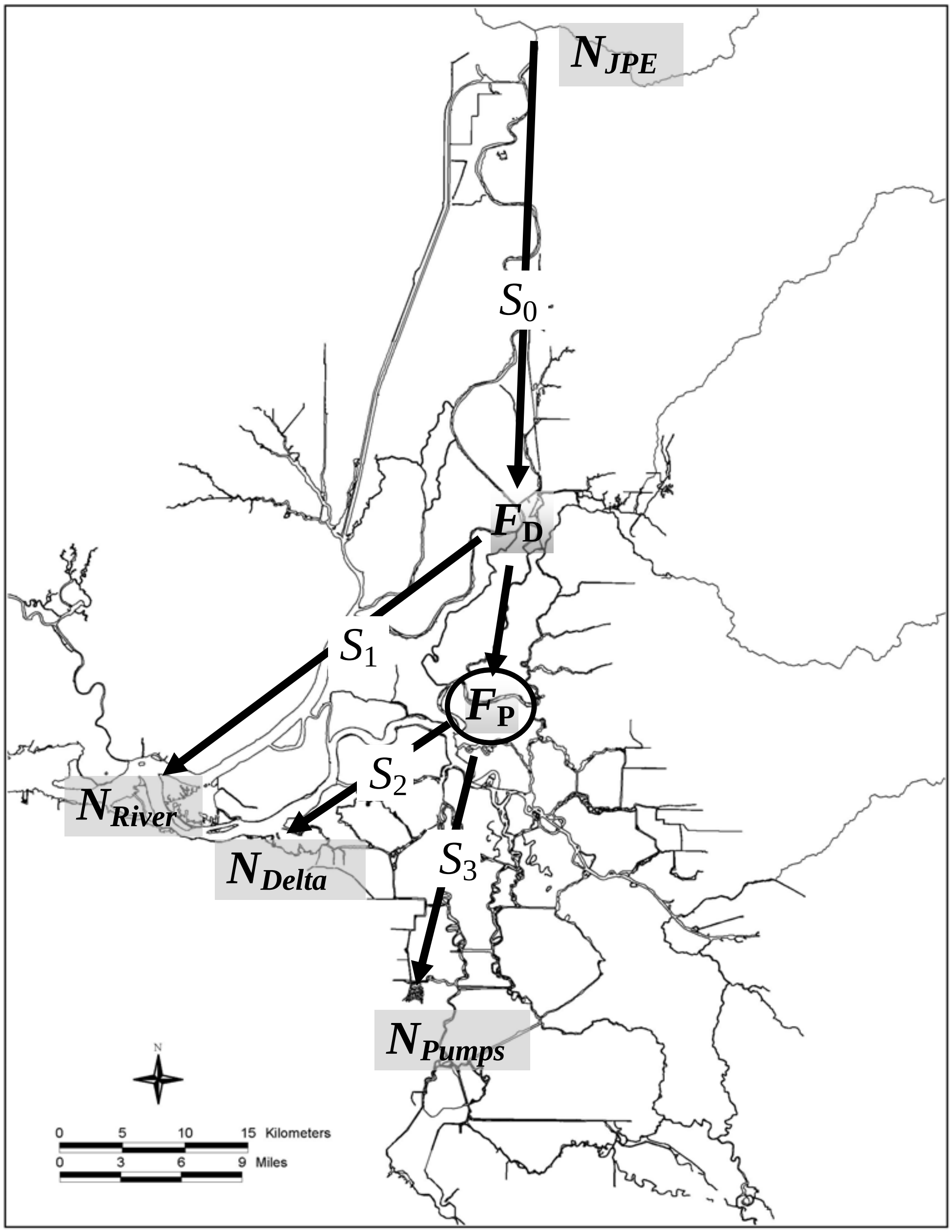

Figure B1. Of the total smolt migration from the Sacramento River, N_{JPE}, the numbers that reach the estuary through river, N_{River}, and inner Delta, N_{Delta}, passage routes, or become entrained in the pumps, N_{Pumps} ,are determined by the partition of fish into the delta F_D and into the pumps, F_P, and the survivals, $S_{\#}$, over each segment.

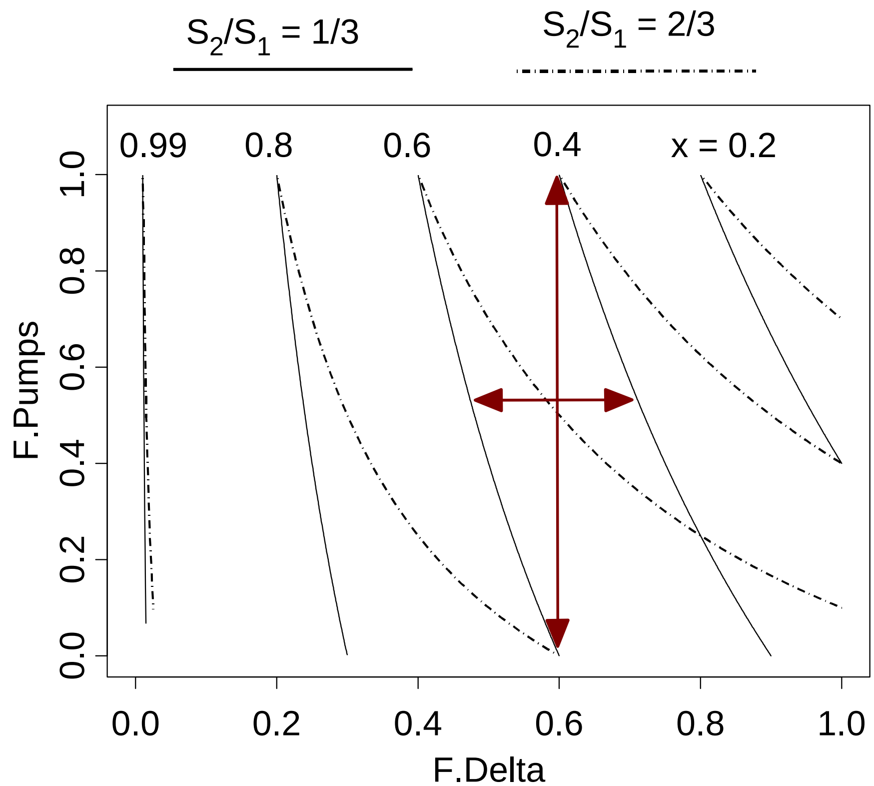

Figure B2.The effect of delta and pump diversions (F.delta and F.pumps) on the relative passage survival x is indicated for x = 0.2 to 0.99. The solid lines depict relative passage survivals for survival ratio of the inner Delta, S_2 to the river S_1 of 1/3 and the dashed lines depicts relative passage survivals for a ratio of 2/3. The vertical and horizontal arrow indicated changes in diversion fractions to achieve equivalent changes in survival for S_2/S_1 = 1/3.

Dr. Johnnie Moore
Lead Scientist, California Bay-Delta Authority
CALFED-CBDA
650 Capitol Mall, 5th Floor
Sacramento, California 95814

Dear Dr. Moore

On December 20, 2005, in a letter from Rodney R. McInnis to you, the National Marine Fisheries Service (NMFS) submitted its comments on the draft report *Review of the Biological Opinion of the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan*. The Technical Review Panel appreciates the time and effort given by NMFS staff in their review. We have considered all the comments and where appropriate, have revised the text of the report. Those revisions have improved the final document. The purpose of this letter is to inform you of our response to the general and specific comments submitted by NMFS. Our responses are in italics.

Response to the General Comments

We believe the ESA sets a high level of expectations for Biological Opinions. While we realize that the statute requires NMFS to act quickly after a BA is completed, we also understand that NMFS collaborated with the Bureau and DWR in the much longer process of drafting the BA, on which the BO was largely based. Analyses of climate change that were available in the published literature by June 30, 2004, could have been used to address climate change in a general way, with due attention to the uncertainties involved; this would have entailed little time and little cost.

Response to the Specific Comments:

NMFS comment -- In the Introduction the first paragraph should contain the date the biological opinion was issued (*i.e*., October 22, 2004), and who it was issued to (*i.e*., U.S. Bureau of Reclamation and California Department of Water Resources). The second paragraph contains the names, addresses, and short resumes of each panel member. We suggest moving this description of the panelists to an appendix.

Response -- We added the date the Biological Opinion (BO) was issued and the agencies that received it. The names and resumes of the Panel members remained in the Introduction.

NMFS comment -- Panel Charge, pg. 8 and 9. Redundant, contains the same text as in the executive summary. The more detailed discussion should be here of the seven questions and an explanation regarding their combination into four issues. Suggest deleting the Panel’s Background and Charge, stated in the Executive Summary.

Response -- We did not make the suggested changes.

NMFS comment -- Background, pg.11. Under Jeopardy Analysis Guidelines. The statement between Numbers 1 and 2, "Based on this information the biologist determines if the species can survive" is not an official guideline. This wording is not contained in the ESA Handbook or Federal regulations. We would suggest you strike it or replace with; "Based on this information the biologist attempts to determine if the proposed action is likely to reduce the probability of both survival and recovery of the species." See BO pg. 90.

Response -- We revised the text as suggested.

NMFS comment -- Overarching Issues, pg. 13. The Panel believes that BO was lacking an analytical framework and a life cycle approach. We do not agree. In order to systematically address the effects of the project under the ESA, a matrix was developed for each specific region or project (*e.g*., Trinity River, Sacramento River, Freeport Project) moving from the upstream tributaries to the Delta.(see pg 90, steps for jeopardy determination and pg 96, life history table and assumptions). Each of these regions was formatted into a life cycle approach starting with adults, egg and fry mortality, smolt survival, and then moving into the suitability of the habitat for these different life stages.

Response -- We did not state in the review report that the BO lacked a life cycle approach. We did say that the life cycle framework used in the BO could have been improved. We did modify the text in the section dealing with the analytical framework to recognize that there was a framework in the BO, but it was not explicitly described.

NMFS comment -- Conceptual Framework, pg. 13. The reference to the information in the NMFS document (Bottom et al. 2005) being available in draft form for this BO is incorrect; the standard protocol is not to release draft documents (even internally) until they are reviewed and published. The concept for the Delta is that salmon and steelhead smolts do not spend much time rearing in this environment, but rather emigrate quite quickly through the region, spending most of their time in the upper tributaries and mainstem Sacramento River. The Columbia River estuary and the Sacramento River Delta are not similar; salmon behave differently in each (see BO Assumptions for Diversions and Entrainment, pg. 95). Unlike the Pacific Northwest, Chinook salmon in the Central Valley show little estuarine dependency (MacFarlane and Norton 2000).

Response -- Bottom (2005) was available in draft form before June 20, 2004; several of us downloaded copies from the web before that date. NMFS apparently misunderstood the major point of the discussion of the conceptual frameworks; it applies to the whole salmon life-cycle, not just to the estuarine phase. In any event, the MacFarlane and Norton (2002) study dealt only with the saline part of the San Francisco estuary, not the Delta, and with juveniles sampled in the bays and the Gulf of the Farallones between 30 April and 15 July, 1997. The claim in MacFarlane and Norton (2002) that Chinook in the Central Valley show little estuarine dependency applies only to the bays. It is not clear that all juvenile Chinook and steelhead emigrate quickly through the Delta.

NMFS comment -- Flow and Temperature Effects and Analyses, pg. 19. NMFS BO describes the uncertainty involved in using a monthly time-step in the calculation of the egg mortality model (pg. 90). In an effort to reduce this uncertainty NMFS required the Bureau of Reclamation to improve the current temperature control model (see term and condition 6.d., pg. 229). This new modeling effort will incorporate hourly observations, not available at the time the BO was written, into the currently used model for the upper Sacramento River (*i.e*., critical spawning reaches). This data gap was recognized in the BO and has already been changed.

Response -- *We modified the text of the report. In addition we have the following comment: The BO only identifies uncertainty as an aspect of using numerical model (i.e., that it exists). However, NMFS made no attempt to quantitatively identify uncertainty associated with the temperature models. The Panel acknowledges the desire by NMFS to pursue continued evaluation and potential improvements to the temperature model as a valuable aspect of the process. However, section 6.d. is vague with respect quantification of uncertainty and it appears to be focused on Shasta Reservoir modeling and temperature control through cold water management, versus addressing system-wide temperature simulation modeling.*

NMFS comment -- Issue 3- Too narrow a treatment of temperature effects. pg. 22. First paragraph. The statement that fry migration of fall-run Chinook salmon in the Sacramento River currently migrate one month earlier than before the Shasta Dam was built is irrelevant since it is now part of the environmental baseline. Fall run Chinook salmon were not considered for this BO, except to draw comparisons to their similar life cycles. The Panel speculated the reason for this change, "because of warmer water in the winter." Water temperatures are never above 56^{o}F after November 1st in the upper Sacramento River, if there was a shift in migration it was more probable that it was due to the change in spawning location downstream below the dam.

Response -- *We do not agree that a change in the timing of emergence and migration of fall-run in the Sacramento River is irrelevant, because it illustrates the general point that the temperature regime has important effects on salmon other than mortality. Rutter (1904) and Clark (1928) documented considerable spawning by fall-run downstream from Shasta, so that it unlikely that a change in spawning location explains the observed change in the timing of the downstream migration of juvenile fall-run.*

NMFS comment -- Issue 5- Incomplete documentation of how other models (e.g., decision tree, fish allocation) were used in the analysis. pg. 23. The use of the Salmon Decision Tree to protect Chinook and steelhead smolts is described in the project description under Adaptive Management Process (BO pg. 37 and the OCAP BA Appendix B). We are not sure what the Panel means by "fish allocation" there is no discussion of harvest in the BO.

Response -- *We deleted issue 5 from our report.*

NMFS comment -- Issue 9 – Too little attention paid to effects and impacts on life history and population structure. (Questions 2, 3, and 4). pg. 27. Last paragraph, (2) evidence for faster juvenile salmon growth in the Delta. The evidence suggests that the opposite is true, juvenile Chinook salmon show little growth in the Delta (MacFarlane and Norton 2002). NMFS agrees that Floodplain growth is more rapid than riverine (Sommer, et al. 2001). In the BO we weighed this more rapid growth against the loss of juveniles to isolation and stranding in these areas.

Response -- MacFarlane and Norton (200) studied growth through the estuary, not through the Delta. Their upper sampling station was west of the Delta and so this study is not informative of the growth of the young-of-the-year salmon in the Delta. However McFarlane and Norton did note that changes in the water diversion may have affected the Delta forage base. They also speculated that degradation of the estuary may have affected growth of salmon and in turn their life history strategy.

NMFS comment -- Table 3. pg. 29. Thirteen effects that were not quantified and not mentioned in the BO. Seven of these effects (2, 3, 4, 5, 6, 7, 10) were analyzed in the BO, or included in Table 10 under Baseline Project Effects. The effects of long-term water contracts are included in Table 9 (pg. 194 of the BO) and are combined with the effects of unscreened CVP diversions. Many of the effects in Table 3 of the report were originally in Table 9 of the BO, but later dropped to shorten the table, since they were sub-lethal or unquantifiable.

Response -- Table 3 was revised by deleting items 7 and 10 in the original table and by specifying that item 2 refers to spring Chinook. The statement in your comment "Thirteen effects that were not quantified and not mentioned in the BO" is not a correct interpretation of this issue. We specifically state the 13 effects (now revised to 11) are mentioned in the BO. Our point was that it is not clear how these effects were taken into account in the Synthesis of Effects section. For NMFS to ignore the effects that cannot be quantified as indicated in the comment is, in our opinion, not consistent with the guidelines NMFS said they must follow in developing the BO.

NMFS comment -- Issue 14: Questionable use of surrogates in some situations. (Questions 1, 2, and 3). pg. 31. The use of surrogates for estimating the take of spring-run Chinook yearlings is the topic of a workshop unto itself. At the present time, until the use of a non-lethal genetic identification can be applied quickly and at a low cost, NMFS has determined that this method is the only one that can be used. The approach suggested by the Panel is described in the BO under assumptions, pg. 97, and is representative of those spring-run yearlings that originate in Deer, Mill, and Antelope Creeks. Spring-run in Butte Creek are not considered represented by the surrogate late-fall releases because they are predominately young-of-the-year (YOY) and not yearlings when they emigrate. Through the Data Analysis Team the use of late-fall surrogates is matched up each year with the timing of natural spring-run yearlings in the upper Sacramento River. The surrogates are released at Battle Creek above most of the spring-run tributaries in order to best replicate the natural timing of yearlings in the Sacramento River. Incidental take for YOY spring-run Chinook salmon can not be quantified because they can not be identified from fall-run Chinook salmon at the fish salvage facilities.

<u>Response</u> -- *Monitoring on Mill and Deer creeks by CDFG has established that most juvenile spring-run leave these streams as young-of-the-year. NMFS can obtain the data from Colleen Harvey-Arrison at the CDFG Red Bluff office.*

Literature cited:

Clark, G. H.. 1928. Sacramento-San Joaquin salmon (Oncorhynchus tschawytscha) fishery of California. Division of Fish and Game of California, Fish Bulletin No. 17.

Rutter, C. 2004. Natural history of the quinnat salmon. Bulletin of the United States Fish Commission 22:65-142.

Sincerely,

Jim Lichatowich
For the entire Panel