Draft Analytical Approach for Analysis of Longfin Smelt Take from Implementation of the Proposed California WaterFix[1]

Introduction

The California Endangered Species Act (CESA) prohibits take of species listed by the state as endangered, threatened or candidate species (California Fish and Game Code [Fish & Game Code] § 2080). Section 86 of the Fish & Game Code defines *take* as to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." The California Department of Fish and Wildlife (CDFW) may authorize take that is otherwise prohibited by Section 2080 with an incidental take permit (ITP). The requirements for an application for an ITP under CESA are described in the California Code of Regulations (CCR) (14 CCR 783.2). CDFW may issue an ITP if it finds that all of the following criteria are true.

- The take authorized will be incidental to an otherwise lawful activity.
- The applicant will minimize and fully mitigate the impacts of the take authorized.
- The measures required to meet the permit obligations will be roughly proportional in extent to the impact of the authorized taking on the species. Where various measures are available to meet this obligation, the measures required will maintain the applicant's objectives to the greatest extent possible. All required measures will be capable of successful implementation.
- The permit will be consistent with any regulations adopted pursuant to Fish & Game Code Sections 2112 and 2114.
- The applicant has ensured adequate funding to implement the measures required under the permit to minimize and fully mitigate the impacts of the taking, and to monitor compliance with, and the effectiveness of, the measures.
- The issuance of the permit will not jeopardize the continued existence of the species.

The Department of Water Resources intends to submit an application for authorization of incidental take associated with construction and operations of the proposed California WaterFix project, which is described in Chapter 3 and associated appendices of the *Biological Assessment* that accompanies this submittal. Subsection (a)(6) of 14 CCR 783.2. requires that the application include "An analysis of the impacts of the proposed taking on the species". The following report provides a description of the analytical framework proposed to be used for the incidental take analysis for longfin smelt.

[1] This analysis will be used in Department of Water Resources' permit application to California Department of Fish and Wildlife for issuance of incidental take under Section 2081(b) of the Fish and Game Code.

Summary of factors that affect abundance of Longfin Smelt

Entrainment

Salvage of juvenile and adult Longfin Smelt at the SWP and CVP is relatively low during most water year types. Salvage increases as OMR flows become more negative (Grimaldo *et al.* 2009), suggesting that management actions to reduce negative OMR flows for Delta Smelt and salmonids during the winter and spring will likewise benefit Longfin Smelt because they are salvaged during the same time period (Grimaldo *et al.* 2009). It is believed that larval Longfin Smelt can be entrained in high numbers (see Baxter *et al.* 2010), however because the SWP and CVP salvage facilities do not count fish less than 20-mm SL, it is difficult to ascertain how many larvae are entrained. Similar to methods used in the DFW ITP for the SWP/CVP (California Department of Fish and Game 2009a), the effects of the proposed project on larval entrainment were assessed with a Particle Tracking Modeling (PTM). As described below, insertion points and outcomes were estimated with reference to Smelt Larval Survey data.

Outflow-abundance Relationship

There is a strong positive relationship between Longfin Smelt fall midwater trawl (FMWT[2]) abundance index and winter-spring outflow, suggesting that increased Delta outflow promotes conditions that increase survival of larvae and small juveniles during winter and spring, producing increased abundance during fall of the first year of life. The slope of this relationship has remained the same over the last three decades but there have been two notable downward shifts in the intercept of this statistical description of juvenile relative abundance; the first followed the introduction of the overbite clam in 1987 and the second occurred during the Pelagic Organism Decline of the early 2000s, suggesting that reduced food supply contributed to lower Longfin Smelt abundance after 1987, with unknown factors resulting in the second downward step change in the early 2000s (Thomson *et al.* 2010).

The mechanisms underlying the positive outflow-abundance relationship remain unknown (Kimmerer *et al.* 2009). DFW (California Department of Fish and Game 2009b) hypothesized that high outflows transport Longfin Smelt larvae from upstream freshwater spawning habitats to downstream low salinity rearing areas which leads to higher growth and survival; greater dispersal may also be of importance. Studies by Grimaldo *et al.* (2014) indicate that spawning and hatching of larvae occur over a range of low salinity water (0 to 8 ppt), not just in freshwater. In addition, previous work shows that Longfin Smelt that hatch in low salinity water up to 4 ppt have higher survival than larvae hatched in freshwater or more saline water (Hobbs *et al.* 2010). Thus, transport flows alone cannot sufficiently explain the suite of mechanisms that likely contribute to the Longfin Smelt flow-abundance relationship. Grimaldo *et al.* (2014) hypothesize that availability of suitable spawning habitat, which includes open shallow water and tidal marsh channels, contributes to successful larval recruitment. Further, they hypothesize that available spawning habitat increases as outflow increases because there are more marshes and shallow habitat west of the confluence of the Sacramento-San Joaquin Rivers.

Kimmerer *et al.* (2009) speculate that the Longfin Smelt outflow-abundance relationship could be explained by increased gravitational circulation and subsequent retention of Longfin Smelt within the estuary during extended high outflow periods (Figure 1). Under sustained high outflows, salinity stratification intensifies as the underlying salt wedge moves further upstream to the shallow waters of

[2] The fall midwater trawl index is considered the standard index of relative abundance for several pelagic fishes in the San Francisco Estuary; see https://www.wildlife.ca.gov/Conservation/Delta/Fall-Midwater-Trawl for further information.

Suisun Bay, which increases retention of organisms behaving like passive particles (e.g., phytoplankton) and facilitates increased retention of fish.

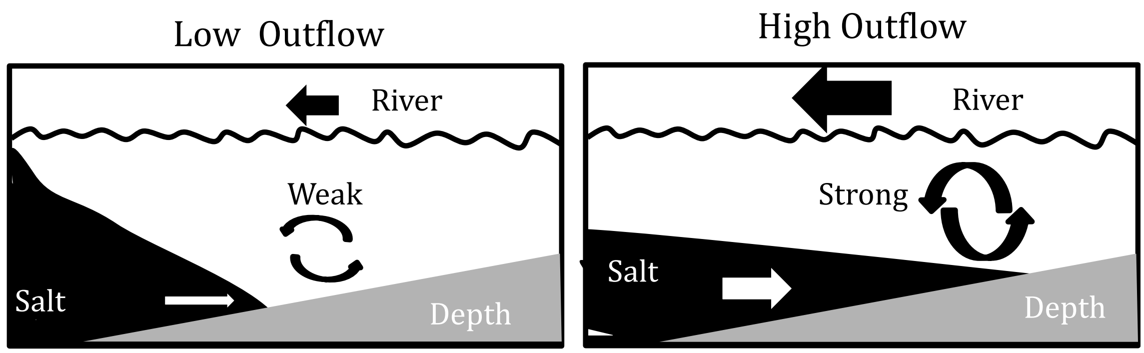

Figure 1. Conceptual Model of the Effect of Outflow on Stratification and Retention.

An understanding of the mechanisms that interact to affect Longfin Smelt will help DWR and DFW develop outflow objectives to benefit the Longfin Smelt population. For example, if the mechanism underlying the flow-abundance relationship is related to suitable spawning habitat, the outflow objective may be achieved through actions that promote intersecting stationary and dynamic (physical-chemical) habitat (Peterson 2003).

Analyses to be Included in the 2081 Permit Application

A number of potential analyses exist to better understand how proposed project operations could affect some key mechanisms that underlie Longfin Smelt abundance in the estuary, which could be used in order to inform the take analysis:

1. Evaluate larval entrainment risk and transport fate using a DSM2-based PTM analysis.[3]
2. Evaluate how abundance changes using the Kimmerer *et al.* (2009) flow-abundance relationships.
3. Evaluate abiotic habitat extent using the 3D UnTRIM model, and use 3D PTM based on UnTRIM outputs to assess how gravitational circulation changes retention in different geographic areas/salinity ranges over low and high outflows.
4. Examine marsh habitat overlap with dynamic (salinity-related) habitat by linking GIS analysis with UnTRIM and PTM output.

Methods for 1 and 2 above are relatively straightforward and were used in similar form in 2013 for the public draft BDCP; however, entrainment risk was revisited for the present take analysis using Smelt Larval Survey data, not the Striped Bass Egg and Larval Survey data as was done previously in the 2009 DFW Incidental Take Permit (California Department of Fish and Game 2009a); the fuller accounting of spatial distribution from the Smelt Larval Survey data, as opposed to focusing only on entrainment from locations within the Delta based on the Striped Bass Egg and Larval study data, provides a broader

[3] Note that the analysis of larval retention under bullet 3 also includes assessment of entrainment by various water diversions using outputs of the PTM associated with the UnTRIM outputs.

perspective on potential entrainment risk. A particle tracking starting distribution was developed to reflect these data and included the PTM-based analysis in a draft take analysis provided to CDFW on 11/3/2015. Also included in the draft take analysis was the potential effect of changes in winter-spring outflow based on the regression relationships from Kimmerer *et al.* (2009), calculated without consideration of a step change and including 95% confidence intervals based on the X2 coefficients[4].

Methods 3 and 4 above will not be used as part of the take analysis in the 2081 permit application. It was determined that the effort required to complete these analyses was greater than time will allow, and because CWF operations will not commence until water conveyance construction is complete (ca. 2030), these analyses, along with other research and monitoring efforts, can be conducted after 2081 permit issuance to better understand the ecology of Longfin Smelt and the strength of operational effects on their recruitment. If necessary, the permit could be amended on the basis of those findings. These two studies would be included as part of the Science Program to support future collaborative science and adaptive management activities proposed in the 2081 Application (described further in Section 3.4.7 of the accompanying *Biological Assessment*). DWR is committed to implementing these analyses in conjunction with the Longfin Smelt settlement agreement studies, which could ultimately be used to help adjust project operations if appropriate for Longfin Smelt. These analyses will also facilitate greater understanding of the factors that could be affecting the species and inform other management or regulatory decisions as they relate to Longfin smelt.

In comments provided on the 11/3/2015 draft take analysis, DFW had concerns regarding the frequency, location, and unresolved fate of particles from the 45 day PTM analysis. Regional density differences were taken into account, but not temporal (across survey) differences. Taking means of means reduces variability across water year types. Ideally CDFW desires bi-weekly injections, injection locations, number of particles injected, a greater temporal period for particle transport (i.e., 90 days), and additional flux locations to better illustrate the fate of unresolved particles (i.e., particles that do not reach Chipps Island or the CVP/SWP south Delta export facilities)[5]. More details regarding the method and approach to the PTM analyses have been requested by CDFW. Additionally CDFW was concerned with the method of calculation of abundance index confidence intervals for the outflow/abundance regressions based on Kimmerer *et al.* (2009). Because the published paper does not provide confidence intervals for all coefficients, the most recently updated fall midwater trawl index and Delta outflow data were obtained in order to provide a similar approach based on general linear modeling, for which confidence intervals have been calculated incorporating all sources of variation for all coefficients. Responses to both of these concerns and some new analysis were provided in a revised take analysis submitted to CDFW on 1/20/2016, as reflected in the document <2081_Ch04 2_Take_Analysis_longfin_smelt_01202016_CLEAN.docx> (provided as part of the review materials).

DFW's comments provided on the draft take analysis noted that analysis of entrainment of adult and juvenile life stages had not been included in the draft take analysis, and suggested that a quantitative or

[4] The regressions show the relationship between Longfin Smelt fall midwater trawl index and the mean position of the near-bottom 2-ppt salinity isohaline, known as X2, from January-June of the same year; see Jassby et al. (1995) for an explanation of the conceptual model behind examining these relationships.

[5] CDFW notes that there is evidence (spring of 2012) that reduced south Delta export pumping and low outflows in the hatching/larval period are capable of translating to increased juvenile salvage. Essentially, larvae may have been unable to exit the central and south Delta because of low flows, and subsequently grew large enough to be counted in salvage (only fish 20 mm and larger are measured). For this reason, CDFW suggests further exploration of the fate of unresolved particles from the PTM.

qualitative approach could be used to address this omission. In the 1/20/2016 revised take analysis, a qualitative assessment based on observed relationships between salvage and Old and Middle River (OMR) flows described by Grimaldo *et al.* (2009) was provided, in consideration of CalSim-modeled differences in OMR flows between proposed project and no action alternative scenarios.

Further Take Analysis to be Conducted

As the 2081 Application is still in development, certain analyses have been discussed with CDFW but have not yet been completed. The following discussion describes those analyses and their role in the take analysis. The CDFW-requested analysis are as follows (request in bold, proposed approach beneath it):

1) **An analysis of the extent to which the proposed project could result in take and the effects of that taking. Rather than a comparison to existing levels of take resulting from current SWP operations, this would be an analysis of the absolute levels and impacts of take anticipated to result from the proposed project.**
    a. Under the assumption that the larval % entrainment estimate from DSM2-PTM is an accurate reflection of absolute entrainment potential, this estimate would be used as an estimate of absolute take of larvae (which could be converted to number of larvae if necessary), which would then be considered together with the take of other life stages in order to address the request identified by DFW.
    b. The X2/outflow-abundance analyses (Kimmerer *et al.* 2009; GLM-based analysis included in revised draft take analysis) provide an index of a difference from baseline, which in essence is the proportion of the population that did not survive but otherwise could have. This could be converted to an absolute number of fish if overall abundance can be estimated, but in view of the great uncertainty in total abundance, is probably best expressed as a proportion. These results would then be used to estimate of take of the juvenile life stages, which would be considered together with the take of other life stages in order to address the request identified by DFW.
    c. For adult and juvenile south Delta entrainment, the analysis would describe the range in observed salvage for water years 2009 to 2015, noting that based on the modeling, this magnitude of entrainment or lower would be expected to continue under CWF.
    d. For north Delta diversion (NDD) effects, the analysis would present a qualitative discussion of the proportion of the Longfin Smelt population that would be expected to occur near the NDD, akin to the analysis presented in *Biological Assessment* Section 6.1.3.2.1.4.2, *Population-Level Effects*, addressing effects on Delta Smelt.
2) **Using the take results from the analyses described above, consolidate the take from multiple sources (i.e., entrainment and flow effects and take associated with other SWP facilities proposed for ITP coverage) to express total proposed CWF take in either absolute or "proportion of population" terms.**
    a. Take in terms of larval survival would already be expressed as a proportion of the population (see bullet 4a above); an additional source of take that could be estimated based on PTM would be at the North Bay Aqueduct Barker Slough Pumping Plant (the estimates are included in the draft take analysis).

b. Adult absolute estimates of take by south Delta entrainment can be expressed in a population-level context by making estimates of population size using a similar extrapolation methodology to that used by DWR (2009) in the ITP application for the SWP, or the method used by the federal and state water contractors in comments included as part of the California Department of Fish and Game (2009b) status update for Longfin Smelt; in fact, it may simply be more straightforward to provide the estimates contained in those documents in order to provide context, as any updates to those analyses would be expected to result in similar estimates. The most suitable approach would be discussed with DWR and DFW before being implemented.

c. Similarly, absolute estimates of juvenile take by south Delta entrainment can be expressed in a population-level context in a manner similar to that used by the federal and state water contractors in comments included as part of the California Department of Fish and Game (2009b) status update for Longfin Smelt, i.e., volumetric extrapolation based on net efficiency adjustments (using relationships established for Delta Smelt by Kimmerer [2008]). Because of the potential overlap with the estimates of larval take from the PTM-based analysis, this analysis would include only the proportion of the population of salvageable size. ICF will discuss the most suitable approach with DWR and DFW, then implement it.

d. Analyses of the proportion of the population that could be taken would combine the various sources of information presented above, i.e., entrainment proportion, proportional effects of winter/spring Delta outflow on abundance, and the very small proportion of Longfin Smelt that could be taken at the NDD.

3) Using the take values derived from the foregoing analyses, present a population analysis that estimates the cumulative effect of proposed project take on the abundance of Longfin Smelt over the term of the ITP.

a. It is unlikely that the take estimates related to entrainment provided to address request 2, above, would inform a useful population analysis, because studies have not shown entrainment (or its proxies, such as OMR flows or exports) to be a driver of population dynamics (Mac Nally *et al.* 2010; Thomson *et al.* 2010; Maunder *et al.* 2015).

b. As previously discussed, an important driver of population patterns appears to be winter/spring outflow/X2; however, as noted in the revised draft take analysis provided to DFW on 1/20/2016 (<2081_Ch04 2_Take_Analysis_longfin_smelt_01202016_CLEAN.docx>; see review materials provided), the existing published analyses examining population dynamics either do not include an outflow/X2 term (Maunder *et al.* 2015) or else had various issues with model fit (Nobriga and Rosenfield 2016), which would result in these models not being useful to estimate effects over time in the manner that DFW requested. In addition (and as discussed in the revised draft take analysis), the exploration by Nobriga and Rosenfield (2016) suggested that Delta outflow effects may subsequently be tempered by density-dependent survival in the juvenile life stage (occurring in marine or mesohaline waters), which suggests that small effects of slightly lower Delta outflow under the proposed project may not accumulate over time. It is therefore proposed to retain only this qualitative discussion in the take analysis to address DFW's request, as opposed to pursuing a quantitative approach.

It is important to note that the take analysis is a work in progress, with the materials provided for review current as of the 1/20/2016 draft; however, the core analyses included in that draft remain.

Materials Provided for Review

The following files are provided for review in relation to the longfin smelt take analysis:

- Draft take analysis: <2081_Ch04 2_Take_Analysis_longfin_smelt_01202016_CLEAN.docx>
- Draft appendix with Longfin Smelt quantitative analyses: < App_4.A Longfin smelt_01202016_CLEAN.docx>
- Particle tracking modeling outputs: < Jan_Apr_45day_PTM_results_QA_081315.xlsx>

In addition, Appendices 5.A and 5.B provided as part of the Biological Assessment review materials are relevant to the review of the Longfin Smelt take analysis.

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