Independent Review Panel Report for the 2016-2017 California WaterFix Aquatic Science Peer Review Phase 2B

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Scope and Purpose of the Review: This report presents the findings of the 2016 California WaterFix (CWF) Aquatic Science Peer Review, Phase 2B. An Independent Review Panel (Panel; Appendix 1) was convened by select staff of the Delta Science Program to provide the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (FWS), and California Department of Fish and Wildlife (CDFW) with the views of experts not involved in the CWF Endangered Species Act (ESA) consultation and 2081(b) permit on the use of best available scientific information in the California WaterFix Incidental Take Permit (CWF ITP) application. The agencies further requested review of the Adaptive Management Framework proposed to integrate future scientific research, monitoring, and decision making during construction and operations of CWF.

Accordingly, the Panel was charged with reviewing NMFS' analytical approach and FWS' analytical framework, status of the species and critical habitat, environmental baseline, and effects analysis sections of the draft BiOps on CWF for all ESA- and California ESA (CESA)-listed aquatic species and their critical habitat (see Charge, Appendix 2). After reviewing the charge and a set of prescribed documents (Appendix 3), the Panel participated in a public meeting in Sacramento, CA on January 23-24, 2017. On the first day of this meeting, the Panel interacted with agency representatives after they gave presentations on the topics above. On the second day, the Panel communicated internally and then discussed its preliminary findings with agency representatives and the public (Appendix 4).

1 Executive Summary

The California WaterFix (CWF) Aquatic Science Peer Review (Panel) reviewed the products from two phases of the on-going CWF assessment: (1) responses by the Agencies to the Panel's initial Phase 1 review comments, the Adaptive Management Framework, and the Biological Assessment under the California Endangered Species Act (CESA); and (2) draft Biological Opinions (BiOps) for two genetic stocks of Chinook Salmon, Steelhead, and Green Sturgeon (prepared by NOAA's National Marine Fisheries Service; NMFS) and Delta and Longfin smelts (prepared by the US Fish and Wildlife Service; FWS) under the auspices of the Endangered Species Act (ESA). The Panel wishes to express its appreciation for the extensive responses to the Phase 1 review comments and comprehensive analyses and documentation prepared in time for Phase 2. As described below under a summary of the Panel's basic charge questions, we found vast improvement in the State and Federal Fish Agencies (NMFS, FWS, CDFW) approaches to assessing potential CWF impacts to CESA- and ESA-listed species. However, the Panel found that our review was hindered by the lack of a comprehensive "road map" that would clarify the Panel's understanding about how the complex CWF steps and phases fit together and contribute to systematic conservation and recovery of the protected species.

Using the best available science, the Fish Agencies have provided evidence that some aspects of the Proposed Action (PA) will have significant adverse effects on listed species and critical habitat. The BiOps include conservation measures for the conservation and management of listed species, including monitoring and research supporting mitigation of the PA's adverse effects on listed species. Suggested conservation measures include conservation banking, habitat restoration, and a framework for collaborative science and adaptive management. Although insufficiently described, conservation measures could provide some mitigation. However, the Panel did not find strong linkages between the definitive determinations about adverse effects on listed species and definitive plans to avoid, minimize, and mitigate the more significant effects. While the Panel understands that some of these effects will be subject to future consultation, we believe that the BiOps and subsidiary documents should more clearly demonstrate a convincing framework for mitigation decision making. Adverse effects of PA construction and operation will require significant mitigation beyond the conservation measures described in the BiOps in order to minimize impacts. The Panel encourages the development of a comprehensive mitigation plan that takes into account the need for restoration actions that often take years to become fully beneficial. Monitoring and adaptive management will be required to ensure that mitigation is successfully implemented as intended, and to determine whether the mitigation actions are providing the anticipated benefits to the species.

Response to Phase 1 review comments and Adaptive Management Framework

The Panel found that most of the comments in the Panel's presentation at the Phase 2A public Panel meeting were addressed and observed that considerable attention to detail was added in the characterization of uncertainty. In particular, the Panel observed that the further classification of uncertainty would improve the ultimate assessment of risk and exposure. Similarly, the Panel appreciates the explicit commitment to include monitoring for effects of climate change in the Adaptive Management Framework, and the commitment to adjust planning in response to feedback from adaptive management and CWF operations. The Panel notes that, in response to comments in Phase 1, the NMFS BiOp is explicit about applying the general principle of institutionalized caution, or giving the benefit of the doubt to the species, when considering the uncertainty of the data, analytical methods, and results.

Best Available Information:

The NMFS and FWS BiOps were comprehensive in their evaluation of potential impacts of the PA on salmonids and smelts, and they largely relied upon best available information and science. Overall, species status, critical habitat, and associated environmental baseline knowledge typically reflected the best, and often most recently available, scientific information, while also acknowledging critical deficiencies.

Data Gaps and Uncertainties:

Overall, species status, critical habitat and environmental baseline text reflected the best available scientific information, as well as acknowledging critical deficiencies. Data gaps and uncertainties in PA effects on Chinook Salmon and Steelhead were typically recognized, although description of the variability in life-history stage composition (especially in juvenile migrant habitat-use in riverine floodplains and across the Delta) was not complete. Furthermore, potential bias by the use of surrogate species should have been discussed in more detail; e.g., to what extent, if any, might surrogates (species, size, life history types) bias the findings of some analyses. The considerable uncertainty surrounding basic biology and life history information on the smelts is broadly recognized to constrain quantitative assessments of their risk and vulnerability at the population level. The Panel stresses the importance of identifying the most critical gaps and information needs (from the list of recognized uncertainties) and prioritizing them for adaptive management applications. Those data that would inform adaptive management triggers and thresholds should be targeted with the highest priority. In particular, more temporally responsive triggers for Delta Smelt and Longfin Smelt need to be identified. The Panel stresses that funding assurances are needed immediately to ensure that critical research needs are met.

When linking a series of physical and biological models, such as was done in the life cycle models and fish routing models, it is important to have confidence in each model in the modeling cascade. Limitations of data received from input models, such as large time steps or limited confidence in model calibration, need to be accounted for when drawing conclusions from any models in the modeling chain.

Construction Considerations:

There are numerous construction effects to consider, including: increased turbidity and chemical exposure throughout the Delta from the expected 15,000 barge trips; creation of predation hot spots at construction barge landings; predation along the very long cofferdam walls; fish exposure to potentially stressful pile driving noise; and predation increases during construction at Clifton Court Forebay.

Construction-related effects of the PA on salmon were evaluated in detail to the extent possible given the preliminary construction plans; significant adverse effects of construction activities were appropriately identified. The Panel acknowledges that flow-related operations are highly likely to change before construction is complete, and thus the effects analyses based on the present operations will become less relevant to actual construction-related effects.

Loss of Delta Smelt habitat upstream of the North Delta Diversion (NDD) is expected to occur if cofferdams constrict the river channel and cause accelerated water velocities to impede Delta Smelt access to upstream habitats. The Panel emphasizes that high-flow years, which are years when the distribution of adults expands upstream, downstream, and laterally, will also be years that have relatively high velocities near the proposed cofferdams, and the associated increased impediment to upstream dispersal could inhibit a potential compensatory mechanism for population recovery (i.e., any recovery that is facilitated by expansion of the adult range).

Operational Effects:

The Panel commends NMFS scientists for the development of a new winter-run Chinook salmon life-cycle model and the new salmon survival analysis that were specifically constructed to evaluate PA effects. These analytical tools address previous Panel requests to develop a life cycle model specific to the CWF and to incorporate new data. Nevertheless, the Panel expects further refinement of the life-cycle model and application of the model to other ESA-listed salmonids to the extent possible. The life-cycle model recognizes five life history strategies of winter-run Chinook Salmon and identified a significant reduction in overall survival associated with PA operations. Evaluation of PA effects on critical salmon habitat was adequately addressed, except it should have considered long-term changes in habitat quantity and quality associated with water removal from NDD operations and the resulting effect on salmon distribution and access to habitats, as well as important habitat characteristics such as salinity, sedimentation, vegetation, water depth and velocity. Regarding all listed species, conducting both pre- and post-construction studies at the NDD is a robust approach to evaluating the effects of sediment transport, tidal interaction with diversion rates, refugia from predation, and fish-screen hydraulic performance. Monitoring-type studies of various duration (months to entire length of permit) will assess long-term entrainment, impingement, and screen design/ performance.

The Panel cautions that there are four important hydrodynamic downstream effects of NDD operations that must be considered in the BiOps. Firstly, the Delta Cross Channel will open and close on a different schedule, which has implications for both the diversion of fish into the central Delta and central Delta water quality. Secondly, changes in the location of the transition between unidirectional flow and bi-directional flow along the Sacramento River will both increase fish migration times and increase the number of times fish are exposed to junctions to the central Delta near the Georgiana Slough/Delta Cross Channel junction. Thirdly, the movement of the low salinity zone above X2 = 81 km will result in repeated separations of Delta Smelt from their open-water rearing habitat during certain months. And lastly, depending on the position, size, and design of tidal restoration in the Delta, NDD operations could potentially alter habitat availability by reducing the frequency and duration of tidal inundation of fish spawning and rearing habitats. These issues should be considered in the new life cycle model and in the new flow/routing/survival analysis for winter-run Chinook Salmon and should also be considered in the final BiOps.

Longfin Smelt Outflow Criteria:

The underlying mechanism for the Longfin Smelt abundance-Delta outflow relationship is a critical research topic. Until research directs otherwise, using a minimum Delta outflow operational criteria for the spring period (February/March through May), similar to what occurs under current authorizations for the CVP and SWP, could help to minimize the effects of the CWF on Longfin Smelt. We recommend that criteria be developed using the 8 River Index (8RI) regressed against historical Delta outflow data using a linear plus quadratic model. Despite the conceptual appeal of the previous month's 8RI (PMI), its value predicts the current month's Delta outflow with high uncertainty (low r^2), as compared with predicting from the current month's 8RI. Thus, we recommend rigorously comparing the uncertainty of outflow predictions based on PMI versus the compounded uncertainty of predicting the current month's 8RI and then in turn predicting future outflow from the current month's predicted 8RI. However, the decision to use either PMI or the predicted current 8RI should also be informed by an analysis of any predictable consequences to Longfin Smelt; e.g., incidental take at the Central Valley Project (CVP) and State Water Project (SWP).

2 Contents

3 Introduction

3.1 Background

As part of its formal charge**,** the Panel was given the following background for its review, which we quote in its entirety:

"*The California Department of Water Resources (DWR) and the Bureau of Reclamation (Reclamation) coordinate the operations of the Central Valley Project (CVP) and the State Water Project (SWP). As a part of California WaterFix (CWF), DWR proposes to construct and operate new water conveyance facilities in the Sacramento-San Joaquin River Delta, including three intakes, two tunnels, associated facilities, and a permanent Head of Old River gate; as well as operate existing south Delta facilities in coordination with these new facilities.*

DWR intends to obtain California Endangered Species Act (CESA) authorization under Fish and Game Code Section 2081(b) for incidental take related to the construction and operation of the CWF water facilities and modified operations of the SWP. DWR submitted an Incidental Take Permit (ITP) application to California Department of Fish and Wildlife (CDFW) on October 5, 2016. This application includes analyses of the effects of the proposed action on CESA-listed species. CDFW is reviewing the analyses of perceived impacts on state-listed species and may issue a permit if conditions in Fish and Game Code sections 2081(b) and (c) are met.

Reclamation is consulting with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) on the construction and operation of the new dual conveyance facilities. As a part of these consultations, Reclamation and DWR have written a Biological Assessment (BA) that summarizes the effects of the action on ESA-listed species and their designated critical habitats. A draft of the BA analyses and draft NMFS analytical approach to the Biological Opinion (BiOp) were reviewed in Phase 1 of this review.

Current CVP/SWP operations require scientific research and monitoring to support real-time operations, decision making, and more complete understanding of the relationship between the CVP/ SWP operations and ESA- and CESA-listed fish species. Moving forward, adaptive management will be used to integrate real-time operations, ongoing scientific research, monitoring, and long term operations of CWF for the SWP and CVP. The draft adaptive management framework has been included as part of the CWF proposed action and was reviewed in Phase 2A.

The purpose of this independent scientific peer review is to obtain the views of experts not involved in the CWF ESA consultation on the use of best available scientific information as it pertains to the analyses of effects on ESA-listed aquatic species during construction and operations of CWF."

End of Quote

3.2 Charge to the Panel with Summary Panel Responses

3.2.1 Question 1: How well does the Analytical Approach in NMFS BiOp respond to Phase 1 comments?

Overall, the Panel found that most of the comments in in the Panel's presentation at the Phase 2A public Panel meeting were addressed to some degree, and often quite comprehensively.

Question (1): Uncertainty and decision rules

In their analytical approach (NMFS BiOp, Section 2.1) by NMFS now defines High/Medium/Low weights of evidence (p. 15), which is an improvement over the Phase 1 draft reviewed by the Panel. However, it is unclear if these "weights" are intended to be equivalent to the High/Medium/Low "certainties" that are stated in construction (NMFS BiOp, Section 2.5.1.1) and upstream operations (NMFS BiOp, Section 2.5.2.2). In addition, we note that High/Medium/Low certainties are not stated anywhere in the Delta operations section (NMFS BiOp, Section 2.5.2.2) and this appears inconsistent.

If "weights" and "certainties" are not equivalent, then the latter need clarification. The categorical "certainties" (High/Medium/Low) would be more meaningful and objective if their designation criteria were defined in advance. In addition, how would these designations differentially influence the ultimate assessment of risk and exposure?

Furthermore, the paragraph preceding Table 2-2 in the analytical approach has been revised to mention uncertainty, as the Panel suggested in its Phase 1 review. However, there is still no description of how either the "weights of evidence" or the "certainty" designations (High/Medium/Low) will influence the true/false determinations of Tables 2-2 and 2-3 (NMFS BiOp, Section 2.1.3.1). For example, one could decide, *in advance,* that any stressor effect designated as either Low or Medium magnitude, but with Low weight of evidence and/or High uncertainty, would lead to True decisions in one or more of Steps C-F of Table 2-2. If rules such as these cannot be articulated in advance, then the Panel suggests stating that the True/False determinations of Tables 2-2 and 2-3 will ultimately be determined by expert judgment.

Question (1): Adaptive Management

The Panel concluded that while the Adaptive Management Framework (AM Framework) is a good starting point, much more work is needed before adaptive management can be successfully implemented as part of the BiOps to reduce critical uncertainties with regard to the ability of the Proposed Action (PA) to avoid impacts to the listed species. The Panel also appreciates the commitment to include monitoring for effects of climate change in the AM Framework, and to adjust planning in response to feedback from adaptive management and CWF operations.

The NMFS BiOp reflects a thorough approach to addressing Panel comments to date. The Panel is impressed with the development of a detailed and well thought-out AM Framework, which includes an explicit commitment to employing active as well as passive AM in efforts to avoid, minimize, and offset negative effects on listed species, and to provide for their conservation and management. That said, while the Panel notes that the general outline of the AM Framework is sound, details and assurances regarding critical uncertainties and funding are lacking. Also missing are details about monitoring for effectiveness of conservation measures, but the Panel recognizes that these will be examined closely and evaluated for their capacity to reduce uncertainty and facilitate AM in future consultations.

The Panel asked for clarification regarding links between real time operations and AM. The NMFS BiOp explains that AM will be used to make modifications to criteria and/or ranges identified by real-time operating monitoring. Effects of any such modifications will be analyzed by the US Bureau of Reclamation (Reclamation) and CA Department of Water Resources (DWR), in consultation with NMFS and US Fish and Wildlife Service (USFWS), to determine if Reclamation should reinitiate consultation prior to implementation. The Panel notes that the consultation history provides evidence that NMFS, FWS, and CDFW (Fish Agencies) are using AM to reduce negative effects of water operations on species. For example, AM was a provision in one of the NMFS 2009 BiOp RPA actions, relating to Shasta Reservoir operations. AM was used to detect the need for a modification to the Shasta RPA actions due to recent multiple years of drought conditions, new science and modeling, and data demonstrating low population abundance levels of Sacramento River winter-run Chinook Salmon and Sacramento River spring-run Chinook Salmon. The Panel appreciates that NMFS is in the process of adjusting the RPA to reflect new understandings of the situation, in line with the tenets of AM.

The Panel notes that, in response to comments in Phase 1 (Simenstad et al., 2016), the NMFS BiOp is explicit about applying the general principle of institutionalized caution, or giving the benefit of the doubt to the species, when considering the uncertainty of the data, analytical methods, and results. The primary mechanism for addressing uncertainties in effects will be the AM Framework, which NMFS says will "focus heavily" over the next decade "on filling critical data and information gaps, enhancing the existing monitoring network and improving quantitative modeling capability." The Panel would like to see a more explicit prioritization of research needs to reduce critical uncertainties.

In Phase 1 and 2A, the Panel asked for better articulation of the relationship between monitoring and assessing the impacts of real-time operations and adaptive management. We recognize that the NMFS BiOp governing existing operations will be revised distinctly and independently from the PA operations. However, the Panel is still unclear about whether, and how, the AM Framework will be incorporated into the North Delta Diversion (NDD) operations. For instance, the NMFS response is unclear: "*Real-time operations and adaptive management will be designed to incorporate uncertainty and allow action within reasonable timeframes for those activities given opportunities or scenarios to address uncertainties.*"

Question (1): Cumulative system effects

One concern expressed in the Panel's Phase 1 review (Simenstad et al., 2016) was failure to treat the Delta in the context of a dynamic freshwater-bay system (i.e., an estuary). The Panel appreciates the improved conceptualization of critical habitat (and essential fish habitat), which (logically) expands analysis of potential PA impacts on individuals and species to include the entire Delta, considering both direct and indirect impacts. However, a comprehensive view of potential effects of the PA operations on hydrodynamic, trophic, and sedimentological processes that affect the listed species and their critical habitats remains relatively ignored.

Question (1): Climate change

Finally, but not inconsequentially, the Panel continues to be concerned that climate change is only considered through 2030, which is not appreciably long-term relative to the potential system-wide effects of the PA operations. The Panel recognizes that future atmospheric CO_2 concentrations are unknown beyond mid-century, but this should not preclude evaluation of different climate scenarios. The BiOps should discuss how the projected climate change effects on flow, temperature, and productivity might differentially affect listed species under the PA versus the No Action Alternative (NAA).

3.2.2 Question 2: How well do the draft BiOps use best available scientific and commercial information?

(2a): Do the status of the species and critical habitat and environmental baseline reflect the best available scientific and commercial information?

Overall, species status, critical habitat, and associated environmental baseline knowledge presented in the draft BiOps generally reflect the best available scientific information and acknowledge critical deficiencies. The BiOps represent the more relevant and recent scientific information, particularly in the case of salmon and steelhead, and the key, persistent information gaps, such as for both smelts. The inclusion of new information from Perry et al. (in review) and the use of trawl data to support the new life cycle model (Hendrix et al., 2017; Table 5) are significant improvements.

Question (2a): Salmon

The Panel found some inconsistencies, such as timing of adult spring-run Chinook Salmon relative to vulnerability to pile driving effects. Relative to their vulnerability to construction and operational impacts, the timing of adult Chinook Salmon passing through the Delta needs to be clarified, because timing is not consistently reported in each section of the NMFS BiOp, especially with regard to timing of adult spring-run Chinook Salmon and their exposure to intense pile driving noise. For example, the environmental baseline section (NMFS BiOp, Section 2.4.2.1) states that adult spring-run Chinook Salmon enter the San Francisco estuary in late January and early February, and enter the Sacramento River primarily in May and June and continue to enter the river into September. This suggests adult salmon would be exposed to impact pile driving, but the impact analysis (NMFS BiOp, Section 2.5.1.1.1.1.1.2; Table 3-5) concludes that relatively few adult spring-run Chinook Salmon are present in the Delta during the pile driving period, June-October. This information should be clarified and supported with references that specifically examined migration timing of adult salmon.

Information on life history diversity of salmon genetic stocks are underrepresented, considering its potential importance to population diversity and resilience. NMFS BiOp Section 2.2 and the associated Appendix XX-*Rangewide Status and Species and Critical Habitat* and provide reasonably detailed information on the current status of salmonids, including abundance trends, productivity, diversity, and spatial structure. However, given the importance of rearing of juveniles in the Delta and adult migration through the Delta and the potential direct and indirect effects of the PA on salmonids in the Delta, additional details on the life history of these species in this critical habitat should be described. The Panel recommends that inclusion of a comprehensive table describing spatial and temporal variation in life history stages and traits (body size frequency distribution, residence time, ecology, characteristics of habitats use by life history types and associated survival) for each stock would help readers understand both their status and vulnerability to PA impacts across the Action Area. This information would be supported by an analysis of beach seine and trawl data that have been collected since the mid-1970s, although the limitations of these data should be recognized and hopefully data gaps (e.g., migrant fry) would be targeted for near-term research and monitoring. More complete and greater detail for these data would support the evaluation of key viable salmon population (VSP) criteria, which are highlighted in the BiOp approach.

Question (2a): Other ESA listed species

Unfortunately, given the paucity of information for the Delta, few details could be provided on the life history and specific factors affecting survival of Green Sturgeon, which also deserves further highlighting for future, near-term research and monitoring. It is also noted that the background information on southern resident Killer Whales (Orcas) could be updated. The BiOp indicated 84 whales at the end of 2015. However, additional mortality of Killer Whales was observed in 2016. As of Oct 29, 2016, there are 81 Killer Whales in the three pods (http://www.orcaconservancy.org/2016/10/30/2016-population-update-southern-resident-killer-whales/). The loss of three Killer Whales is relevant because the population is so small, the numbers have been trending down, and they consume Chinook Salmon originating from the Action Area.

(2b): How well is the best available science used in the effects analysis and findings sections?

Considering the limited extent of population abundance, life history and ecological information for the listed species, particularly for the smelts, the best, and most recent, available science is appropriately utilized in the effects analysis and findings sections. Effects on salmon, smelts and sturgeon were supported by comprehensive analyses when feasible, and new data and modeling were used in the BiOp. Some elements of the effects analysis, such as mechanisms of acoustic stress and variable response in fishes, are very complete, although as noted below in Question 4, there may still be some issues with the BiOp assumptions of fish exposure to some risk factors. Similarly, many avoidance and minimization measures appear to be well established and directly applicable, especially for construction effects.

Recent synthesis of juvenile salmon in the Delta (Perry et al. 2016a) and the emerging life cycle model (Hendrix et al., 2017) measurably advance former information gaps, particularly incorporating more life history detail on listed salmonids.

There are a few questionable applications of the biophysical data. For example, in evaluating upstream effects, the use of monthly averages for both temperature and flow, produce uncertain results (e.g., relating CALSIM II monthly flow to the stranding of juvenile salmon, which is a mechanism related to rapid change in flow). The NMFS BiOP recognizes this limitation but simply assumes that hourly flow fluctuations are not likely to change under the PA.

Question (2b): Exploiting recent advances in statistical modeling

Delta Smelt salvage is related to X2, Old and Middle River flows (OMR), and turbidity, as shown in Figure 9.2.2.2.1-3, Section 9.2.2.2.2 of the FWS BiOp. It is very unlikely that the scatter in each panel of Figure 9.2.2.2.1-3 is due solely to interactions of the other two (non-plotted) covariates, as implied in the note under the figure. There are surely other factors that also contribute scatter. For this reason, one should not necessarily expect that a “good” regression model, driven only by X2, OMR and turbidity, could explain all the scatter seen in the figure.

However, the plotted relationships do offer an opportunity to employ recent advances in statistical modeling. A modern, nonlinear multiple regression structure such as Random Forests, Boosted Trees, or Generalized Additive Models*,* could be used to model the relationships shown in Figure 9.2.2.2.1-3; that is, to model Delta Smelt salvage as a joint function of X2, OMR, and turbidity. These computer-intensive methods represent nonlinear and interactive effects of multiple covariates. In addition, partial effects plots derived from such models can estimate the nonlinear effect of each covariate on salvage, correcting for effects of the other two (Hastie et al., 2008).

A partial-effects strategy could also be used to apply the resulting regression model to the NAA and PA scenarios. These scenarios can specify values for X2 and OMR, but not for turbidity. However, for any scenario-specified value of (X2, OMR) one could assume a turbidity value that is equal to the mean of the historical turbidity levels measured in conjunction with all those historical (X2, OMR) values occurring within some neighborhood of the specified (X2, OMR). We do acknowledge that turbidity has been steadily decreasing at a decadal scale, which would be problematic in this approach. And, this strategy does not realistically allow for turbidity, by itself, to be affected by either climate change or PA actions, during the 82-year scenarios. However, predicting salvage for PA and NAA, from OMR as the sole predictor, is even less realistic, given the clear relationships seen in Figure 9.2.2.2.1-3.

Because OMR is often used as a parameter to relate flow in the south Delta to different parameters of interest, such as salvage, it is important to understand that the flow parameter OMR does not represent a physical location in the south Delta. The California Data Exchange Center (cdec.water.ca.gov) reports a daily, tidally-filtered flow and an hourly flow for a fictional station called OMR. This “station” has a calculated flow based on the combined observed flows at an Old River station (OBI) and a Middle River station (MDM). The hourly flow reported is the sum of the OBI and MDM event flow data sampled at the top of the hour. In reality, the south Delta export facilities are located in the tidal zone of the south Delta, and flows in the channels leading to those south Delta facilities cannot be simplified to daily, tidally-averaged flows. In fact, the tidal velocities are approximately ten times greater than the tidally-averaged velocities in this region. Therefore, because this is a tidal region, there are still two periods in each 24-hour day during which tidal flood flow is towards the export facilities, even during positive OMR flow conditions. Therefore, scatter in regression plots relating any parameter to OMR should be expected since OMR a very simplistic representation of the hydrodynamics of the south Delta region (see Appendix 2 of Anderson et al., 2014).

3.2.3 Question 3: Do the draft BiOPs adequately address data gaps and uncertainties?

(3a): Are the assumptions in the effects analysis clearly stated and reasonable based on current scientific thinking?

Question (3a): Delta Smelt

The FWS BiOp for Delta Smelt acknowledges that flow-related operations are likely to change before construction is complete, and thus the effects analyses based on the present operations will become less representative with time (FWS BiOp, Section 9.2.2.1.6). Flow-related operations are presently under revision to improve compliance with older BiOps. One of these revisions is operational adjustments to improve compliance with RPA Action Suite 1.2, which involves flow-related upstream temperature management for salmonids under the 2009 NMFS BiOp. These adjustments are acknowledged in the FWS BiOp to have unknown effects on future flows within Delta Smelt habitat (FWS BiOp, Section 9.2.1.4.1). Likewise, current operations at the South Delta Diversions (SDD) are under revision and are thus likely to change (FWS BiOp, Section 9.2.2.2). The FWS BiOp notes that only the status quo was evaluated by the CWF BA, and not future operational changes such as these.

In general, the FWS BiOp holds that construction effects are too uncertain to be evaluated in detail, and thus will be assessed by future consultations after descriptions of final construction designs and modified flow baselines have become available. Nevertheless, the FWS expects that most construction effects on Delta Smelt will be small during the approximately 13 years of construction (FWS BiOp, Section 9.2.2.1.6).

A major exception to the conclusion of small construction effects is the loss of habitat upstream of the NDD that is expected to occur if cofferdams constrict the river channel and cause accelerated water velocities to impede Delta Smelt access to upstream habitats. The Panel emphasizes that high-flow years, which are years when the adult range naturally expands upstream, downstream, and laterally, will also be years that have relatively high velocities near the proposed cofferdams, and the associated increased impediment to upstream dispersal could inhibit a potential compensatory mechanism for population recovery (i.e., any recovery that is facilitated by expansion of the adult range). In other words, the cofferdams could impart a disproportionately negative feedback to the otherwise positive effects of high-flow years.

After construction is complete, operations are also expected to block Delta Smelt habitat access to a similar (very extensive) degree as the cofferdams, albeit through a different mechanism (i.e., screen impingement rather than cofferdam-related acceleration of flows). The Panel advises that the construction period should be viewed as a period of potential Delta Smelt recovery, simply because recovery cannot be ruled out, and thus blockage of upstream movement during the construction period remains a concern even though complete upstream habitat blockage is expected to ultimately occur later, during the operational phase.

Another future change, which may or may not have a real-world effect on circulation, water levels, or water quality within the Delta Smelt habitat range, is the 8,000 acres of tidal marsh that is slated to be restored as part of 2008 FWS BiOp RPA Habitat Component 4. This mitigation is scheduled for completion by 2018, yet inclusion of this future change could not be simulated in the NAA because the restoration locations have not been finalized.

Question (3a): Salmon

NMFS BiOp analyses for salmon typically recognize data gaps while describing assumptions and limitations. For example, the new winter-run Chinook Salmon life cycle model (LCM) identifies the origin of parameter estimates, its use of empirical data, and limitations of the model; e.g., the model is best used to provide guidance on the relative performance of the two actions (PA versus NAA) rather than to forecast actual fish abundances. Additional assumptions and limitations are described in the detailed model report (Hendrix et al., 2017; this document should be referenced in the NMFS BiOp). The NMFS BiOp also provides the basis for the new Perry et al. (in review) flow-survival simulation model but it could provide more detail, such as the range in sizes of acoustically-tagged Chinook Salmon, and implications of the CALSIM II model flows that were necessary to match observed flow reversal patterns. Refer to the Panel's Question 3c response for further details.

A significant data gap and limitation in most salmon analyses involves PA effects on smaller juvenile salmon in the Delta, especially those ~70 mm and less. The NMFS BiOp recognizes that smaller Chinook Salmon rear in shallow Delta habitats for extended periods, but there is little discussion on how the PA might differentially affect these small salmon compared with the large hatchery yearling late-fall Chinook Salmon used in the flow-survival simulation (range: 130-170 mm; NMFS BiOp, Section 2.5.1.2.7.4.2) (Note: The Panel recognizes fish size limitations imposed by acoustic tags and wishes to acknowledge recent significant improvements by the incorporation of 2,170 tagged salmon in this new analysis). Trawl data at Chipps Island show that most spring- and winter-run Chinook Salmon in mid-channel are greater than 70 mm, but beach seine data indicate a high percentage of small Chinook salmon fry and parr along the shoreline. For example, during 2012-2016, 51% of winter-run Chinook Salmon (549 fish sampled) were 35-70 mm long and 74% of spring-run Chinook Salmon (1233 fish sampled) were 31-70 mm long. The overall percentages of the total populations that rely on shallow nearshore habitat is unknown, but this percentage probably reflects outmigration timing and habitat availability in the Delta, and thus varies year to year; e.g., winter-run Chinook that enter the Delta with high flows in November and December are smaller and likely have a high percentage of fish that rear in shallow habitats. Further otolith microstructure and microchemistry research could help identify the relative abundances of various life history strategies of Chinook Salmon in the Delta and in other habitats.

The flow-survival model and LCM model indicate that mortality of winter-run Chinook Salmon in the Delta is positively correlated with residence time, e.g., juvenile Salmon that spend more time in the Delta have increased risk of predation and other mortality factors. This is logical for larger fish, and tagging of large fish supports this pattern. In contrast, smaller juvenile salmon have extended rearing in the Delta where they presumably grow fast and experience higher survival after entering the bay and ocean. Shallow, productive, low flow habitats probably support higher survival, possibly because there are fewer piscivorous fishes in the shallow water.

At the Phase 2B public meeting, the Panel asked the Fisheries Services and the ICF consultants about representativeness of the acoustically-tagged Chinook Salmon survival estimates for smaller salmon. The Panel recognizes the important information provided by route-specific survival of 2,170 large (130-170mm) hatchery fall Chinook Salmon in the Delta, but we have questions about whether or not smaller Chinook Salmon were similarly influenced by the PA. In response, NMFS scientists presented a figure from Perry et al. (2016a) that suggested that the flow-survival <u>pattern</u> for 156 mm fish was similar to that for 81 mm fish, while also recognizing that absolute survival may differ with fish size. Perry et al. (2016a) provides important information that should be considered in the NMFS BiOp.

As noted above, the FWS BiOp acknowledges that flow-related operations are likely to change before construction is complete, and thus the effects analyses based on the present operations will become less representative with time (FWS BiOp, Section 9.2.2.2). Potential changes in operations should be discussed in the NMFS BiOp with regard to uncertainty about potential effects on availability and integrity of juvenile salmon habitat, operational effects on juvenile salmon, and how potential changes in operations might influence the current analyses.

(3b): How extensively are gaps in aquatic species life history information considered and appropriately addressed?

Question (3b): General

Given the difficulty of quantifying and tracking the amount of individuals at each life-history stage of each fish species, the use of the terms “small proportion”, “medium proportion”, or “large proportion” is appropriate. This approach allows cross comparison among stocks/ESUs with differing data completeness or quality at the same resolution. However, as noted elsewhere in the Panel’s review (e.g., Question 2a), description of the variability in life-history stage composition, especially in juvenile migrant salmon and smelt habitat-use in riverine floodplains and across the Delta, is not complete.

Question (3b): Delta Smelt

Delta Smelt spawning habitat is unknown, but is thought to consist of shallow, sandy substrates with sufficient flow located upstream of the low-salinity zone that is used as larval/juvenile rearing habitat. It is believed that the geographic spawning range within fresh and brackish waters expands during wet years, and that the combination of spring flows and water temperature, in particular, may limit spawning area and spawning-season duration. For example, warm winters and early springs cannot be exploited as spawning times, even if wet, because Delta Smelt have not yet matured at this time of year. Although impacts on putative Delta Smelt spawning habitats were generally considered consistently throughout the FWS BiOp, the Panel feels that such potential uncertainties and constraints on Delta Smelt spawning area and spawning season are very important and warrant additional study effort.

Regarding diversion of particulates at the NDD, it should be noted that the FWS BiOp emphasizes the effect this will have on turbidity (FWS BiOp, Section 6.2, p. 39). However, the sediment retained at the NDD is expected to be coarse-grained (> 0.002 mm) (FWF BiOp, Section 6.2, p. 27), and thus should have a reduced contribution to turbidity within the downstream Delta relative to the particulates that originally enter the NDD with the river water. The plan for mitigating diverted spawning substrate (i.e., sand) is described as re-introduction of sediment to the river mainstem to allow its natural remobilization to downstream spawning areas.

Question (3b): Salmon

The NMFS BiOp stated that it will add a discussion of rearing juveniles after the fry habitat analysis has been completed (NFMS BiOp, Section 2.5.1.2.7.1.2). The type of fry habitat analysis was not described. This evaluation should include a discussion of how the project might differentially affect smaller fry that rely on estuarine habitats.

The new life cycle model accounts for extended rearing in the Delta by "Delta smolts." Although this is a significant addition to the effects analysis presented in the BA, the Panel is uncertain whether or not the model incorporates PA flow effects while these fish inhabit the Delta below the NDD. Also, although the life cycle model adjusted habitat capacity based on changes in salinity, it did not appear to consider long-term changes in habitat associated with PA flow effects and water diversion. The new life cycle modeling effort recognizes that there is a significant data gap in addressing more complex spatial-temporal patterns in biological behavior and habitat interactions (Hendrix et al., 2017). The BiOP should identify potential effects of the PA that are not addressed by the LCM.

(3c): How well are statistical uncertainties considered when assessing effects to individual survival (e.g., loss from predation, entrainment, impingement, etc.)?

Question (3c): Salmon Entrainment at NDD

The NMFS BiOp provided little information on the uncertainty surrounding its estimates of salmon entrainment and impingement at the NDD. The NMFS BiOp notes that diversion of up to 3,000 cfs at each of three screens would increase exposure of juveniles to entrainment and impingement, and simply assumes up to 50% of the migrants would be exposed; it is not clear why 50% of migrants would be "exposed" to screens given that many fish are at mid-channel and on the opposing river bank. The entrainment rate was assumed to be 1% of those fish within the exposure zone, leading to entrainment of 0.5% of the population (0.01 x 0.50). Impingement was assumed to injure 2.5% and kill 3.7% of the exposed fish (50% of total), leading to 1.25% and 1.85% injury and mortality rate for each screen. Table 2 (NMFS BiOp, Section 2.5.1.2.7.5.2) includes take estimates based on an assumed proportion of the population exposed to the screens, ranging from 25% to 50%. The overall take rate for all three screens ranged from 5% to 10% of the migrating salmonids. Entrainment rate, impingement injury rate, and impingement mortality rate are constants and do not consider variability, such as that caused by river flow, water volume diverted, and the size of salmonids migrating downriver. In addition, the same rates are assumed for all three screens. Realistically, fish successfully navigating past any one screen may be weakened by the effort, and hence their loss/injury rates are likely to increase for the next screen, and again for the next. Small salmon, which are more common along the shoreline, would be most vulnerable to the NDD, whereas larger smolts are farther offshore, less exposed, and less likely to be impinged on the screens. Further examination of data on salmon size by species and date from the beach seine and trawl dataset could facilitate this evaluation. The new LCM assumed near-field mortality of 5% or 0% at the NDD, but 5% NDD mortality only led to a difference of 1.3% in the cohort replacement rate (Table 2, Scenario 2 versus 2A, NFMS BiOp Section 2.5.1.2.7.5.2).

NMFS BiOp, section 2.5.1.2.7.4.2. Perry et al. (in review) Flow Survival Model.

The analysis of NDD operations effects on salmon makes extensive use of the Perry (in review) model. Perry (2016b) described how this model was applied to compare the through-Delta routing, travel time and survival of winter Chinook smolts, under the PA and NAA scenarios.

The Panel is concerned that the NAA and PA applications do not adequately reflect the substantial uncertainty in reach-specific survival estimates that are seen in Perry (2016b) Figure 3. For example, in reaches 5, 6 and 8 at certain discharges, the 95% credible intervals for the joint uncertainty of the survival parameter estimate and the random effect of release group span the entire range of possible survival values from 0 to 100%. In the PA and NAA simulations, each fish was assigned a random route choice and random travel times along that route, based on random draws from the estimated posterior distributions of those parameters (Perry 2016b; p. 5). This approach is an effective way to incorporate the uncertainty of travel time and routing estimates into the simulations. In contrast, when estimating survival, the simulations used the median of the survival estimates for all fish.

We suggest that random draws of the reach-specific survival instead be used, instead of the median, for each fish, so that the uncertainty of all three parameters (travel time, survival, routing) is incorporated in a consistent way. When this idea was suggested to Dr. Perry during the Panel meeting, he responded that the additional computing load would be too great. However, we do not see that one additional random draw for each fish would add much computing effort.

Furthermore, the combination of low median survival and high variability as shown in Reach 8 (interior Delta) highlights the need to identify the mechanism(s) that causes survival to be high versus low. To what extent is this high variability in survival associated with predation versus other factors? Evaluation of this variability could lead to methods for increasing survival, but the Panel also recognizes that many factors likely influence salmon survival in this large complex area.

Hydrodynamic Model Representation of Flows in the Delta

The hydrodynamic models provide the base physical process information (e.g., tidal flow volumes, velocities, transport time scales, tidal excursion distance) for most of the environmental models used in the BiOps. This information, in turn, drives key parameters in other environmental models. Therefore, it is critical that the hydrodynamic models represent stage and flow correctly at stations throughout the Delta.

Perry et al.'s (in review) fish routing analysis at the Sacramento River/Delta Cross Channel/Georgiana Slough junction needs to have tide reversals accurately timed. However, for that analysis, the model fit between DSM2 flow and observations at the Sacramento station below Georgiana Slough (Perry et. al, in review, Figures 14-15) was extremely poor both in flow magnitude and phase. Clearly, some of the input modeling parameters were not correct, and Perry et al. recognized this problem. The documentation discusses that hydrodynamic model output from DSM2 version 8.0.6 was provided to Perry et al. (in review) for this fish routing analysis because it was a DSM2 model run that was consistent with Bay Delta Conservation Plan inputs. However, the DSM2 version 8.1.2 represented the junction region better.

Since the purpose of the Perry et al. (in review) analysis was to look at fish routing through this critical junction, results from the version of the hydrodynamic model that best represented this junction region should have been provided to Perry et al. The benefit of keeping the DSM2 model output consistent with BDCP modeling was completely negated when Perry had to do additional statistical analysis to create realistic flows in the region rather than use hydrodynamic model output.

Other General Comments

In general, the Panel notes that both BiOps rely heavily on AM to address data gaps and uncertainties. For example, the NMFS analytical approach says the AM program will address uncertainties associated with the effectiveness of management actions taken to avoid jeopardy and adverse modification of critical habitat "<u>*and meet other regulatory standards*</u> *applicable to state listed species for: ongoing operations of the SWP/CVP, habitat restoration actions required for CWF and/or the CVP/SWP BiOps and CESA authorizations, and construction and operation of the CWF.*" Examples are provided of the kinds of things the Fish Agencies will focus on and potentially adjust, <u>including water operations.</u> The Panel notes that a significant and overarching uncertainty is how robustly the AM plans will be implemented, which will depend on decision making authority and the discretion of the Interagency Implementation and Coordination Group (IICG) proposed in the AM Framework. The Panel is uncertain whether NMFS and FWS are relying on the robustness of the AM program in order to ensure future compliance with regulatory standards. This point needs clarification since it has important implications for structuring decision making.

3.2.4 Question 4: Given the preliminary design specifications for the construction of CWF, how adequate are the analyses of effects for the various construction activities on the considered species in the draft BiOps? Consider the extended construction time frame.

(4a): Have the BiOps identified which construction-related effects pose a repeated and considerable effect to the species?

The FWS BiOp has adequately identified substantial construction effects, but maintains (p. 217-218) that construction designs have not been finalized enough to allow detailed evaluation, and thus evaluation must be deferred to future consultations. Assuming cofferdams (if permitted) will remain in place for much or all of the duration of NDD construction (p. 190, 206), impacts on adult Delta Smelt will likely occur at the NDD, as discussed in the FWS BiOp and in the Panel's answer to question 4b below. The townet survey indicates Delta Smelt larvae, in particular, are near other proposed construction sites (i.e., in the eastern Delta) during the spring (e.g., refer to FWS BiOp, Fig. 9.2.1.1-7 on p. 123, and also to 20-mm survey maps from April-June 1999, which is the most recent year to have a Delta Smelt summer townet index >10). Adults are also in this general area (FWS BiOp Fig. 9.2.1.1-7), and because spatial locations of spawning habitat are not precisely identified, the possibility exists that areas near proposed construction sites will be used as habitat for spawning adults, eggs, and larvae. However, in-water construction activities in the eastern Delta will avoid the January-June period when adult spawners, eggs, and larvae are most likely to be in eastern construction areas (FWS BiOp, Table 6.3-8).

The NMFS BiOp comprehensively identified numerous construction effects to consider including: increased turbidity and chemical exposure throughout the Delta over an extended period of time from the expected 15,000 barge trips; creation of predation hot-spots at construction barge landings and pilings; predation along very long cofferdam walls; fish exposure to extensive pile driving noise; and, predation increases during construction at Clifton Court Forebay, a region that is already a predation hot-spot (Grossman 2016).

The BiOp evaluation of impacts to salmon caused by these construction activities was mostly adequate. Pile driving is expected to adversely affect many adult steelhead and adult fall Chinook Salmon because a large proportion of the populations will be exposed to pile driving noise. Large numbers of piles will be driven into in the Delta across a broad area and over multiple years. In addition to the location-specific evaluations, it would be helpful to present the total number of piles by size and material (steel or concrete) that is expected. Pile driving is reportedly not expected to affect adult spring-run Chinook Salmon because they are not expected to be present in the Delta during the work window (Section 2.5.1.1). However, other sections of the BiOp (Section 2.4, Environmental Baseline) indicated spring-run Chinook Salmon would be present in the Delta during the work window. Timing information should be consistently presented in the BiOp (and the BA). Additionally, it would be worthwhile to describe the basis for the timing data as a means to indicate certainty in the information.

(4b): Which construction-related effects will be most challenging to mitigate either by the methods proposed by the BA or other methods?

Question (4b): Delta Smelt

For Delta Smelt, it is noted that cofferdams at the NDD construction sites will increase river velocity and block or impede upstream migration of spawning Delta Smelt. No options for mitigation were proposed. Aside from these negative effects, cofferdams may have the beneficial effect of physically separating construction activities from habitat use. The FWS BiOp states that consultation will be re-initiated if the use of cofferdams is not feasible.

Each intake wall will be >1,000 ft in length. This distance, coupled with water velocity, represents an effective barrier to Delta Smelt swimming upstream (FWS BiOp, p. 208). Because very few adults are expected to survive upstream passage of all three intake sites (p. 201-202), "the Service anticipates that construction of the NDD will result in a contraction of the delta smelt's historical range" (p. 201-202). This issue will be worsened by future salinity intrusions brought about by droughts or climate change. One ramification of this conclusion is that any Delta Smelt mitigation upstream of the NDD will not be effective (p. 204).

For Delta Smelt, 348 acres of "suitable" habitat will be used for mitigation, consisting of 103 acres to offset construction impacts and 245 acres to mitigate habitat that will be lost upstream of the NDD. Much of the 245 acres represents a 1:1 mitigation ratio. However, the actual footprint of the NDD will be mitigated at 5:1. Possible mitigation sites include Sherman Island, Cache Slough, and different locations within the north Delta. It is estimated that 36 acres of spawning habitat (sandy beach) will be lost between the lowermost diversion and the present upstream extent of the Delta Smelt's range (FWS BiOp, p. 207), and this will be mitigated at 3:1 (108 acres) as part of the 245 acres.

The FWS BiOp acknowledges that DWR has not identified specific mitigation sites (p. 35), but these should be "constructed and protected prior to PA impacts." Protection and management in perpetuity will be funded by an endowment or other FWS-approved financial assurance, and documented in writing. If such lands/areas involve listed species or critical habitat under United States Army Corps of Engineers (USACE) Phase I permitting, then the USACE must re-initiate consultation.

For purposes of comparison only, note that the FWS BiOp states that 8,000 acres of tidal marsh will be restored as part of 2008 FWS BiOp RPA Habitat Component 4, with completion by 2018. This mitigation was not simulated in the NAA because not all mitigation sites have been selected.

Question (4b): Salmon

The Panel did not see any proposed mitigation actions that would address adverse impacts identified in the NMFS BiOp caused by pile driving, impingement and entrainment at the NDD, contaminant re-suspension, physical injury, barge movement and sediment spill risk, predation associated with structures, and operational effects on redistribution of salmonids in relation to salinity and fish distribution. A number of avoidance and minimization measures were identified, e.g., work windows, use of a vibratory hammer and bubble curtains around piles. Avoidance and minimization measures help to reduce the impacts on ESA species but the analyses indicate considerable impacts on salmon still remain.

The most challenging PA effects to mitigate will be those that affect survival, especially if they affect survival over a long period. Habitat restoration is often used as a mitigation measure but it is difficult to empirically evaluate the contribution of habitat restoration to salmon survival. Furthermore, habitat restoration may take years or even decades to reach full benefit in some systems. The BA indicated salmon habitats damaged by construction activities would be restored at a 3:1 ratio. Given the time for some habitats to recover and the fragile viability of ESA-listed species, the Panel asks: Is the 3:1 ratio is sufficiently precautionary to protect the ESA species?

The Panel did not review in the NMFS BiOp detailed plans to mitigate for construction or operational impacts on salmon survival. Nevertheless, at the public meeting, the Panel was told that mitigation would begin well before construction activities begin because habitat restoration actions often take years before full benefits can be obtained. The Panel agrees that habitat restoration should begin well before construction activities. However, detailed mitigation plans need to be developed soon. These plans should consider the effects of habitat restoration on Delta hydrodynamics and how these changes might affect the species.

Monitoring is needed to (1) identify impacts caused by the PA on the species, (2) finalize the level of mitigation that is needed, (3) ensure that mitigation actions area adequately implemented, and (4) demonstrate that mitigation is having the expected benefit to the species. Therefore, a detailed monitoring plan is needed along with the detailed mitigation plan. These documents should be linked to the AM Framework, which is essential for ensuring goals and objectives are met, given current uncertainties.

3.2.5 Question 5: How adequately do the draft BiOps address the key operational effects of the proposed action?

(5a): How well do the analyses provide sound information to adequately characterize the effects of north Delta diversion operations on outmigrating salmonids and sturgeon?

The new NMFS life cycle model represents a significant improvement in the evaluation of PA operational effects because it incorporates survival through each life stage and from generation to generation. Life-stage-specific analyses are also discussed in the BiOp and the BA, as they should, but it is very difficult to comprehend the cumulative PA effect on the salmon population when examining findings for each specific life stage. The problem is that small effects during each life stage may not be apparent until they are propagated across the entire life cycle. The new NMFS life cycle model, in addition to the older IOS model, integrates survival across life stages, and therefore facilitates the CWF effects analysis.

The NMFS life cycle model incorporates five life histories for winter-run Chinook Salmon, an important step toward a more realistic evaluation of potential PA effects. The model is extremely complex but well-documented in the model description by Hendrix et al. (2017). As recommended by previous independent science reviews (Rose et al., 2011), this model was developed to specifically address proposed operational effects of the CWF. The model was reviewed by three independent experts in late 2015, as noted in the model description, and provided to the Panel. Although the life cycle model is a significant step forward in the evaluation of CWF, the Panel anticipates that the model will continue to be refined, as is common with complex life cycle models.

The Panel understands that the life cycle modeling framework will be used to develop a model for spring-run Chinook Salmon. However, as noted in the independent reviews, the model will require important modifications in order to adequately reflect the diverse life history strategies of spring-run Chinook Salmon, which occupy both the Sacramento and San Joaquin watersheds. The LCM currently does not reflect climate change scenarios beyond year 2030; it therefore does not fully evaluate PA effects when environmental conditions, including the ocean, are likely less favorable than during recent decades.

During the presentation to the Panel on January 23, 2017, NMFS consultants (Perry and Hendrix) presented additional beneficial uses of the NMFS life cycle model. In particular, the model may be used to examine the effects of alternative water diversion scenarios on Chinook Salmon. Conceivably, this type of analyses might lead to benefits to both fish and other water users. Although these scenario evaluations appear to be highly useful, model limitations and assumptions should also be considered when interpreting model output.

The life cycle model indicated significant adverse effects of the PA on winter-run Chinook Salmon compared with the NAA; e.g., a 7.4% to 8.8% decline in the mean cohort replacement rate or up to a 60% difference in spawner abundance in some years. The adverse effect declined slightly when Level 1 water diversion controls were implemented. An analysis of PA effects by life history type revealed that most of the reduction in survival occurred for the lower river life history type. "Lower River smolts" rear in the lower Sacramento River before passing through the Delta. In contrast, "Delta smolts" enter the Delta at a smaller size (perhaps in November and December) and rear in the Delta for an extended time before smolting and entering San Francisco Bay. Most winter-run smolts exit the Delta in March. Given this observation from the model, the BiOp should discuss why Delta smolts, which rear in the Delta for an extended period, are affected by the PA less than lower river smolts. Is it the month of passage from the lower river to the Delta that drives this pattern, or some other relationship? Is the location of rearing in the Delta by Delta smolts assumed to be influenced relatively little by the PA? Further evaluation of the modeling results can help understand mechanisms affecting salmon survival and help to refine the model.

The new life cycle model appears to incorporate PA effects on small juvenile salmonids in the Delta (e.g., 30-70 mm), which are an important component of the winter-run Chinook Salmon population. These fish appear to be represented by the Delta smolt life history type. The BiOp should clarify the definition of Delta smolt. For example, for Delta smolt, the BiOp should describe the approximate size range, migration timing, and rearing location within the Delta, and how the enhanced Particle Tracking Model (ePTM) influences this life history strategy compared with lower river smolts.

The LCM incorporates PA effects on salinity and salmon rearing capacity (Hendrix et al., 2017, Table 1), but, as noted earlier, it does not appear to incorporate long-term changes in habitat resulting from PA operations (and habitat restoration). These long-term effects may be especially important for smaller Chinook Salmon that rear in the Delta for extended periods. Long-term changes in habitat characteristics should be a key component when evaluating effects of the PA on critical habitat.

When reviewing the NMFS BiOp and Hendrix et al. (2017), it was unclear whether the NMFS life cycle model incorporated reduced salmon entrainment at the south delta pumps during PA versus NAA. This should be clarified. Entrainment at the south delta pumps will be more important for spring-run Chinook Salmon. The LCM model assumed NDD entrainment scenarios ranging from 0% to 3% to 5% mortality.

Hydrodynamics and Delta Cross Channel (DCC) Operation Guidelines:

The Sacramento River junction at Georgiana Slough and the Delta Cross Channel (DCC) under current bathymetric configuration and operations is the transition zone from unidirectional flow to bidirectional tidal flow in the Sacramento River watershed region of the Delta. This transition is observed both in field measurements and numerical models. Perry et al. (in review) found that "*the NDD bypass rules, as implemented under the assumptions of our simulation, increased the frequency and duration of reverse flows of the Sacramento River downstream of Georgiana Slough, with the magnitude of increase varying among scenarios.*" This conclusion is logical, based on the physics of the system.

In the discussion of Perry et al.'s (in review) findings, it was suggested that the frequency of reverse flows at Georgiana Slough would be reduced if NDD real-time operations were used rather than the constant flow assumptions that Perry et al. used for this analysis. The Panel believes that it is highly unlikely that "real time" operations can reduce the frequency of reverse flows at Georgiana Slough based on the bathymetry and basic physics. The Panel notes, however, that future restoration in the Delta that will significantly alter the bathymetry of the Delta will likely modify the location of the transition from unidirectional to bi-directional flow along the Sacramento River. This is one reason that hydrodynamic modeling should be constantly updated as regions throughout Suisun Bay, Cache Slough and Delta are altered either through habitat restoration or levee failure.

Another key finding from Perry's routing analysis is that the Delta Cross Channel gates will not close as often during wet years, once the NDD is operational. The current DCC flow closure criteria specifies that the DCC to be closed under high flow conditions. These criteria will not be triggered as frequently with NDD operations because the flow in the Sacramento after NDD exports would be lower compared to what it would be without NDD operations (Perry et al., in review).

The operational criteria for the Delta Cross Channel should be re-examined considering the change of the point of diversion to the NDD facilities. When the Delta Cross Channel is open, there are lower salinity concentrations and better overall water quality in the central Delta, but having the DCC open also causes a higher potential for diversion of fish into the Central Delta. Some key questions that should be evaluated are: Will the Delta Cross Channel be operated in the same way currently operated? Should the criteria for DCC closure be specified to a flow measurement station above or below the NDD? Should DCC operations be different depending on water year type? To what extent are these questions addressed in the salmon life cycle model?

(5b): Do the analyses appropriately use novel techniques for assessing effects in the vicinity of the north Delta diversions? What improvements could be made to the developing methods to better inform management of the new infrastructure?

The Panel recognizes that conducting both pre- and post-construction studies at the NDD (FWS BiOp, Tables 6.2-5 and 6.2-6) is a robust approach. Pre-construction studies will address sediment transport, tidal interaction with diversion rates, refugia from predation, and fish-screen hydraulic performance.

Monitoring-type studies of various duration (months to entire length of permit) will assess actual entrainment, impingement, and screen design/performance regarding salmonids and smelts. Studies 1-8 in these tables must be completed before final intake design. Studies 9-11 involve survival of juvenile salmonids and Delta and Longfin Smelts during operation, and also study changes in predator density at the NDD during operation—these must start before construction and continue afterwards for at least three years.

Given the low abundance of Delta Smelt in the area of the NDD, the Panel is concerned how entrainment (e.g., Study 5) will be assessed. However, the Panel also reminds the FWS that droughts or sea-level rise could increase the occurrence of both species of smelt in the area of the NDD in the future.

In reference to FWS BiOp, Section 9.2.2.2.1, the CWF BA estimated that upstream-migrating Delta Smelt would have a 7.3% probability of successfully passing the downstream-most NDD fish screen. The BA concluded that smelt would thus have a 7.3% x 7.3% x 7.3% = 0.04% probability of passing all three NDD screens. However, this calculation assumes that any smelt surviving past the first screen has an undiminished chance of getting past the second screen, and likewise for the third screen. More realistically, the effort that a smelt must expend to make its way past any one screen will very likely reduce its chance of getting past subsequent screens. Thus, the probability of passing screen 2 is likely to be less than 7.3%, conditional on passing the first screen. And the probability of passing screen 3, conditional on having passed screens 1 and 2, is likely to be even smaller. So, the overall probability of passing all 3 screens is almost certainly less than 0.04%.

The NDD effects on salmon were addressed in comments on the NDD effects analysis in Question 3c.

(5c): How thoroughly do the data, analyses, and findings presented in the BiOps capture the risks to individuals and populations from the proposed actions? Are there significant risks that have been overlooked or other scientific information that should be considered?

Question 5c: Delta Smelt

The considerations presented for Delta Smelt by the FWS BiOp are comprehensive, but are largely qualitative interpretations of previous analyses that were presented in the BA. Regarding operations effects on Delta Smelt, the FWS BiOp addressed three categories of impact: (1) salvage, entrainment, impingement, and injury; (2) changed shoreline/large structures that affect predation and preclude habitat; and, (3) diversion effects on hydrodynamics, flow rates, and habitat features/ecology within the suspected Delta Smelt's range.

In qualitatively addressing the first of these categories, it was concluded that Delta Smelt larvae are the only stage subject to entrainment at the NDD, but no larvae are expected to occur at NDD because all spawning will be downstream. Adults will not be able to spawn upstream of the NDD because they will make repeated contact with the screens and will impinge upon the screen or will or be eaten by predators there (FWS BiOp, Section 9.2.2.2.1; Refer to Table 1 for FWS BiOp page numbers.); this conclusion exists despite recognition that screen designs may be improved by Fish Facilities Technical Team. The Panel also points out that an individual's odds of passing one screen are likely to decrease with each successive screen that is passed (i.e., a cumulative negative effect will likely be present—see the Panel's answer to Question 5b); this concept was not reflected in the FWS BiOp.

Reduced entrainment at the South Delta Diversion (SDD) under the PA may allow Delta Smelt to become better established in the San Joaquin River (FWS BiOp, Section 9.2.2.2.2). The PA will reduce introduction of turbid Sacramento River water into the south Delta (which also forces negative flows in the San Joaquin's distributaries, Old and Middle Rivers), and will reduce the shift of Delta Smelt southward in association with Sacramento River water and turbidity (FWS BiOp, Section 9.2.2.2.2,). Entrainment at the SDD should thus go down. Opening and closing the Head of Old River Gate (HORG) may also reduce entrainment. However, closing HORG may send more larvae and juveniles to the SDD by other routes such as Turner and Columbia Cuts (FWS BiOp, Section 9.2.2.2.3).

In qualitatively addressing the second of these categories, it was concluded that predation at Clifton Court Forebay (CCF) should not increase under the PA. In fact, decreased entrainment at the SDD may help reduce predation (FWS BiOp, Section 9.2.2.2). Aside from this, it was recognized that gates and rock structures associated with the PA will create eddies that could facilitate predation.

In qualitatively addressing the third of these categories, it was not clear which, if any, Delta Smelt life stages are considered to be food-limited. The FWS BiOp indicated Delta Smelt larvae and early juveniles near X2 may be food-limited (FWS BiOp, Section 9.2.2.2.8). Process-based habitat relationships are implied in the third paragraph on p. 239, but these are not actually explained; the NMFS quotation in the fourth paragraph improves, but does not complete, the explanation of these relationships. Experimental evidence does not support larval food limitation (p. 247), and it was added that adult Delta Smelt are not thought to be food-limited (p. 246). The Panel feels that the matter of food limitation at different life stages needs more consideration.

The FWS BiOp also observed that exports are increased during summer in order to keep flows high during spring and fall (FWS BiOp, Section 9.2.2.2.8). Most notably, under the PA, X2 will frequently be located upstream of Chipps Island during July, August, September, separating the low salinity zone (LSZ) from downstream, open-water habitats that have been historical rearing areas for Delta Smelt. The FWS BiOp states, "For context, the location of X2 during summer months under the PA is commensurate with habitat conditions delta smelt are currently experiencing under drought conditions." (FWS BiOp, Section 9.2.2.2.8). This was not deemed acceptable because the LSZ would then be located in a more channelized area that may have an inadequate supply of shallow-water habitat, zooplankton prey and turbidity, as the greater Suisun Marsh area contributes to both of these habitat factors (FWS BiOp, Section 9.2.3.3.3). Montezuma Slough is expected to be restricted as juvenile rearing habitat except in wet and above normal years (FWS BiOp, Section 9.2.3.3.4). All figures that compare PA and NAA conditions (e.g. FWS BiOp, Figure 9.2.3-1 through Figure 9.2.3-6) should mark the X2 = 81 km location to signify the location above which X2 is in the western Delta, a channelized, tidal, high-velocity, high-flow region of the Delta with minimal access open-water habitat.

Reduced turbidity (10%) resulting from diversions at the NDD is thought to relate to both feeding and predation (FWS BiOp, Section 9.2.2.2.8). The NDD would rarely entrain >5% of the Delta's phytoplankton standing stock in any given month (FWS BiOp, Section 9.2.2.2.8). The FWS BiOp also recognized that >50% reduction in water exports at the SDD under the PA could improve the overall phytoplankton supply in the Delta. However, it was added that total Delta exports will increase under the PA, resulting in a 4% net loss of phytoplankton. There was lack of consistency in this argument (see second-to-last paragraph on p. 246 and also top of p 266) (FWS BiOp, Sections 9.2.2.2.8, 9.2.3.3.1).

The FWS BiOp indicated higher flows in San Joaquin River (QWEST) under the PA (due to reduced exports at the SDD) will reduce Microcystis blooms there (FWS BiOp, Section 9.2.2.2.8). However, this may increase the likelihood of blooms in Sacramento River (QRIO) if the higher turbidity there does not inhibit the blooms; the Sacramento River has not historically been the site of Microcystis blooms. The FWS BiOp alludes to residence time analysis (2nd type of analysis) that suggests more blooms will occur in the southern Delta under the PA. Given that Microcystis blooms occur in warm water temperatures, the blooms would affect larvae and juveniles by killing copepods or by making copepods toxic. Climate change may worsen this effect through warming (FWS BiOp, Section 9.2.2.2.8).

Selenium is expected to increase under the PA as more San Joaquin River enters the Delta under the PA, especially during spring. The selenium body burden should increase while staying below the toxicity threshold, thus producing no population effect on Delta Smelt.

In summary, PA operations should result in a net reduction in entrainment/impingement of Delta Smelt. Access to migratory habitat will become restricted due to higher summer and possibly higher fall exports (depending on triggers) that will move X2 east of historical rearing habitats in below normal, dry, and critical water years (FWS BiOp, Section 9.2.2.2.9). Upper Sacramento River habitat will be lost to Delta Smelt because they will not be able to swim past the NDD. There will be a small reduction in the plankton-based food supply (4% higher total entrainment with higher total exports), increased predation at new structures, and other effects (see top of p. 251 and second paragraph on p. 258). Many effects remain speculative (FWS BiOp, Section 9.2.1.1).

In terms of critical habitat, baseline trends for critical habitat Primary Constituent Elements (PCEs) are generally deteriorating (FWS BiOp, Section 9.2.3.4); PA effects on these are summarized in FWS BiOp Table 9.2.3-2 (p. 280). The PA will create a migration barrier at the NDD, will increase salinity, and will reduce the quantity and quality of rearing habitat. Overall, positive and negative PA effects are summarized concisely on p. 281 (FWS BiOp, Section 9.2.3.4). The Delta Smelt is considered to already be habitat-limited, and the PA will exacerbate this condition. Population-level effects include the previously mentioned conclusion that very few adult Delta Smelt are expected to survive upstream passage of all three intake sites, resulting “in a contraction of the delta smelt’s historical range” (p. 202). With the critical habitat assessment, the stated risk to Delta Smelt is summarized as “the effects of the PA on critical habitat, and the current and future cumulative effects, will prevent the ability of delta smelt designated critical habitat to serve its intended conservation role for the species and will preclude the species’ recovery” (p. 282).

Table 1. Summary of Delta Smelt Topics Addressed by the Panel in Question 5c.

Delta Smelt Topics Address in Phase 2B report	FWS BiOp Section	FWS BiOp Page Numbers (draft version provided to Panel in Reading Material list)
Operations: NDD Entrainment	9.2.2.2.1	221-225
Operations: SDD Entrainment	9.2.2.2.2	225-226
Operations: SDD Turbidity	9.2.2.2.2	229-230
Head of Old River Gate: Changes to Interior Delta Flow Routing	9.2.2.2.3	231
Predation at Clifton Court Forebay	9.2.2.2.2	225
Food Limitation near X2	9.2.2.2.8	239, 246-247
X2 and low salinity zone (LSZ) moves eastward into the Delta Channels	9.2.2.2.8	240, 259
LSZ Rearing Habitat Characteristics	9.2.3.3.3	268-276
Montezuma Slough as Rearing Habitat	9.2.3.3.4	281
Turbidity	9.2.2.2.8	244
Phytoplankton	9.2.2.2.8, 9.2.3.3.1	245, 246, 266
Microcystis blooms	9.2.2.2.8	248
Copepods	9.2.2.2.8	249-250
Extent of Delta Smelt Rearing Habitats in Suisun Bay and the Delta	9.2.2.2.9	251, 252
FWS BiOp, Section 9.2.1.1 p. 259	9.2.1.1	259
Primary Constituent Elements (PCEs)	9.2.3.4	278-279
Positive and negative PA effects	9.2.3.4	281-282

Question 5c: Salmon

Overall, the draft NMFS BiOp was comprehensive and well-written, although we note that some sections remain incomplete; e.g., the life cycle model (LCM) needs to be adapted to incorporate the diverse life histories of other salmonid species. Significant adverse impacts on salmonids were identified in response to both construction activities and PA operations. Important new analyses were presented in the evaluation of PA operations on salmon, including the life cycle model for winter-run Chinook Salmon, a new flow-route-survival simulation based on 2,170 acoustically-tagged large (130-170 mm) late fall-run Chinook Salmon during 2007-2011, and a new egg mortality model. These new analyses represent significant contributions beyond those presented in the Biological Assessment. The LCM incorporates five life history types that contribute to evaluations of diversity and spatial structure, a significant improvement over previous models. Furthermore, the models may be used to identify water diversion scenarios that balance salmon survival with water needs of people. Findings from the new LCM and flow-route-survival simulations are generally consistent with the older Interactive Object-oriented Salmon Simulation (IOS) LCM modeling approach in that they all indicate significantly greater mortality associated with the PA than the NAA. The BiOp recognizes that seemingly small absolute changes in survival of these ESA-listed species could lead to significant population-level impacts.

The Panel did not find any significant risks that have been overlooked or other scientific information that should have been considered. However, we mention in our review that risks to smaller salmonids that utilize shallow productive habitats in the Delta may be underestimated. Less information is available on the distribution and relationships of these smaller salmon with nearshore estuarine habitats in the Delta. Likewise, the critical habitat analysis should consider alteration caused by NDD removal of water and complex interactions among salinity, vegetation, and other habitat features that support rearing salmon over the long term. We also note that PA operations of the Delta Cross Channel must be identified and incorporated into both the new life cycle model and the flow-route-survival simulation. The flow-survival simulation should be based on hydrodynamic modeling that accurately reflects the operation of the Delta Cross Channel.

The NMFS BiOp sections reviewed by the Panel contained some information on avoidance, minimization measures and mitigation, but the information was incomplete. The Panel believes that offsetting adverse effects of the PA will be challenging. Therefore, the Panel recommends development of a comprehensive monitoring and mitigation plan that is closely linked to the AM Framework and a more detailed AM plan that guides the pathway to maintaining species viability.

3.2.6 Question 6: How clear is the proposed approach to establish Longfin Smelt outflow criteria for assuring spring outflow as modeled in the CESA permit application and presented as part of Phase 2A of the CWF Aquatic Science Peer Review?

The Panel found the slide presentation (Hilts 2017) about the Longfin Smelt outflow criteria for assuring spring outflow to be an improvement over the earlier Phase 1 and Phase 2A documents, but still disjointed and unclear at times, largely because of its bulleted format.

The slide presentation described the approach for predicting monthly Delta outflow for a current month (March, April, or May) from the 8-river index (8RI) of the previous month (denoted by PMI) rather than the 8RI value of the current month. This approach is intuitively appealing because PMI, unlike the 8RI of the current month, need not itself be predicted.

However, for the examples given in the presentation (Hilts 2017, slides 11-13), PMI appears to be a weak predictor of outflow, with low r2 values. In contrast, outflow predictions from the current month's 8RI have considerably higher r2 (Hilts 2017, slides 5, 6). Indeed, one would expect the current 8RI to be a generally stronger predictor because the current month's outflow is equal to the current 8RI, amended by various withdrawals and other flow sources. Consequently, the Panel recommends estimating the compound prediction error of the two-stage prediction, in which one first predicts current 8RI (with some error; Slide 4), and then predicts current outflow from that predicted 8RI (with some error; Hilts 2017 slides 5, 6). It is possible that this compound error is actually smaller than the prediction error of a one-stage prediction driven by PMI. At a minimum, this exercise would provide quantitative evidence about the asserted superiority of PMI as a predictor of outflow.

We pose three additional suggestions about the outflow criteria modeling:

1) In the Panel meeting, the presenter asserted that the relationship between outflow and 8RI (or PMI) had a definite upward curvature, rather than being linear. Based on the scatter in slides 5,6, 11,12,13, (Hilts 2017) we remain unconvinced about this curvature, although we do see a consistent pattern of increasing residual variance at higher flows. We recommend that the existence of the curvature be tested, not just asserted. This could be done, for example, by fitting (linear+quadratic) regression models, as was done in the original version of the presentation, and then testing for the significance of the quadratic term.

2) The Panel still does not understand the rationale for using simulated outflow (slide 6) rather than observed outflow (Hilts 2017, slide 5) as the "existing conditions" baseline for the regression modeling. It is true that the latter shows more scatter in its relationship with 8RI, probably due to changing demands, regulations and infrastructure, as stated in slide 5. However, it is unrealistic to believe that these factors will remain static in the future, with the WaterFix project itself being only the most obvious future change in infrastructure. Thus, any regression based on simulated outflows (Hilts 2017, slide 6) will almost surely overstate the tightness of the relationship between actual future outflows and 8RI, leading to unexpectedly high prediction errors. We suggest that historical outflows instead be used for all years in slides 10-14 (Hilts 2017).

3) The applications of the final models (Hilts 2017, slides 11-13), to set the criteria for targeting setting and sensitivity analyses (Hilts 2017, slide 18), appear to be based on point predictions only. We recommend that the final outflow criteria take account of the prediction uncertainties of these models.

4 Acknowledgements

This Phase 2A and Phase 2B panel review occurred under an abbreviated timeline. The two reviews were spaced only a month apart, which meant that the panel was reading one set of documents, preparing for meetings in Sacramento, and asking the Delta Science Program and the agencies clarifying questions while the agencies were still developing the documents and charge questions for the second phase of the review. The Panel truly appreciates the assistance of Yumiko Henneberry and Lindsay Correa from the Delta Science Program for their efforts to keep the processes going. In multiple ways, Yumiko, Lindsay, and other select staff of the Delta Science Program staff went far beyond the call of duty for both the Panel and the agencies.

We would also like to thank the agencies and ICF International consultants for assembly of documents and their responses to our inquiries. Despite the challenging timelines, they were willing to do their best to keep the process rolling on their end as well.

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Appendix 1 Biographies of CA WaterFix Aquatic Science Peer Review Panel Members

Charles "Si" Simenstad (Chair) Charles ("Si") Simenstad is a Research Professor in the University of Washington's School of Aquatic and Fishery Science, where he coordinates the Wetland Ecosystem Team. Prof. Simenstad is an estuarine and coastal marine ecologist who has studied the organization and function of estuarine and coastal marine ecosystems throughout Puget Sound, Washington, Oregon and California coasts, and Alaska for over forty years. Much of this research has focused on the functional role of estuarine and coastal habitats to support juvenile Pacific Salmon and other fish and wildlife, the associated ecological processes and community dynamics that are responsible for enhancing their production and life history diversity, and whether restoration of estuarine ecosystems can contribute to the recovery of depressed salmon populations. Si's most recent research focus is on developing and testing an estuarine ecosystem classification system for the Columbia River estuary, and employing it to delineate juvenile Pacific Salmon habitat through the estuary gradient.

Prof. Simenstad is a Fellow of the American Association for the Advancement of Science, Co-Editor-in-Chief for Estuaries and Coasts, and Associate Editor for San Francisco Estuary & Watershed Science, Revue Paralia and the Encyclopedia of Puget Sound. He also serves on the Chief of the US Army Corps of Engineers Environmental Advisory Board and Washington Department of Natural Resources, Commissioner of Public Lands' Expert Council on Climate & Environmental Change. He has authored or co-authored 85 peer-reviewed scientific papers, 22 book and proceedings chapters, 34 miscellaneous publications and >125 workshop proceedings and technical reports. He has served as academic advisor for 32 M.S./Ph.D. graduate students, and served on an additional ~47 graduate student committees. Si holds a B.S. (1969) and M.S. (1971) from the School of Fisheries at the University of Washington.

John Van Sickle, Ph.D. (Lead Author, Phase 1) Dr. Van Sickle is a consulting environmental statistician, recently retired from the U.S. Environmental Protection Agency's Office of Research and Development. Since 1998, his research has focused on the monitoring and assessment of freshwater ecosystems, with an emphasis on indicators of health for multispecies biological assemblages, and on estimating the risks of aquatic stressors to biota. Prior to 1998 Dr. Van Sickle taught and did research in systems modeling, mathematics, statistics and ecology at Oregon State University and the University of Zimbabwe. Dr. Van Sickle earned his B.S. and M.S. in mathematics, and his Ph.D. in systems science, from Michigan State University, and also received an M.S. in statistics from Oregon State University.

Nancy Monsen, Ph.D. (Lead Author, Phase 2) Dr. Monsen's research has focused on multi-dimensional hydrodynamic modeling of the SacramentoSan Joaquin Delta and Suisun Bay for the last twenty years. Her Ph.D. research was based on the TRIM3D hydrodynamic model and recently she has been working on Stanford's SUNTANS hydrodynamic model. She also has consulting experience with the DELFT3d hydrodynamic model. Nancy Monsen joined Stanford University in August 2011, having worked previously with Philip Williams & Associates, Ltd. (now ESA PWA) and the U.S. Geological Survey (USGS). Funding for her Stanford research ended in August 2014 but she continued part-time as a visiting scholar at Stanford until August 2015, writing papers and assisting current PhD candidates and Post-Doctoral researchers in the Environmental Fluid Mechanics Laboratory. She has recently been on several science review panels including the Independent Review of the Draft Bay Delta Conservation Plan Effects

Analysis (2014), the State of the Science Workshop on Fish Predation on Central Valley Salmonids in the Bay-Delta Watershed (2013), and the Independent Review Expert Science Panel of the Collaborative Adaptive Management Team (CAMT) Proposed Investigations on Understanding Population Effects and Factors that Affect Entrainment of Delta Smelt at the State Water Project and Central Valley Project (2014). Dr. Monsen earned her doctorate in Civil and Environmental Engineering at Stanford University.

Hannah Gossnell, Ph.D. Dr. Hannah Gosnell is an Associate Professor of Geography in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University. Her research focuses on agricultural landscape change, water resource management, climate change and environmental governance in the context of rural working landscapes; and how laws and institutions might evolve to better reflect changing geographies and facilitate social-ecological transformation when necessary. Her PhD research focused on implementation of Section 7 of the Endangered Species Act and the development of a Reasonable and Prudent Alternative for the Animas-La Plata Project in the Colorado River Basin. Previous research also includes an examination of social and institutional processes leading to the development of the Klamath Basin Restoration Agreement and the Klamath Hydroelectric Settlement Agreement in 2010. A member of the Resilience Task Force of the IUCN Commission on Ecosystem Management, Dr. Gosnell has authored or co-authored over 40 peer-reviewed scientific articles and was Associate Editor for Rangeland Ecology & Management. She has served as a social scientist on several scientific review panels for the National Science Foundation's Long Term Ecological Research (LTER) program and is the Lead Social Scientist at the H.J. Andrews Experimental Forest LTER Program. She is currently a member of the Adaptive Water Governance Project funded by NSF's Socio-Environmental Synthesis Center and a Fellow at Colorado State University's Center for Collaborative Conservation. She was the 2015 recipient of the Quivira Coalition's Radical Center Research Award for "remarkable and enduring leadership in the difficult job of working in the radical center - the place where people are coming together to explore their common interests rather than argue their differences." Dr. Gosnell earned MA and PhD degrees in Geography from the University of Colorado, and a BA in American Civilization from Brown University.

Ernst Peebles, Ph.D. Dr. Ernst Peebles is an Associate Professor of Marine Science at the University of South Florida. He received his Bachelor's degree from Tulane University in his native New Orleans, and his Master's and doctoral degrees from USF in Tampa. After receiving his doctoral degree, Dr. Peebles worked as summer faculty at the Gulf Coast Research Laboratory in Ocean Springs, Mississippi, and also served as adjunct graduate faculty at Florida Gulf Coast University in Ft. Myers, Florida. His 89 publications reflect more than thirty years of experience working with dynamic coastal fish and shellfish habitat, with an emphasis on freshwater inflow effects, life history, and biomass pathways. Dr. Peebles and his students are currently developing a new method for reconstructing the geographic and food-web histories of individual fish using stable-isotope records that are stored within fish eye lenses.

Gregory Ruggerone, Ph.D. Dr. Greg Ruggerone has investigated population dynamics, ecology, and management of Pacific Salmon in Alaska and the Pacific Northwest since 1979. He was Project Leader of the Alaska Salmon Program, University of Washington, from 1985-1993, and he continues to supervise graduate student research in Alaska. Most of his research involves factors that affect growth, age at maturation, and survival of salmon in freshwater and marine habitats (http://www.researchgate.net/profile/Gregory_Ruggerone/contributions). For the past 10 years, he has evaluated management of salmon fisheries in Russia, Alaska, British Columbia and California for sustainability using Marine Stewardship Council criteria. He recently served as the fish ecologist on the Secretary of Interior review of dam removal on the Klamath River. He is past-Chair of the Columbia River Independent Scientific Advisory Board (after serving the maximum 6 year term) and member of the Independent Scientific Advisory Board.

Appendix 2 Phase 2B Charge to Panel

Charge for the California WaterFix Aquatic Science Peer Review – Phase 2B

Background

The California Department of Water Resources (DWR) and the Bureau of Reclamation (Reclamation) coordinate the operations of the Central Valley Project (CVP) and the State Water Project (SWP). As a part of California WaterFix (CWF), DWR proposes to construct and operate new water conveyance facilities in the Sacramento-San Joaquin River Delta, including three intakes, two tunnels, associated facilities, and a permanent Head of Old River gate; as well as operate existing south Delta facilities in coordination with these new facilities.

DWR intends to obtain California Endangered Species Act (CESA) authorization under Fish and Game Code Section 2081(b) for incidental take related to the construction and operation of the CWF water facilities and modified operations of the SWP. DWR submitted an Incidental Take Permit (ITP) application to California Department of Fish and Wildlife (CDFW) on October 5, 2016. This application includes analyses of the effects of the proposed action on CESA-listed species. CDFW is reviewing the analyses of perceived impacts on state-listed species and may issue a permit if conditions in Fish and Game Code sections 2081(b) and (c) are met.

Reclamation is consulting with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) on the construction and operation of the new dual conveyance facilities. As a part of these consultations, Reclamation and DWR have written a Biological Assessment (BA) that summarizes the effects of the action on ESA-listed species and their designated critical habitats. A draft of the BA analyses and draft NMFS analytical approach to the Biological Opinion (BiOp) were reviewed in Phase 1 of this review.

Current CVP/SWP operations require scientific research and monitoring to support real-time operations, decision making, and more complete understanding of the relationship between the CVP/ SWP operations and ESA- and CESA-listed fish species. Moving forward, adaptive management will be used to integrate real-time operations, ongoing scientific research, monitoring, and long term operations of CWF for the SWP and CVP. The draft adaptive management framework has been included as part of the CWF proposed action and was reviewed in Phase 2A. The purpose of this independent scientific peer review is to obtain the views of experts not involved in the CWF ESA consultation on the use of best available scientific information as it pertains to the analyses of effects on ESA-listed aquatic species during construction and operations of CWF.

Panel charge

The panel will review NMFS' analytical approach and FWS' analytical framework, status of the species and critical habitat, environmental baseline, and effects analysis sections of the draft BiOps on CWF for all ESA-listed aquatic species and their critical habitat. The Panel members will have at least 30 days to familiarize themselves with the materials. The Panel will also be given relevant background information and supplemental materials to consider and will receive presentations from the relevant agencies at the public meeting.

Phase 2B: Specific questions for review of sections of the draft NMFS and FWS BiOps on CWF:

Overarching objective: Identify to what extent the analyses for aquatic species in the draft BiOps on CWF are scientifically sound and defensible, with consideration of the following questions:

1. How well does the analytical approach used in the NMFS BiOp respond to the panel's comments provided in Phase 1 of this review? Is the approach well applied in the determination of effects on individuals and the species?
2. How well do the draft BiOps use best available scientific and commercial information? Specifically:
    a. Do the status of the species and critical habitat and environmental baseline reflect the best available scientific and commercial information?
    b. How well is the best available science used in the effects analysis and findings sections?
3. Do the draft BiOps adequately address data gaps and uncertainties? Specifically:
    a. Are assumptions in the effects analysis clearly stated and reasonable based on current scientific thinking?
    b. How extensively are gaps in aquatic species life history information considered and appropriately addressed?
    c. How well are statistical uncertainties considered when assessing effects to individual survival (e.g., loss from predation, entrainment, impingement, etc.)?
4. Given the preliminary design specifications for the construction of CWF, how adequate are the analyses of effects for the various construction activities on the considered species in the draft BiOps? Considering the extended construction time frame, specifically:
    a. Have the BiOps identified which construction-related effects pose a repeated and considerable effect to the species?
    b. Which construction-related effects will be most challenging to mitigate either by the methods proposed by the BA or other methods?
5. How adequately do the draft BiOps address the key operational effects of the proposed action? Specifically:
    a. How well do the analyses provide sound information to adequately characterize the effects of north Delta diversion operations on outmigrating salmonids and sturgeon?
    b. Do the analyses appropriately use novel techniques for assessing effects in the vicinity of the north Delta diversions? What improvements could be made to the developing methods to better inform management of the new infrastructure?

c. How thoroughly do the data, analyses, and findings presented in the BiOps capture the risks to individuals and populations from the proposed action? Are there significant risks that have been overlooked or other scientific information that should be considered?

6. How clear is the proposed approach to establish Longfin Smelt outflow criteria for assuring spring outflow as modeled in the CESA permit application and presented as part of Phase 2A of the CWF Aquatic Science Peer Review?

Appendix 3 Materials for CA WaterFix Aquatic Science Peer Review – Phase 2B

Materials for Independent Science Panel Review

Review materials

1. NMFS Draft BiOp (Selected sections from Ch.1 and 2) i. Analytical Approach
   ii. Status of the Species/Status of Critical Habitat
   iii. Environmental Baseline
   iv. Effects of the Proposed Action
2. FWS Draft BiOp (Selected sections) a. Delta Smelt and its Critical Habitat Analyses i. Analytical Framework for the Jeopardy and Adverse Modification Analyses
   ii. Status of the Species/Status of Critical Habitat
   iii. Environmental Baseline
   iv. Effects of the Proposed Action
   v. Project-level Reinitiation Triggers and Programmatic Approach with Subsequent Consultation
3. Proposed approach to establishing Longfin Smelt outflow criteria

Supplemental materials

1. CWF BA Chapter 3
2. CWF BA Chapters 5 and 6
3. CWF BA Appendices 5A, B, C, D; 3D, E, G
4. FWS Draft BiOp a. Description of the Proposed Action
   b. Description of the Action Area
5. NMFS Draft BiOp a. Introduction and description of the Proposed Action
6. NMFS Central Valley Chinook Salmon Life-Cycle Model Documentation
7. USGS Entrainment Model Manuscript and CWF Operations Report
8. USGS Flow-Survival Model Manuscript Abstract

Appendix 4 Agenda of Phase 2B Public Meeting

Day 1 (January 23, 2017)

I. Introduction

9:00 – 9:10 Welcome Remarks

9:10 – 9:40 Opening Remarks – NMFS, FWS, CDFW

II. NMFS Draft BiOp Sections

9:40 – 11:15 Analytical Approach, Status of the Species/Status of Critical Habitat, Environmental Baseline, Effects of Proposed Action – NMFS

11:15 – 12:00 Review Panel/ Presenter Q&A

12:00 – 1:00 Lunch

III. FWS Draft BiOp Sections

1:00 – 2:30 Delta Smelt and its Critical Habitat Analyses: Analytical Framework for the Jeopardy and Adverse Modification Analyses, Status of the Species/Status of Critical Habitat, Environmental Baseline, Effects of the Proposed Action, Project-level Reinitiation Triggers and Programmatic Approach with Subsequent Consultation – FWS

2:30 – 3:15 Review Panel/ Presenter Q&A

3:15 – 3:30 Break

IV. California Endangered Species Act

3:30 – 4:15 Proposed Approach to Establishing Longfin Smelt Outflow Criteria – CDFW

V. General Presenter/ Review Panel Discussion

4:15 – 4:50 Review Panel/ Presenter Q&A

VI. Public Comment

4:50 – 5:00 Public Comment Period

5:00 Adjourn

Day 2 (January 24, 2017)

VII. Presentation of Initial Recommendations from the Review Panel

2:00 – 3:00 Presentation of Initial Findings and Recommendations – Review Panel

3:00-3:30 Break

3:30 – 4:30 Discussion between the Review Panel and Presenters from the Previous Day

VIII. Concluding Remarks

4:30 – 4:45 Public Comment

4:45 – 5:00 Next Steps

5:00 Adjourn