CIE REVIEW OF NOAA-FISHERIES BIOLOGICAL OPINION ON EFFECTS OF PROPOSED CENTRAL VALLEY PROJECT CHANGES ON LISTED FISH SPECIES

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I. Executive Summary of Comments and Recommendations

The lack of information on population effects of habitat alterations from Water Operations on Central Valley salmon and steelhead (Baker and Morhardt 2001; Moyle and Israel 2005) has been well described by previous investigators. This lack of information, and the lack of a spatially explicit population model mirroring that was developed for water management with CALSIM, makes evaluation of changes in habitat quantity and quality to individuals and populations of listed species very difficult in light of the complexity of salmonid life histories and the complexity of Project operations and structures that can effect species survival and performance. Within these data constraints, the Biological Opinion (BO) appears to be based on best available information with regards to temperature effects on survival of salmonid embryos and early fry in the upper Sacramento River and major tributaries, and on estimating potential losses of juvenile salmonids to diversion and entrainment within the Delta. The report makes a good faith effort to address the many complex factors affecting each listed species in each unique context (e.g., upper Sacramento River, Feather River, etc.). Inclusion of more detailed evaluation of spawning gravel quality and quantity, indirect effects of temperature on emergence timing, and overall rearing habitat availability and suitability into the assessment would expand its scope to encompass more affected life stages beyond the current emphasis on embryo survival effects. A more detailed uncertainty analysis of what are likely key limiting factors/time periods for juveniles would help better define the upper and lower bounds of likely juvenile abundances under varying abiotic (e.g., water temperature, entrainment) and biotic conditions (e.g., predation levels).

Recommendations for enhancing scientific basis for future consultations include studies to determine:

- thermal optima and tolerances of listed species to verify and validate Salmon Mortality Model
- use of flushing flows to enhance spawning gravel quantity and quality
- contribution to adult recruitment of the various sizes/life stages of juveniles entrained in the Delta
- indirect effects of elevated temperatures on emergence and out-migration timing
- relationship between surface water and egg pocket water temperature
- occurrence of cool water refuges for adult and juvenile salmon and steelhead
- historical temperature conditions
- juvenile density:habitat-type relationships

II. Background

The purpose of this independent review is to evaluate and comment on the use of the best available scientific information underlying the 2004 NOAA-Fisheries Biological Opinion (BO) on the Bureau of Reclamation's and California Department of Water Resource's Plan (OCAP) to revise water operations within the California Central Valley Project. Materials referenced in addition to the BO and OCAP reports included supporting appendices, the NOAA Fisheries Essential Fish Habitat Consultation report, model documentation, and various other reports and journal articles located during a literature search.

The proposed Central Valley Project consists of three major components: 1) increased minimum flows in the Trinity River; 2) decreased flows and increased temperatures in the upper Sacramento River due to decreased water diversion primarily resulting from #1; 3) decreased flows and accompanying temperature increases in the American River and other drainages due to greater water diversion or decreased storage to meet downstream uses; and 4) changing water flow patterns in the Delta and associated increase in fish salvage and entrainment due to a substantial change in timing and increase in pumping of Delta water at the Tracy and Banks pumping facilities.

The purpose of the NOAA-Fisheries BO was to evaluate whether these effects are likely to jeopardize the continued existence of affected Endangered Species Act (ESA)-listed winter and spring Chinook salmon and steelhead or result in destruction or adverse modification of designated critical habitat for these species. In brief, the BO reached the following conclusions based on anticipated Project impacts:

1. Overall Project effects (elevated water temperatures, direct and indirect pumping loss in the Delta) are expected to result in the loss of an additional 3-20% of the winter run Chinook salmon juvenile population, 5-20% of the spring run Chinook salmon juvenile population, and 12.5-27.5% of the steelhead juvenile production (BO:193).
2. The proposed Project is not likely to jeopardize the continued existence of listed species nor likely to adversely modify critical habitat because a) the loss represents an estimated overall loss of less than 1-2% of the total production of juvenile out-migrants, b) listed species have generally been increasing in numbers the past 8 years, and c) planned and existing adaptive management processes (water reserve management; new temperature monitoring and management protocols; conservation hatchery for winter run Chinook, reduced sport, commercial, and illegal harvest; improved habitat access; and restoration in the upper Sacramento River) will likely offset projected losses due to proposed changes in Project operations.

Reviewers were asked to address each of the fundamental questions listed below related to the scientific basis of these decisions. I focused my review on the assumptions, analyses, and results of the anticipated temperature increases in the upper Sacramento River and other drainages on listed species, and of the anticipated increase in loss of these species associated with increased winter pumping of Delta water during downstream migration.

III. Fundamental questions for the CIE reviewers

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

Yes. The two main analytical tools used to assess impacts at the individual and population level are the Salmon Mortality and Delta Loss models. Both allow quantitative measurement of the relative impacts of various project operations under a range of potential hydrologic and water management scenarios.

Salmon Mortality-Temperature Model: The main technical tool the BO and OCAP used for assessing the effects of projected water temperature changes from the proposed Project on the Trinity River, Sacramento River below Keswick/Shasta dams, and in tributaries was the Reclamation's Salmon Mortality Model developed in 1991. The Salmon Mortality Model is used to determine impacts of temperature on individual eggs and early fry, and inference is made to population impacts based on this individual-survival model. The model is based on laboratory studies of temperature and survival of Chinook salmon embryos and early fry (OCAP: Table 6-2). The spreadsheet model cumulatively calculates mortality rates under different water types (wet, dry, critical) by relating temperature level, duration of exposure (function of spawning timing and rate of development), and distribution information to output from the water temperature model to estimate instantaneous mortality at various temperatures (BO: 125). The advantage of the model is that it allows quantitative comparisons of projected egg/early fry mortality losses under different project/temperature scenarios. By my interpretation, the impact to the population level is then estimated by assuming a direct relationship: i.e., the change in the number of eggs and early fry due to temperature effects is directly equivalent to an equal change in the number of juvenile out-migrants (additive mortality).

Delta Loss Model: A variety of analytical approaches are used to determine impacts to individuals and to the populations of listed species from projected increases in Delta pumping. The loss of individuals through entrainment at the pumps was estimated by assuming a direct relationship between pump volume and fish loss. Direct loss of individual species under various pumping scenarios was then calculated by relating projected monthly pumping volumes timing of out-migration through the Delta of each listed species (based on observed salvage numbers). The Particle Transport Model was also used to estimate how entrainment rates might differ with increased diversion of Delta water due to pumping. In addition, the NOAA Fisheries BO factored in estimated indirect losses of fish due to very significant predation levels on fish diverted to the south Delta prior to their encounter of either the Tracy or Banks pumps. The total individual loss due to pumping was then projected under various pumping rates and compared to the total estimated juvenile out-migration via the Juvenile Production Estimate Model based on adult escapement counts (OCAP: Table 6-7) to calculate population impacts.

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

The BO and OCAP reports do a commendable job at attempting to explicitly state assumptions used in the assessment (e.g., BO: 95-97; OCAP: 8-31), although I believe there are several key assumptions that would benefit from more in-depth evaluation. The efficacy of each of the main assumptions used in the assessment is discussed below.

Temperature Targets and Assumptions: For successful reproduction of Chinook salmon and steelhead, the water management temperature target is assumed to be ≤56 F based on laboratory studies of Chinook embryo and early fry survival versus temperature (BO). This is a reasonable, and conservative (protective) assumption for both species as cited laboratory studies with Chinook salmon do demonstrate a clear decrease in survival at temperatures above this threshold. An unstated assumption of the Salmon Mortality Model is that laboratory survival studies with Chinook embryos and early fry accurately reflects survival in the field; however, this apparently has not been evaluated and would be beneficial information for future assessments.

For juvenile Chinook and Coho salmon rearing, target water temperatures of <60 F are considered optimal for survival and growth based on previous laboratory studies. This is a reasonable assumption for both species based on the scientific literature. For Chinook salmon, an in-depth laboratory evaluation has demonstrated that optimal growth is near 59 F at 60% ration, a level considered to be a realistic food availability level in nature (Brett et al. 1982 in McCullough 1999; McCullough et al. 2001). The applicability of thermal criteria derived from the laboratory has long been debated, and unfortunately, there has been no confirmatory lab or field data for the growth vs. temperature relationship for any of the listed species in the Central Valley to assess if laboratory results are transferable to these southern stocks (Myrick and Cech 2004). However, the target levels do seem to be reasonable targets for species protection given that recent studies suggest that temperatures near the optimum growth in a laboratory setting likely frame the upper limits of suitable temperatures for salmonids in nature (McCullough 1999; Selong et al. 2001). In addition, recent field documentation of Coho salmon distribution vs. temperature in northern California found that Coho were absent from streams with maximum weekly average temperatures > 62.2 F (Welsh et al. 2001), which lends support to the management target of <60 F for the Trinity River.

The assumed temperature target of ≤65 F for adequate protection of juvenile steelhead survival and growth is reasonable based on some scientific information, but other information suggests that this target may be too high. Wurtsbaugh and Davis (1977, as cited in Myrick and Cech 2004) found 61.5 F to be the optimum growth temperature for steelhead, whereas Myrick and Cech (2005) found that American River steelhead grew fastest at 66.2 F over the range of 51.8-66.2 F. If optimal growth in the laboratory represents an upper temperature limit in the field, then the Wurtsbaugh and Davis laboratory results suggest that temperatures above 61.5 F for prolonged periods may cause reduced growth and survival. As Myrick and Cech (2004) point out, however, these southerly steelhead stocks may have greater thermal tolerance, as perhaps evidenced by their results. Given that steelhead have the longest freshwater rearing phase among the listed salmonids, and exceedance of the 65 F target in some of their main rearing areas (Feather, American, Stanislaus) is common and likely to increase, more information on the effectiveness of this assumed temperature target for juvenile steelhead would help resolve this apparent discrepancy. Laboratory thermal tolerance testing over long periods mirroring what juvenile steelhead experience in nature, coupled with field validation using individually tagged fish, would provide a much needed clarification of the growth-temperature relationship and provide a stronger scientific basis of the temperature management target for steelhead.

Delta survival model and assumptions: Because of a well documented scarcity of empirical data on the relationship between fish loss and pumping rates (Baker and Morhardt 2001), the BO relied on a number of assumptions in assessing fish loss due to increased pumping and the overall population effect of this loss. The main assumptions were: 1) loss rate is a direct function of pumping rate; 2) salvage represents only a small fraction of Delta loss as many fish are lost to predation and entrainment prior to reaching the pumps, and 3) although increased pumping will result in additional juvenile losses of 10-20%, the population effects will be minimal because a) the amount of water diverted to the Delta via the Delta cross channel will not appreciably change, and b) the number of fish lost represent <1% of the total. These assumptions all seemed reasonable given the data.

Population Impacts: It appears that the BO assumes that mortality losses from projected Project operations are additive rather than compensatory. In particular, the BO directly compares temperature related 1-2% losses of eggs and early fry to pumping related losses of juveniles (p. 188), concluding that upstream temperature losses are higher than pumping losses, and that all losses are functionally equivalent and can be added to determine population effects (Table 9). However, if out-migrant mortality is the more limiting factor regulating numbers of returning adults (Baker and Morhardt 2001), then perhaps the presumed greater mortality effect from egg loss compared to direct out-migrant loss is overstated. It was unclear if egg losses were converted to smolt equivalents to allow direct comparison (although the statement on p. 188 suggests that this might be the case) and if so, what assumptions and calculations were used to estimate this conversion. If egg mortality was converted to smolt loss equivalent, then adding mortality sources is probably a reasonable assumption. But, if population effects from egg losses are considered equivalent to juvenile losses without using a similar currency, then I believe more explanation is needed to justify/explain the reasoning behind this assumption and the scientific justification for it (see question below about whether egg survival limits juvenile salmonid production in general).

Finally, the BO assumes that the anticipated minimal increase in mortality from proposed Project changes will likely be offset by current and planned adaptive management protocols for real time management of water and temperature, reduced ocean harvest, and recent and planned improvement in habitat (e.g., Battle Creek, fish passage and use above ACID below Keswick Reservoir). Given that Chinook salmon have apparently rapidly colonized new areas following improved passage and that ocean harvest rates have declined appreciably, this seems like a reasonable assumption given the data.

C. Do the data, analyses, results, and conclusions presented lead to a thorough understanding of the risks to individuals and populations from the proposed project impacts? If not, what relevant scientific information should be considered?

The BO and OCAP reports provide a thorough risk assessment of anticipated temperature increases on embryo/early life stage survival. The listed sources for the Salmon Mortality Model appear to provide a relevant scientific basis for measuring embryo/early fry loss under different temperature/flow scenarios, although a check of literature in McCullough's (1999) comprehensive review on Chinook salmon temperature requirements might be helpful as the primary listed sources for the model are quite dated (e.g., Seymour 1956) and the Mortality model appears to have been developed in 1991 and may need to be updated with more recent studies.

Although both reports do explicitly recognize that other life stages and environmental factors are important in determining overall juvenile out-migrant production, detailed assessment of these other potential influences is limited. For the embryo/early fry stage, the quantity and quality of spawning gravel is not addressed in the effects analysis, though there is indication that spawning gravel quantity may be limited and of poor quality as evidenced by heavy armoring (BO: 132), presumably from a lack of flushing flows and long term blockage of gravel transport by dams, and the call for gravel additions as a mitigative measure below tributary dams. Though it may be argued that spawning gravel quality and quantity may not differ appreciably pre and post Project, an alternative possibility is that gravel quality may already be limiting, or change over the life of the Project, and that temperature changes would increase mortality to a more critical level. Since fine sediment intrusion and overall gravel quality is the factor most limiting to reproductive success of salmonids in most situations (Everest et al. 1987), the analysis would be more complete with consideration of current and future conditions of this parameter.

Another factor not included in the analysis is the potential for indirect effects of temperature changes. Small temperature increases of even 1 or 2 F during incubation can lead to a very significant change in the timing of emergence; such changes in timing may have more profound effects on survival than do direct effects by altering the timing of critical habitat shifts (Holtby et al. 1989). Even small temperature increases, such as those anticipated as a result of the proposed Project operations, could shorten emergence timing considerably. Similarly, small temperature increases during winter can lead to significant changes in timing of smolt out-migration the following spring (ibid). For species such as fall-run Chinook that migrate downstream soon after emergence, earlier emergence could result in an altered timing of seawater entry that could reduce smolt survival (ibid). Conversely, for species with more protracted freshwater rearing, such as winter and spring Chinook and steelhead, earlier emergence could be potentially positive by lengthening the growing season, but may be detrimental if earlier emergence increases chance for displacement from rearing areas by increased exposure to high flows (ibid). Though listed species in the Central Valley show quite a variable spawning range, modeling of peak spawning times and predicted temperature increase effects on emergence timing could provide further insight into when species are likely to emerge from the gravel, what conditions they are likely to encounter, and the potential survival consequences. For example, given projected temperature increases under different water years, how much sooner is emergence likely to occur, and what conditions will fry encounter upon emergence? Though I understand quantitative survival modeling of such effects on 'take' would be difficult, it would nevertheless provide a qualitative assessment and would at least highlight the need for further research into this potentially significant indirect effect of altered temperature and flow regimes.

Other than the implementation of protective temperature targets, no other aspect of juvenile rearing habitat quantity or quality is assessed in detail in the BO. Information on the types of habitats used by juvenile salmon and steelhead in relation to flow level and temperature appear to be lacking, precluding quantitative assessment of changes in habitat availability and suitability in accord with Project operations. Ongoing studies listed in BO Appendix A hopefully will be addressing this information gap.

D. 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 should be used to best address the impacts of this large-scale water project as examined in the BO?

Given the limitations of the data, I have no recommendations for additional analytical techniques other than the suggestions outlined in IIC.

E. 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 that might impact the BO substantively?

The BO and OCAP present an in-depth analysis of uncertainties in water delivery quantity and timing and their subsequent effects on water temperatures in the upper river and pumping rates in the Delta, with subsequent development of probabilities encountered under different water management and water year types. The availability of the CALSIM model allowed a thorough assessment of the range of possible future physical conditions.

I think the biological assessment would benefit from a bit more uncertainty analysis relative to several key life history periods. First is the effect of predation at the Red Bluff Diversion Dam. Predation losses on juveniles are estimated at 39% for winter-run Chinook salmon and 36% for juvenile steelhead during out-migration, levels which seemed quite significant. These losses are much greater than projected temperature related losses of embryos and early fry of about 8-10%. Similar to the modeling of how dry and wet water years might effect water temperature or pumping rates, how might variation in predation rate at RBDD influence juvenile production under low and high predation rates in wet vs. dry years? In turn, juvenile production estimates are derived from escapement estimates apparently based on a fixed rate of egg to smolt survival. How might these production estimates vary over a range of high versus low freshwater survival ranges, particularly in years other than the recent years of high adult returns?

F. 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 exposures? Were comparisons made to other species with similar impacts?

The BO and OCAP reports do a quite detailed evaluation of all possible factors affecting the listed species, from dam operations, predation and entrainment losses, hatcheries, flow and temperature changes, and harvest. As noted, most of this information was dealt with qualitatively and was not included in the quantitative assessment for apparently two reasons: first, a lack of correlative data, and second, these factors were not assumed to change under proposed Project operations and therefore changes were not anticipated to occur from current conditions. Within these constraints, I found the assessment made a good faith effort at addressing most possible risks associated with Project impacts.

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

I do not have additional suggestions re: missing information beyond suggestions outlined in IIB and IIC.

H. Was evidence provided to support conclusions relative to species responses to demographic changes (*e.g.*, changes in fecundity rates, changes in growth rates for individuals, and changes in numbers of individuals that immigrate or emigrate from populations)? Was evidence provided to support the conclusions about how the proposed actions affect the species' demographies?

To estimate species' demographic responses to habitat alteration, a desired scenario is the development and application of population models based on 'observed' conditions, which are then used to model likely biological responses to 'future' conditions (Levings et al. 1989). In the absence of such a population model for listed species in the Central Valley, the BO report relied on making inferences about individual survival under current baseline conditions to that under future Project operations. Population level effects were then inferred by comparing cumulative changes in survival baseline vs. proposed Project [vs proposed project what?] to overall numbers of juvenile out-migrants. The assessment concentrated on two phases of freshwater life stage: embryos/early fry and out-migration through the Delta, and confined the quantitative assessment to individual survival rate effects only; no estimation of changes in juvenile growth, for example, were included in the assessment. In short, the assessment asked the question: how does survival of embryos/early and out-migrants in the Delta change with the proposed change in Project operations? While this approach does allow direct quantitative estimates of losses for use for the necessary 'take' estimates, as noted in IIIC and E above, considerations of synergistic effects and effects not directly related to survival (e.g., changes in juvenile growth rates) are not explicit components of the effects model. This may limit its scope and effectiveness beyond estimation of 'take.'

VII. Conclusions and Recommendations

The lack of information on population effects of habitat alterations from Water Operations on Central Valley salmon and steelhead (Baker and Morhardt 2001; Moyle and Israel 2005) has been well described by previous investigators. This lack of information, and the lack of a spatially explicit population model mirroring the model developed for water management with CALSIM, makes evaluation of changes in habitat quantity and quality to individuals and populations of listed species very difficult in light of the complexity of salmonid life histories and the complexity of Project operations and structures that can effect species survival and performance. Within these data constraints, the BO appears to be based on best available information with regards to temperature effects on survival of salmonid embryos and early fry in the upper Sacramento River and major tributaries and on estimating potential losses of juvenile salmonids to diversion and entrainment within the Delta. The report makes a good faith effort to address the many complex factors affecting each listed species in each unique context (e.g., upper Sacramento River, Feather River, etc.). Inclusion of more detailed evaluation of spawning gravel quality and quantity, indirect effects of temperature on emergence timing, and overall rearing habitat availability and suitability into the assessment would expand its scope to encompass more affected life stages beyond the current emphasis on embryo survival effects. A more detailed uncertainty analysis of what are likely key limiting factors/time periods for juveniles would help better define the upper and lower bounds of likely juvenile abundances under varying abiotic (e.g., water temperature, entrainment) and biotic conditions (e.g., predation levels)

In addition to answering the questions posed above, reviewers were asked to provide recommendations to help ensure that best available information is used for future ESA consultations. My recommendations for enhancing the scientific underpinnings of future consultations are made with the understanding that there are many new projects being conducted under CALFED research (Jacobs et al. 2003), thus some of the suggested research may already be underway, and that much more extensive tagging studies and marking of all hatchery fish are planned that will address fundamental questions about survival rates of out-migrants in relation to major Project operations.

Recommendations:

1. Conduct a combination of laboratory and field studies to more directly address thermal optima and tolerance of listed species, particularly with regards to potential stock-specific adaptations and requirements, in order to verify and validate the Salmon Mortality Model. The strong need for this work has been recently addressed in detail by Myrick and Cech (2005), but I would add that some new laboratory approaches for testing thermal requirements that incorporate survival and growth responses over much longer time periods than traditional testing methods (e.g, Selong et al. 2001; Bear 2005) would be especially applicable for addressing the chronic exposure effects of elevated temperatures as found in the Central Valley. Coupling of laboratory results with *in situ* field evaluation of elevated temperature effects on incubating eggs (e.g., with artificial redds or redd caps) and on juvenile growth,

survival, and distribution (e.g., growth of PIT tagged individuals, fish held in sentinel cages, fish occurrence in relation to temperature as described by Welsh et al. 2001) would provide an improved scientific underpinning for future modeling of the key effects of temperature changes on listed species.

2. Include measurements of redd scour and discharge so that risk of harm to existing redds from various discharge levels can be better quantified.
3. Conduct studies to assess the contribution of various life stages of out-migrants to adult recruitment (via otolith or scale microchemistry, recovery of tagged fish, or scale growth pattern) to better address the population-level effects of out-migrant loss at the Delta pumps.
4. Conduct studies on the effects of elevated temperatures on timing of key habitat shifts (emergence from gravel, out-migration) and how such temperature-related shifts may alter exposure to, and hence survival of, varying environmental conditions influenced by Project operations (exposure to high flows, loss at Delta pumps, gate operations at diversion dams).
5. Because there is some evidence that egg survival can occur at temperatures above the preferred range (BO:117), conduct studies to assess the relationship between stream temperature and redd/egg pocket temperature in all spawning areas for better modeling of changes of dam releases to actual thermal conditions in redds, to support application of results acquired in #1.
6. Identify location and use of cool water refuges by juvenile and adult salmon in order to 1)model how such areas change with changes in dam releases, and 2) identify potential areas where such cool water refuges might be enhanced.
7. Explore the possibility of modeling historical temperature conditions in the major drainages. Though the dams have been in operation for many decades prior to good temperature records, it is important to have better knowledge of thermal history of listed species so that a better conceptual context is in place of what conditions they evolved in historically and how much these conditions have likely changed with Project operations so as to direct possible restoration alternatives. Studies by Theurer et al. (1985; and associated studies detailed in McCullough 1999) and Holtby (1988) have provided some innovative approaches for re-creating historical temperature records for smaller salmonid streams and may provide some ideas for doing the same in some of the Project rivers.
8. Develop fish-habitat models that relate juvenile and spawning redd density to habitat type so as to allow better quantitative assessment of fish habitat gain/loss under different management scenarios, including habitat restoration or other mitigative measures.

Appendix A. References

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Appendix B. Statement of Work

Consulting agreement between the University of Miami and Dr. Thomas McMahon

December 1, 2005

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's (NMFS) Biological Opinion (BO) on the 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 projects potential to jeopardize the continued existence of listed Central Valley salmonids are correct.

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

Fundamental questions for the CIE reviewers

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

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

- Do the data, analyses, results, and conclusions presented lead to a thorough understanding of the risks to individuals and populations from the proposed project impacts? If not, what relevant scientific information should be considered?

- 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 should be used to best address the impacts of this large-scale water project as examined in the BO?

- 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 that might impact the BO substantively?

- 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 exposures? Were comparisons made to other species with similar impacts?

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

- Was evidence provided to support conclusions relative to species responses to demographic changes (*e.g.*, changes in fecundity rates, changes in growth rates for individuals, and changes in numbers of individuals that immigrate or emigrate from populations)? Was evidence provided to support the conclusions about how the proposed actions affect the species' demographies?

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 shall address possible inadequacies 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.

Notice of an Additional OCAP Technical Review and Relation of CIE Review to It

The OCAP has also been requested to provide an independent review of the BA and BO. They have taken on that request and held a public workshop Oct 12-13 in Davis, California to provide background and testimony about relevant scientific aspects of the OCAP. The terms of reference for their reviewers are similar to those given above.

Although based upon the same information, the CIE reviews will be independent of the OCAP review. The CIE reviewers will provide comments to NMFS through the CIE.

General Requirements

The CIE shall provide three independent scientists for this review. Expertise is required in hydrology and watershed ecology, salmonid biology and ecology, and fish stock assessment. No consensus opinion among the CIE reviewers is sought.

The activities required under this Statement of Work shall be conducted electronically, so no travel is needed.

CIE reviewers shall access the following 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.

These documents and other background material (or links to them) have been posted on the CALFED website (http://science.calwater.ca.gov/workshop/workshop_ocap.shtml).

Background information on the ESA and NMFS's responsibilities for implementing the ESA is available from the NMFS Office of Protected Resources web site at: http://www.nmfs.noaa.gov/pr/laws/esa.htm.

Specific Requirements

Each reviewer's duties shall not exceed a maximum total of 7 days - several days for document review and several days to produce a written report of the findings. Each reviewer may conduct their analyses and writing duties from their primary location. Each written report is to be based on the individual reviewer's findings, and no consensus report shall be accepted.

The itemized tasks of each reviewer consist of the following.

1.Read the two documents listed above, which provide the primary material to be considered in the review.

2.Consider additional scientific information as may be necessary.

3. No later than December 19, 2005, submit a written report[1] that addresses the fundamental questions listed above. See Annex I for additional details on the report outline. Each report shall be sent to Dr. David Die, via email at ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via email at mshivlani@rsmas.miami.edu.

[1] Each written report will undergo an internal CIE review before it is considered final.

ANNEX I: REPORT GENERATION AND PROCEDURAL ITEMS

1. The report shall be prefaced with an executive summary of comments and/or recommendations.

2. The main body of the report shall consist of a background, description of review activities, summary of analyses and comments, and conclusions/recommendations.

3. The report shall also include as separate appendices the bibliography of materials reviewed and a copy of the statement of work.