Draft Outline of a Scope of Work for
Factors Affecting Adult Delta Smelt Entrainment
CAMT Workplan Element 3-2-1
(to address CAMT Progress Report 2/7/14 Table 3-2, Element 1)

Note: Comments from Scoping Team members have purposefully be left in this document to provide additional context for investigators and reviewers regarding the discussion of entrainment.

Work Element 3-2-1: *Assess factors affecting adult Delta Smelt entrainment.*

Investigators:

Rick Deriso, ATTC
Lenny Grimaldo, ICF (Lead Investigator)
Ed Gross, RMA
Josh Korman, Ecometrics
Bryan Manly, West Inc.
Mark Maunder, ATTC
Matt Nobriga, USFWS
Pete Smith, retired USGS

Goal/Purpose: The goal of this element of the workplan is to identify the circumstances that produce entrainment events particularly those events that might have substantial population level consequences.

Relevance/Rationale: *A better understanding of the conditions that lead to adult movements into high risk* or low risk *entrainment areas could allow for identification of* additional *management actions that could be used to reduce entrainment* while at the same time allowing for improvement in water supplies.

Key Questions: What conditions determine the proportion of adult delta smelt in the central Delta, and given those conditions, what factors lead to entrainment of the fish?

a. *How should winter "first flush" be defined for the purposes of identifying entrainment risk and managing take of Delta Smelt at the south Delta facilities?*
b. What is the distribution and relative abundance of delta smelt across seasons both in the central and south Delta and elsewhere within its range?
c. *What* combination of habitat *conditions (e.g. first flush, turbidity* levels and gradients, salinity levels and gradients, relative flows, *food, time of year*, stage of maturity, prior distribution) *lead to adult Delta Smelt* in the area of the confluence to *enter and occupy the central and south Delta?* That is, what causes some fraction of the fish to move from the

Comment [mln1]: This is not an "unknown". There has been general agreement among CAMT subgroup participants and invited experts that we've got the major drivers of this part figured out.

It is the first part and the behavioral mechanics that we can learn more about.

Comment [SAH2]: I agree with Matt that there seems to be general agreement that turbidity, OMR, prior distribution, water temperature, salinity and perhaps food distribution influence entrainment. But I don't think we understand well enough how these factors work in concert to allow us to model with confidence entrainment events and non-events.

Comment [mln3]: This is routinely monitored and thus will seem odd to potential readers. The question is more along the lines of "How well do existing monitoring surveys characterize the distribution and relative abundance of delta smelt?"

Comment [SAH4]: Once again I agree with Matt. But how does one answer the question Matt is asking? An alternative way of asking Matt's questions might be: Under what circumstances is the distribution of adult delta smelt in the SKT survey not likely to accurately characterize the actual distribution? Is this a question we should address under 3-1-1?

Version	Date	Author	Change Description
2.0	10/23/14	Scott Hamilton, Bruce DiGennaro	Incorporates scoping team comments into a cleaner version. Track changes removed. Team updated.

c. confluence in certain directions and not others?
d. When Delta smelt are in the central Delta, what factors (e.g. positive OMR flows, turbidity gradients, food, temperature), if any, have been associated with movement back out of the Central Delta?
e. To what degree has implementation of RPA reduced Delta Smelt entrainment, and at what water cost?

Possible Investigative Approach:

1. Adopt or develop a conceptual model that is consistent with the most recent thinking, reflected in the CAMT Report and subsequently, on factors that lead to entrainment using the best available information on the distribution and abundance of delta smelt, on inter-annual and inter-seasonal variation in salient habitat factors, and on the hydrodynamics of the regulated Delta.

2. Utilizing findings from the team reviewing monitoring methods for delta smelt, researchers should consider how existing data sets can be utilized to address the questions raised in this work plan element.

3. Use historical data to test the conceptual model and explain entrainment events and periods without entrainment; explicitly considering – what constitutes a first flush, the timing of first flush events, turbidity levels and gradients, Sacramento River flows, OMR flows, pre-event delta smelt distribution, the density and distribution of zooplankton and larval fishes, water temperature, and local-scale conditions (flow velocities, gradients in essential physical and biotic factors).

4. If time permits, Model delta smelt movement, linking behavior, habitat suitability and Delta hydrodynamics. Apply models that consider delta smelt behavior and flows to examine conditions that initiate delta smelt dispersal and that influence the direction of movements at key geographic locations from which delta smelt may move into areas influenced by water project operations (including the confluence and 3 Mile Slough). Behavioral responses to asymmetries of tides and turbidity, salinity, temperature, turbidity and flow velocities over tidal cycles should be considered.
    a. Utilize existing behavior models (e.g. RMA model) if appropriate.
    b. Consider delta smelt behavior under varying environmental conditions (e.g. Anderson et al. 2013 -- LOBO panel report,

Comment [mln5]: I think it is pretty well established (as implied elsewhere in this doc) that turbidity is a major driver of what water delta smelt choose to occupy. Adult diets are much more diverse than those of younger fish. As a result, it might be pretty tricky to make a compelling statement about when and where food is higher or lower without making a bunch of simplifying assumptions.

Comment [SAH6]: No disagreement. I would expect food to be lower on the list of factors affecting distribution in the spring. The question that needs answering is: is it on the list at all, and if so, how to we characterize it? Hence the need for this work.

Comment [mln7]: Why only this parameter? Are we interested in the correlation between Sacto flows and turbidity – in other words are we asking for a test of Manly's model?

Comment [mln8]: There is not much available information on prey for adult delta smelt (i.e., few reasonably concurrent samples). In addition, they eat a lot more things than the younger life stages so no single survey can characterize "food". It's a combination of copepods (CB samples), mysids (mysid trawls), amphipods and other similarly sized epibenthic crustaceans (not monitored unless reported in benthic surveys) and larval fishes (smelt larval survey/20-mm). The spatial coverage of these surveys is inconsistent – EMP's surveys sample fewer times and places than larval fish surveys except for CB samples collected along with larval fishes – but those data sets lag a couple years behind the fish ID because it is very specialized and labor intensive work that is lower priority than the fish ID.

The bigger catch is that the prey densities that cause smelt to switch from one prey to another are not known so even if all of the data sets get compiled and linked to FMWT or SKTS distributions, this will be a very exploratory analysis.

Comment [SAH9]: I recognize Matt's concern, but haven't others found food to be important? And it seems to vary greatly by region. Is this an area where our understanding could improve?

Comment [mln10]: This topic has had high degrees of support in the subgroups last two meetings. It was also recommended to the Service by our LOBO review panel last fall. We consider this a very high priority.

Comment [SAH11]: Again I agree with Matt about this being a high priority item. But it seems our understanding of factors affecting entrainment, beyond OMR and turbidity, is lacking. How do we build better models without a better understanding of the mechanisms? The suggestion implicit in this work plan, is that we test the conceptual models to better identify the mechanisms, and then build better explanatory and predictive models.

Version	Date	Author	Change Description
2.0	10/23/14	Scott Hamilton, Bruce DiGennaro	Incorporates scoping team comments into a cleaner version. Track changes removed. Team updated.

Appendix 4).

c. Develop probability of detection distributions for delta smelt under different environmental conditions.
d. Examine range of environmental conditions and corresponding geographic distributions.
e. Identify targeted physical and biotic variables (or surrogate measures) to be used to assess local conditions (and threshold conditions) that can be used predict high- and low-risk entrainment events probabilities (in the future).
f. Determine the smaller-scale conditions that interact with landscape-scale factors and phenomena to influence delta smelt behavior and movement.

Investigative Challenges:

Entrainment is difficult to quantify. Salvage may be a poor indicator of entrainment, and even if it were to be accurate, considerable uncertainty surrounds delta-wide and local population estimates. An alternative potential measure of entrainment impact, the proportion of delta smelt in the south Delta, is also subject to substantial assumptions and sampling error.

Comment [mln12]: There is no analysis of field data that is immune to assumptions and sampling error. The real investigative challenge is that these analyses require compilation of datasets that are collected at different spatial-temporal scales and that they may require the use of sophisticated statistical or modeling approaches to generate a better level of scientific understanding than we already have.

Methods:

To be determined by investigators. Should include specific hypotheses to be tested and information on covariates of interest, relevant data sets, and statistical approaches and methods.

Resources available to investigators:
IEP fish survey data, including catch per unit effort and abiotic data
Larval survey data and some concurrent zooplankton data
Synthetic turbidity data
Bathymetry and water volume data
Flow velocity data
Zooplankton survey data
Benthic survey data
Phytoplankton data
Data from continuous recorders;
Salvage data
Dayflow data
GIS services,
Bay-Delta Live Visualization tools
Hydrodynamic models
Informal discussion or review with scoping group members and advisors.

Version	Date	Author	Change Description
2.0	10/23/14	Scott Hamilton, Bruce DiGennaro	Incorporates scoping team comments into a cleaner version. Track changes removed. Team updated.

Example Draft Hypotheses:

The probability of observing adult Delta Smelt in the central and south Delta is significantly higher following the first major increase in Delta inflow (e.g. >25,000 cfs), which contributes to rising turbidity levels in the central and south Delta.

Comment [SAH13]: If researches believe this questions has already been addressed there is no need to reconsider it.

The proportion of adult delta smelt in the central delta in the period from December through March is determined by the prior distribution of delta smelt in the vicinity of the confluence and absolute and relative abiotic conditions (primarily velocity and turbidity) in the San Joaquin River.

The relative salvage of adult delta smelt from December through March is determined by a non-linear interaction among three factors, the proportion of adults in the central and south delta during that period, water clarity (turbidity) near the pumps, and net flows in OMR.

Comment [SAH14]: This question may have already been answered. Models I have seen to date include turbidity and OMR but without a link to the distribution. Including this component is important and may have already been done.

Applications of Findings To Management:

Identifying the factors that influence entrainment may help develop new management strategies to reduce or prevent entrainment, and can be used to identify periods of low entrainment risk, when additional water may be exported without jeopardizing the delta smelt population. For example, strategies that limit the turbidity in the central delta at key times may limit the presence (and abundance) of delta smelt at that location.

Technology Transfer:

Investigators should be prepared to provide a written report, manuscript, and presentation of findings to CSAMP. Investigators should provide data sets, including covariates utilized in analyses, and any model that have been developed, to the scoping group at the completion of the study.

Version	Date	Author	Change Description
2.0	10/23/14	Scott Hamilton, Bruce DiGennaro	Incorporates scoping team comments into a cleaner version. Track changes removed. Team updated.