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

Prepared for:

National Marine Fisheries Service

U.S. Fish and Wildlife Service

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Executive Summary

I was asked to provide input, as an independent scientist, on whether the biological opinion is scientifically sound and the conclusions are based on the best available scientific information as it pertains to Delta smelt; scientifically defensible. Relevant background materials and sections of the biological opinion to be reviewed were provided.

In short, I believe that the BiOP provides enough information to demonstrate that the status of delta smelt critical habitat under the PA will most likely be degraded by cumulative effects under the early long-term. However, I think this is more due to the lack of information demonstration by Reclamation than analyses in the BiOP. In particular, it is almost impossible to identify what the overall PA effects would be in measureable terms other than estimated percent change to outflow.

Information provided in each section is disorganized and not enough information is provide in background. For instance, why 1850-1967? Why is Figure 4 Biomass of six “pelagic” species placed in the 1850-1967 period?

BiOP should be more fully developed into the life cycle of delta smelt. What is the timing of each life stage? What are the key physical requirements for each life stage? Then clearly articulate the timing and effects of each component of the PA as it relates to delta smelt. Delta smelt life stages are not well defined and in many cases, have conflicting or ambiguous descriptions of the fish.

Estuary seasonality is not well described in the environmental setting. For instance, “wet and dry season” are alluded to in document but the seasonality of habitat flood-up and subsequent water quality and foodweb activity are not well established. There is significant information available on the trophic interactions of the estuary, including seasonality as it related to the life cycle of delta smelt. How would the PA influence this?

What are the implications for not re-classifying delta smelt? The argument made that “there are bigger fish to fry” is not well supported and if the conclusion of this BiOP is that the PA will make things worse for delta smelt and that the numbers are continuing to decrease, coupled with a conservation hatchery expected to go on line at the date delta smelt are expected to blink out of the environment, doesn’t that suggest great peril for the species?

Tables and Figures do not adequately explain what information is being described (see specific comments below). In short, they should be “stand alone”. Acronyms and initials should be clearly spelled out in captions. This includes explanation of color differences in best-fit lines and what appears to be confidence intervals etc.

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# Introduction

## Background

I was asked to provide input, as an independent scientist, on whether the biological opinion (BiOP) is scientifically sound and the conclusions are based on the best available scientific information as it pertains to Delta smelt; scientifically defensible. Relevant background materials and sections of the BiOP to be reviewed were provided. I also participated in a single conference call with the other reviewers and USFWS representatives for discussing key topics prior to submitting the individual review report.

Under section 7 consultation, the USFWS has been given the daunting task of evaluating the ROC PA effects on listed species and designated critical habitat of several species, including delta smelt. An analysis and conclusion of whether the entire ROC action as described in the PA is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of their critical habitat are meant to be provided within the BiOP.

This report on review of the draft BiOp section on delta smelt was submitted using the format provided, addresses questions posed by USFWS and was delivered electronically to the Anchor QEA representative, Michelle Havey, for consolidation with other review reports. Due to the overwhelming amount of information provided and the relatively short window for review (this is in the middle of my field season), I requested a 48-hr extension.

## General Observations

Two main points I take away from reading this: (1) delta smelt numbers are so low, it is difficult to track habitat use and life stages. Therefore, why aren’t they listed? (2) Even though numbers are too low to track, PA suggests increased water deliveries at all times.

Information provided in each section is disorganized. Build a document strawman with headings and subheading put in order and an explanation of each. For instance, why 1850-1967? Why is Figure 4 Biomass of six “pelagic” species placed in the 1850-1967 period? Once this is done, populate with text, figures etc.

Who is responsible for describing each action and the best science available for delta smelt? Shouldn’t USFWS hold Reclamation responsible for “doing their homework” first? Otherwise, doesn’t USFWS become responsible for making sure information is correct?

BiOP section on delta smelt should be more fully developed into the life cycle of the fish. What is the timing of each life stage? What are the key physical requirements for each life stage? Then clearly articulate the timing and effects of each component of the PA as it relates to delta smelt (see recommendations below).

Delta smelt life stages are not well defined and in many cases, have conflicting or ambiguous descriptions of the fish. “Primarily pelagic or primarily occupies open water”, semi-anadromous, migration vs dispersal (what is the difference?).

Estuary seasonality is not well described in the environmental setting. For instance, “wet and dry season” are alluded to in document but the seasonality of habitat flood-up and subsequent water quality and foodweb activity are not well established. Winder and Schindler (2004) provide an excellent example of depicting seasonality of the Lake Washington trophic interactions and how climate change is altering/decoupling these relationships. See example figures from Merz et al. (2016) manuscript.

What are the implications for not re-classifying delta smelt? The argument made that “there are bigger fish to fry” is not well supported and if the conclusion of this BiOP is that the PA provided will make things worse for delta smelt and that the numbers are continuing to decrease, coupled with a conservation hatchery expected to go on line at the date delta smelt are expected to blink out of the environment, doesn’t that suggest great peril for the species?

Tables and Figures do not adequately explain what information is being described (see specific comments below). In short, they should be “stand alone”. Acronyms and initials should be clearly spelled out in captions. This includes explanation of color differences in best-fit lines and what appears to be confidence intervals etc.

# Responses to Questions

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

The draft sections use reasonable science, including modeling, to predict entrainment effects and generally where X2 is, and delta out flow etc. However, there is much related to trophic interactions, seasonal water quality etc that has not been well described or used. Please see specific comments below.

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

Please see comments below.

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

In general, yes. However, there is conflicting and ambiguous language related to seasonal movement of delta smelt, the life stages and associated habitat needs of the fish. See comments below.

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

In short, the BiOP demonstrates that the PA generally will reduce delta outflow with relatively little evidence from Reclamation that this will not negatively alter delta smelt from its present trajectory. Please see comments below.

### 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?

Not sure this is relevant.

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

In general, I believe that the methods provide the minimum requirements to determine jeopardy of delta smelt critical habitat by the proposed action. However, please see my comments below.

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

For the information, including the analyses provided, it is imperative that each section of the BiOP provide key information as to what it is meant to be accomplished. For instance, the background section, while this seems self-explanatory, does not offer the reader what information it is meant to provide. In contrast, the Environmental Baseline section does provide an explanation as to what the authors are meant to convey. This should be standardized and will help readers follow the immense amount of information, including analyses, provided.

The reasons why Reclamation requested re-initiation of consultation are:

1. New information related to drought
2. low smelt populations (this is confusing; conserved one population in the wild)
3. New expected information from “ongoing collaborative work”

However, these statements are ambiguous at best and there appears to be little relationship between these data and what actions are being proposed. From the background reviewed, the PA appears primarily driven by increasing reliability of water delivery. Should that be clearly stated in the Background?

The BiOP purpose is also a bit confusing. For instance, Table 1 (Consultation Approach for Programmatic Components of the Proposed Action) identifies 11 actions but does not clearly articulate what species each is meant to benefit. It is also confusing as to why studies are considered “actions”. Furthermore, there are significant actions related to water deliveries and flow changes that are not provided in the table. Finally, if Tidal Habitat Restoration was already initiated in 2008, how can the entire 8,000 acres be included in PA?

## Description of Proposed Action

Shouldn’t power generation be included?

Table 2 (pg 6) – needs full description for each project component. Describe NLAA and LAA in caption. Why delta smelt, yb cuckoo, valley elderberry long horn beetle, giant garter snake etc and not other species? Why call out delta smelt critical habitat in some locations and not others? Finally, most of the document focuses on delta smelt so why are other species brought up here?

Under Analytical Framework for the Jeopardy Determination (pg 18) clearly articulate how each action might impact delta smelt.

## Environmental Baseline

Page 3- “delta smelt primarily occupies open-water habitats…” This is un-substantiated and existing information supports the contrary. This is also an example where the BiOP over-simplifies by lumping delta smelt life stages. For instance, Aasen (1999) found that juvenile delta smelt densities were significantly greater in shallow water habitat of Honker Bay and Sherman Lake than in adjacent channels, indicating they use shallow bay areas and flooded islands as nursery habitats. There also appeared to be differences in smelt size related to habitat. Chotkowski (1999) reviewed historical Bay-Delta shallow water surveys and found that delta smelt were common in beach seine surveys (1976-1999). A draft manuscript using beach seine and Kodiak trawl data (Merz et al. in prep) demonstrates relatively higher CPUE in beach seine than Kodiak Trawl (Figure 1) and that as Delta inflow increased, adult delta smelt move toward shore areas susceptible to beach seine (Figure 2). These data suggest that 8,000 acres of seasonal wetlands may benefit offset some of the negative impacts related to increased diversions under the PA. However, neither Reclamation or USFWS provide how this habitat will work and how they might influence the identified drivers (e.g., salinity, turbidity, food, temperature, critical habitat etc) of where delta smelt are and how susceptible they are to entrainement etc.



Figure 1. Catch per unit effort of delta smelt by beach seine and Kodiak trawl within the Sacramento San Joaquin Delta, January through May 2002 to 2007. No Kodiak samples were collected April 2002 through January 2003.

Page 4 – The description of delta smelt relationship to flow has not been well defined. When describing flow relationships, what are some of the classical environmental relationships to a hydrograph? In short, why would flow affect delta smelt? Is it just moving the fish or alter where X2 is? Flow, volume, timing, duration, frequency and magnitude all have demonstrated effects on migratory fish and their habitat. From sediment mobilization to triggering food web dynamics, to migrations. In a paper by Zeug et al (2014), flow management from CVPIA projects not only alters native migratory fish size and survival but life history strategy.

Figure 1 (pg 5) – A map is provided to depict tidal wetland and open water available circa 1950. Why not provide an estimate of acreage? Why not provide all rivers associated with CVPIA? Why only river inflow icons on some river? What is the purpose?

Page 6- confusing section to follow. It is not a part of the environmental setting- more an explanation as to why X2 is used today. Figure 2, what is yellow line? What is blue and green?



Figure 2. Pearson correlation between mean monthly Delta inflow and monthly beach seine minus Spring Kodiak Trawl CPUE. Pearson correlation = 0.641 (p <0.00001).

I would suggest that a life cycle model be provided, including the timing, fish size and general characteristics, and general habitat needs for each life stage. This is critical in evaluating historical impacts (see page 7 discussion where X2 is by season) and PA impacts.

### Environmental Setting (1850-1967)

This section does not clearly articulate environmental setting. For instance, why does it begin with flow relationships? First, clarify why 1850 – 1967 was chosen. Then, clarify from large-scale- California Mediterranean climate – cold-wet to warm-dry seasonality. Flooding and desiccation driving foodweb and productivity. Then the physical and biological changes, from largescale mining, water management, introduced species etc. that changed during this time.

Bay-Delta Estuary- Since PA includes 8000 acres of habitat restoration; shouldn’t historic wetland and tidal habitat estimates be cited to put that into context of what occurred historically? What about sediment and nutrient inputs? Historic flooding? (Quantify figure 1 page 5) Jumping into flow-salinity relationship – why? How does salinity fit into the life cycle of delta smelt? Don’t they disperse/migrate along a salinity gradient?

Page 7 “By 1920, most of the Delta tidal wetlands had been reclaimed”. Not only is this a poor characterization of habitat conversion/destruction/removal, but it provides no measureable terms to put actions into context.

What is the context of striped bass and American shad establishment? What are the ramifications of this? CDFW and others have provided historic list of introductions (Light et al 2005).

Shipping Channel dredging has caused hydrodynamic changes and facilitated species introduction via shipping traffic but what about hydro-chemical effects?

Page 9. Why is Figure 4 put under 1850-1967 heading?

Page 10. How would future development of major storage stop conflict? If average annual water exports have leveled off, then why haven’t we seen rebound in major fish species of interest? This suggests that a graph of annual exports alone isn’t enough. What about annual flow variability?

Page 12. Figure 6. When did Fed and State projects start and how did they affect that pre-project % unimpaired? See first paragraph on page 10. That suggests that a fitted line, long-term is misleading. 1990 => present appears almost flat.

Page 14. Clearly explain language about abundance indices in Figure 8.

Page 16 Figure 8. Years are tiny in figures. Provide year ranges in caption.

Page 18. The discussion of temperature effects and spawning success could benefit from graphics demonstrating life stage timing and environmental conditions conducive to success.

This can then be used to depict how various aspects of the PA might change this. Language suggests spawning may occur from January through June depending on water temperatures.

So are you saying that a female, with appropriate water quality and sufficient food, could produce up to 5 clutches from January through June?

Page 20. The term “disperse” is ambiguous and confusing. Just because delta smelt aren’t migrating specifically up the Sacramento or San Joaquin, doesn’t mean they aren’t migrating to ward environmental conditions conducive to reproductive success. Delta smelt is a seasonal reproductive migrant (diadromous). Variability in migration behavior, not just winter (Sommer et al. 2011). Some DS remain year-round in fresh water, primarily in north Delta (Erkkila et al. 1951; Merz et al. 2011; Sommer et al. 2011; Sommer and Mejia 2013).

For instance, they clearly move toward freshwater, appropriate temperature and turbidity, and if hypotheses about substrate size are correct, they must seek this as well. The concept of “spreading out” suggests they are simply reducing competition or are primarily driven by density dependent behavior. Low salinity is a key driver of movement- this has been a reason for their past description as a semi-anadromous fish. Note that in Table 2 (page 31), the term “adult migration” is used when defining critical habitat.

As mentioned previously, I would suggest a generalized life cycle figure that can be referenced throughout the BiOP. I would further suggest a calendar Gantt chart that depicts the life stages of delta smelt. PA items, including timing could then be laid over this chart to offer a clearer depiction of proposed actions as they relate to specific life cycle and environmental needs.



Figure 3. Conceptual delta smelt life cycle including what is known about general timing, water quality, movement, and size by life stage.

#### Food

Food page 22. This section is disorganized. It should be put into the seasonality of the system and the life cycle of delta smelt.



Figure 4. Relationships between the (A) primary drivers solar declination and precipitation and mean monthly air temperature for Port Chicago Naval Depot, and (B) electro-conductivity (EC), water clarity, surface water temperature, and (C) primary productivity and zooplankton biomass for the 15 zooplankton stations monitored during the pre-clam invasion period (1978 – 1985). Lines represent Locally Weighted Scatterplot Smoother (Lowess), which is the locally weighted fit of the simple curve at sampled points in the domain (Cleveland 1979). Means are standardized for comparisons and presented as Z-scores. Figure from Merz et al. (2016).

In Figure 4(C), note relatively high turbidity in cool wet period most likely associated with fine sediment dispersal due to flow and storm disturbance. Once, clearing phase occurs, phytoplankton increases and zooplankton follows closely after. The second turbidity pulse is most likely a response to primary productivity. There is then a second clearing phase (most likely invertebrate consumption of primary productivity) with a second, smaller pulse in the late summer. In short, before suspension-feeding overbite clam invasion in the mid-1980s, the estuary demonstrated monomictic thermal mixing in which winter turbidity and cool temperatures contributed to seasonally low productivity, followed by a late-spring-summer clearing phase with warm water and peak phytoplankton blooms that continued into early winter.

Overall, Merz et al. (2016) demonstrates abiotic factors and species introductions have trophic interactions including altered food web timing, disrupted life cycles, and changed life history expressions and the temporal scale of population dynamics in zooplankton communities. Following clam invasion (Figure 5), a shift in peak phytoplankton bloom timing occurred, with peak productivity now occurring in May compared to June prior to invasion. Peak abundance of several zooplankton taxa (Eurytemora affinis, Pseudodiaptomus, other calanoids, and non-copepods) also shifted to earlier in season. This suggests a timing shift of peak abundance for zooplankton species that are key prey items of delta smelt. These timing shifts may have exacerbated well-documented food limitations of delta smelt due to declines in primary productivity since the invasion of overbite clam. This suggests that future management actions should consider measures designed to restore the timing and magnitude of pre-invasion phytoplankton blooms. How might the PA flow schedule influence this?



Figure 5. Patterns of water quality variables and Chlorophyll-a and zooplankton within the Estuary associated with the three time periods. Lines of corresponding color represent the Locally Weighted Scatterplot Smoother (Lowess), which is the locally weighted fit of the simple curve at sampled points in the domain for mean monthly measurements (Cleveland 1979). Means were standardized for comparisons. Broken lines indicate the weighted mean month for each measurement for each period.

More background should be given to key environmental parameters, such as food, as they relate to delta smelt life cycle. For instance, USFWS (2004) noted change in food web structure could decrease growth efficiency: “When food ingestion rates are low, gross growth efficiency is low. At low gross growth efficiencies, larval fish take much longer to metamorphose to juveniles. Long larval stage durations increase the likelihood that density dependent mechanisms (e.g. predators, overgrazing of food resources, etc) and density independent mechanisms (e.g. adverse salinities, temperature, absence of zooplankton, water diversion entrainment and impingement mortality, etc) would develop to adversely affect survival and recruitment.”

The Interagency Ecological Program focused on the mismatch between delta smelt larvae and food (Armor et al 2005, Figure 9 & pp. 29-30) whereby a spatial or temporal separation of larvae and food may lead to increased mortality or decreased growth. The concern was specific to larval smelt as the problem was believed to diminish as the swimming ability of delta smelt improved. They observed unusually poor growth rates and condition in fish from Suisun Bay that they did not attribute to contaminants, and therefore deduced the problem was due to food limitations (Armor et al 2005, p. 38; Baxter et al 2008 p. 22). Such food limitations during juvenile development, they suggested, could lead to greater predation, higher disease incidence and lower abundance.

#### Climate Change

Winder and Schindler (2004) provided an excellent example of how climate change is decoupling the food web of the Lake Washington. The Merz et al (2016) manuscript suggests the SFE foodweb behaves similarly to this large lake. I suggest you give more background on seasonality of the SFE and how climate and proposed PA might affect this seasonality.

Fewer “good” turbidity days- what does this mean?

Figure 12 (page 27) – caption should clarify what all acronyms stand for.

##### Recovery and Management

The subject of variable hydrograph is only touched upon with primary focus on the fall. Spring is also a period of productivity and movement yet not mentioned.

#### Conservation Role of Delta Smelt Critical Habitat

This is the first time that “successful completion of the life cycle” is mentioned. It is also the first time I can find where specific life stages are identified. Per Rosenfeld and Hatfield (2006), for species with multiple life history stages, sufficient individuals need to recruit to each life history stage to meet the adult recovery target. When life history stages are dependent on different habitats, separate habitat–abundance relationships, stage-specific population targets, and critical habitat areas need to be defined to meet the adult population recovery target. So, Table 2 should be a critical component of the document and life stage timing and descriptions should be consistent with language through the rest of the document. If science has changed from 1994 to 2016, it seems appropriate to provide the science that supports that change. For instance, “Adults are never fully ripe and ready to spawn before February….” First, this sentence is confusing and can be simplified. “Delta Smelt mature and can successfully spawn after January”. Where is this information from? Suggest a citation column added to support these changes.

#### Primary Constituent Elements

Why are only spawning and adult habitat associations described in “Physical Habitat”?

Again, pelagic and open water as terms to describe the general location of delta smelt are inappropriate.

Turbidity- Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid include clay, silt, very tiny inorganic and organic matter, algae, dissolved colored organic compounds, and plankton and other microscopic organisms. Turbidity should be viewed as a measurement of what causes it. Again, the Lake Washington story provides an example of how complex this subject is. Within the BiOP (and many discussions of delta smelt), turbidity seems to be considered a habitat parameter, more so than the parameters that create turbidity or other conditions that tend to correlate with turbidity. For instance, lake turnover is typically a period of low water clarity and often corresponds with re-suspension of nutrients vital to the food web. Is it possible that relatively low turbidity may be an indication of reduced seasonal disturbance of the estuary that supports seasonal productivity? How might climate change affect this? Again, how might the PA influence this?

Page 38 – What do delta smelt eat by life stage?

Page 39 – River flow and smelt movement- are the mechanisms all the same? Delta smelt don’t have well-formed swim bladders or fins until after ~15 mm TL. This suggest less controlled swimming abilities. See conceptual life cycle provided above.

Page 42 – What was the historic shape of the hydrograph (flow entry and exit) during each of the periods? What causes the turbidity? What was the seasonality of the estuary? How did the environmental conditions known to influence each delta smelt life stage respond to those conditions? How have these changed?

Figure 17 page 43. Entrainment proportional to what? Why the 42 and 66 cm Secchi?

Page 44. What is the value of explaining the delta smelt can survive at relatively high salinities if forced to? It appears that delta smelt move along a gradient and like other fish that utilize freshwater estuaries, especially anadromous fish, while they can tolerate a range of salinities at most life stages, there tends to be preferred levels for each life stage.

### Summary of Status of Delta Smelt Critical Habitat

It seems appropriate that tis summary should be formatted following the life cycle of the delta smelt. This should be reflected in Table 3 as well. “seasonally” should also be defined by period for each life stage.

### Effects of Delta Smelt from Operations of the CVP/SWP

Flow and subsequent environmental responses

Page 4 – what is “meaningful numbers”?

Terms such as “migration”, “dispersal”, and “transport” are vague.

Dispersal is the lengthening of the mean distance between neighboring individuals. Migration is a continued movement in a more or less definite direction, in which both movement and direction are under the control of the animal concerned (Schneider 1962). In many ecological studies, juveniles often disperse from high concentrations due to both controlled and uncontrolled movement. In contrast, migration is often considered intrapopulational, round‐trip movements toward and away from breeding sites. If numerous breeding sites are available, this might give the impression of dispersing but, in fact, adults are moving to appropriate spawning grounds. Furthermore, if a portion of delta smelt move from fresh to saline to fresh water to complete the life cycle, wouldn’t that constitute anadromy?

Page 6 Figure 2. The three regimes displayed in Figure 2 are not discussed anywhere else in the BiOP. If used, it is important to explain in background what they are and why they are meaningful. Why the term “muddy” for secchi =42cm? Is it assumed that substrate disturbance in causing turbidity? What are the red lines?

Table 2- What is difference between OMR Flow vs Index? The term 50% loss threshold is not defined in document.

Page 12 – The swimming ability of delta smelt changes with age/size. We can assume that delta smelt larvae are more susceptible to flow than juveniles and adults. Simonis and Merz (2018) found that juvenile delta smelt density was highly spatiotemporally autocorrelated and strongly tracked prey availability yet was also constrained by local hydrological factors (salinity, turbidity, velocity). They assumed this was partially explained by relatively poor swimming ability. Therefore, how well does particle tracking inform entrainment susceptibility for larvae compared to more developed lifestages?

Figure 7. Why not fit a line to the dots to demonstrate relationship between flow and particle entrainment?

#### Larval and Early Juvenile Entrainment

The modeling predicts (does not show) that conditions in June will be similar between PA and COS. From April through June, OMR flow shall be no more negative than 5,000cfs. What does “similar” mean? DO the models predict more, less or no difference in entrainment for each life stage?

#### Future Increases in Entrainment

Clarify what is meant by “supplementing a wild population that is more resilient to withstanding the effects of entrainment “.

The language surrounding hatchery completion and population supplementation is vague and suggests the schedule is later than the expected loss of population in wild. For instance, production increase goal date is 2025 but hatchery completion is 2030.

Don’t understand “This interim measure will increase the likelihood that the population will be sustained in the wild…” How will hatchery do this?

#### Clifton Court Forebay Aquatic Weed Program

What is the purpose of weed control?

#### Delta Operations

Why are you not clearly laying present and PA flow conditions over delta smelt life cycle?

The water transfer information is written more as a professional opinion. What do the models say? Recognize, all monitoring in the delta now requires an estimate of take. Why does that not occur here?

#### Delta Smelt Summer-Fall Habitat

##### SMSCG Operation

It seems inappropriate that diversions are to be increased yet the gates will be operated ‘experimentally”. How do they propose they will work? Why is this proposed as adaptively operated? If the gate operation doesn’t work, then outflow increased etc.

Pages 24-25 has 2 Figure 12’s.

##### Non-Operational Actions

Hatchery – Language is somewhat ambiguous and suggests hatchery doesn’t come on line until high extinction is predicted. States that no effect of FCCL is expected to delta smelt- what about gene pool? Also, why not build a delta smelt food hatchery? Supplement macroinverterbrate population?

##### Tidal Habitat Restoration

Reclamation is proposing to build the rest of the habitat. However, how is the habitat already built working? Is it providing food? Are delta smelt using it?

Predation Hotspot Removal

Agreed that predator hotspot removal effects on delta smelt is unknown. However, stating that “it is believed that” predation on smelt is driven by macroscopic drivers and therefore not likely to affect predation greatly follows the same logic. Neither is strongly supported.

# References

## Materials Provided Prior to the Review

ICF, 2017. *Public Water Agency 2017 Fall X2 Adaptive Management Plan Proposal.* Draft. Submitted to United States Bureau of Reclamation and Department of Water Resources. ICF 00508.17. August 30, 2017.

Sommer, T., and L. Conrad, 2018. “Suisun Marsh Salinity Control Gates Action.” October 2018.

Sommer, T., L. Conrad, and M. Koller, 2019. *Suisun Marsh Salinity Control Gate Study.* January 2019.

U.S. Bureau of Reclamation, 2019. *Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project*. Final Biological Assessment. Central Valley Project, California Mid-Pacific Region. January 2019.

## Supplemental Materials Review

Aasen, G.A. 1999. Juvenile delta smelt use of shallow-water and channel habitats in California’s Sacramento-San Joaquin Estuary. California Fish and Game 85(4):161-169.

Bennett, W.A. 2005. Critical Assessment of the Delta smelt Population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science, 3(2). jmie\_sfews\_10969. Retrieved from: http://escholarship.org/uc/item/0725n5vk. Last accessed on 9 September 2015

Chotkowski, M., 1999. List of fishes found in San Francisco Bay-Delta shallow water habitats. IEP Newsletter, 12(3), pp.12-8.

Hartman, R., Sherman, S., Contreras, D., Furler, A. and Kok, R., 2019. Characterizing macroinvertebrate community composition and abundance in freshwater tidal wetlands of the Sacramento-San Joaquin Delta. BioRxiv, p.598482.

Hobbs, J.A., W.A. Bennett, and J.E. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low salinity zone of the San Francisco estuary. Journal of Fish Biology 69(3):907-922.

Light, T. T. Grosholz and P. Moyle. 2005. Delta Ecological Survey (Phase I): Nonindigenous aquatic species in the Sacramento-San Joaquin Delta, a Literature Review. Final Report for Agreement #DCN #113322J011 USFWS, Stockton CA.

Merz, J.E., Bergman, P.S., Simonis, J.L., Delaney, D., Pierson, J. and Anders, P., 2016. Long-Term Seasonal Trends in the Prey Community of Delta Smelt (*Hypomesus transpacificus*) Within the Sacramento-San Joaquin Delta, California. Estuaries and Coasts, 39(5), pp.1526-1536.

Moyle, P.B. 2002. Delta smelt, *Hypomesus transpacificus* McAllister. In Inland Fishes of California, ed. P.B. Moyle, 227-232. Revised and expanded. University of California Press.

Schneider, F., 1962. Dispersal and migration. Annual Review of Entomology, 7(1), pp.223-242.

Sommer, T., F. Mejia, M. Nobriga, F. Feyrer, and L. Grimaldo. 2011. The spawning migration of delta smelt in the upper San Francisco Estuary. San Francisco Estuary and Watershed Science 9(2). Available from: http://escholarship.org/uc/item/86m0g5sz. Last accessed on 9 September 2015.

Winder, M. and D.E. Schindler 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology 85(8): 2100–2106.

Winder, M., D.E. Schindler, T.E. Essington, and A.H. Litt. 2009. Disrupted seasonal clockwork in the population dynamics of a freshwater copepod by climate warming. Limnology and Oceanography 54:2493-2505.

Zeug, S.C., Sellheim, K., Watry, C., Wikert, J.D. and Merz, J., 2014. Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries management and ecology, 21(2), pp.155-168.