Independent Review of the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

Prepared for:

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Executive Summary

The upper San Francisco Bay Estuary, including the Sacramento-San Joaquin River Delta, is the only known habitat of wild Delta Smelt. Over the past century there have been substantial anthropogenic alterations of the system, including a highly engineered system designed to store and distribute freshwater resources for human uses. In recent decades substantial declines in the abundance of native fishes have been observed and underlying causes remain a matter of scientific debate. Once abundant in the estuary, Delta Smelt is now among the species listed under the Endangered Species Act as being at risk of extinction.

The U.S. Fish and Wildlife Service Biological Opinion (BiOp) effects analysis of the Proposed Action associated with the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project is intended to evaluate potential impacts on Delta Smelt and their critical habitat for a mixture of standard site-specific and programmatic action elements The analyses are based largely on information derived from research and modeling efforts conducted primarily by cohorts of creative and talented individuals at universities, state and federal agencies and private institutions with a keen interest in the San Francisco Bay Estuary and associated watersheds.

The effects analyses that are the subject of this review rely on four interrelated components: (1) Status of the species, (2) the Environmental Baseline, (3) Effects of the Action and (4) Cumulative Effects. The key to understanding the effects analyses presented in this BiOp is in the definition and interpretation of these components.

The status of Delta Smelt is not an issue. The species is listed as threatened under the Endangered Species Act and is routinely nominated as a candidate for being listed as endangered. However, endangered status has been precluded by consideration of species given higher priority, even though there is a scientific consensus that Delta Smelt are on an accelerating path toward extinction in the wild.

The definition of Environmental Baseline is perhaps the most important key to understanding how risk to the survival of Delta Smelt and their critical habitat is evaluated. The Environmental Baseline includes “all the past and present impacts of all Federal, State and private actions and other human activities in the Action Area”. The purpose is to describe the condition of the listed species and its critical habitat in the absence of the Proposed Action subject to a current consultation. In essence, this means that the Environmental Baseline is reset prior to each consultation.

Effects of a Proposed Action are then considered largely in isolation from all known and unknown effects that may have occurred prior to the Action. Researchers have produced a diversity of perspectives, ideas and hypotheses regarding the underlying causes of the decline of native species, including Delta Smelt. However, experimental studies to test these ideas, in a rigorous manner and with minimal assumptions, are often expensive and time-consuming. So a variety of conceptual and numerical models have been developed to guide future research and to make predictions based on suites of assumptions that may ultimately be flawed. Nonetheless, predictions from these models are used in the effects analyses to make determinations about the risk of jeopardy to Delta Smelt and their critical habitat. It is often acknowledged that a high degree of uncertainty is associated with such findings but they are presented in the BiOp as the best available information. Also, there continue to be substantial gaps in key pieces of information related to the critical habitat of Delta Smelt (e.g., spawning substrates). How can one assess risk to an unknown critical habitat?

Cumulative effects are confused with additive effects in the BiOp analyses. This seems to flow directly from the definition of Environmental Baseline. In the BiOp analyses, cumulative effects are considered to be all of the current potential risks to the survival, growth and reproduction of Delta Smelt and its critical habitat. However, real cumulative effects require a temporal component. That is, repeated exposure to the same, or a series of different stressors. This does not seem to have a role in the current effects analyses.

A lack of consideration for the effects of ecological thresholds, sometimes referred to as tipping points, is a potentially serious omission in the BiOp’s effects analyses. Small changes in environmental conditions, particularly in connection with true cumulative effects, can produce abrupt and unexpected changes in ecosystems and/or their components. This review strongly recommends a consideration of ecological thresholds in future analyses of potential effects of actions on Delta Smelt and their critical habitat.

The successful hatchery-rearing of Delta Smelt for use in research and possible supplementation of the wild population has provided research opportunities that have yet to be fully exploited for the purpose of filling important knowledge gaps that would aid in future effects analyses. One such area involves testing hypotheses about preferred spawning habitat and behavior.

Finally, there is an apparent shift in focus away from water operations as a direct or indirect risk of jeopardy to Delta Smelt and toward a growing number of “non-operational” potential risk factors or stressors. Dealing with an increasing number of moving parts increases the risk of management decisions having negative effects on listed species in the Delta. One of the overarching new risk factors considered in the BiOp is climate change. Associated increases in temperature and sea level rise are expected to substantially reduce suitable habitat for Delta Smelt in the Sacramento-San Joaquin Delta ecosystem. If these predictions are true, radical measures may be required to restore this species in the wild. Perhaps it is time to seek a new estuarine habitat for Delta Smelt.

Table of Contents

1 Introduction 1

1.1 Background 1

1.2 General Observations 2

2 Responses to Questions 5

2.1 How well do the draft sections of the biological opinion for delta smelt use best available scientific and commercial information? 5

2.2 Do the draft sections of the biological opinion adequately analyze effects of the proposed action on delta smelt and critical habitat? 10

3 Additional Thoughts, Concerns, and Suggestions for Improvements to the Analyses 15

4 References 17

4.1 Materials Provided Prior to the Review 17

4.2 Supplemental Materials Review 17

Appendices

Appendix A Minor Comments for Consideration

# Introduction

## Background

Water flowing through California’s Central Valley and into the San Francisco Bay Estuary is directed spatially and temporally through a highly engineered system developed over the past 85 years or more by federal and state agencies. The complex system was designed to regulate the temporal and spatial distribution of water resources for a variety of human uses including agriculture, flood control, municipal water supplies, power generation, etc. The allocation of water in the system is based on an entangled legal structure of water rights that attempts to accommodate a diverse set of user needs. The development of this complex engineered and legal structure did not originally account for the support of natural aquatic resources, including native fishes such as anadromous salmon, sturgeon and Delta Smelt *Hypomesus transpacificus*, which is the subject of this review.

There is little scientific dispute regarding the cumulative effects of anthropogenic alterations in the watersheds of the San Francisco Bay Estuary on native aquatic organisms over the past century. Aquatic habitat suitable for the growth, survival and reproduction of many species, particularly Delta Smelt, has been compressed in spatial extent and quality to the point that a clear path to extinction has become evident.

The passage of the Endangered Species Act (ESA) by the U.S. Congress in 1973 formally recognized the need to protect and recover imperiled species and the ecosystems on which they depend.

**Section 7(a)(2) of the ESA requires that any action taken, funded or authorized by Federal agencies is not likely to jeopardize the continued existence of a listed species. This includes anything that would appreciably reduce the likelihood of the survival or recovery of a listed species in the wild by reducing the reproduction, numbers or distribution of that species.**

**Section 7(a)(2) also requires that Federal agencies are not involved in anything that directly or indirectly diminishes the value of critical habitat for protected species.**

In April 2019, the U.S. Fish & Wildlife Service (USFWS) requested an independent peer review of their draft Delta Smelt effects analysis in connection with a Reinitiation of Consultation regarding Proposed Actions involving the Coordinated Long-Term Operation of the Central Valley Project and State Water Project.

Delta Smelt is currently listed as threatened under the ESA. This means it is likely to become endangered in the foreseeable future. The USFWS has repeatedly submitted Delta Smelt as a candidate for endangered status but it has been precluded by listings of other species with higher priority. Under the ESA, endangered means “a species is in danger of extinction throughout all or a significant portion of its range.” The range of Delta Smelt is limited to lower salinity portions of the San Francisco Bay Estuary, with the population centered in the Sacramento-San Joaquin delta in the Central Valley of California. Delta Smelt occupy a limited niche at the southernmost range of inland smelt species and are unlikely capable of establishing a viable population south of their current location along the U.S. Pacific Coast. Furthermore, if current climate change predictions are correct, it seems likely that environmental conditions will become suitable to support the extant wild population of Delta Smelt in the foreseeable future.

## General Observations

The Biological Assessment submitted by Reclamation to the USFWS in January 2019 seems to emphasize opportunities to maximize water supply delivery and power generation by minimizing constrains on operations and emphasizing actions other than long-term water operations (LTO) of the CVP and SWP as a way of avoiding significant adverse effects on Delta Smelt.

The October 19, 2018 Presidential Memorandum on promoting the reliable supply and delivery of water in the West directing the Secretaries of the Interior and Commerce to streamline regulatory processes involving western water infrastructure cited in the BiOp’s Consultation History section, seems to suggest the existence of federal political pressure favoring water operations over the preservation of endangered species. Within this context, it appears that USFWS historically has been very accommodating to requests from Reclamation to relax restrictions on water operations intended to avoid negative effects on Delta Smelt.

The USFWS understands that current information demonstrates “the increasingly imperiled state of Delta Smelt and its designated critical habitat”. Furthermore, “emerging science shows the importance of outflows to all life stages of Delta Smelt and to maintaining the primary constituent elements of designated critical habitat”. Nonetheless, the Proposed Actions seem to be attempts to shift responsibility for adverse effects on Delta Smelt away from water operations and place the focus on “nonoperational factors”. This seems to propagate the public impression that environmental regulations on water operations have been unnecessarily limiting water diversions, particularly for apparently ineffective protections of threatened and endangered species such as Delta Smelt. However, while constraints on water operations to protect Delta Smelt have been relatively modest during Water Years 2011-2018 (see Table 6 in Reis et al. 2019) outflows to San Francisco Bay during the critical winter-spring period has been declining over the past several decades to the point where the estuary may be experiencing drought conditions in most years (Reis et al. 2009).

Food limitation has emerged as a focus of interest in constraining the growth and survival of Delta Smelt in most life stages but, even if true, the underlying cause(s) of limited food supply are not disconnected from water operations. A recent analysis of temporal changes in chlorophyll a and zooplankton in the San Francisco Estuary during the period 1969-2014 showed that nearly all of the observed declines in pelagic primary productivity could be related to invasion of the clam *Potamocorbula amurensis* and water exports from the state and federal pumping facilities. While there appears to be a current general scientific consensus that limited pelagic food resources and/or temporal shifts in normal seasonal patterns of food availability (e.g., Merz et al. 2016) may be jeopardizing the survival and recovery of Delta Smelt, the role of water exports have not been eliminated as an underlying driver in the process.

The USFWS effects analysis relies on four interrelated components: (1) Status of the species, (2) the Environmental Baseline, which is the current condition and factors responsible for that condition, (3) the Effects of the Action, and (4) Cumulative Effects, which evaluates the effects of FUTURE NON-FEDERAL activities in the action area. These same categories are applied in the consideration of effects on both Delta Smelt and its critical habitat. This seems a bit redundant because effects on critical habitat are also effects on Delta Smelt. If there were a fishery for Delta Smelt, perhaps it would be appropriate to consider fishing effects on the population dynamics to be separate from effects on critical habitat but it is difficult to distinguish any effects on Delta Smelt that are independent of the suitability of their critical habitat.

A key to understanding how USFWS evaluates the risk of jeopardy to Delta Smelt is found in the functional definition of Environmental Baseline which includes “all the past and present impacts of all Federal, State and private actions and other human activities in the Action Area”. The purpose is to describe the condition of the listed species and its critical habitat in the absence of the Proposed Action subject to a current consultation. In essence, this means that the Environmental Baseline is reset prior to each consultation. The fact that previous actions are known to have likely caused negative effects to a species or its critical habitat is discounted and any evidence that could be generated to show continued or additional effects of a Proposed Action would be unavailable until sometime after the action was undertaken, at which point the effect becomes incorporated into the next Environmental Baseline. This has implications for how “cumulative effects” are defined and analyzed. Cumulative effects require a time component (i.e., the history of effects) such as sequential exposure to a stressor.

For example, an action that results in the loss of 10% of a population may not have a long-term negative effect as an isolated event as long as reproduction can result in the recovery of those losses within a certain time frame. However, a series of impacts from the same action with each occurrence resulting in the loss of 10% of the population before the population has sufficient time to rebound is a cumulative effect.

The treatment of any real cumulative effects on Delta Smelt seems to be effectively ignored, or at least obfuscated, in the BiOp by virtue of the definition of Environmental Baseline, which does not allow any past or future actions to be considered in the analysis. How can the cumulative effects of only current actions be evaluated? There is no temporal element involved. The BiOp seems to consider a suite of stressors operating concurrently to be cumulative effects, but these are better described as “additive effects”. Cumulative effects are actions or suites of actions repeated over time. The definition of Environmental Baseline essentially eliminates a consideration of cumulative effects in this analysis.

# Responses to Questions

## How well do the draft sections of the biological opinion for delta smelt use best available scientific and commercial information?

This question solicits a qualitative answer that involves consideration of not only the volume of available information but the quality of the information being relied upon, the original purpose for which it was assembled, and how it was used in the effects analyses. In conducting any study or summary of information, it is common for authors to make observations not directly related to the central focus of the research, particularly if there is a possible connection to some issue of perceived importance. Usually these observations and associated opinions are expressed as hypotheses for future consideration and testing. However, sometimes these ideas, which were not tested in the original study, can improperly be used as evidence in support of a given position.

The San Francisco Bay Estuary area is fortunate to have an abundance of talented and creative scientists working in universities as well as government and private agencies and institutions, most with a keen interest in understanding how this ecosystem functions. This wealth of talent has produced a diversity of perspectives, ideas and hypotheses. Experimental studies to test these ideas, in a rigorous manner and minimal assumptions, are often expensive and time-consuming. So it is not surprising that a variety of conceptual and numerical models also have been developed to guide future research and to make predictions based on suites of assumptions that may ultimately be flawed; measures of uncertainty associated with such findings are essential to consider when applying such predictions.

The BiOp includes much of the pertinent and current information regarding factors that are likely to affect the survival, growth and reproduction of Delta Smelt so, from this perspective, the draft BiOp does a good job of capturing the available information. Important basic information on the habitat requirements (e.g. spawning habitat) of Delta Smelt seems to continue to allude researchers, which makes it difficult to conduct a complete effects analysis on critical habitat.

Although time constraints on the production of this report precluded a thorough analysis of the applicability of available information used in the effects analyses, there were examples (discussed in subsequent sections) where the available information seemed inappropriately applied or applied beyond the scope of a study from which it was derived in order to support conclusions that effects on Delta Smelt or their critical habitat were minor.

### Do the analyses in the status of the species and critical habitat, and environmental baseline sections reflect the best available scientific and commercial information?

Not always, and for a number of reasons, sometimes involving the way that the definition of Environmental Baseline is used in the analyses. The concept of ecological thresholds and rapid transitions in state resulting from apparently minor shifts in conditions (e.g., see Clements and Ozgul, 2018 and references therein) do not appear to be considered in the analyses of species status, critical habitat, environmental baseline or effects of the proposed action. The following narrative provides some examples.

Reclamation presented a “without action scenario” as part of the Environmental Baseline which excludes CVP and SWP operations.

The USFWS claims to be unaware of any available scientific evidence that can distinguish among four hypotheses presented to explain why there has been no discernible relationship between freshwater flows and Delta Smelt population dynamics:

1. A relationship never existed.
2. Any historical relationship that may have existed was extinguished by decades of landscape and flow regime changes prior to initiation of monitoring programs.
3. Changes in community structure and food web functioning masked any historical relationship not detected prior to initiation of monitoring programs.
4. Some combination of (2) and (3) above.

The assertion that there is no scientific evidence for a relationship between freshwater flows and Delta Smelt population dynamics may not be defensible. Although time constraints prevented a more thorough review of the literature, this reviewer found at least two recent publications that seem to support either a direct or indirect association between freshwater exports and decline of the Delta Smelt population.

Reis et al. (2019) found, as a result of exports, that the percentage of Central Valley runoff reaching San Francisco Bay during the winter-spring period, which is critical to the propagation of Delta Smelt, has declined over the past several decades such that the estuary essentially experiences drought conditions in most years. This pattern also is shown in Figure 6 of Part 3 of the BiOp as bars labeled “Super Critical”. The use of a line showing an apparent decline in exports relative to unimpaired flows is misleading because exports become constrained by deteriorating water quality at some absolute threshold level of exports. This distracts from the apparent fact that exports since 1980 have resulted in many more “super critical” years than prior to 1980 (i.e., artificial drought conditions).

Hammock et al. (2019) found a relationship between declining chlorophyll a concentration, which supports a pelagic food web essential to Delta Smelt, and the combined effects of filtering by the invasive overbite clam and freshwater exports; together these two factors could account for 97% of the decline in chlorophyll a, and exports alone could account for 74%.

Figure 4 in Part 3 of the BiOp shows a time series of biomass of six pelagic fishes, including Delta Smelt, from 1967 to 2017 and is presented as evidence that biomass of Delta Smelt was already lower than the other species by the time water exports from the pumping facilities were initiated in 1968. If this is meant to provide evidence that water exports have not been responsible for the general decline of Delta Smelt biomass over the time period depicted in the figure, it fails to do so. First, the dataset does not provide any actual “baseline” information on Delta Smelt biomass in most of the years prior to the initiation of exports. Second, it provides evidence for a drastic decline in the biomass of all species, but especially Delta Smelt, in the 37 years after 1980. The effects of freshwater exports, particularly if they operated indirectly to impact food supply or available critical habitat, would likely develop over time in such a large system as a Cumulative Effect. However, because of the definition of Environmental Baseline used in the BiOp, all effects prior to the current consultation are incorporated in a new baseline and so are discounted.

It is difficult to evaluate the analysis of Delta Smelt population trends for a number of reasons. First, it seems to be based largely on methods described in a publication (Polansky et al., 2019, in press or in revision) that was not available to this reviewer. However, there was an Appendix that provided additional details. A stage-structured model of population dynamics used data from several gear types. Second, each gear likely has a different catch effectiveness and all are almost certainly size-selective as has been shown by several recent studies (e.g., Peterson and Barajas 2018, Mitchell et al., 2017, 2019). It is difficult to account for all of the biases associated with combining data collected from different gear types and the combined effects on the results of models to capture historical dynamics of the Delta Smelt population, much less to predict future population dynamics from such models. Third, while all models predicted a continued decline in Delta Smelt abundance, it was also clearly noted that prediction uncertainty was “extreme”.

Concerns about the accuracy and precision of Delta Smelt population estimates are partially balanced by the fact that there have been recent and significant incremental improvements in Delta Smelt monitoring. Consequently, it is likely safe to conclude that there is a scientific consensus that the population has past yet another threshold in decline that appears to be leading to extinction in the wild (e.g. Moyle et al. 2016, Baumsteiger and Moyle 2017, Hobbs et al. 2017).

Information on the reproductive requirements, especially in terms of critical spawning habitat, is woefully scarce and uncertain. For example, spawning behavior is only known from captive populations and preferred spawning substrates remain unknown. This makes it very difficult to identify specific critical spawning habitat. Eggs of Delta Smelt are demersal and adhesive so could be attached to any number of substrates including coarse sand, gravel, crevices in stones, submerged logs or even algal mats or the lower portions of emergent vegetation in shallow subtidal or wet intertidal habitats. It is difficult to protect critical spawning habitat without knowing what it is, much less to analyze the potential effect of any action on critical habitat.

Climate change was recently added to a growing list of threats to Delta Smelt. While the list of threats grows, progress toward maintaining and recovering Delta Smelt in the wild continues to fail. At best, it might be said that extinction could have occurred already had it not been for protective actions previous taken, but there is no substantial scientific support for this.

The role of turbidity in critical habitat of Delta Smelt is based largely on positive associations between turbidity and catches of Delta Smelt in trawls and in salvage at the pumping stations. The USFWS seems to dismiss the suggestion that turbidity simply covaries with undetermined underlying causal factors such as sampling gear effectiveness in clear versus turbid water or flow rates. Turbidity *per se* is a very coarse variable that may need to be qualified in order to be useful. For example, there may be no functional equivalency between any given turbidity value due to the sediment suspension versus robust growth of phytoplankton in response to nutrient levels. In the first case, there may be little or no connection between turbidity and useful food resources for Delta Smelt. In the second case, different source nutrients (e.g., ammonium vs nitrate) at certain concentrations can lead to very different size classes of primary producer communities (e.g., Glibert et al. 2016) that support zooplankton communities of different food value to Delta Smelt. Measures of turbidity alone are of no value in making these functional distinctions.

In an apparent search of some mechanistic advantage of turbidity, the BiOp (Part 3, p. 36) argues that turbidity produces a dark background against which larval Delta Smelt can better see their translucent prey citing Hasenbein et al. 2013, 2016 to support the suggestion that feeding success and survival of larvae are higher at 12-80 NTU than at lower or higher turbidities and that juvenile Delta Smelt are less reliant on turbidity to see their prey. However, an examination of the data in these references shows that the only statistically significant differences in larval survival were between 25 NTU, which was associated with higher survival than at either 5, 120 and 250 NTU; there was no difference in survival at any other level of turbidity (see Fig. 1 in Hasenbein et al. 2016). Similarly, not only was there little difference in feeding rates of juvenile Delta Smelt across a wide range of turbidity but some evidence that feeding rates were greatest at 0 NTU and declined with increasing turbidity (see Fig. 1 in Hasenbein et al. 2013). Furthermore, it is also suggested that juvenile Delta Smelt rely on turbid waters to avoid predation. The two positions suggesting that a dark background aids Delta Smelt in locating their prey but at the same time hides them from their predators seems inconsistent. Delta Smelt are largely translucent and not darkly colored, so why would they not be more visible to their predators in turbid waters?

The association of turbidity fronts with the location of X2 and concentrations of food for Delta Smelt is perhaps the most convincing connection between turbidity and Delta Smelt abundance but this only occurs in relatively small regions of the habitat. Environmental variables other than turbidity (e.g. temperature and salinity) have a demonstrable physiological effect on all species, including all life stages of Delta Smelt (e.g., Hammock et al. 2017) but the importance of turbidity remains an open question. Consider that Delta Smelt are now being successfully reared in captivity. Is turbidity from sediment suspension an essential element for successful growth and survival in hatchery stocks in the same way that temperature and salinity ranges are crucial?

The BiOp argues that turbidity persists at and near X2 while Delta Smelt catches have continued to decline, which disproves the hypothesis that turbidity affects gear effectiveness (Part 3, p. 36). This argument is difficult to understand. No one seems to be questioning the decline in Delta Smelt abundance but trawl gears can be less effective in clear water. There are other issues related to tidal stage and distribution of Delta Smelt that could affect gear effectiveness (e.g., if fish move toward shallows on ebbing tides but gear is used in deeper water, catch will be reduced); effects of sampling gear issues on estimates of abundance should not be discounted.

On p. 44, Part 3 of the BiOp it states that since the RPA in the 2008 BiOp was implemented, there has been a much lower likelihood of water operations that are highly detrimental to Delta Smelt spawners or larval transport. However, how is this determined? Delta Smelt population size has declined substantially since implementation of the RPA, so how is effectiveness measured?

### Are assumptions in the effects analysis clearly stated and reasonable based on current scientific thinking?

Assumptions were sometimes made to justify the finding that some element of an action would have no further impact on Delta Smelt. For example, because all Delta Smelt entrained at the pumping facilities are assumed to be lost, the salvage operation is judged to have no additional effect on the population. This could be viewed as a very conservative approach but at some level suffers from a lack of logic. For example, if live Delta Smelt are present in salvage, the assumption is proven false. It also calls into question the use of salvage as a means of determining take at the pumping facilities.

Another issue with assumptions is that even when they are clearly stated they are sometimes inconsistent with the Proposed Action as, for example, Table 2 in Part 4 of the BiOp, there is no decision to favor the protection of Delta Smelt. Instead, the decision will be made in real time by management groups identified in the Proposed Action. Essentially, the analysis defaults to others and any effects, either positive or negative, become part of the next Environmental Baseline.

In other cases, assumptions were not readily apparent. The narrative in Appendix 2 (GLM relating an index of proportional entrainment loss to turbidity and OMR flow) is an example.

The Polansky et al. 2019 referenced relied on heavily in this appendix was unavailable at the time of this review of the BiOP. The approach is based on a number of assumptions and does not distinguish natural mortality from entrainment mortality. Also the method described uses an OMR Index which the LOBO 2017 panel strongly discouraged because of its failure to capture true variations from gage data due to tidal flows, especially through the critical range of -2500 to -5000 OMR flows. The LOBO panel proposed a method that could improve predictions of the USGS tidally filtered OMR flow estimates (see LOBO 2018, Appendix 2) but it is unclear if the OMR Index used was the same, or an adjusted version in response to prior concerns.

Adult DS abundance estimates were based on Spring Mid-water Trawls from 1993-2000 and on Spring Kodiak Trawls from 2001-2015. I presume the “Spring Mid-water Trawl” referred to in this Appendix is the survey that the more effective surface Kodiak Trawl replaced for the collection of DS. Mid-water trawls are not as effective as surface trawls for DS and a number of gear efficiency issues can lead to implausible patterns in catch densities when using different gears and sampling approaches under different environmental conditions (e.g. turbidity) and fish abundance levels (e.g., Peterson and Barajas 2018; Mitchell et al. 2017, Mitchell et al. 2019).

## Do the draft sections of the biological opinion adequately analyze effects of the proposed action on delta smelt and critical habitat?

As mentioned previously in this report, there seems to be very little difference between the analyses of effects on Delta Smelt and effects on their critical habitat. One issue that could be considered further involves any action to improve the amount or quality of habitat for Delta Smelt at stationary locations (e.g., marsh restoration or food web enhancements in the Cache Sough complex). These should be analyzed in light of actions (e.g., shifts in X2) or anticipated events (e.g., climate change) that are likely to change environmental conditions for Delta Smelt.

Much of the effects “analysis” is based on models that are being applied for purposes they may never have been intended. For example, the complex CalSim II model is perhaps the most relied upon water management model but when used inappropriately could very well lead to analytical controversies and misunderstandings. Such issues were addressed in Ferreira et al. 2005, which was not referenced in the BiOp.

This holds as well for Delta Smelt population models which have high degrees of uncertainty largely due to the current small population size and associated issues with sampling and incomplete understanding of how critical habitat is being defined and affected.

### Did the Service adequately analyze effects for both standard/site-specific (described at a site-specific level with no future consultation required) and programmatic (which require future consultation before they can be implemented) components of the proposed action?

As acknowledge in the BiOp, the Proposed Action by Reclamation is considered a mixed programmatic action with many elements subject to reinitiation of consultation, in essence deferring analysis until additional information is available. Many of the action elements are associated with a high degree of uncertainty with respect to effects on Delta Smelt and their critical habitat. The following narrative highlights some issues that stood out in this review of the BiOp with respect to uncertainty associated with the effects analysis of critical habitat and cumulative effects.

The BiOp considers that turbidity associated with sediment load is important to mediate effects of predation on Delta Smelt and facilitate feeding of larvae, but the effects of the Proposed Actions on suspended sediment are not estimated. Despite the lack of information regarding sediment load, the current BiOp assumes the Proposed Actions will have only minor effects on critical habitat in the winter compared with the Environmental Baseline.

The BiOp does not expect food resources to change as a result of Delta outflow and cites several actions including habitat restoration, water management and food web subsidy studies, most of which are considered part of the Environmental Baseline but will not be completed until later. It is assumed that these actions may provide data to inform adaptive management of food webs. As with much of the analysis on critical habitat, there are many hypotheses but relatively few substantial scientific facts or tests available. For example, tidal habitat restoration is expected to improve the availability of food for all life stages of Delta Smelt but “at unknown locations and to an unknown degree”. This is not a very compelling endorsement.

The operation of the Suisun Marsh Salinity Control Gate to direct more freshwater into Suisun Marsh in summer and fall under certain constraints was presented in the context of improving habitat for Delta Smelt but the action may be primarily intended to benefit waterfowl. The results of a pilot study suggested that Delta Smelt may see some modest benefit from the action but this remains to be seen.

Other actions are also guided by the hypothesis that food resources can be redistributed to benefit Delta Smelt but other species, perhaps superior competitors, may benefit as well and there is a risk of redistributing contaminants from agricultural and areas affected by ship traffic (e.g. hydraulic reconnection of the Sacramento Ship Channel with the mainstem of the river). Delta Smelt are already exposed to contaminants in the Liberty Island/Cache Slough complex (e.g., Hammock et al. 2015), which is being targeted for the redistribution of potential food resources from the ship channel.

Similarly, what appears to be a cooperative effort among the DWR, Reclamation and water users to flush nutrient-rich water from the Colusa Basin Drain into the Yolo Bypass and north Delta, may also contribute additional agricultural contaminants to the target area.

The BiOp states that the net direction and magnitude of the effect of these actions to stimulate the food web is currently unknown. This also means that the risk of jeopardy is also unknown and by the time it is known the effects will be incorporated into the next Environmental Baseline.

Table 2 in Part 5 of the BiOp summarizes Proposed Actions for the summer-fall habitat by water year type. In wet years, it appears that the trade-off being made for the Suisun Marsh Salinity Control Gate action is to reduce outflow such that X2 is located at 80 km in September and October closer to a critical threshold for maintaining acceptable salinity levels near the center of the juvenile and subadult Delta Smelt population in the vicinity of Suisun Bay. Threshold levels at which critical conditions change abruptly from acceptable to unacceptable are usually only considered in the context of operating as close to those thresholds as possible. While this may maximize exports, it increases the risk of jeopardy to Delta Smelt, particularly in areas where the populations are most abundant. However, the BiOp states that the management actions “will likely provide better salinity conditions for rearing Delta Smelt than those modeled in CalSim II, but the magnitude of the effect is uncertain”. How can anything be considered “likely” if the effect is “uncertain”. Could this be one of those issues that CalSim II was not designed to address (Ferreira et al. 2005)? The argument appears to be that significant landward shifts in X2 would have occurred in September and October. However, when considering substantial shifts in X2, it would be appropriate to consider that restoration areas remain stationary and under the current Environmental Baseline, how will water quality in the restored habitats be affected by shifts in X2?

Figure 10 in Part 5 of the BiOp shows how frequently X2 is expected to be located at or above 85 km, which results in no overlap of the low-salinity zone with Suisun Bay under the proposed actions relative to current operations according to 82 simulation runs of the CalSim II model. During September to December. X2 is predicted to be located at or above 85 km much more frequently than under current conditions. This shows that conditions will be less favorable more often in the primary center of the Delta Smelt population. It is difficult to imagine how these predicted conditions could be considered an acceptable risk to the critical habitat of a listed species.

In regard to river flow (p. 19, Part 5 of BiOp), USFWS asserts that “new scientific understanding of factors affecting entrainment risk suggest that turbidity in addition to river flow plays an important role in attracting migrating adults to spawning habitat.” Sommer et al. (2011) is cited to support the notion that freshwater flows in combination with turbidity cue adult Delta Smelt to disperse to spawning habitat in December through March. However, Sommer et al. (2011) concludes that the spawning migration pattern is variable. First flush flow events in winter are identified as the primary trigger for upstream spawning migration and turbidity may be associated, but is not presented as a trigger; turbidity may be associated, but is not presented as a trigger. Also mentioned in this paper is a strong association between the center of Delta Smelt abundance and X2 in the fall. Proposed actions would drive X2 farther upriver in the fall, degrading critical habitat at the core of remaining Delta Smelt population. Turbidity seems to receive ubiquitous mention in much of the literature as a factor that affects key processes (e.g., feeding, survival, migration, etc) affecting all life stages of Delta Smelt but the linkages are rarely clear.

The treatment of any real cumulative effects on Delta Smelt seems to be effectively ignored, or at least obfuscated, by virtue of the definition of Environmental Baseline, which does not allow any past or future actions to be considered in the analysis. How can the cumulative effects of only current actions be evaluated? As described in this section, the effects of multiple risk factors are better described as “additive effects” not cumulative effects, which are repeated over time. The definition of Environmental Baseline essentially eliminates a consideration of cumulative effects in this analysis.

Furthermore, as in other sections of the BiOp, there seems to be a selective use of the findings in cited literature. One example is the use of Nobriga et al. (2004) to support the assertion that Delta Smelt seem to have a low vulnerability to entrainment associated with unscreened water diversions used in the irrigation of agricultural fields. The study was limited to measurements of entrainment at two agricultural irrigation diversions, one screened and the other unscreened. Sampling occurred during periods of approximately 40 hrs over two days in July over each of two years (2000 and 2001). No Delta Smelt were collected from the screened diversions and a total of 42 Delta Smelt were collected at the unscreened diversions. In general, these numbers were lower than those of other species collected from the unscreened diversion but the interannual variation in numbers of fish entrained was very high. For example, 59 Threadfin Shad were collected in 2000 but 7,824 were collected in 2001. The authors acknowledged several uncertainties in their results including the fact that they did not know how many Delta Smelt (or other species) were impinged on the screen diversion and that the findings may not have been representative of entrainment at other diversions. They believed that the low number of Delta Smelt entrained by the diversion reflected an offshore rather than nearshore distribution of fish (i.e., Delta Smelt were not susceptible to entrainment). Placed in the context of cumulative effects on a listed species, the number of Delta Smelt entrained in this study would have to be expanded by the number of agricultural diversions in operation and the total number of hours or volume pumped in areas occupied by Delta Smelt. This study did not attempt to do this, yet the limited temporal and spatial coverage of the results seems to be applied to support the conclusion that small water diversions for agricultural (regardless of their number or location) pose only a minor risk to survival of Delta Smelt. This single limited study (Nobriga et al. 2004) is used in a summary of cumulative effects to suggest that the Delta Smelt is at low risk as a result of agricultural diversions. However, this seems rather thin evidence to discount a “death by a thousand cuts” type of risk.

The potential effects of contaminant and nutrients in the analysis of cumulative effects seems to be largely descriptive and, like other sections of the BiOp, replete with unknowns and uncertainties. Given that some of the Proposed Actions involve the redistribution of nutrients (and likely contaminants) in an effort to enhance food resources for Delta Smelt, the many uncertainties with respect to potential impacts on survival, growth and reproduction of Delta Smelt become an issue in the cumulative effects analysis.

While it is possible that changes in key environmental factors (e.g., temperature, salinity, etc) that are known to effect the survival, growth and reproduction of Delta Smelt will likely lead to the extinction of the species in the San Francisco Bay Estuary, climate change is not part of the cumulative effects that have led to the current status of Delta Smelt.

### Are the methods utilized appropriate to determine if the proposed action is likely to jeopardize delta smelt or adversely modify its critical habitat?

The short answer is no. See the answers to previous questions. There is an apparent lack of consideration of ecological (environmental) thresholds with respect to effects on Delta Smelt and their critical habitat, apparent confusion over additive and cumulative effects, an often high degree of uncertainty in methods applied in the analyses, and a definition of environmental baseline that seems to preclude a consideration of real cumulative effects.

# Additional Thoughts, Concerns, and Suggestions for Improvements to the Analyses

A set of minor comments on consistent form, missing references and typos detected while reviewing the draft BiOp are provided in Appendix A – Some Minor Comments for Consideration.

Following are some recommendations/suggestions for future effects analyses, research and potential relocation of Delta Smelt in the wild:

1. A consideration of ecological thresholds in future effects analyses is strongly recommended. See Clements and Ozgul (2018) and references therein for a recent review and synthesis of concepts and applications. At or near threshold levels, small changes in conditions can lead to rapid and dramatic changes in Delta Smelt populations and the quality of their critical habitat.
2. Now that Delta Smelt are available for experimentation from hatchery stock, it is possible to test hypotheses about preferred spawning substrate, spawning water depth, spawning periodicity and synchrony (e.g. tidal, lunar, diurnal/nocturnal, light level) – all key issues for defining critical spawning habitat. Mesocosm experiments could be conducted to provide choices of possible spawning substrates (e.g., coarse sand, gravel, algal mats, submerged aquatic vegetation, tule shoots, etc.) at different relative water depths could certainly help to provide basic information on critical spawning habitat.
3. If climate change is now a serious concern, how will this affect plans to reintroduce or supplement Delta Smelt when the wild population is considered functionally extinct? Because Delta Smelt is already at the southern end of its potential range, and the species does not migrate to the ocean, there is little possibility that natural northerly dispersal of the population with changing temperatures can occur. Although this will be perceived as a radical idea, perhaps it is time to consider a new home for Delta Smelt in the wild; it may not be able to survive in the Sacramento/San Joaquin Delta in the future even if supplemented with hatchery fish. Also, once hatchery fish are released into the wild, and if hatchery support is required for successful reproduction, the required introduction of wild popn genes into the hatchery fish may no longer be possible.

Undoubtedly, there would be resistance and legal hurdles to overcome in transplanting Delta Smelt between watersheds or states, it may be time to search for a new wild home for this species in estuaries north of San Francisco Bay. It is becoming clear that the choice between restoring Delta Smelt populations in the San Francisco Bay Estuary and providing a reliable source of water for human uses has already been made. It may be time to remove the Delta Smelt-child from its current guardian and place it in a foster home. Are there any suitable estuaries north of San Francisco Bay that could sustain populations of Delta Smelt? If so, there is a certain irony in the fact that Delta Smelt, if relocated, would likely be considered a non-native species.

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Appendix A
Minor Comments for Consideration

1. Recommend consistency in referring to Delta Smelt in the BiOp. “Delta Smelt”, “Delta smelt” and “delta smelt” are all used. Although it was never my personal preference, the American Fisheries Society 7th edition of the Common and Scientific Names of Fishes (2013) recommended capitalizing common names (i.e., Delta Smelt). My current understanding is that the USFWS adopted this convention for fishes.
2. The X-axis of Fig 16 in Part 3 of the BiOp is improperly labeled as “Julian Day”; the axis actual shows the number of days since the beginning of the calendar year; Julian Date is the number of days since the beginning of the Julian Period, January 1, 4713 BC.
3. In the time allotted to produce this review (10 days), I was unable to check all of the references in the Literature Cited to determine if there were missing citations or the cited literature was actually referenced in the text of the BiOp, but I did happen across the following errors:
	1. DWR 2009a and DWR 2011 were cited in the BiOp text (p. 7, Part 6) but do not appear in the Lit Cited section.
	2. EPA 1999 was cited in the BiOp text on p. 5 of Part 6 but did not appear in the Lit Cited section.
	3. Glibert (2011) cited on p. 5 of Part 6 should be Glibert et al. 2011 according to the Lit. Cited.
	4. On p. 6 of Part 6 there is a reference to Dugdale et al. 2013 that is not included in the Lit. Cited; could this be Dugdale et al. 2012?
	5. Also on p. 6 of Part 6, Delta Protection Commission 1997 is cited but is not in the Lit. Cited; could this be Delta Protection Commission 2012 instead of 1997?
	6. Publication year of Huber and Knutti is cited in the text (p. 7, Part 6) as 2011 but listed in the Lit Cited as 2012. I believe the text should be corrected to 2012, even though the paper was first published on line in December 2011.
	7. Solomon et al 20092009 is cited on p. 7 of Part 6; one of the “2009” should be deleted.
	8. Inkley et al. 2004 is cited in the BiOp text but does not appear in the Lit Cited.
	9. Moyle et al. 2016 appears to be listed twice in the Lit Cited. The first reference appears to be incomplete and the second omits an author (Hobbs, J.A.).
	10. Murphy and Hamilton 2013 in the Lit Cited should be moved to appear following Moyle et al 2010.
	11. California Department of Boating and Waterways (2003) cited on p. 6 of Part 6 does not appear in the Literature Cited.