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Progress Report to the! Collaborative Science Policy Group!

Prepared'by:'

The'Collaborative'Adaptive'Management'Team'(CAMT)'

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February'14,'2014'

[Version!6.1!FINAL]!

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1.0 Introduction

Purpose

This document provides a nine-month progress report on the establishment of a new Collaborative Science and Adaptive Management Program (CSAMP) being undertaken in the Sacramento—San Joaquin Delta.

Content

The report documents the organization, activities, and initial outcomes of a series of meetings and workshops held by the program's Collaborative Adaptive Management Team ("CAMT") operating under the leadership and guidance of the Collaborative Science Policy Group ("Policy Group"). Further, the report includes initial workplans for three broad topic areas that emerged as sources of significant disagreement among participants. Lastly, the report includes relevant background information, a discussion of the framework and process needed to successfully implement collaborative science and adaptive management, a summary of the current and future activities planned as part of the CSAMP, and highlights of the collaboration efforts currently underway.

General Background

The CSAMP was launched following a decision by the United States District Court for the Eastern District of California on April 9, 2013 entitled "Memorandum Decision and Order regarding Motion to Extend Remand Schedule" ("Court Order"), issued in response to a motion to extend the court-ordered remand schedule for completing revisions to salmon (NMFS 2009) and Delta Smelt (FWS 2008) Biological Opinions ("BiOps").

The Court Order allowed the parties making the motion (i.e., U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the California Department of Water Resources) additional time for the development of a proposed "robust science and adaptive management program, with collaboration of the scientists and experts from the Public Water Agencies ('PWAs') and the NGO community" intended to "inform the development and implementation of the BiOps" (Lohoefener 2012 and included in O'Neill 2013).

Organization

Following the issuance of the Court Order, a two-tiered organizational structure was established to implement CSAMP comprised of: (1) a Policy Group made up of agency directors and top-level executives from the entities involved in the litigation, and (2) the CAMT including designated managers and scientists to serve as a working group functioning under the direction of the Policy Group.

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Mission Statement

The CAMT arrived at the following mission statement at its July 23, 2013 meeting:

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> The Collaborative Adaptive Management Team (CAMT) will work, with a sense of urgency, to develop a robust science and adaptive management program that will inform both the implementation of the current Biological Opinions, including interim* operations; and the development of revised Biological Opinions.
>
> *The term "interim" refers to the period during which revised Biological Opinions are being developed.

CAMT Behavioral Norms

At its first meeting on June 11, 2013, the CAMT expressed a willingness to work together according to behavioral norms proposed by Jim Beck, General Manager of the Kern County Water Agency and a member of the Policy Group. Beck suggested that throughout its deliberations, CAMT members should strive to be:

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- **Transparent:** Significant communication regularly occurring with all participating parties present.
- **Accessible:** Ability for everyone to be heard and participate in the dialogue.
- **Solution-Oriented:** Looking for how to get things done.
- **Honest:** Direct without being disrespectful.
- **Timely:** Issues raised are addressed in a rapid manner, and schedules are met.
- **Creative:** Willingness to think outside the box.
- **Open Minded:** Willingness to truly consider all points of view – even when "I know I am right."

Disagreements and Collaborative Science

At the outset, it should be stated that strong disagreements persist among CAMT members regarding the state of knowledge in certain areas of importance to water project operations. Nonetheless, all CAMT members strongly support collaborative science; and in spite of unresolved differences regarding the premises, formulation, and management implications of certain workplan elements, CAMT has chosen to be as inclusive as possible in the content of topic area workplans.

!

CAMT members agreed that a collaborative approach to science offered a means of improving decision-making and reducing disagreements resulting from factual uncertainties, provided that the collaborative approach relies on accepted standards for scientific analysis and review. Consequently, CSAMP studies will need to be pursued with as much scientific rigor as is possible, and without bias.

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The CAMT hopes that the results will help refine the understanding of biological processes, the role of water project operations, and other forces in determining biological outcomes. The CAMT believes the development of reliable information through collaborative, inclusive scientific studies will help reduce disagreements over time.

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Identification of Priority Topics for 2013

Addressing the need to focus on specific topic areas of urgency and relevance to CAMT members, a preliminary list of potential topics was developed at the June 25, 2013 CAMT meeting, together with a list of screening considerations to assist in arriving at a short list of priorities. Those considerations identified by CAMT members are included in Table 1-3 below.

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It is important to note that this list is a compilation of diverse factors offered by individual CAMT members during a brainstorming exercise. Consequently, the relative importance of each item varies considerably among individuals, with some CAMT members assigning no importance to certain of the considerations listed.

Table 1-1

Considerations for CAMT Near-term Priorities
SCOPE
Are the activities within the Delta?
Does it address the issues defined as part of the remand process?
EFFECTIVENESS
Is there the potential for significant, meaningful results that can inform management actions?
Is there a potential for significant near-term benefits to fish species?
Is there the potential to significantly reduce uncertainty and increase understanding?
EFFICIENCY
Is there a potential for using water supply to provide fish protection more efficiently?
Is this an opportunity to show fish protection and water supply can be managed together?
Can results be achieved in a timely manner?
RESOURCE AVAILABILTY
Does it reinforce and capitalize on successful existing efforts?
Is there capacity (staffing) and capability (funding) available in the time remaining?
TEAM BUILDING
Could is this be an opportunity to demonstrate successful adaptive management?
Is this an opportunity to strengthen the trust and relationships among the participants?

Source: CAMT Meeting #2 Minutes (June 25, 2013)

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Following group discussions of both topic areas and relevant screening questions, the CAMT agreed upon four general topic areas for further development. They included:

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- Old and Middle River (OMR) Flow Management and Entrainment of Delta Smelt, Longfin Smelt, and Salmonids,
- Fall Outflow Management for Delta Smelt,
- South Delta Salmonid Survival, and the
- Effectiveness of Habitat Restoration.

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At a July 25, 2013 progress update meeting of the CAMT Co-Chairs and the Policy Group, several Policy Group members questioned whether or not the CAMT had the time and resources needed to complete all four of the topic areas selected. The Co-Chairs agreed to take the issue

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up!with!the!full!CAMT!and!render!a!final!decision.!At!its!August!27,!2013!meeting!the!CAMT!agreed!to!table!further!investigation!of!the!Effectiveness!of!Habitat!Restoration!until!March!2014.!At!that!point,!the!final!list!of!initial!topic!areas!was!confirmed!(see!Table!13-2).!

Table 1^2: Final List of CAMT 2013 Priority Topic Areas

Topic Area	Regulatory Framework
Fall Outflow Management for Delta Smelt	FWS,!CDFW!
OMR Management and Entrainment of Delta Smelt	FWS,!CDFW!
South Delta Salmonid Survival	NMFS,!CDFW!

Relationships to other Adaptive Management Programs and Research

Finally,!it!should!be!noted!that!there!are!several!research!programs!and!adaptive!management!efforts!currently!underway!outside!of!the!CSAMP.!The!CSAMP!does!not!replace!these!efforts!or!reduce!their!importance.!Instead,!the!CSAMP!will!supplement!and!inform!them.!

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The!CSAMP!will!provide!a!new!approach!to!integrating!stakeholder!points!of!view!into!these!processes,!or!to!create!new!groups!if!necessary!to!collaboratively!address!remand-related!questions.!The!CAMT's!intent!is!to!ensure!that!disagreement!about!the!basis!for!and!effectiveness!of!the!RPAs!be!addressed!by!a!science-based!process!that!is!legitimate,!credible,!and!relevant!to!stakeholder!concerns.!

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2.0'Process'Framework'

Introduction'

In!addition!to!focusing!on!the!development!of!individual!workplans!for!the!priority!to pic!areas! presented!in!Table!132,!CAMT!members!particip ated!in!regular!discussions!regarding!the! framework!and!process!for!both!the!design!and!implementation!of!recommendations!contained! in!this!report,!as!well!as!an!ongoing!process!for!collaborative!science!and!adaptive!management! during!the!current!revision!of!the!BiOps!and!over!the!longer!term.!

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At!the!foundation!of!the!CAMT!process!is!its!mission!"to!develop!a!robust!science!and!adaptive! management!program"!with!increased!collaboration!among!state!and!federal!agencies,!PWAs,! and!NGOs!that!are!parties!to!the!remand!process.!In!the!court!exhibit!entitled,!Federal!and!State! Proposal!for!Modification!to!the!Remand!Schedule!and!an!Alternative!Process!for!Development! of!Operational!Strategies!and!a!Collaborative!Science!and!Adaptive!Management!Program,! dated!November!29,!2012,!the!proposed!purposes!for!the!CAMT!process!were!presented!as! follows:!

!

> The!adaptive!management!process!will!include!the!active!evaluation!of!current! hypotheses!associated!with!key!operating!parameters!that!are!associated!with!the!Bay! Delta!oriented!measures!of!the!BiOps,!synthesizing!current!scientific!information,! developing!new!modeling!or!predictive!tools,!and!testing!and!evaluating!alternative! operational!strategies!and!other!management!actions!to!improve!performance!from! both!biological!and!water!supply!perspectives.!(DN!108031,!2)!
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> !

!More!specifically!the!Court!Order,!quoting!from!the!declaration!of!Lohoefner,!stated!d:

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> With!respect!to!the!disputed!BiOps,!CSAMP's!specific!goals!are!to:!(a)!Identify!and! evaluate!management!actions,!including!but!not!limited!to!actions!set!forth!in!the! [BiOps'!Reasonable!and!Prudent!Alternatives!("RPAs")],!to!protect!one!or!more!of!the! listed!species;!(b)!Develop!a!monitoring!program!to!allow!for!the!evaluation!of!costs!and! benefits!and!of!alternative!management!actions;!and!(c)!Support!the!development!and! adoption!of!an!annual!operational!plan!by!no!later!than!December!15!of!each!year!

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The!CAMT!science!process!will!be!broadly!consistent!with!the!adaptive!management!process! described!in!the!DOI!Adaptive!Management!Technical!Guide!and!the!Delta!Science!Plan.!The! first!steps!in!that!process!consist!of!identifying!problems,!translating!those!problems!into!goals! and!objectives,!and!formulating!and!evaluating!alternative!actions!to!achieve!the!goals!and! meet!the!objectives,!thereby!dealing!with!the!problems!(see!Figure!231).!

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These!initial,!general!steps!involve!development!of!conceptual!models,!identifying!uncertainties! and!disagreements,!formulating!hypotheses!or!questions !that!address!the!uncertainties!and! disagreements,!and!testing!those!hypotheses! or!answering!questions!using!various!scientific!

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techniques,!including!collection!or!generation!of!new!data,!and!analysis!and!modeling!of!existing!data,!with!appropriate!attention!to!sources!and!reliabi lity!of!data.!

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This!progress!report!represents!a!preliminary!version!of!these!initial!steps.!Problem!statements!have!been!developed!for!each!topic,!as!have!questions!and!hypotheses.!Preliminary!versions!of!conceptual!models!are!included!in!this!report.!More!detailed!specification!of!questions,!hypotheses,!and!conceptual!models,!potentially!incorporating!review!by!science!experts!(including!independent!scientists),!will!be!an!important!next!step.!So!will!specification!of!who!will!carry!out!the!work,!and!what!approaches!and!methods!are!feasible!and!appropriate.!!

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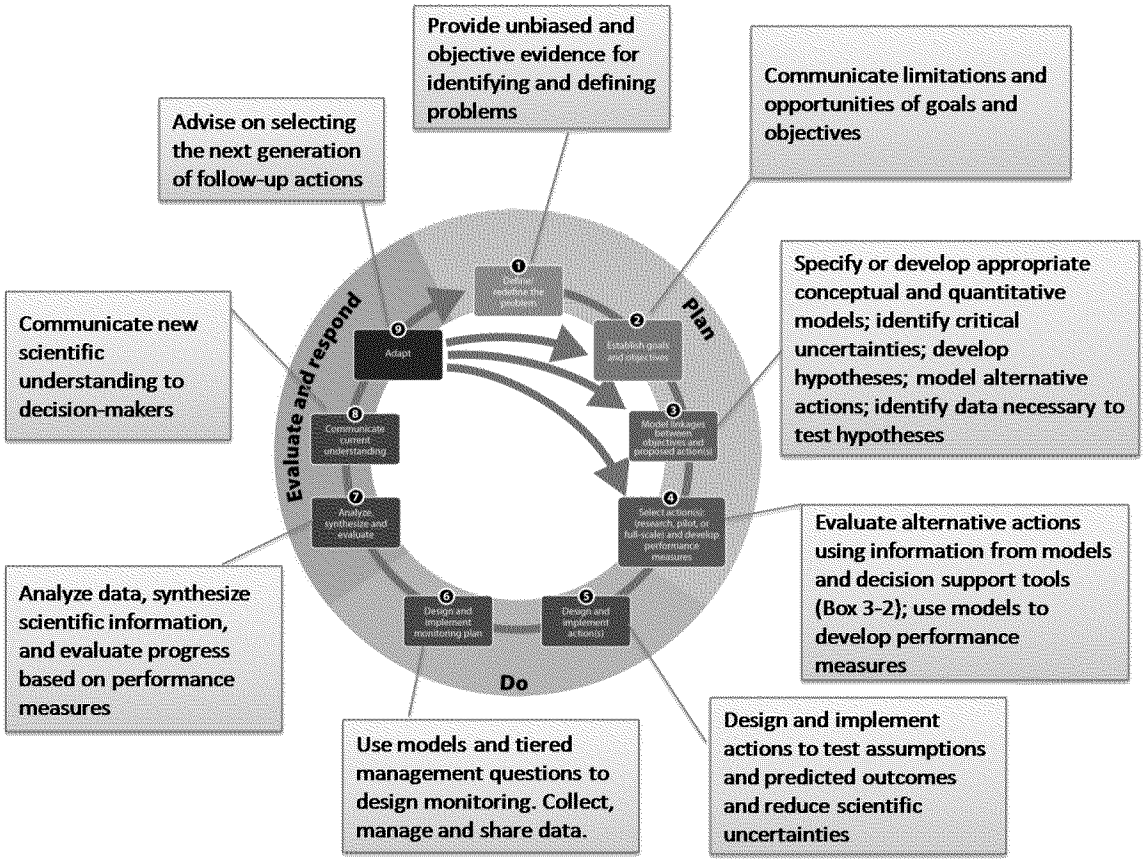

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(Source:!Delta!Science!Plan!12/30/2013,!23)!

Figure'2^1:'Delta'Plan's'Adaptive'Management'Framework'with'the'role'of'science'identified'in'call^out'boxes'for'each'step.'

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In!the!CAMT!process,!the! results!of!these!initial!steps!have!identified!some!disagreements!and!better!defined!the!uncertainties.!As!shown!in!Figure!231,!a!key!initial!step!of!the!science!effort!is!the!development!of!CSAMP!conceptual!models!for!the!priority!topics!listed!in!Table!132.!Preliminary!versions!of!these!models!are!included!in!this!report.!As!the!CSAMP!process!

!

proceeds,!the!conceptual!models!will!be!continually!improved!and!serve!as!a!useful!tool!to!clearly!identify!uncertainties!and!disagreements,!keeping!the!CSAMP!effort !focused!on!feasible!and!appropriate!means!of!addressing!them!

!

Where!existing!adaptive!management!or!other!research!programs!have!developed!and!adopted!conceptual!models!upon!which!ongoing!studies!are!based,!those!models!are!not!expected!to!be!replaced!by!the!CSAMP!conceptual!models,!although!the!collaborative!process!may!result!in!changes!to!the!existing!models!as!it!moves!forward.!

!

Discussions!regarding!the!precise!point!of!entry!to!the!adaptive!management!cycle!for!each!of!the!priority!topic!areas!revealed!the!complexity!of!intervening!during!ongoing!adaptive!management!activities,!as!well!as!the!differences!among!the!ongoing!science!programs!within!each!topic!area.!CAMT!members!expressed!divergent!views!about!the!extent!to!which!the!CAMT!should!create!new!groups!to!address!specified!tasks!versus!relying!on!existing!efforts,!while!not!wanting!to!impede!or!duplicate!current!programs.!A!challenge!for!the!CAMT!moving!forward!will!be!efficient!coordination!with!the!existing!programs!in!completing!the!package!of!investigations!the!CAMT!concludes!are!needed!to!inform!the!remand!process.!

Formulation'of'CSAMP'Problem'Statements'and'Scientific'Questions'

The!CAMT!recognized!the!need!to!develop!its!own!problem!statements!(Step!1!in!Figure!231)!for!each!of!the!topic!areas!and!spend!time!articulating!disagreements!regarding!conceptual!models!and!hypotheses!underlying!the!associated!RPA!actions.!!

!

To!carry!out!its!activities!consistent!with!the!adaptive!management!framework,!CAMT!members!also!saw!the!need!to!engage!qualified!scientists!and!experts!who!could!contribute!to!developing!new!scientific!information!for!the!CSAMP.!Recognizing!that!the!CSAMP!is!an!overlay!on!other!programs,!this!expertise!would!be!applied!to:!!

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- Develop!problem!statements!
- Review!current!conceptual!models!and!science!activities!
- Identify!relevant!key!questions !
- Articulate!alternative!conceptual!models!and!hypotheses!to!facilitate!assessment!of!disagreements!
- Propose!data!collection!and/or!analysis!capable!addressing!areas!of!uncertainty!

Schedule'and'Phasing'

As!presented!in!Table!231,!the!CSAMP!process!can!be!viewed!in!four!distinct!phases:!(1)!the!initial!nine3month!period!between!the!issuance!of!the!Court!Order!and!February!15,!2014,!when!the!parties!will!submit!a!joint!status!report!to!the!Court;!(2)!the!period!from!February!15,!2014!to!the!end!of!court!approved!extensions;!(3)!completion!of!the!new!BiOps;!and!(4)!the!long3term!future!following!the!completion!of!the!revised!BiOps.!The!final!schedule!will!be!determined!by!court!decisions!from!the!district!and!appellate!courts.!

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The!focus!of!this!section!is!on!the!second!phase!of!the!process,!and!it!assumes!that!the!CAMT!will!continue!its!efforts.!

Table'2^1:'CSAMP'Phases'

Phase'	Duration'	Milestones/Dates'	
		Start!	Finish!
1. Initial'Extension '	9!Months!	Court!Order!(4/9/13)!	Joint!Status!Report! Submittal!(2/15/2014)!
2. Subsequent' Extension(s)'	2!years!	Court!decision(s)!on! further!extensions!	Court!order[1]!
3. Completion'of' Revised'BiOps'	!	When!extensions!end!	Court!order!
4. Operations' according'to' revised'BiOps'	Long3Term!	Acceptance!of!Revised! BiOps!	Ongoing,!with! collaborative!science! and!adaptive! management!milestones!

[1]!The!current!court!order!requires!the!USFWS!to! issue!its!final!biological!opinion !by!December!1,!2014,!and! NMFS!to!issue!its!final! biological!opinion!by!February!1,!2017. !

!

There!was!broad!agreement!within!the!CAMT!that!a!successful!long3term!program!of! collaborative!science!and!adaptive!management!requires!a!credible!and!legitimate!framework! and!process!that!ensures!broad3based!acceptance!and!support!for!the!science!and!decisions! resulting!from!the!process.!

!

At!the!same!time,!for!the!CSAMP!process!to!be!considered!successful!in!the!immediate!near! term,!the!completion!and!implementation!of!detailed!workplans,!building!on!the!progress! achieved!during!Phase!1,!is!essential!to!maintaining!trust!in!the!legitimacy!of!the!program!for! many!CAMT!members.!

!

CAMT!members!agreed!that!credible!workplans!required!input!from!qualified!scientific! professionals!with!expertise!and!experience!in!the!issues!being!addressed;!and!that!there!must! continue!to!be!urgency,!perseverance,!and!resources!applied!to!the!completion!of!the!resulting! science!activities!in!keeping!with!the!commitment!made!by!the!federal!and!state!agencies!to! evaluate!and,!if!appropriate,!refine!the!RPAs.!

Integration'with'other'Science'Activities'

CAMT!members!are!hopeful!that!that!the!CSAMP!process!can!complement!and!add!value!to! existing!science!initiatives!by!strengthening!stakeholder!engagement!and!offering!a!new!bridge! between!and!among!stakeholders,!scientists,!management!agencies,!and!policy3makers.!!

Completion'and'Implementation'of'Topic'Area'Workplans'

Two!initial!CAMT!subgroups!prepared!draft!problem!statements!and!identified!key!questions! and!hypotheses!related!to:!(1)!OMR!Flow!Management!and!Entrainment!of!Delta!Smelt,!Longfin! Smelt,!and!Salmonids;!and!(2)!Fall!Outflow!Management!for!Delta!Smelt.!CAMT!members!

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deferred!consideration!of!a!third!subgroup!and!built!on!the!final!report!prepared!by!the!SDSRC.! Some!items!in!the!workplans!could!add!to,!but!will!not!replace,!existing!ongoing!studies!planned! for!2014,!such!as!FLaSH!or!other!IEP!studies.!

!

Plans!include!questions!and!hypotheses!that!can!be!addressed!using!existing!data!sets!(as! opposed!to!requiring!the!collection!of!new!data).!The!specific!tasks!may!vary!depending!on!the! nature!of!the!specific!question(s)!being!addressed.!The!process!may!rely!on!(1)!existing! investigations!by!others!(e.g.!Fall!Outflow!AMP!or!South!Delta!Salmonid!Research!Collaborative);! (2)!new!work!by!agency!staff,!stakeholder!staff,!and!other!experts;!or!(3)!a!combination!of!the! two.!Such!investigations!may!be!incorporated!into!existing!efforts!such!as!the!Fall!Outflow!AMP! or!IEP!Project!Work!Teams,!or!they!may!be!done!outside!of!these!efforts.!

Expanding'the'Public'Communications'and'Engagement'

From!the!outset,!the!Policy!Group!and!CAMT!members!recognized!that!for!the!CSAMP!to!have! lasting!value!beyond!the!court3ordered!remand!process,!it!would!need!to!reach!out!to!and! engage!wider!circles!of!stakeholders!and!interests!than!those!organizations!that!are!parties!to! the!remand.!A!detailed!proposal!for!communications!and!outreach!will!be!a!critical!element!of! the!Phase!2!process.

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3.0'CAMT'Workplan'

Tables!3.1!through!3.3!outline!proposed!near3term!priority!work!elements!for!each!of!the!three!high!priority!topic!areas!identified!by!CAMT!(see!Table!1.2).!The!tables!below!focus!primarily!on!work!to!be!conducted!in!2014,!recognizing!that!some!work!elements!will!require!more!than!one!year!to!complete!and!thus!will!extend!into!2015.!The!process!for!identifying!priorities,!managing!investigations,!and!facilitating!credible!science!in!further!developing!and!executing!the!work!plans!is!described!below.!

Identifying'Priorities'

CAMT!members!and!their!designees!determined!priority!work!elements!based!on!a!review!of!the!key!questions!and!other!materials!prepared!by!technical!subgroups!(see!Section!4).!Criteria!for!determining!priority!work!elements!included!their!timeliness!(i.e.!they!could!be!completed!within!the!next!two!years),!relevance!to!interim!operations!and!the!Biological!Opinions!(i.e.!results!would!inform!the!development!of!revised!biological!opinions),!and!potential!to!directly!address!specific!disagreements!between!CAMT!participants!regarding!the!design!or!interpretation!of!existing!analyses.!!

Scoping,'Conducting'and'Reviewing'Science'Investigations'

CAMT!members!view!a!clear,!transparent!process!for!scoping,!conducting!and!reviewing!new!science!investigations!as!critical!to!ensuring!the!relevance!and!legitimacy!of!the!collaborative!science!and!adaptive!management!process!and!outcomes.!CAMT!proposes!to!organize!its!work!according!to!the!following!three!functions:!

1. *Scoping**–!This!function!will!be!conducted!by!new!CAMT!designated!Scoping!Teams!with!guidance!from!the!Delta!Science!Program!to!ensure!consistency!with!the!Delta!Science!Plan.!The!purpose!of!these!teams!would!be!to!scope!workplan!investigations,!interact!with!others!doing!related!work,!develop!workplans!for!conducting!investigations,!report!progress!back!to!the!full!CAMT,!and!assist!the!CAMT!in!revising!work!plans!as!needed.!"Scoping"!means!establishing!the!relevance!and!legitimacy!of!work!plan!elements!and!putting!boundaries!on!the!breadth!of!what!would!be!investigated!as!part!of!the!CAMT!work!plan!so!as!to!assure!relevance!to!the!Biological!Opinions!and!the!CAMT!mission;!it!does!not!mean!prescribing!exactly!how!and!by!whom!studies!will!be!conducted.!Scoping!Teams!may!also!assist!with!guiding,!coordinating,!and!tracking!implementation!of!work!elements,!as!requested!by!CAMT.!!
2. *Conducting*Investigations*!–!Actual!science!investigations!would!be!performed!by!qualified!technical!experts,!identified!and!recommended!by!the!DSP,!with!input!from!the!Scoping!Teams,!and!approved!by!CAMT.!Investigations!may!be!performed!by!individuals!or!teams!of!individuals.!CAMT!would!rely!on!existing!groups!and!programs!when!appropriate,!and!would!engage!new!groups!as!needed.!
3. *Reviews*!–!Structured!reviews!would!be!organized!and!managed!by!the!Delta!Science!Program!for!both!study!plans!and!work!products!resulting!from!investigations.!

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The!following!provides!additional!details!on!the!formation!and!responsibilities!of!the!Scoping!Teams:!

- Scoping!teams!will!be!comprised!of!CAMT!members!or!their!designees,!a!representative!from!the!Delta!Science!Program;!a!facilitator;!and!additional!people!nominated!by!CAMT!co3chairs,!and!approved!by!CAMT,!who!provide!additional!skills,!subject!area!knowledge!and!experience.!The!CAMT!co3chairs!will!designate!scoping!team!chairs!with!the!approval!of!the!full!CAMT.!!
- Scoping!teams!will!refine!the!key!questions!and!hypotheses!and!identify!more!detailed!workplans,!for!each!workplan!element,!in!conjunction!with!the!technical!experts.!!
- Scoping!teams!will!submit!workplans!(including!budgets!and!schedules)!and!reports!to!CAMT!for!approval.!!
- The!Delta!Science!Program!shall!oversee!independent!review!of!workplans!and!any!reports!produced!as!a!result!of!the!investigations.!!
- Scoping!teams!will!report!directly!to!CAMT.!

Delta'Science'Program'Assistance''

The!CAMT!proposes!to!draw!upon!the!resources!of!the!Delta!Science!Program!(DSP)!and!mechanisms!outlined!in!the!Delta!Science!Plan!to!facilitate!implementation!of!the!work!plan.!!The!CAMT!views!this!as!critical!to!ensuring!the!credibility!and!integrity!of!the!scientific!process!and!the!outcomes.!CAMT!proposes!that!under!the!direction!of!the!Delta!Lead!Scientist,!the!DSP!would:!!

- Provide!guidance!on!scientific!methods!and!best!practices!to!be!used!in!developing,!refining!and!implementing!workplans!and!ensure!consistency!with!the!Delta!Science!Plan.!
- Help!identify!technical!experts!that!would!design!and!carry!out!the!scientific!investigations!called!for!in!the!CAMT!work!plan!and!synthesize!results.!These!experts!would!be!provided!the!freedom!and!flexibility!to!design!and!conduct!specific!investigations!within!the!boundaries!of!the!scope!established!by!the!CAMT!scoping!teams!described!above.!
- Help!the!CAMT!identify!any!additional!subject3related!expertise!that!would!assist!with!scoping!and!coordination!tasks.!
- Manage!and!implement!all!independent!reviews!of!CAMT!science!proposals,!study!plans,!and!results.!This!would!occur!under!the!leadership!and!decision3making!authority!of!the!Delta!Lead!Scientist.!Additional!review!may!come!from!the!Delta!Independent!Science!Board!(DISB),!if!deemed!appropriate!by!the!CAMT.!

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The!DSP!would!also!continue!to!assist!the!CAMT!in!general!by!identifying!specific!mechanisms!for!facilitating!credible!science!processes!as!outlined!in!Sections!4.5!and!4.6!of!the!DSP!plan.!!

Coordinating'with'Ongoing'Studies'

One!goal!of!the!CAMT!workplan!is!to!leverage!existing!studies!and!monitoring!to!avoid!duplication!of!effort.!Tables!provided!in!Section!5!illustrate!IEP!studies!that!may!address!CAMT!data!needs,!hypotheses,!and!questions.!Multiple!surveys,!data!sets,!and!studies!will!be!necessary!to!address!the!questions!and!hypotheses.!The!CAMT!Scoping!Teams!would!be!responsible!for!coordinating!and!integrating!CAMT!activities!with!these!existing!efforts.!!

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Principles'for'Designing'and'Implementing'Science'Studies'

To!assure!relevance!and!credibility,!all!CAMT!studies!will!be!designed!and!implemented!according!to!scientific!principles!in!the!Delta!Science!Plan!and!include!

- Well3stated!goals!and!objectives!
- A!statement!of!relevance!to!the!CAMT!priority!work!elements!!
- Clear!conceptual!and/or!mathematical!model(s)!
- Questions!and!hypotheses!that!are!clearly!linked!to!the!conceptual!or!mathematical!model(s)!
- A!study!design!capable!of!addressing!the!questions!with!sufficient!precision!and!accuracy!and!with!standardized,!well3documented!methods!for!data!collection!
- Analytical!rigor!and!sound!logic!for!analysis!and!interpretation!
- Clear!documentation!of!methods,!results,!and!conclusions!
- Publication!of!results!in!peer3reviewed!scientific!journals!or!reports!

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Independent!review!of!proposals,!study!plans,!and!results!managed!and!implemented!by!the!DSP!(see!above)!will!assure!that!all!analyses!will!be!carried!out!with!scientifically!credible!and!rigorous!investigative!methods!and!accepted!analytical!techniques.!!

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Specific!analyses!and!experiments!designed!to!address!key!questions!and!hypotheses!listed!in!Tables!331,!332,!and!333!will!be!developed!in!Phase!2!of!the!CAMT!process!(see!Table!231).!Because!of!time!constraints,!initial!efforts!will!focus!on!the!analysis!of!existing!data!sets.!These!investigations!will!not!involve!experimental!designs!in!the!traditional!sense!of!lab!or!field!data!collection,!but!will!be!designed!and!implemented!according!to!the!same!rigorous!scientific!principles.!!

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New!field!and!lab!experiments!identified!following!the!initial!data!analyses!will!include!explicit!experimental!designs!focused!on!addressing!specific!hypotheses!or!predictions.!This!may!include!large3scale!adaptive!management!experiments!(i.e.!active!adaptive!management)!and!associated!field!data!collections,!monitoring!and!studies!associated!with!non3experimental!(passive)!adaptive!management,!and!smaller3scale!field!and!laboratory!studies.!!

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To!the!extent!feasible,!CAMT!will!work!with!existing!ongoing!science!efforts!to!leverage!opportunities!for!collection!and!use!of!any!new!data.!The!CAMT!may!also!review!and!consider!ongoing!data!collection!and!monitoring!programs!to!assess!the!need!for!possible!refinements!that!could!improve!the!applicability!of!the!data!for!evaluating!the!key!questions!and!hypotheses!articulated!by!CAMT!

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Finally,!this!workplan!reflects!a!good3faith!effort!on!the!part!of!the!CAMT!to!respond!to!the!urgency!of!its!mission,!recognizing!that!resources!constraints,!changing!circumstances,!or!unexpected!events!could!impact!proposed!schedules.!For!example,!the!timely!availability!of!third3party!investigators!has!not!been!confirmed;!and!uncontrollable!circumstances,!such!as!the!drought,!may!impose!new!priorities!that!may!impact!schedules.!

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Table 3(1 CAMT Fall Outflow Workplan

Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
High Priority Items!					
1. Review! monitoring! methods!for! delta!smelt! !	Are!there!biases!in!the! IEP!survey!data?!! How!should!the! survey!data!be!utilized! if!biases!do!exist?!	NA!	Investigate!and!clarify! characteristics!of!existing! monitoring!data!sets,! including!potential! weaknesses!in!spatial! coverage!and!other!details! of!study!design.! Clarification!of!weaknesses! will!help!ensure!that! analyses!based!on!these! datasets!are!appropriately! qualified.!Could!allow!for! corrections!(or! adjustments)!to!more! accurately!represent! underlying!variables.! Findings!may!suggest!that! results!of!previous!studies! should!be!reviewed.! Findings!may!also!allow!for! improvements!in!future! data!collection.!!	Convene!a!workshop!to! discuss!possible!survey! problems!and!identify! opportunities!to!address! in!2014!with!existing! data.!! Consider!ongoing!work! and!approaches!of! Emilio!Laca.!Many!of! these!issues!have!been! proposed!by!FWS!to!be! addressed!through!a! package!of!gear! efficiency!and!smelt! distribution!studies!(see! Section!5);!however,! that!package!includes! extensive!field!work,! and!some!elements! have!timelines! extending!beyond!the! remand!period.! ! ! !	Discuss!at!IEP! Resident!fishes! PWT!meeting!on! Feb!20,!2014! ! Workshop! (discuss!E.!Laca!! study!plan)!! April!2014! ! Finalize!study! plan!–!May!2014! ! Gear!efficiency! study! discussions!! June!2014! ! Draft!report! Sept!2014! ! IEP!Presentation!! Feb!2015! !

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Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
High Priority Items					
2. Investigate importance of fall period for delta smelt.	Under what circumstances does survival in the fall affect subsequent winter abundance?	Survival of delta smelt during the fall varies significantly from year to year and is important in explaining the annual changes in abundance.	Needed to establish whether survivorship through the fall is important in influencing year to year changes in delta smelt abundance. Survivorship through the fall is one vital rate that may be important.	Quantitatively determine the contribution of delta smelt survivorship in the fall to inter-annual population variability. Review available lifecycle models for applicability.	Scoping group to evaluate available life cycle models July 2014 Study plan Dec 2014. Draft report April 2015
3. Investigate effects of fall outflow on delta smelt.	Under what circumstances do environmental conditions in the fall season contribute to determining the subsequent abundance of delta smelt?	A significant correlation exists between the survival of delta smelt from summer to winter in a year and habitat conditions in the fall.	This element re-examines analyses presented in the 2008 BiOp. New work would include review of new information as it applies to the original analyses, and complement or challenge existing analyses to evaluate the relationship between outflow through the Delta and demographic response in delta smelt.	Investigate the relationship between fall outflow and the relative change in delta smelt abundance using univariate and multivariate and available historic data. Related to work undertaken in the MAST report, which examined pairs of dry and wet years in 2005/6 and 2010/11. Also explore effects occurring through other avenues (e.g. growth or fecundity).	Study plan development June 2014 Draft report Nov 2014

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Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priorities					
4. Examine project impacts on fall outflow. !	How much variability in tidal, daily, weekly, and monthly fluctuations in fall X2 is attributable to water project operations? ! !	Changes over time in the distribution and extent of habitat, as represented by the distribution and extent of the "low" salinity zone (or the position of the X2 isohaline) during the fall is attributable to water export project operations. ! !	The intent is to refine our understanding of how project operations are influencing outflow volumes.	Hydrological modeling tools to determine the prospective locations of X2 in the fall under circumstances with and without project operations. An analysis of historical data will also be carried out to examine outflow during periods when the projects were required to meet specific outflow requirements, to evaluate the degree of control that has been possible at various time scales. See work addressing this issue by: Grossinger, Hutton, and a paper by Cloern & Jassby 2012 ! ! ! ! ! !	Relevant IEP presentation by Paul Hutton, MWD – Feb 26, 2014

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Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priorities					
5. Investigate importance of summer period for Delta Smelt	Under what circumstances is survival of Delta Smelt through the fall related to survival or growth rates in previous life stages?	Survival of Delta Smelt through the fall is related to survival or growth rates in previous life stages.	This topic complements some of the investigations in the FOAMP. By establishing whether survival or growth rates through any life stage (or season) are dependent on the status or condition of Delta Smelt entering that life stage, the potential exists to identify environmental factors in preceding seasons that influence survival during the fall.	Compare Delta Smelt survival during the fall to both survival in prior seasons and to fork length at the end of the summer/start of the fall. New data is being collected as part of FOAMP. Consider IBM modeling.	Draft study plan – Oct 2014 Analysis of existing data – mid 2015

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Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priorities					
6. Investigate the relationship between fall outflow and habitat attributes.	Does outflow during the fall have significant effects on habitat attributes that may limit the survival and growth of Delta Smelt during the fall?	A significant relationship exists between the survival of Delta Smelt from summer to winter within a year and habitat conditions experienced by Delta Smelt during the intervening fall.	This element re"examines analyses presented in the 2008 BiOp. New work would include review of new information as it applies to the original analyses, and complement or challenge the existing work by developing new analyses to evaluate the strength of evidence for mechanisms under which outflow may influence Delta Smelt survivorship growth rates during the fall.	There may be competing approaches that will be simultaneously pursued. One is to develop graphs and conduct univariate and multivariate analyses involving survival ratios and growth rates. Test whether month"to" month declines in abundance or growth during the fall is greater when X2 is located further east. See also the analytical approach in MAST report, work by Kimmerer, Burnham & Manly.	Work may begin in 2014 as resources allow

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Work Element	Key Question(s)	Example Draft Hypotheses	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priorities					
7. Develop a new habitat index for Delta Smelt!!	Can an index based on multiple habitat attributes provide a better surrogate for Delta Smelt habitat than one based only on salinity and turbidity?!!! ! !	The distribution and areal extent of the low"salinity zone (or the position of the X2 isohaline) in the estuary in the autumn is significantly correlated with the distribution and extent of habitat available to support Delta Smelt. ! !	An updated habitat index may provide a useful tool to mangers to identify areas for restoration and improved management actions. ! ! Earlier analyses used only abiotic factors to define habitat. Additional information since 2008, could allow for development of a better habitat index based on additional potentially important habitat variables.	Review approaches in existing literature. There may be competing approaches that will be simultaneously pursued, depending on expert advice. One possible approach is to develop suitability index curves and combine geometrically to create a habitat quality index. Utilize data from areas where Delta Smelt are frequently observed to assess habitat quality. See work by Burnham Manly, and Guay.	Work may begin in 2014 as resources allow!
8. Identify impacts of fall project operations on Delta Smelt!	Under what conditions (e.g., distribution of the population, prey density, contaminants) do fall operations have significant effects on survival?!	!	Complements and/or challenges previous studies. Important for identifying the impact of project operations on the success of Delta Smelt during the fall. !!	Utilizing relationships identified in the above studies, simulate how changes in project operations may influence survival of Delta Smelt during the fall.	Work may begin in 2014 as resources allow!

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Table 3 (2 CAMT OMR/Entrainment Workplan

Work Element	Key Question(s)	Draft Example Hypotheses	Investigative Approaches	Schedule
High Priority[1]				
1. Assess factors affecting adult Delta Smelt entrainment ! !	What factors affect adult Delta Smelt entrainment during and after winter movements to spawning areas? (4) 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 habitat conditions (e.g. first flush, turbidity, water source, food, time of year) lead to adult Delta Smelt entering and occupying the central and south Delta?	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.	Summarization of environmental and fish distribution/abundance data (e.g. FMWT, SKT). Multivariate analyses and modeling (e.g. 3D particle tracking) to examine whether fall conditions affect winter distribution. Completion of First Flush Study analyses. The Delta Conditions Team (DCT) is currently developing a scope of work to use turbidity modeling to examine various "first flush" conditions, expected entrainment risks, and potential preventative actions that could be taken to reduce entrainment, consistent with key question (a). The DCT could also conduct analyses to address key question (b). !	Detailed workplan for key question (b) April 2014 ! Initial report on (a) for OCAP review panel Sept 2014 ! Independent review for key question (a) Nov 2014 ! !

[1] Work element #1 from the Fall Outflow Workplan is also considered a high priority work element for the OMR/Entrainment topic area.

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Work Element	Key Question(s)	Draft Example Hypotheses	Investigative Approaches	Schedule
High Priority				
2. Assess population effects ! !	What are the effects of entrainment on the population? (6) a. What is the magnitude (e.g. % of population) of adult and larval entrainment across different years and environmental conditions? b. How do different levels of entrainment for adults and larvae affect population dynamics, abundance, and viability? !	Delta Smelt are entrained at Project facilities at levels that are likely to affect the long-term abundance of the Delta Smelt population.	2.a. Application of different models (e.g. IBM, life history) to estimate proportional entrainment. A direct approach to addressing 6a has been proposed by Kimmerer 2008 as modified in 2011. This or a derivative approach should be explored as a means to directly estimate the proportional entrainment that has occurred in recent years. Apply to as much of historical record as possible. ! 2.b. Application of different models (e.g. IBM, life history, PVA) to simulate effects on population dynamics, abundance, and variability. ! ! ! ! ! ! !	Detailed workplan for direct approach April 2014 ! Product (based on direct approach) for submission to Long-term Ops Opinion panel Sept 2014 ! Independent review (Long-term Ops Opinion panel) Nov 2014 ! Final peer reviewed product for Life Cycle Model approach June 2015

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Work Element	Key Question(s)	Draft Example Hypotheses	Investigative Approaches	Schedule
Secondary Priorities				
3. Develop a better estimate of adult Delta Smelt entrainment	How many adult Delta Smelt are entrained by the water projects? (1d)	NA	Workshop or expert panel review. Testing of new field methodologies such as SmeltCAM. Gear efficiency and expanded trawling experiments. Evaluation of alternative models to estimate abundance, distribution and entrainment.	Work may begin in 2014 as resources allow
4. Develop a better estimate of post-larval Delta Smelt entrainment	How many larval and post-larval Delta Smelt are entrained by the water projects? (2d)	NA	Expert panel or workshop review. Testing of new field methodologies such as SmeltCAM. Gear efficiency and expanded trawling experiments (e.g. 20 mm). Evaluation of alternative models to estimate abundance, distribution and entrainment.	Work may begin in 2014 as resources allow

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Work Element	Key Question(s)	Draft Example Hypotheses	Investigative Approaches	Schedule
Secondary Priorities				
5. Evaluate conditions that affect adult movement prior to spawning	What conditions prior to movement to spawning areas affect adult Delta Smelt entrainment? (3) ! Is there a relationship between Delta Smelt distribution and habitat conditions (e.g. turbidity, X2, temperature, food) during fall and subsequent distribution (and associated entrainment risk) in winter?	Adult Delta Smelt distribution and abundance in winter is influenced by Delta Smelt distribution and abundance in the fall, as well as habitat conditions (e.g. turbidity, salinity, temperature, food availability), and hydraulics (e.g. velocity, tidal flow splits) during winter.	Summarization of environmental and fish distribution/abundance data (e.g. FMWT, SKT). Multivariate analyses and modeling (e.g. 3D particle tracking) to examine whether fall conditions affect winter distribution. Completion of First Flush Study analyses. !	Work may begin in 2014 as resources allow.
6. Assess factors affecting larval and post-larval Delta Smelt entrainment	What factors affect larval and post-larval Delta Smelt entrainment? (5) a. How does adult spawning distribution affect larval and post-larval entrainment? b. What conditions (e.g. first flush, spawning distribution, turbidity, water source, food, time of year) lead to larvae and post-larvae occupying the central and south Delta?	Larval Delta Smelt distribution and abundance in spring is influenced by adult Delta Smelt distribution and abundance, habitat conditions (e.g. turbidity, salinity, temperature, food availability), and hydraulics (e.g. velocity, tidal flow splits).	Summarization of environmental and fish distribution/abundance data. Statistical analysis and modeling (e.g. 3D PTM) of effects adult distribution (e.g. SKT) on larval (e.g. 20 mm) distributions. Summarization of environmental and fish distribution/abundance data (e.g. 20 mm). Multivariate analyses/modeling to identify conditions promoting occupancy of central and south Delta.	Work may begin in 2014 as resources allow.

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Work Element	Key Question(s)	Draft Example Hypotheses	Investigative Approaches	Schedule
Secondary Priorities				
7. Explore alternative management actions	What new information would inform future consideration of management actions to optimize water project operations while ensuring adequate entrainment protection for Delta Smelt? (8) a. Can habitat conditions be managed during fall or early winter to prevent or mitigate significant entrainment events? b. Should habitat conditions (including OMR) be more aggressively managed in some circumstances as a preventative measure during the upstream movement period (e.g. following first flush) to reduce subsequent entrainment? !	NA	Synthesis of available information and study results by CAMT Entrainment Team, designated expert panel, or both. Consultation with regulatory agencies and operators about the feasibility of different actions.	Work may begin in 2014 as resources allow!!

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Table 3 (3 CAMT South Delta Salmonid Survival Workplan

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
High Priority: Expected for Implementation in 2014				
1. Synthesize published reports and empirical data on water export effects and link to the current SDSRC conceptual model; identify/document scientific agreements and disagreements regarding the effects of south Delta water operations on juvenile salmonid survival in the Delta.	What are key uncertainties, agreements, and disagreements in the understanding of direct and indirect effects of south Delta water operations on salmonid survival as linked to the SDSRC conceptual model? What are the areas/issues of scientific agreements and disagreements that contribute to the controversy over the effects of project operations on salmonid survival? Can the population level effects of a single management action be evaluated? If so, what tools are available?	Unfinished business of the SDSRC in 2013; identified as a priority for 2014 in the 2013 Progress Report. Potential opportunity to consider the PWA and other interests' questions, tasks, and hypotheses yet to be considered by CAMT.	Convene a series of working sessions to review and potentially refine the current SDSRC conceptual model; identify, screen and document published reports and empirical data, as linked to the conceptual model. Identify key information gaps. Identify key scientific agreements and disagreements. Review PWA questions and hypotheses in this context, and develop a collaboratively produced report.	"Status updates in April, June, and August of 2014 "Draft report September 2014 "Final report November 2014

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
High Priority: Expected for Implementation in 2014				
2. Briefing about SWFSC winter-run salmonid life cycle model (LCM).	What is the general structure of the model and what are key assumptions, key uncertainties, and evaluation metrics used to assess biological responses to alternative export operations, changes in river flows, DCC gate operations, habitat capacity, and other actions on salmon survival and abundance? How will the model be validated? Will the model be available for independent peer review and simulations?	In order to ensure development of a widely accepted LCM, its development should be transparent and shared with interested parties.	A briefing needs to be held on the status of the SWFSC salmonid LCM and its specific components with interested and knowledgeable parties.	Briefing to CAMT and interested parties by April 2014
3. Data synthesis and meta-analysis	Can synthesis of data from previous Delta salmonid tagging studies be combined and analyzed to address key questions/uncertainties about the direct and indirect ecological effects of exports on salmonid	There are numerous salmonid tagging studies conducted in the Delta over the past several decades that, when considered together, can potentially address key uncertainties about factors affecting migrational behavior and survival of juvenile	Pending review and agreement on a proposal: 1) establish a working group to plan and oversee the strategy for identification and meta-analysis of existing data; 2) identify initial questions to address and relevant	SDSRC will revise and agree on a written proposal by April 2014; Progress report March 2015; anticipated to continue in 2015; draft report by November 2015; manuscript for publication completed

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
High Priority: Expected for Implementation in 2014				
	survival?!!!	salmonids!!	data sets; and 3) conduct preliminary analyses.	by June 2016
4. Pending results of the gap analysis and initial data synthesis efforts (Elements 1 and 3); investigate alternative metric(s) for management of south Delta water operations.	Are there alternative or additional metrics (e.g., OMR flows, export volumes, monthly export limits, etc.) that can be used to manage south Delta water operations, and improve survival of migrating salmonids in the south Delta?	SDSRC participants discussed metrics in addition to, or other than, inflow:export ratio that may be relevant to manage south Delta water operations to improve salmonid survival.	Convene a working group to synthesize and evaluate existing data to identify potential metrics and evaluate their benefits and limitations.	"Status check in June 2014 "Progress report November 2014
5. Re"charter the SDSRC	Should the SDSRC be re" chartered to report to the CAMT?	!	Modify the charter to require the SDSRC to periodically report progress to the CAMT. SDSRC will continue to use existing facilitator.!! ! !	!

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priority: May be implemented in 2014, contingent on progress of high priority workplan elements				
6. Pending outcomes of Elements 1, 3, and 4, investigate tools to evaluate the efficacy of export management actions.	To what extent and under what conditions do the export management actions reduce mortality of migrating salmonids?!	!	Summarize tools available or in development that can be used to evaluate the efficacy of export management actions.!!	Pending outcomes of other workplan elements, status check in November 2014! !
7. After briefing on SWFSC LCM, assessment of other potential modeling needs. Pending outcomes of Elements 1"4 identify and evaluate indirect ecological effects of project operations that affect the survival of listed salmonids.	Are there questions important to CAMT that cannot be answered using the SWFSC LCM?! Are there elements of other salmon models that would be beneficial to incorporate or link to the winter"run model (e.g., IOS, DPM, OBAN, SALMOD, Bureau egg mortality model, CALSIM, DSM2, etc.)?! Are there alternative management actions that can address water project effects on listed salmonids?! ! !	CAMT is continuing to discuss the scope of management actions that should be evaluated within the CAMT scope. Future discussions should include:!! What management actions have the greatest influence on survival of salmonids migrating in the south Delta?! What water management actions might be taken to improve salmon survival?! What is the relative effectiveness of current and potential alternative management actions in improving salmon survival?!	Pending acquisition of new resources, convene a working group to evaluate the potential for existing models or new tools to inform the consultation on project operations including:! 1) Review available information (including literature, data, and models) to identify controllable factors, linked to project operations, with greatest influence on survival; 2) Identify actions which might be taken to improve survival; 3) Evaluate actions and report relative	Status Update in September 2014! Pending outcomes of Elements 1"4, complete preliminary analysis and write"up by November 2014.! !

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priority: May be implemented in 2014, contingent on progress of high priority workplan elements				
			contribution to survival.	
8. Define an expanded scope for the SDSRC to include indirect ecological effects of south Delta water operations	What are the indirect ecological effects of water export; and are there management actions to minimize indirect project effects that influence salmonid survival?!	The SDSRC worked within a narrow scope focusing on direct export effects on hydrodynamics and direct behavioral and survival effects of altered hydrodynamics. Broadening the scope to including indirect effects (e.g., predation effects) could potentially inform approaches to minimize south Delta project operation effects on salmonid survival.	Conduct a working session of the SDSRC to agree on a detailed description of an expanded scope; link to the current SDSRC conceptual model.	Revised scope by March 2014
9. Enhanced learning from 6"year steelhead study (OCAP BiOp RPA VI.2.2)	Are there experimental modifications of the 6' year steelhead study that will enhance the understanding of the effect of inflow/export conditions on south Delta survival of steelhead?!	The 6"year steelhead study is intended to estimate steelhead survival over a range of ambient inflow:export conditions. Recent analysis of conditions tested during the first three years identified several conditions that have not been tested or are underrepresented among the conditions tested to date. A greater range of conditions will also enhance learning in	Identify opportunities and develop plans to enhance learning from the 6"year steelhead survival study (RPA IV.2.2) by testing untested or underrepresented I:Es, testing combinations of very high and very low San Joaquin inflows and very high and very low export levels; and testing similar I:Es at different discharge volumes (e.g.,	Given evolving drought, it may be challenging to manipulate operations in April and May of 2014. "Identify options, develop implementation plans, and prepare request for prescribed conditions no later than June 2014; implementation in 2015 or later depending on environmental

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
Secondary Priority: May be implemented in 2014, contingent on progress of high priority workplan elements				
		ongoing USFWS fall run Chinook survival studies.	1:1 at 1,500cfs/1,500cfs; 6,000cfs/6,000cfs. Any new experimental components will include a clear statement of objective, approach, and statistical analysis plan.	conditions; study plan, including proposed operations, would be developed for review no later than March 15.

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
Third Priority: Important to CAMT but not likely to be implemented in 2014 pending results of ongoing research and development of necessary technology				
10. Salmonid near-field movement under selected export and tidal conditions.	Does tidal forcing in combination with export volumes affect migrational behavior and survival of migrating south Delta salmonids?	The 2012 IRP recommended investigating the combined influence of export and tidal forcing on salmonid migrational behavior and survival. Based on a concept proposal developed in the SDSRC in 2013, this study was identified for further development.	Convene a working group to develop a detailed proposal suitable for peer review; including objectives, experimental approach, and a detailed statistical analysis plan. Arrange for and submit to external peer review. Review results of Enhanced PTM tool in development by SWFSC. A prerequisite for this	Proposal and peer review by November 2014; Review of Enhanced PTM tool when available; Implementation of Near-Field Movement study dependent on availability of a predation-sensitive acoustic tag (probably 2015)

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Work Element	Key Question(s)	Relevance/Rationale	Possible Investigative Approach	Schedule
Third Priority: Important to CAMT but not likely to be implemented in 2014 pending results of ongoing research and development of necessary technology				
			element is completing the testing and validation of the technology to distinguish a free swimming tagged salmonid from one that has been preyed upon.	
11. Pending gap analysis, investigate hatchery" and natural" origin salmonid surrogacy.	Are results of tests using hatchery" reared salmonids representative of results of natural" origin salmonids? Are the results of tests using one run of Chinook salmon representative of results of other runs? Are the results of tests using Chinook salmon representative of steelhead? If not, in each case can a correction factor be developed to allow for application of such test results?	The question of whether results of tests conducted using hatchery" reared salmonids are representative of results relevant to natural" origin salmons is a key uncertainty routinely identified in most survival studies.	Convene a working group to review and synthesize existing information on hatchery" and natural" origin surrogacy; if warranted, develop a concept proposal to investigate surrogacy.	SWFSC study planned for spring 2014 may provide information relevant to wild vs. hatchery surrogacy.

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Development*of*Experimental*Designs*

Specific!experiments!designed!to!address!key!questions!and!hypotheses!listed!in!Tables!3"1,!3"2,! and!3"3!above!will!be!developed!in!Phase!2!of!the!CAMT!process!(see!Table!2"1).!Initial!efforts! will!focus!on!the!analysis!of!existing!data!sets.!These!investigations!will!not!involve!experimental! designs!in!the!traditional!sense!of!lab!or!field!data!collection,!but!will!include!clearly!defined! methods!and!accepted!analytical!techniques,!and!will!include!review!and!examination!of!the! existing!data!sets!and!how!those!data!were!obtained.!Any!new!field!experiments!identified! following!the!data!analyses!will!include!explicit!experimental!designs!focused!on!addressing! specific!hypotheses!or!predictions.!These!designs!will!be!consistent!with!the!scientific!process! including!the!following!elements:!

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- Well"stated!objectives!
- A!clear!conceptual!or!mathematical!model!
- A!good!experimental!design!with!standardized!methods!for!data!collection!
- Statistical!rigor!and!sound!logic!for!analysis!and!interpretation!
- Clear!documentation!of!methods,!results,!and!conclusions.!

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To!the!extent!feasible,!CAMT!will!work!with!existing!ongoing!science!efforts!to!leverage! opportunities!for!collection!and!use!of!any!new!data.!The!CAMT!may!also!review!and!consider! ongoing!data!collection!and!monitoring!programs!to!assess!the!need!for!possible!refinements! that!could!improve!the!applicability!of!the!data!for!evaluating!the!key!questions!and!hypotheses! articulated!by!CAMT.!

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The!SDSRC!has!already!initiated!discussions!regarding!conceptual!designs!for!the!research! proposals!it!has!suggested.!This!work!included!a!power!analysis!to!assess!sample!sizes!and!other! factors!that!would!be!necessary!to!detect!statistically!significant!differences!in!juvenile!survival! under!various!environmental!conditions.!The!SDSRC!has!also!examined!the!ongoing!6"year! Steelhead!study!(now!entering!its!fourth!year)!to!assess!possible!adjustments!in!the! experimental!design!that!could!enhance!the!value!of!the!study.!

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Similarly,!the!ongoing!FLaSH!studies!being!administered!by!IEP!and!the!Fall!Outflow!AMP!involve! specific!experiments!designed!to!assess!environmental!conditions!and!ecological!responses!to! those!conditions,!including!the!testing!of!specific!predictions!articulated!in!the!AMP!

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4.0*Background*on*CAMT*Priority*Topic*Areas*

The!following!provides!background!information!on!each!of!the!three!priority!topic!areas,!including!problem!statements,!key!questions,!and!relevant!conceptual!models!identified!through!the!CAMT!process!to!date.!Information!provided!in!the!tables!below!represents!draft!concepts!developed!by!each!respective!technical!subgroup!(Fall!Outflow,!OMR/Entrainment,!and!South!Delta!Salmonid!Survival).!The!information!in!the!tables!below!is!not!a!plan!of!work.!Rather,!it!is!meant!to!be!used!as!a!resource!to!inform!development!of!the!CAMT!workplan.!!

4.1* Fall*Outflow**

The!2008!Biological!Opinion!for!Delta!Smelt!contains!a!Reasonable!and!Prudent!Alternative!(RPA,!Action!4)!intended!to!improve!fall!habitat!for!Delta!Smelt.!The!action!specifically!seeks!to!maintain!the!position!of!X2!in!the!fall!at!74!km!east!of!the!Golden!Gate!Bridge!in!wet!years,!and!at!81!km!east!in!above!normal!years.!!

Fall*Outflow*Problem*Statement*

Questions!have!been!raised!by!some!about!the!biological!effectiveness!of!the!RPA!that!stem!from!disagreements!about!the!scientific!basis!for!the!fall!outflow!action.!These!disagreements!concern!the!factors!that!may!limit!the!extent!and!quality!of!habitat!for!Delta!Smelt!in!the!fall,!the!extent!to!which!fall!habitat!is!a!limiting!factor!on!the!survival!and!reproduction!of!the!population,!the!use!of!X2!as!a!surrogate!indicator!for!Delta!Smelt!habitat,!and!the!costs!and!benefits!of!different!approaches!to!restore!Delta!Smelt!habitat.!Questions!have!also!been!raised!in!CAMT!discussions!regarding!the!sampling!methods!used!to!collect!the!data!that!are!used!to!calculate!abundance!indices!(i.e.!do!they!accurately!reflect!the!size!and!distribution!of!the!population).!An!updated!and!more!complete!understanding!of!the!habitat!requirements!of!Delta!Smelt!might!help!clarify!under!what!circumstances!project!operations!may!adversely!impact!habitat!in!the!fall,!and!subsequently,!what!habitat!modifications!would!benefit!Delta!Smelt!annual!year!class!success.!This!improved!understanding!may!also!allow!more!effective!use!of!project!water!supplies!to!protect!Delta!Smelt.*

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A!Fall!Outflow!Adaptive!Management!Plan!(FOAMP,!Reclamation!2011,!2012)!was!developed!to!resolve!some!of!the!uncertainties!and!questions!regarding!the!RPA,!but!not!all!CAMT!parties!have!been!engaged!to!date!in!the!FOAMP.!The!FOAMP!developed!a!set!of!conceptual!models!and!a!suite!of!studies!about!the!importance!of!"fall!low!salinity!habitat"!(FLaSH)!for!Delta!Smelt.!As!an!ongoing!adaptive!management!project,!the!FOAMP!will!be!informed!by!the!results!of!the!FLaSH!studies,!the!CAMT!efforts,!and!other!input.!Additional!information!on!the!FOAMP!and!ongoing!investigations!is!provided!in!Section!5!of!this!report.!

Fall*Outflow*Key*Questions*and*Hypotheses*

Tables!4"1!and!4"2!below!list!key!questions!and!draft!hypotheses!developed!by!a!technical!subgroup!for!use!as!a!resource!in!framing!specific!science!investigations!for!the!CAMT!workplan.!Table!4"1!lists!questions!related!to!Delta!Smelt!habitat!and!recruitment,!while!Table!4"2!lists!key!questions!related!to!identifying!and!managing!risks!to!Delta!Smelt.!The!key!questions!presented!in!Tables!4"1!and!4"2!reflect!the!recommendations!of!the!technical!subgroup!and!have!not!been!

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modified by CAMT. CAMT may refine these questions for the purposes of developing its workplan (see Section 3), and expects that further refinements to the questions and draft hypotheses will be made in the process of developing detailed study plans for specific work elements. Ultimately, it is expected that pursuing answers to key questions will lead to the resolution of disagreements about the relative importance of drivers and mechanisms and result in more efficient use of resources and greater protection for the species.

Addressing the questions presented in Tables 4-1 and 4-2 will require evaluation of available data and some combination of ongoing and new studies. Several of the hypotheses presented in these tables are addressed at least in part in the existing Fall Outflow Adaptive Management Plan (AMP) and/or in the IEP Management, Analysis, and Synthesis Team (MAST) report.

Table 4-1

Understanding How Habitat Attributes in the Fall Affect Growth and Recruitment
Questions
1. Under what circumstances do the habitat attributes listed in the conceptual model limit growth and survival of Delta Smelt in the fall? a. How, and under what circumstances do habitat attributes such as food availability, toxicity, harmful algal blooms, predation, water temperature, turbidity, and size and location of the low salinity zone in the fall, collectively or individually, affect growth and/or survival of Delta Smelt during the fall? b. What are the mechanistic (ecological) relationships underling each factor? Under what conditions does each factor act? Do the existing descriptions of interconnections between environmental drivers acting on Delta Smelt in the available conceptual models and their expected effects on ecosystem responses within and among seasons need to be revised? c. How can existing data sets be further analyzed to better explain how outflow affect Delta Smelt growth, health, and condition variability during fall, winter and spring? d. Is there a need to include additional habitat attributes or environmental drivers from previous seasons and/or fall in the fall conceptual model? Is the timing and intensity of hydrology (separate from outflow) ecologically important? e. Under what set of circumstances do environmental conditions in the fall season contribute to determining the subsequent abundance of Delta Smelt? f. Which habitat attributes limit the abundance or growth of Delta Smelt in the summer and/or fall? What actions could be implemented to address those limiting attributes? g. Can a better habitat index be developed? *
Draft Hypotheses
(H1) The habitat attributes of food availability, toxicity, harmful algal blooms, predation, water temperature, turbidity and size and location of the low salinity zone in the fall, collectively or individually, have a significant effect on the growth and/or survival of Delta Smelt during the fall. *(H1a) There is a statistically significant relationship between abundance and two factors, abundance in the previous fall and previous fall X2.*

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(H2)&There&is&a&significant&correlation&between&growth&during&the&fall&and&subsequent& recruitment&&
(H3)&The&variability&in&growth&of&Delta&Smelt&during&the&fall&that&is&explained&by&abiotic&variables& is&less&than&that&explained&by&biotic&variables&
(H4)&Survival&of&Delta&Smelt&during&the&fall&varies&significantly&from&year&to&year&and&is& important&in&explaining&the&annual&changes&in&abundance&
(H5)&Survival&of&Delta&Smelt&through&the&fall&is&related&to&survival&in&previous&or&subsequent&life& stages&
(H6a)&A&significant&correlation&exists&between&the&survival&of&Delta&Smelt&from&summer&to&winter& in&a&year&and&Delta&outflow&in&the&fall.!
(H6b)&A&significant&correlation&exists&between&the&survival&of&Delta&Smelt&from&summer&to&winter& in&a&year&and&habitat&conditions&in&the&fall.!
(H7)&Delta&outflow&in&the&fall&has&significant&effects&on&habitat&attributes&found&to&be&limiting&
(H8)&Years&with&low&survival&during&the&fall&can&be&associated&with&limiting&levels&of&habitat& attributes&found&to&be&significant&in&analyses&associated&with&H1&
(H9)&&The&timing&and&intensity&of&hydrology&(separate&from&outflow)&during&the&fall&is& ecologically&important&to&Delta&Smelt&(i.e&affects&the&survival&and/or&growth)&&
(H10)&&Entrainment&risk&to&adult&Delta&Smelt&during&the&subsequent&winter&and&spring&are&lower& when&average&X2&is&below&81km&in&the&fall.!

Table*4K2*

Identifying*Risks*and**Management*Strategies *
Questions*
1. Under!what!circumstances!(e.g.,!distribution!of!the!population,!prey!density,! concentrations!of!contaminants)!do!project!operations!in!the!fall!have!significant!effects!on! survival,!population!viability,!and!recovery!of!Delta!Smelt?!! 2. When!circumstances!occur!in!the!fall!that!place!Delta!Smelt!at!high!risk!of!mortality,!what! actions!can!be!implemented!to!reduce!the!impacts!of!project!operations!on!the!fish?! 3. How!can!those!actions!(under!2.!above)!be!implemented!and!be!consistent!with!the! objectives!of!the!water!projects?!How!can!strategic!increases!in!fall!outflow!be!achieved! with!minimal!water!supply!impacts?! 4. How!much!variability!in!tidal,!daily,!weekly,!and!monthly!fluctuations!in!fall!X2!is! attributable!to!water!project!operations?! *
Draft*Hypotheses*
(H11)&&In&the&Fall&the&extent&of&the&area&occupied&by&Delta&Smelt&is&significantly&correlated&with& the&area&extent&of&the&low&salinity&zone&(or&the&position&of&the&X2&isohaline)&& *&(H12)&&The&distribution&and&extent&of&habitat&for&Delta&Smelt&as&represented&by&the&distribution& and&extent&of&the&low&salinity&zone&(or&the&position&of&the&X2&isohaline)&during&the&fall&has& diminished&over&the&available&historic&record&* *(H13)&&Changes&over&time&in&the&distribution&and&extent&of&habitat&as&represented&by&the& distribution&and&extent&of&the&low&salinity&zone&(or&the&position&of&the&X2&isohaline)&during&the& fall&is&attributable&to&water&export&project&operations&*

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(H14)&There&is&a&significant&positive&correlation&between&the&survival&rate&of&Delta&Smelt&during&the&fall&and&the&percentage&of&the&Delta&Smelt&population&in&the&confluence&or&west&of&it&during&the&fall&.

Delta*Smelt*Conceptual*Models*

Figures!4"1!and!4"2!below!depict!recent!conceptual!models!for!Delta!Smelt!proposed!by!the!Interagency!Ecological!Program!(IEP),!Management,!Analysis,!and!Synthesis!Team!(MAST)!draft!July!2013!report.!While!uncertainty!exists!regarding!some!mechanisms!and!the!relative!importance!of!the!various!habitat!attributes!and!drivers,!these!models!generally!incorporate!and!reflect!the!research!that!has!been!done!on!Delta!Smelt!to!date!(see!reports!describing!the!POD,!FLaSH,!and!MAST,!and!reviews!by!the!NRC!and!Delta!Science!Program).!Continued!work!is!needed!by!universities,!agencies,!and!stakeholders!to!reduce!these!uncertainties!and!improve!our!understanding.!!

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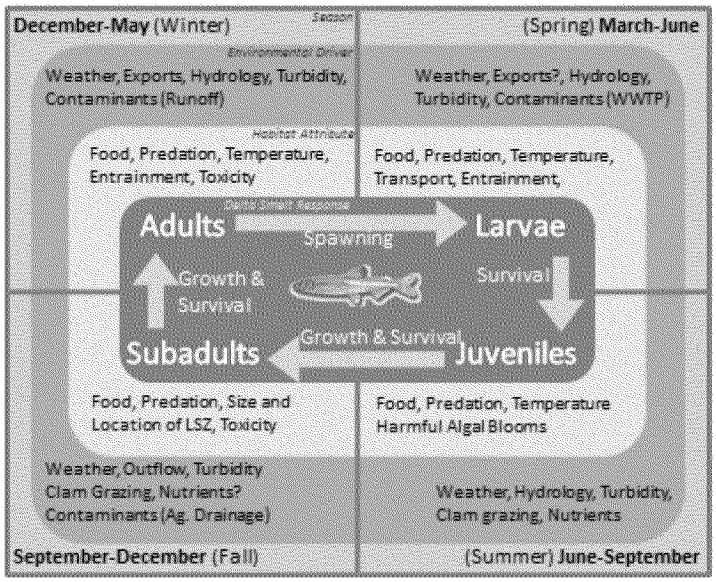

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Figure*4K1*Revised*Conceptual*Model*for*Delta*Smelt*

A!revised!conceptual!model!for!Delta!Smelt!(MAST!2013)!showing!responses!(dark!blue!box)!to!habitat!attributes!(light!blue!box),!which!are!influenced!by!environmental!drivers!(purple!box)!in!four!"life!stage!seasons"!(green!box).!

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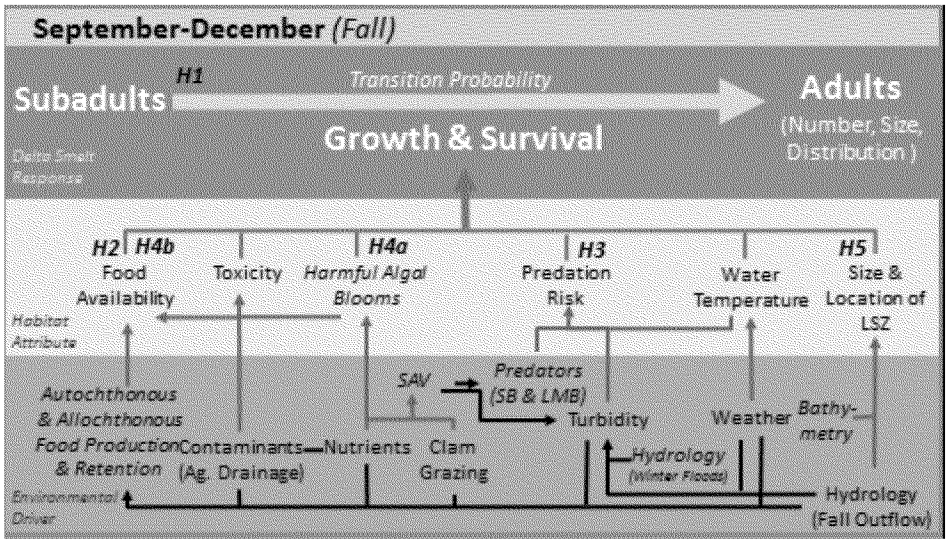

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Figure*4K2*Conceptual*Model*for*Transition*from*
Delta*Smelt*Subadults*to*Adults*K*Source:*(MAST*2013)*

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Fall Habitat and Delta Smelt Distribution

The Fall Outflow Subgroup discussed how Delta Smelt habitat has been defined in the fall and what relationships exist between fall outflow and Delta Smelt distribution in the fall. The Subgroup agreed that these relationships should be updated with the most recent data (e.g., Cache Slough data, data post 2011), and that new analytical approaches could provide more information regarding the relative importance of various covariates yet to be considered. The existing conceptual models suggest the quality of habitat is determined by a complex combination of factors, and is unlikely to be characterized adequately using only salinity and turbidity. As an example, the group agreed that food may limit Delta Smelt abundance or habitat and those biotic factors require further investigation, including understanding the relationships between biotic and abiotic factors. The group also acknowledged that more work could be done to explore the relationship between habitat attributes and the distribution of Delta Smelt.

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The Subgroup also recognized that in some years a portion of the Delta Smelt population may reside in Cache Slough and was interested to see if higher fall outflows might benefit the Delta Smelt population in the Cache Slough area during wet and above normal water year types, and how water project operations affect the Delta Smelt population when fall outflow is at lower levels.

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The Subgroup acknowledged that data sets and habitat attributes that have not been previously considered could be incorporated into the habitat index modeling, but recognized that data limitations exist for some key variables of interest. Nonetheless, the Subgroup agreed that it would be worthwhile to explore other long-term data sets and analyses might benefit from exploratory modeling to determine if relationships could be extrapolated to the full record of the FMWT data.

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Finally, the Subgroup noted that there are inherent shortcomings (including biases) in the existing monitoring data and that those shortcomings may affect inferences regarding the distribution, occurrence, and abundance of Delta Smelt. The group agreed that more work is needed to identify these uncertainties and suggested that some re-analysis of relationships in the conceptual model is necessary. Specifically, an argument was made that the habitat index analysis did not incorporate recently added FMWT data points from Cache Slough and that the historical FMWT survey does not adequately sample the entire Delta Smelt range. In addition, concerns were raised regarding the methods used to determine the habitat index, including that it should be re-calculated with additional variables such as abundance, geography and food.

Delta Smelt Abundance and Stock-Recruit Relationships

The Subgroup discussed existing stock-recruit and stage-recruit relationships for all Delta Smelt life stages and the approaches used to explore how fall habitat variables and especially X2 may improve the "explained variance" in survival and recruitment from fall to the next year. The group acknowledged that the stock-recruit (SR) model used in the FWS Biological Opinion should be updated with the most recent data and that other variables should be tested in the model. However, as noted above, a challenge is finding suitable long-term data sets for key variables of interest. Most importantly, the group acknowledged that the mechanisms underlying SR

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relationships!should!be!explored!in!more!detail!and!noted!that!the!growth!rate!studies!supported!by!the!FLaSH!investigation!should!be!completed.!The!group!also!noted!that!additional!investigations!of!diet!(including!prey!selection)!should!be!conducted!for!all!life!stages!of!Delta!Smelt!in!all!year!types.!!

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The!Subgroup!acknowledged!that!there!is!substantial!variability!in!the!relationship!between!the!FMWT!index!and!the!fall!habitat!index!in!the!same!year,!but!noted!that!the!effects!of!fall!habitat!improvements!may!not!be!realized!immediately!and/or!that!the!antecedent!population!abundance!and!conditions!during!the!preceding!summer!should!be!taken!into!account!as!well!!

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4.2 OMR and Delta Smelt Entrainment

The 2008 Biological Opinion for Delta Smelt contains a Reasonable and Prudent Alternative (RPA) – that includes three actions intended to protect pre-spawning adult Delta Smelt (Actions 1 and 2) and larval and juvenile smelt (Action 3) from excessive entrainment. Specifically, the actions set limits on flows in Old and Middle River (OMR) during December-June.

OMR/Entrainment Problem Statement

A 2010 National Research Council (NRC 2010) review concluded: *"[T]here is substantial uncertainty regarding the amount of flow that should trigger a reduction in exports. In other words, the specific choice of the negative flow threshold for initiating the RPA is less clearly supported by scientific analyses. The biological benefits and the water requirements of this action are likely to be sensitive to the precise values of trigger and threshold values. There clearly is a relationship between negative OMR flows and mortality of smelt at the pumps, but the data do not permit a confident identification of the threshold values to use in the action, and they do not permit a confident assessment of the benefits to the population of the action. As a result, the implementation of this action needs to be accompanied by careful monitoring, adaptive management, and additional analyses that permit regular review and adjustment of strategies as knowledge improves."*

Water users and the Department of Water Resources have raised questions regarding the design and implementation of the RPA and its overall effectiveness in protecting Delta Smelt. The specific disagreements include: (1) whether and, if so, under what circumstances entrainment has an effect on the overall viability of the Delta Smelt population; and (2) the efficacy of managing OMR flows as a means of reducing entrainment (including the establishment of specific triggers and thresholds). The proposed mechanisms by which entrainment could affect the population are described in more detail in this report's conceptual models (see below), and have been tested to varying degrees by modeling studies such as Kimmerer (2008; 2011), Miller (2011), Miller et al. (2012), Maunder and Deriso (2011), Rose et al. (2013a, b), and BDCP (2013). There is disagreement about the interpretation of the model results and the degree to which they indicate population effects. These issues reflect a broader disagreement between water users and other CAMT Entrainment Subgroup members regarding whether, and if so, to what extent, entrainment affects Delta Smelt population dynamics. There may be opportunities to better understand and predict the conditions that influence entrainment levels.

Concerns and disagreements have also been raised regarding the data and methods currently being used to estimate entrainment and to set take limits. Further, as noted by the NRC (2010) and Kimmerer (2011), the historical distribution of Delta Smelt has shifted, and the recent addition of new monitoring stations and techniques has revealed the existence of greater variation in Delta Smelt life history strategies and geographic distribution than was previously recognized. Both changing distributions and different life history strategies may affect the interpretation of current proportional entrainment estimates and their likely response to hydraulic alterations (Miller 2011).

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OMR/Entrainment Background

The CAMT Entrainment Subgroup organized its efforts to address three primary areas of disagreement:

1. How to assess distribution, abundance, and entrainment of Delta Smelt.
2. Circumstances when entrainment affects the viability of the Delta Smelt population.
3. The efficacy of current and alternative actions to manage entrainment or mitigate its effects.

In this document, the term "entrainment" is used to specifically refer to the incidental removal (mortality) of Delta Smelt in water diverted from the estuary by CVP and SWP export pumping in the south Delta. It is distinct from "salvage" which refers to fish captured and counted in the state Skinner Fish Protective Facility (SFPF) and the federal Tracy Fish Collection Facility (TFCF) before they reach the pumps. The fish collected in these facilities are trucked to release sites in the western Delta. Salvage does not account for entrainment-related mortality that occurs before the fish reach the fish facilities ("pre-screen losses") or during the capture, handling, trucking and release process (Baxter et al. 2013, Castillo et al. 2012), nor does it account for fish size or operations-based changes in louver efficiency at the facilities that affect the ability to detect and separate fish from exported water.

Salvage of Delta Smelt at the fish facility screens has been assumed to be an index of entrainment of fish more than about 20 mm in length; at smaller sizes, there is less likelihood that salvage indexes entrainment (Kimmerer 2008, 2011; Miller 2011). The degree to which salvage parallels entrainment under different environmental conditions and pumping rates has only begun to be tested for Delta Smelt, but recent evidence suggests that salvage may not be a reliable measure of the magnitude of Delta Smelt entrainment (Castillo et al. 2012). The results support the hypothesis that under some conditions, pre-screen losses are high, suggesting that salvage measurements will sometimes require a relatively high level of expansion to estimate entrainment. The most recent independent scientific panel review was particularly concerned that "*direct and indirect losses due to entrainment into the pumping facilities and the variance estimates associated with those losses may be substantially underestimated, and are not well-connected to population size estimates.*" The panel also stated that "*(n)ew information about potential losses associated with entrainment at the pumping facilities (e.g., Castillo et al. 2012) suggest that the determination of allowable incidental take even from extended salvage estimates may underestimate actual facility impacts on this species*" (Delta Science Program. 2013. Report of the 2013 Independent Review Panel (IRP) on the Long-term Operations Biological Opinions (LOBO) Annual Review.

This document does not specifically address other hypothesized ecological impacts that have been attributed to water exports from the operation of the Delta water projects such as the loss of food web production to the pumps. There is substantial disagreement in the group about whether these "indirect effects" should be part of the current scope. The environmental NGOs have specifically raised concerns that the CAMT's consideration of hypotheses and actions relating to improved management of entrainment's direct mortality effects must take into

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account!both!these!indirect!effects!and!the!extent!to!which!access!to!habitat!in!the!south!Delta!affects!the!long"term!viability!of!Delta!Smelt&

OMR/Entrainment*Key*Questions*and*Hypotheses*

Conceptual!models!described!in!subsequent!sections!were!used!to!develop!a!generalized!list!of!key!questions!and!potential!hypotheses!that!could!be!used!to!frame!specific!science!investigations.!The!questions!are!organized!into!five!broad!categories!

1. *Measurement&of&Entrainment,&Abundance,&and&Distribution&*This!section!focuses!on!the!data!that!are!needed!to!address!subsequent!categories.!There!are!separate!questions!for!Adults,!and!Larvae/Post"Larvae.!
2. *Factors&Affecting&Entrainment&*This!category!deals!with!the!mechanisms!described!in!the!Mechanistic!Conceptual!Model!and!in!the!preceding!narrative.!The!Hypotheses!were!generated!in!part!from!the!Hypothesis"Driven!Conceptual!Model.!There!are!separate!questions!for!Adults,!and!Larvae/Post"Larvae.!
3. *Population&Level&Effects&*This!category!deals!with!the!population!level!effects!described!in!the!Mechanistic!Conceptual!Model!and!its!preceding!narrative.!!
4. *Implications&for&Management &*This!category!focuses!on!how!addressing!the!previous!questions!could!help!to!guide!management.!The!questions!here!were!generated!based!in!part!on!the!Entrainment!Management!Conceptual!Model.!
5. *Models&*This!category!focuses!on!how!new!information!would!be!used!to!refine,!update,!or!replace!existing!draft!conceptual!models.!This!could!also!be!extended!to!the!further!development!and!refinement!of!quantitative!models.!
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Hypotheses!have!not!been!included!for!all!categories,!partly!because!not!all!questions!lend!themselves!to!hypothesis!testing!(e.g.!method!development!questions),!but!also!because!the!subgroup!did!not!have!sufficient!time.!Additional!revisions!are!likely,!particularly!after!input!from!a!broader!audience!of!experts!and!the!development!of!specific!priorities!

Table*4K3*

Measurement*of*Entrainment,*Abundance,*and*Distribution*
Questions*
1. How!many!adult!Delta!Smelt!are!entrained!by!the!water!projects?! a. What!is!the!best!feasible!method!for!estimating!the!number!of!adults!entrained!by!the!water!projects?! b. What!is!the!relationship!between!salvage!and!entrainment,!how!variable!is!the!relationship,!and!what!factors!influence!that!variability?! c. What!methods!should!be!utilized!to!assess!the!distribution!and!abundance!of!adult!Delta!Smelt!prior!to!entrainment?! d. What!new!tools!would!provide!a!better!understanding!of!adult!entrainment!levels,!abundance,!and!distribution?! 2. How!many!larval!and!post"larval!Delta!Smelt!are!entrained!by!the!water!projects?! a. What!is!the!best!feasible!method!for!estimating!the!number!of!larvae!and!post"larvae!entrained!by!the!water!projects?! b. What!is!the!relationship!between!salvage!and!entrainment,!what!is!the!variability!in!

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Measurement of Entrainment, Abundance, and Distribution
the relationship, and what factors influence that variability? c. What methods should be utilized to assess the abundance and distribution of larval and post-larval Delta Smelt prior to entrainment? d. What new tools would provide a better understanding of larval and post-larval entrainment levels, abundance, and distribution ?

Table 4.4

Factors Affecting Entrainment
Questions
3. What conditions prior to movement to spawning areas affect adult Delta Smelt entrainment? a. Is there a relationship between Delta Smelt distribution and habitat conditions (e.g. turbidity, X2, temperature, food) during fall and subsequent distribution (and associated entrainment risk) in winter? 4. What factors affect adult Delta Smelt entrainment during and after winter movements to spawning areas? 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 habitat conditions (e.g. first flush, turbidity, water source, food, time of year) lead to adult Delta Smelt entering and occupying the central and south Delta? c. What conditions (e.g. flow, turbidity, water source, time of year) cause fish to move towards the export facilities? d. How should the region where entrainment risks are elevated be defined or delineated for the purposes of managing take of Delta Smelt at the export facilities? e. What new methods or tools can be developed to provide a better understanding of factors affecting adult entrainment? 5. What factors affect larval and post-larval Delta Smelt entrainment? a. How does adult spawning distribution affect larval and post-larval entrainment? b. What conditions (e.g. first flush, spawning distribution, turbidity, water source, food, time of year) lead to larvae and post-larvae occupying the central and south Delta? c. What conditions (e.g. flow, turbidity, water source, time of year) cause fish to move towards the export facilities? d. What new tools or methods can be used to provide a better understanding of factors affecting larval and post-larval entrainment?
Hypotheses
(H1) Adult Delta Smelt distribution and abundance in winter is influenced by Delta Smelt distribution and abundance in the fall as well as habitat conditions (e.g. turbidity, salinity,

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Factors Affecting Entrainment
temperature, food availability), and hydraulics (e.g. velocity, tidal flow splits) during winter.
(H2) 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.
(H3) Entrainment levels of adult Delta Smelt are higher when more fish are distributed in the central and south Delta (a consequence of suitable habitat conditions such as high turbidity,) and when there are negative OMR flows. Example sub-hypothesis include:
a. Once adult Delta Smelt are observed in the central and south Delta, they will stay there throughout the spawning period unless water conditions become unfavorable, even if OMR flows become positive.
b. Once adult Delta Smelt have moved into the south and Central Delta, entrainment levels of adults will be correlated in a non-linear way with negative OMR flows and fish abundance.
(H4) Larval Delta Smelt distribution and abundance in spring is influenced by adult Delta Smelt distribution and abundance, habitat conditions (e.g. turbidity, salinity, temperature, food availability), and hydraulics (e.g. velocity, tidal flow splits).
(H5) Entrainment levels of larval Delta Smelt are higher when more fish are distributed in the central and south Delta (a consequence of suitable habitat conditions such as high turbidity, and temperatures <25°C) and when there are negative OMR flows.

Table 4-5

Population Level Effects
Questions
6. What are the effects of entrainment on the population? a. What is the magnitude (e.g. % of population) of adult and larval entrainment across different years and environmental conditions? b. How do different levels of entrainment for adults and larvae affect population dynamics, abundance, and viability? c. How does entrainment affect life history diversity of adults and larvae over time? d. What are "natural" (ie. background levels) mortality rates in the south Delta and how do they compare to rates estimated for entrainment? 7. Which new tools (e.g. Population Viability Analysis, 2 or 3-D particle tracking, Individual based Modeling, life history modeling), etc. provide opportunities to more accurately and precisely quantify the population level effects of adult and larval entrainment? a. What are the strengths and weaknesses of the different approaches? b. How do they complement each other? c. How can these models be used individually or in combination to establish seasonal or real-time measurements of population effects?

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Population Level Effects
Hypotheses
(H6) Individual young of the year Delta Smelt found in the south Delta exhibit similar likelihood of survival compared to young of the year found elsewhere in the estuary.
(H7) Delta Smelt are entrained at Project facilities at levels that are likely to affect the long-term abundance of the Delta Smelt population.
(H8a) There are circumstances under which the losses of Delta Smelt to entrainment are sufficient to cause a demonstrable impact on population viability.
(H8b) The losses of Delta Smelt to entrainment are sufficient to affect N(e) and result in reductions in allelic diversity in the population.

Table 4-6

Implications for Management
Questions
8. What new information would inform future consideration of management actions to optimize water project operations while ensuring adequate entrainment protection for Delta Smelt? a. Can habitat conditions be managed during fall or early winter to prevent or mitigate significant entrainment events? b. Should habitat conditions (including OMR) be more aggressively managed in some circumstances as a preventative measure during the upstream movement period (e.g. following first flush) to reduce subsequent entrainment? c. If Delta Smelt move into the region where entrainment risks are elevated, how can OMR or other habitat conditions be managed to prevent or mitigate significant entrainment of adults and larvae? d. If preventive actions are undertaken to reduce entrainment risk, could there be unintended consequences that adversely affect Delta Smelt population viability or demographics? e. How can the operation and design of the export facilities be modified to reduce entrainment mortality? f. Can low risk circumstances be identified that would not result in significant levels of entrainment but that might allow pumping levels to be increased? g. Are there other actions, which may or may not involve water project operations that could be taken to achieve the same purposes of entrainment RPAs or that could offset or mitigate effects of entrainment? What would these actions be, under what circumstances would they be effective, and what would the effect of each action be? h. What other approaches to data collection and analyses beyond the ones currently in use, could be used to help manage entrainment levels and associated population effects?

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Implications for Management
9. How should conceptual models be updated based on study results designed to answer the preceding questions?!!!!
10. How should quantitative models be further developed based on study results designed to answer the preceding questions?!!!!

Delta Smelt Entrainment Conceptual Models

A key first step in adaptive management is to develop one or more conceptual models to guide the process. Below we describe recent conceptual models that helped frame the development of the study questions and hypotheses. While uncertainty exists regarding some mechanisms and the relative importance of the various habitat attributes and drivers, these models generally incorporate and reflect the existing analyses and spectrum of hypotheses created to date on Delta Smelt. The models will benefit from, and be improved by, a rigorous and comprehensive review and further testing. There is still substantial uncertainty about the relative importance of different habitat attributes and drivers on entrainment, so continued research is needed to improve our understanding and protection of this species.!!

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As presented in Section 4.1 above, the draft MAST Delta Smelt Conceptual Model (Baxter et al. 2013) is intended to be a generalized overview of factors affecting Delta Smelt at various life stages. It illustrates the role of entrainment across different life stages, with respect to other habitat attributes and environmental drivers. To provide further insight into short" and long" term changes in distribution, entrainment, and related management issues, the CAMT Entrainment Subgroup has developed complementary models that focus on more specific aspects of entrainment and provide more details about the interactions of management actions and drivers. These models, and the associated review of background information presented below, is expected to be revised as a result of the CAMT science investigations, and should not be taken as a sign of agreement of all group members to all details of the material presented. At this stage, the conceptual models are tools to identify uncertainties and disagreements and formulate questions and hypotheses intended to help address the uncertainties and resolve disagreements. The models are intended as a starting point that will be refined substantially based on additional input and studies.!!

Although it may be simpler to have fewer models for species management, we provide several formulations because none have been vetted and reviewed by the scientific community; they were developed by the subgroup for the CAMT. Each of the models helps address a specific scientific or management issue that may not be easily portrayed in a single overly" complex model. The specific models and their purposes are as follows:

1. Mechanistic Entrainment Model This model is designed to illustrate how several different mechanisms may interact to cause entrainment, and associated effects on the Delta Smelt populations.!!

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2.!Hypothesis"Driven!Entrainment!Model.!This!model!incorporates!several!of!the!key! mechanisms!from!the!previous!model!to!illustrate!how!specific!hypotheses!can!be!formulated!to! test!the!different!alternatives.!

3.!Management!Action!Entrainment!Model.!This!model!is!designed!to!show!how!management! actions!could!be!considered!to!reduce!entrainment!and!associated!effects.!

Background!Information!for!Entrainment!Models!

Background!information!about!entrainment!is!provided!below!to!aid!in!understanding!the! conceptual!models.!The!basic!entrainment!conceptual!models!cover!two!general!life!stages:!! adult!and!larval!Delta!Smelt.!The!seasonal!timing!of!each!life!stages!varies!from!year!to!year!and! usually!overlaps,!as!depicted!in!the!MAST!conceptual!model!for!the!life!cycle!of!Delta!Smelt! (Baxter!et!al.!2013):!December"May!(winter)!for!adults;!and!March"June!for!larvae!(and!post" larvae[2]).!Note!that!these!periods!are!somewhat!different!than!the!specific!periods!of! management!actions!described!in!the!Delta!Smelt!Biological!Opinion!(USFWS!2008).!As! discussed!in!USFWS!(2008),!the!primary!period!of!concern!for!entrainment!in!a!given!year!is! roughly!bounded!by!“first!flush”!(see!below)!in!winter!through!March!for!adults!and!between! the!onset!of!suitable!spawning!temperatures!and!unsuitably!warm!water!temperatures!for! larvae!and!post"larvae!in!spring!or!early!summer.!Entrainment!during!these!periods!may!have! population!effects,!with!pertinence!to!relevant!management!issues.!

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Delta!Smelt!are!endemic!to!the!San!Francisco!Estuary;!their!nearest!known!relative!is!the!marine! surf!smelt!(Stanley!et!al.!1995).!There!is!no!evidence!that!Delta!Smelt!have!differentiated!into! persistent!sub"populations,!and!a!recent!genetic!study!concluded!that!the!species!is!a!single! population!(Fisch!et!al.!2011).!However,!this!does!not!mean!that!all!individual!Delta!Smelt! behave!the!same!way!or!use!habitat!the!same!way.!Some!Delta!Smelt!live!year"round!in!fresh! water,!and!some!are!found!in!mesohaline!waters;!others!spend!the!summer!and!fall!in!the!low" salinity!zone!of!the!estuary.!Currently,!all!usable!summer"fall!rearing!habitats!are!at!a!relatively! safe!distance!from!the!South!Delta!SWP!and!CVP!pumps.!The!abundance,!distribution,!and! movement!of!adult!Delta!Smelt!affect!entrainment!risk!of!this!life!stage!(Sweetnam!1999;! Sommer!et!al.!2011).!Entrainment!is!also!an!issue!for!larval!Delta!Smelt!that!hatch!during!the! spring.!Dispersal!from!hatching!areas!to!favorable!nursery!areas!with!sufficient!food!to!enable! rapid!growth!through!the!vulnerable!larval!stage!is!generally!considered!one!of!the!most! important!factors!affecting!the!mortality!of!fish!larvae!(Houde!1987).!Many!factors!are!thought! to!affect!larval!Delta!Smelt!entrainment!risk!including!adult!spawning!site!selection,! hydrodynamics,!turbidity,!temperature,!and!proximity!to!the!south!Delta!export!pumps! (Kimmerer!and!Nobriga!2008;!Baxter!et!al.!2013).!!

Adults!

To!help!provide!an!understanding!of!the!entrainment!process,!the!following!discussion!divides! the!issue!into!three!basic!phases:!!1)!the!antecedent!fall!period;!2)!the!spawning!movement! period;!and!3)!the!period!when!entrainment!occurs.!The!first!two!periods!represent!the! conditions!that!determine!the!winter!distribution!of!adult!smelt,!a!primary!factor!that!influences!

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[2]!Defined!here!as!fish!large!enough!to!be!observed!in!salvage!during!late!spring!and!early!summer!

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entrainment risk. In reality, these periods overlap. However, they are described separately to help provide a conceptual context for how different conditions during each phase may influence (or help avoid) subsequent entrainment.

Antecedent Fall Period: The distribution of Delta Smelt during fall has been covered in detail by several studies including Merz et al. (2011), Sommer et al. (2011), and Murphy and Hamilton (2013). Based on the data available from existing surveys, the distribution covers a broad range of salinities from about 0 to 10 psu (Sommer et al. 2011; Sommer and Mejia 2013; Murphy and Hamilton 2013). The FMWT suggests that the apparent distribution is affected by salinity, but the survey has not fully represented habitat use in areas on the periphery of the species' geographic range such as Cache Slough Complex or Napa River (Merz et al. 2011; Sommer and Mejia 2013; Murphy and Hamilton 2013). Distribution also likely depends on several other habitat conditions such as turbidity, temperature, food availability, and predator abundance.

One hypothesis is that distribution and habitat conditions during this period could have an effect on subsequent entrainment risk. For example, it is possible that a more eastward distribution in the fall may increase the risk that fish will later disperse into the lower San Joaquin River and central Delta, where entrainment risk is higher (Grimaldo et al. 2009; BOR 2012). However, Delta Smelt that remain in more distant regions such as Cache Slough Complex or the Suisun region will not be entrained.

Spawning Movement Period: Winter is associated with substantial environmental changes that trigger upstream movements toward freshwater spawning areas in a portion of the Delta Smelt population (Moyle 2002; Grimaldo et al. 2009; Sommer et al. 2011; Murphy and Hamilton 2013). There is disagreement over how large a portion moves upstream versus to channel margins or downstream (Murphy and Hamilton 2013). As noted in recent studies, not all adult Delta Smelt move at the same time or in the same direction. For example, a portion of the Delta Smelt population rears in the freshwater Cache Slough region during fall and likely remains there to spawn (Sommer et al. 2011; Sommer and Mejia 2013). Furthermore, multiple peaks of fish salvaged at the fish facilities suggest that movements during the spawning season are not completely synchronous (Grimaldo et al. 2009).

The factors that trigger Delta Smelt movement to spawning areas are not well understood, but fish may shift their distribution in response to "first flush" (Grimaldo et al. 2009; Sommer et al. 2011). The specific features of a first flush cue for pre-spawning movements of Delta Smelt require an understanding of key characteristics and thresholds. From a physical perspective, first flush refers to the first large storm-induced increases in river flows into the Delta – usually during winter; it is often associated with elevated sediment inputs and sediment-bound pesticides (Bergamaschi et al. 2001). The environmental factors that may trigger and support movements during first flush still need to be investigated. Candidate habitat variables that could be associated with first flush include one or more of the following: increased turbidity, decreased salinity, decreased temperature, increased food availability. It also appears that time of year is important because flow increases in late fall (e.g. November) do not result in major increases in salvage, the primary indicator of entrainment (Grimaldo et al. 2009). Note that the Report of the 2013 Independent Review Panel (IRP) on the Long-term Operations and Biological Opinions (LOBO) Annual Review questioned whether first flush was a critical event based on

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their!comment!that!"it!seems!counter"intuitive!that!an!annual!species!such!as!the!Delta!Smelt! would!have!evolved!to!depend!for!its!survival!on!temporally!unreliable!environmental!cues!to! trigger!migrations!associated!with!crucial!life!cycle!events!such!as!spawning!or!selection!of! nursery!locations."!

As!noted!above,!it!appears!that!not!all!Delta!Smelt!respond,!or!respond!immediately,!to!these! changes!–!movements!do!not!appear!to!be!entirely!synchronous.!It!is!unclear!whether!there!is!a! particular!cue!during!first!flush!events!that!trigger!Delta!Smelt!movements!or!whether!first!flush! events!merely!increase!the!area!of!higher!quality!habitat!for!Delta!Smelt!to!spread!into!(Murphy! and!Hamilton!2013).!However,!the!movements!of!at!least!a!portion!of!the!Delta!Smelt! population!are!consistent!with!migratory!behaviors!exhibited!by!a!suite!of!other!native!fishes! during!the!same!period!(Sommer!et!al.!2011;!2013).!!

The!major!factors!affecting!subsequent!entrainment!risk!during!winter!first!flush!periods!are!the! direction!and!magnitude!of!Delta!Smelt!movement.!Specifically,!South!Delta!entrainment!does! not!occur!unless!adult!fish!swim!into!the!lower!San!Joaquin!River!and!its!central!Delta! distributaries!during!winter.!As!noted!above,!a!hypothesis!is!that!one!or!more!individual! covariates!of!increasing!winter!inflow!(turbidity,!salinity,!temperature,!food!availability)!could! individually,!or!in!combination,!affect!whether!Delta!Smelt!move!into!the!San!Joaquin!River! channels.!Several!of!these!factors!can!be!affected!by!water!operations!or!management!actions! (e.g.!net!flow!direction!and!the!dispersion!of!turbidity).!

Adult!Entrainment!Period!

As!noted!in!the!previous!two!periods,!environmental!conditions!during!winter!and!fall!likely! influence!the!distribution!of!adult!Delta!Smelt.!Fish!that!move!into!the!lower!San!Joaquin!River! system!face!elevated!entrainment!risk!for!themselves!and/or!their!progeny.!The!risks!include!a! continued!movement!towards!the!south!Delta!pumps,!where!the!adults!are!more!vulnerable!to! entrainment,!perhaps!adult!mortality!due!to!unfavorable!habitat!conditions!in!the!vicinity!of!the! pumps,!and!spawning!in!areas!where!their!offspring!are!vulnerable!to!entrainment.!This!section! focuses!only!on!adult!entrainment.!Whether!Delta!Smelt!continue!towards!the!south!Delta! pumps!depends!on!a!number!of!factors!including!hydraulics!and!habitat!conditions.!!

Hydraulics:!One!focus!of!management!actions!is!the!area!near!the!pumps!where!net!flows!are! often!reversed.!Inflow,!tributary!contribution!(e.g.!San!Joaquin!River!versus!Sacramento!River),! export!and!diversion!levels,!and!tidal!effects!all!play!a!major!role!in!whether!and!the!degree!to! which!flows!in!the!south!Delta!are!reversed.!At!present,!Old!and!Middle!River!(OMR)!flows!are! used!as!a!key!indicator!of!the!flow!reversals!that!are!most!relevant!to!the!movement!of!Delta! Smelt!towards!the!south!Delta!pumps,!and!therefore!the!risk!of!fish!entrainment!(Kimmerer! 2008;!Grimaldo!et!al.!2009).!Actions!to!manage!OMR!levels!include!changing!reservoir!releases,! export!rates,!and!Delta!Cross!Channel!gate!operations.!

Habitat!Conditions:!In!addition!to!hydraulics,!habitat!characteristics!including!turbidity,! temperature,!predation!risk,!and!food!availability!could!affect!the!movement!of!fish!into!the!San! Joaquin!River!and!their!subsequent!risk!of!entrainment.!For!example,!salvage!data!suggest!that! adult!Delta!Smelt!entrainment!is!low!when!south!Delta!water!clarity!is!high!(Grimaldo!et!al.! 2009).!A!hypothesized!mechanism!is!that!Delta!Smelt!actively!avoid!moving!into!the!south!Delta! and!its!channel!connections!to!the!SWP!and!CVP!facilities!unless!there!is!a!"bridge"!of!higher!

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turbidities and perhaps other water quality conditions. An alternative hypothesis is that Delta Smelt do not avoid clearer water; rather, apparent entrainment (salvage) does not occur because Delta Smelt are eaten by visual predators before they reach the fish screens. Some of these factors may interact, and could be influenced by management actions such as changing reservoir releases, export levels, and Clifton Court Forebay or Delta Cross Channel gate operations.

Larval Entrainment

Even if adult Delta Smelt that move into the central and south Delta are not entrained, their offspring may be vulnerable to entrainment. The primary period of concern for larval entrainment in the south Delta lasts through spring until temperatures rise to lethal levels, presumably resulting in mortality of any remaining individuals (USFWS 2008). There is uncertainty as to how well current models are able to mimic movement of Delta Smelt; however, studies using a particle tracking model have suggested that entrainment risk increases strongly with proximity to the export facilities (Kimmerer and Nobriga 2008). Thus, a hypothesis is that the adult spawning distribution is of primary importance to the entrainment risk of their offspring during late winter and spring – particularly if outflow does not increase during the period that adults spawn and eggs hatch, thereby helping to move the larvae seaward.

In addition, entrainment risk for Delta Smelt larvae may be influenced by river flow direction and velocity, and by other environmental conditions such as turbidity, temperature, and food. However, the way these environmental conditions affect larvae is likely different than for adults because the younger fish are weaker swimmers, are seeking rearing habitat, and initially are not as strongly associated with turbidity as metamorphosed individuals (e.g. Miller 2011). For example, if adults encounter unsuitable water quality conditions (e.g. low turbidity) in channels adjacent to the pumps, they may have some ability to avoid being entrained by moving toward habitat with better conditons (e.g. higher turbidity). By contrast, unsuitable water quality conditions may not be enough to redirect larval fish movements, especially closer to the export facilities where the ebb tide can be absent.

Salvage numbers are currently used to determine incidental take limits and index entrainment for post-larvae. Fish greater than 20 mm FL are counted at the screens (Grimaldo et al. 2009, Morinaka 2013), but because salvage data suggest that the fish screens do not effectively catch fish smaller than 30 mm FL (e.g. Figure 6 in Kimmerer 2008), there is a high degree of uncertainty about the number of larvae entrained.

Population Effects

Ultimately, a major question for Delta fisheries managers is the effect of entrainment on the Delta Smelt population. For the purposes of the conceptual models, three types of population effects are considered: 1) the proportion of the population entrained at each life stage; 2) the resultant effects on population viability; and 3) demographic effects.

Proportional Entrainment of Delta Smelt: The proportional entrainment of Delta Smelt is a major management issue for the establishment of take limits in the Delta Smelt Biological Opinion (FWS 2008). Given the complexity of the issue, proportional entrainment is exceptionally

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difficult to estimate. Below are two example approaches based on: (1) population estimates and (2) relative measures.

The first approach requires estimates of both entrainment losses and the population size of Delta Smelt. Unfortunately, the relationship between salvage and entrainment is poorly understood and likely variable, making it difficult to get accurate estimates of entrainment (Kimmerer 2011; Miller 2011; Castillo et al. 2012). Second, key information is lacking to develop reliable population estimates for Delta Smelt (Newman 2008). One approach to deal with these issues is to model fish survey and salvage data in combination with multiple (and mostly untested) assumptions (Newman 2008; Kimmerer 2008, 2011; Miller 2011; Mount et al. 2013; Rose et al. 2013a,b). These efforts have provided estimates of both adult and larval losses for selected recent years. However, a major challenge is that Delta Smelt catch in fish surveys has been very low since the onset of the Pelagic Organism Decline in 2002 (Sommer et al. 2007). The present low detection probability means that uncertainty is high about both entrainment and relative population levels.

A second approach to estimate entrainment levels does not require actual population estimates. For example, densities of fish collected at the export facilities can be compared with densities at multiple locations across the distribution of the species (e.g. Kimmerer 2008; Mount et al. 2013). This approach has been used in at least a conceptual way to establish take levels (i.e. winter entrainment) of adults by examining data from the previous season (Fall Midwater Trawl, FMWT) to index relative population levels (USFWS 2008). The FMWT has been used in this relative approach because it has a wider range of sampling stations and a longer historical record than is available in winter (the Spring Kodiak Trawl, and allows the development of take levels in advance of first flush events that often coincide with increased entrainment.

Effects on Population Viability and Dynamics: Understanding the proportion of fish lost to entrainment is a key issue in the determination of incidental take levels, but a broader question is the degree to which entrainment affects Delta Smelt population dynamics and viability. This insight is needed to better describe when Delta Smelt entrainment levels are at a low or high risk to the population.

Several modeling studies have examined Delta Smelt population dynamics and included an entrainment component. As noted in Mount et al. (2013), these efforts, which are based on numerous assumptions, have relied on estimates of population parameters that have not been validated, so caution is needed in the interpretation of the results. One example is a transport" based approach (Mount et al. 2013), which, although moderately uncertain, suggested that changes in flow and export patterns modeled under some BDCP scenarios would reduce entrainment and substantially change long"term survival of Delta Smelt. Another example is a state–space multistage life cycle model to examine the effects of different environmental variables including entrainment on different life stages (Maunder and Deriso 2011). There is disagreement in the CAMT Entrainment Subgroup about whether the Maunder and Deriso (2011) results support the hypothesis that adult entrainment affect population trends. More recently, Rose et al. (2013a,b) developed an individual based life cycle model that included estimates of both larval and adult entrainment. They propose that there is a higher degree of support for entrainment effects, though this claim is based on assumptions about which there is

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disagreement including the assumptions that particle tracking model results are a reliable proxy for Delta Smelt movement and that Delta Smelt engage in a large-scale eastward migration annually. In addition, Miller et al. (2012) found evidence of entrainment effects on adult to juvenile survival but not over the fish's life cycle. Others have examined the effects of covariates on Delta Smelt population trends, but relied on seasonally averaged export levels rather than specific estimates of entrainment (MacNally et al. 2010; Thomson et al. 2010).

Genetic effects are considered as a key tool to understand the effects of harvest mortality on populations. Such effects may include loss of genetic variation, and selective genetic changes (Allendorf et al. 2008). One approach to examine patterns in population viability is to examine effective population size (N_e) based on genetics, as well as overall population size (N) though this is not the only approach and it may yield results inconsistent with other approaches (eg., measurement of allelic richness). Low N_e/N ratios can indicate the population has low genetic variability, potentially resulting in reduced adaptability, persistence, and productivity (Hauser et al. 2002). Efforts are currently underway to measure both N_e and N for Delta Smelt. Population viability can also be examined using alternative, non-genetic approaches. For example, Bennett (2005) presented a population viability analysis (PVA) using historical Delta Smelt FMWT indices to assess the long-term trajectory of the population. To our knowledge, there have been no attempts to incorporate different stressors such as entrainment into a PVA model.

Demographic Effects There is an increasing recognition in fisheries biology that there can be substantial diversity in the life history strategies of individuals and sub-groups of populations (e.g. Secor 1999). It is hypothesized that these different strategies provide "bet hedging" against variable environmental conditions. Recent studies on otolith microchemistry (Hobbs et al. 2007; Hobbs 2010) reveal that Delta Smelt have substantial variability in their use of different salinities across the estuary. Examples of life history types observed include: freshwater residents; brackish residents; and fish that move to and from brackish and freshwater. This type of diversity may not be confined to salinity - other variation such as temporal or geographic could be considered. Given these issues, it is important to understand whether and how entrainment affects the range of life history strategies that can be exhibited by Delta Smelt.

Mechanistic Entrainment Model This model illustrates how several different mechanisms may interact to cause entrainment, and associated effects on the Delta Smelt population. The individual models for adults and larvae are provided below in Figures 4-3 and 4-4, respectively.

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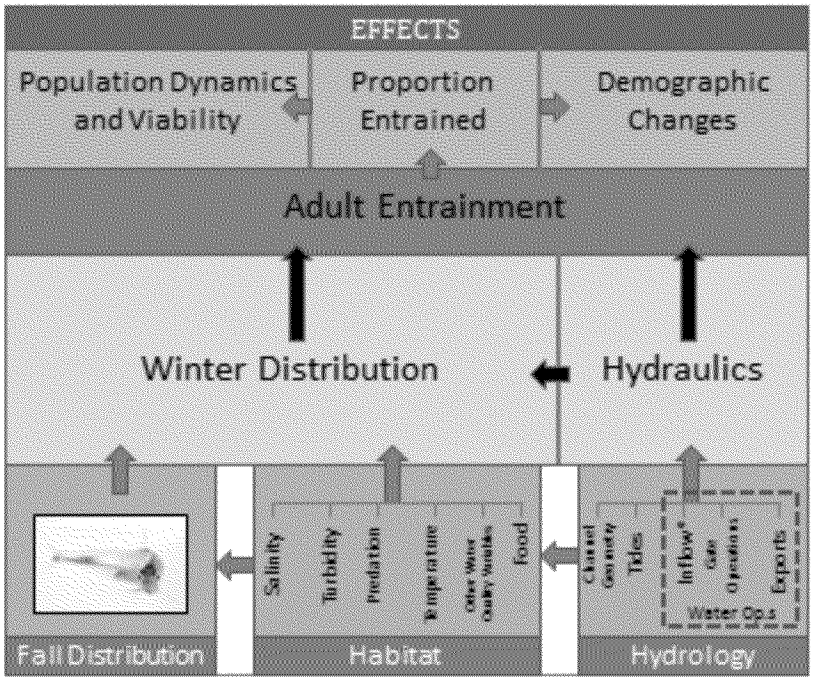

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Figure*4K3*Mechanistic*Entrainment*Model*for*Adult*Delta*Smelt!

!Inflow!is!shown!with!an!asterisk!(*)!in!the!"Water!Ops"!box!(l ower!right)!because!it!is!driven!by! both!operations!and!external!weather!conditions.!!

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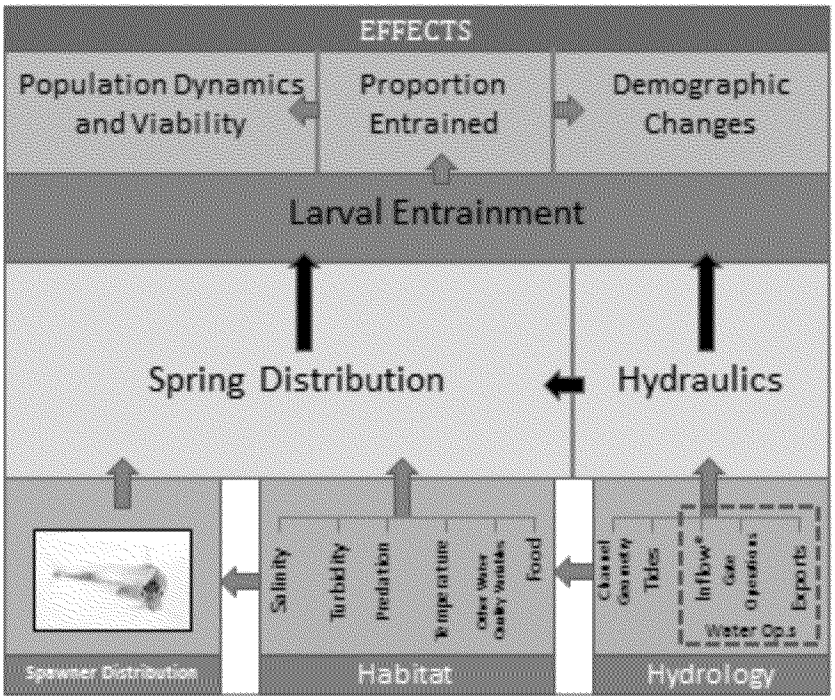

Figure*4K4*Mechanistic*Entrainment*Model*for*Larval*Delta*Smelt!

Inflow!is!shown!with!an!asterisk!(*)!in!the!"Water!Ops"!box!(lower!right)!because!it!is!driven!by!both!operations!and!external!weather!conditions.!

The!background!information!supporting!the!adult!and!larval!Mechanistic!Entrainment!Models!were!provided!in!the!previous!section.!The!following!is!a!brief!explanation!of!how!different!model!components!interact!for!the!adult!model.!

The!focus!of!this!model!is!entrainment,!shown!as!a!dark!blue!row.!The!model!illustrates!how!entrainment!can!have!three!types!of!population!level!effects!(green!rows!in!upper!part!of!figure).!These!effects!can!include!proportional!entrainment,!population!dynamics,!and!demographic!effects.!

A!hypothesis!is!that!the!two!main!factors!influencing!entrainment!(dark!blue!row)!are!Winter!Distribution!of!Delta!Smelt,!and!Hydraulics!(light!blue!row) .!Of!primary!interest!for!Winter!Distribution!is!the!proportion!of!the!Delta!Smelt!spawning!population!that!is!distributed!in!the!region!of!the!lower!San!Joaquin!River!(south!Delta),!where!entrainment!risks!are!elevated!Hydraulics!includes!factors!such!as!Old!and!Middle!River!flow!direction!and!velocity!that!may!influence!movement!of!the!fish!towards!the!south!Delta!export!facilities.!!

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Moreover, the model posits that Winter Distribution (left light blue box) can be influenced by winter Hydraulics (Right light blue box), as well as two additional factors (purple row): Habitat conditions during winter and Fall Distribution of pre-spawning Delta Smelt. Specifically, the model predicts that Delta Smelt will not shift their Winter Distribution into the south Delta unless habitat conditions are suitable. Example Habitat conditions in this model include: Salinity, Temperature, Turbidity, Food, Predation, and Other Water Quality Variables. Fall Distribution of pre-spawning fish is included because fish may be at more or less risk depending on where they are located prior to moving to spawning areas. For example, pre-spawning fish distributed in the Cache Slough Complex are highly unlikely to be entrained by the South Delta export facilities. The model also recognizes that Habitat conditions (middle purple box) can affect the Fall Distribution (left purple box) of pre-spawning Delta Smelt.

Finally, the model proposes that Hydrology (right purple box) affects Habitat Conditions (middle purple box) and Hydraulics (right light blue box). Note that Hydrology is divided into two general categories: (1) non-operational (channel geometry and tides); and (2) operational (exports, gate operations). Inflow is considered a component of both categories. Hence, the latter grouping helps to illustrate the potential role of operations in the management of entrainment.

The Mechanistic Entrainment Model for larvae (Figure 4) is very similar to what was described for adults (Figure 3). The only difference in the organization is that the Spring Distribution of larvae (left light blue box) is determined by Spawner Distribution (lower left purple box in Figure 4) rather than Fall Distribution as described for the adult model (lower left purple box in Figure 3).

Hypothesis-Driven Entrainment Model. This model incorporates several of the key mechanisms from the previous model and background information to illustrate how specific alternative hypotheses can be constructed about the movement of Delta Smelt. We propose that the entrainment of Delta Smelt in the south Delta is a spatially explicit process that depends on the movement of Delta Smelt as depicted in the following conceptual models for adults (Figure 4-5) and larvae and post-larvae (Figure 4-6).

Figure 4-5 for adult Delta Smelt illustrates that there are three general possibilities for winter spawning movements: (1) adults can move seaward; (2) adults can already be rearing in the Sacramento River system and stay there; or (3) adults can be near (or approaching) the confluence of the Sacramento and San Joaquin rivers. Only (3) has any meaningful probability of entrainment in the south Delta (depicted as P(E) > 0).

This conceptual model framework allows multiple alternative hypotheses to be depicted as quasi-mathematical statements. Each numbered alternative in each box represents a different draft conceptual model/hypothesis for why Delta Smelt move in a particular direction during the winter based on habitat conditions and hydraulics (see Figures 4-3 and 4-4 for Mechanistic Entrainment Model).

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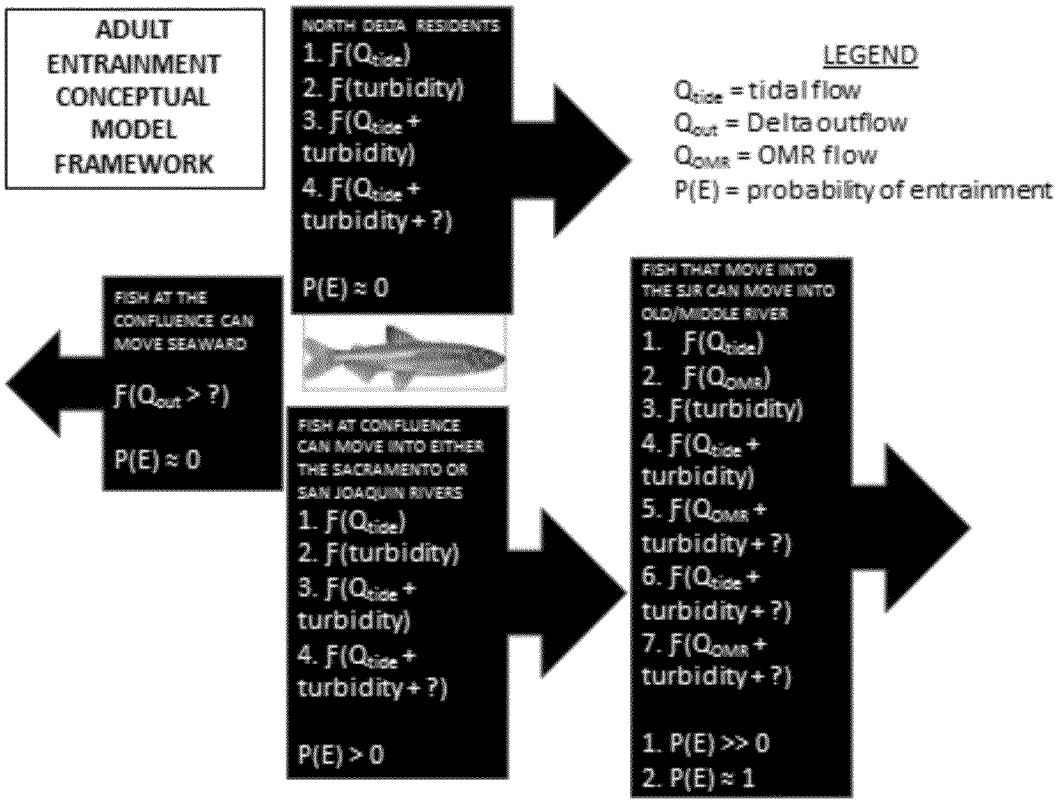

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Figure*4K5*HypothesisKDriven*Entrainment*Model*for*Adult*Delta*Smelt*

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The!larval/post"larval!entrainment!framework!is!very!similar!except!that!it!has!some!different!elements;!for!instance,!the!location!that!eggs!were!spawned!and!hatched!into!larvae!is!included!in!the!hypotheses,!and!tidal!flows!are!de"emphasized!because!the!larvae!(1)!rear!for!extended!periods!in!freshwater!(Dege!and!Brown!2004),!and!(2)!are!not!attempting!to!move!to!freshwater!spawning!areas!like!the!adults.!For!a!small!fish!in!a!tidal!environment!like!Delta!Smelt,!energetically!effective!upstream!movement!requires!tidal!surfing!(use!of!the!flood!tide!to!propel!fish!upstream!and!ebb!tide!to!propel!fish!downstream,!and!avoidance!of!full!velocity!parts!of!the!water!column!to!maintain!position!(Sommer!et!al.!2011;!Feyrer!et!al.!2013).!Very!little!directional!swimming!is!required!for!position!maintenance!in!a!strongly!tidal!environment!(Kimmerer!et!al.!1998;!2002;!Bennett!et!al.!2002).!Particle!tracking!models!have!been!used!to!predict!larval!Delta!Smelt!distributions!(Kimmerer!2008);!however,!models!that!are!able!to!incorporate!tidal!surfing!and!other!behaviors!may!provide!more!confident!predictions!!

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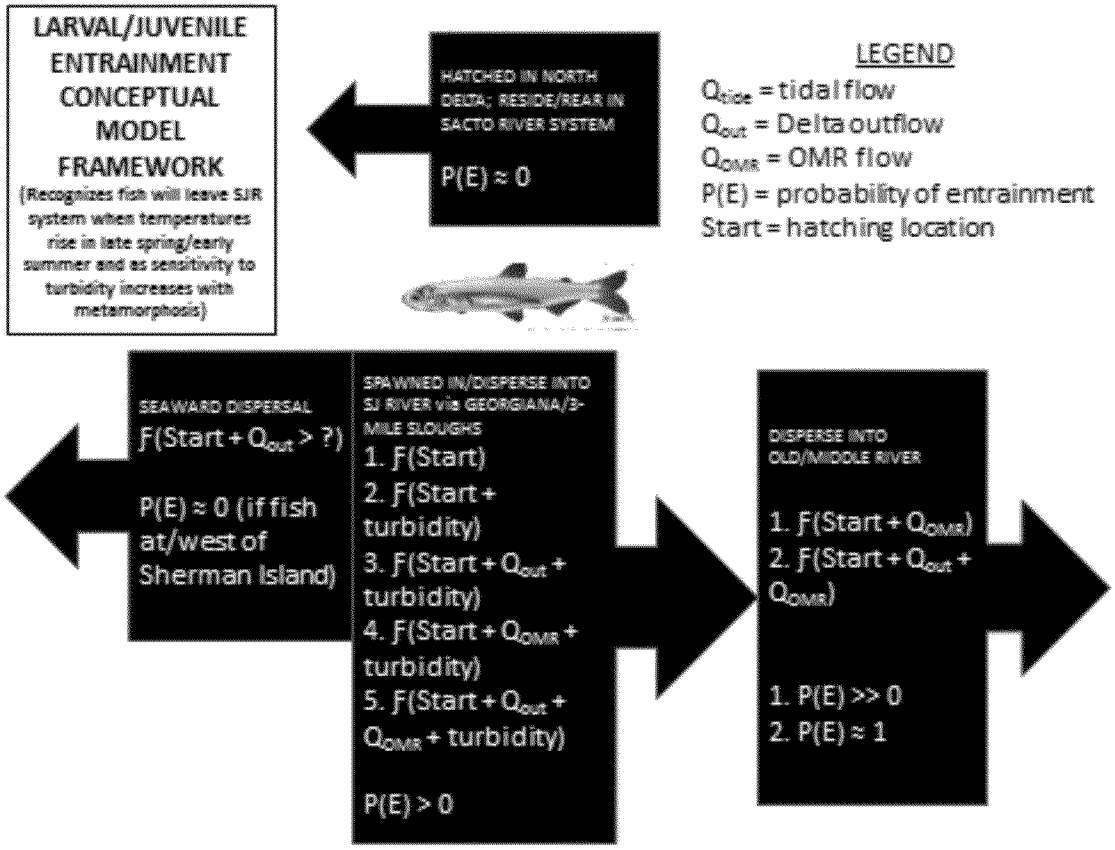

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Figure*4K6*HypothesisKDriven*Entrainment*Model*for**
Larval*and*PostKLarval*Delta*Smelt*

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Management!Action!Entrainment!Model.!The!third!conceptual!model!(Figure!4"7)!is!structured!to!show!how!management!actions!(salmon"colored!boxes)!interact!with!ecosystem!drivers!(blue!boxes)!to!produce!physical!responses!in!multiple!ecosystem!attributes!(green!boxes),!which!in!turn!lead!to!ecological!responses!of!management!concern!(orange!boxes).!The!example!provided!is!for!adult!Delta!Smelt,!but!a!similar!model!could!be!developed!for!larvae.! The!primary!ecological!response!of!management!concern!is!the!proportion!of!the!Delta!Smelt!population!in!the!vicinity!of!the!water!project!pumps!in!the!south!Delta.!Water!project!operations!in!the!south!Delta!may!then!potentially!influence!the!movement!of!fish!toward!project!intake!facilities,!leading!to!entrainment.!The!model!acknowledges!environmental!cues!that!trigger!movement!to!spawning!areas!in!the!winter.!A!working!hypothesis!is!that!pre"spawning!adults!disperse!to!suitable!spawning!habitats!in!response!to!individual!life!history!circumstance!(the!relevance!of!their!area!of!origin)!and!cues!(e.g.!that!might!lead!them!to!fresher!water),!but!the!biotic!and!abiotic!conditions,!particularly!turbidity,!must!be!suitable!for!the!fish!to!initiate!and!sustain!that!movement.!For!Delta!Smelt!located!near!the!river's!confluence,!the!choice!of!whether!to!move!into!the!San!Joaquin!River!system!or!remain!in!the!west!or!northern!portion!of!the!estuary!may!

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be!determined!in!part!by!flows,!tides,!and!habitat!conditions!such!as!water!quality.!Hence,!the!relative!conditions!in!the!San!Joaquin!River!versus!the!Sacramento!River!may!be!a!key!factor!guiding!the!fish!towards!one!tributary!versus!another.!

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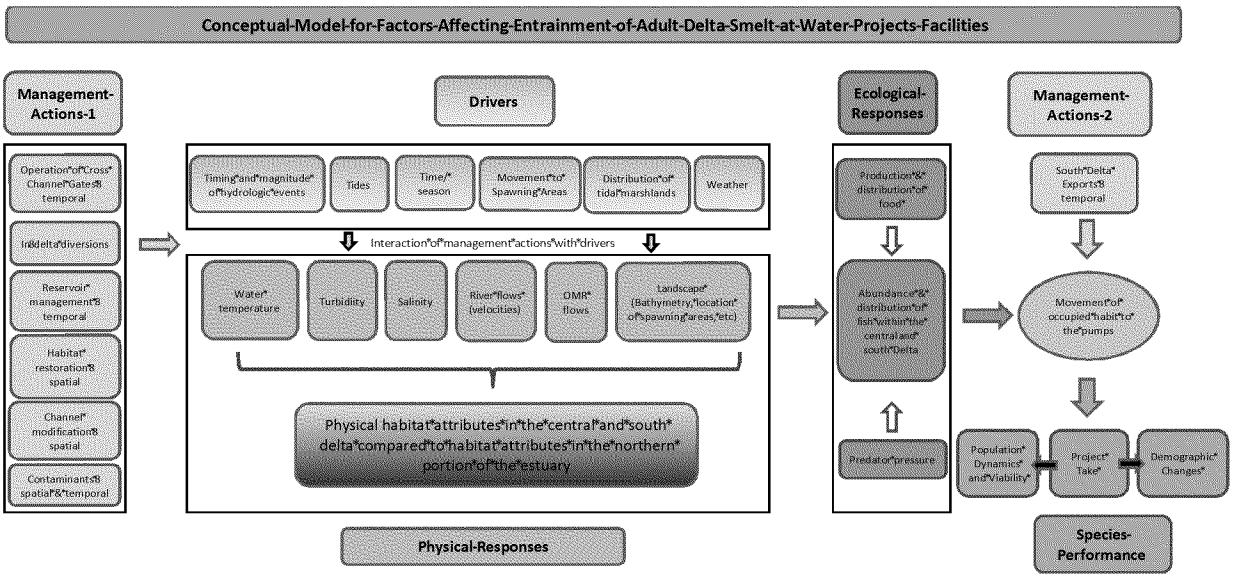

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Figure 4K7 Management Action Entrainment Model for Adult Delta Smelt

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4.3* South*Delta*Salmonid*Survival*

The!NMFS!2009!Biological!Opinion!on!long"term!operations!of!the!CVP!and!SWP!includes!two!RPA!actions!that!focus!on!Delta!project!operations!(and!associated!hydrodynamic!conditions)!and!through"Delta!outmigration!success!of!salmonids:!

> Action!IV.2.3!–!Requires!OMR!flows!to!be!no!more!negative!than!"5,000!cfs;!less!negative!levels!are!required!when!salmonid!salvage!at!the!export!facilities!exceeds!specified!triggers!
>
> Action!IV.2.1!–!Requires!the!projects!to!operate!to!a!particular!San!Joaquin!inflow!to!Delta!export!(I:E)!ratio!based!on!the!San!Joaquin!water!year!classification.!

!

South*Delta*Salmonid*Survival*Problem*Statement*

There!is!general!agreement!that!survival!of!emigrating!salmonids!from!the!San!Joaquin!River!system!through!the!south!Delta!has!declined!in!recent!years!and!is!now!very!low.!There!is!a!range!of!views!regarding!the!effects!of!south!Delta!hydrodynamics,!as!affected!by!San!Joaquin!inflow!or!delta!exports,!on!the!survival!of!salmonids!emigrating!from!the!San!Joaquin!River!(and!for!that!matter!from!the!Sacramento!River)!through!the!south!Delta.!!

!

Whether!I:E!ratio!or!OMR!flows!are!appropriate!metrics!for!linking!to!salmonid!survival!is!subject!to!different!views.!Some!feel!that!both!metrics!are!useful,!some!feel!that!one!metric!may!be!more!useful!than!the!other,!and!some!question!the!use!of!either!metric!as!a!factor!influencing!salmonid!survival.!

!

The!understanding!of!causal!mechanisms!for!the!decline!in!survival!could!be!improved!through!targeted!studies,!additional!in"depth!analyses!of!existing!data,!and!development!of!new!modeling!tools.!This!will!require!consideration!of!linkages!between!various!physical!and!hydrodynamic!factors!and!biological!behavioral!cues!and!responses!(including!those!of!both!salmonids!and!predators).!The!influence!of!San!Joaquin!River!inflows!and!project!exports!on!these!factors!is!of!particular!importance!to!CSAMP!due!to!the!scope!of!the!Section!7!consultation.!Reducing!uncertainties!in!how!management!of!water!operations!affect!patterns!of!survival!and!mortality!of!outmigrating!salmonids!is!a!key!goal!of!the!CSAMP!effort.!

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South*Delta*Salmonid*Research*Collaborative*(SDSRC)*

In!an!effort!to!improve!understanding!and!reduce!uncertainties!concerning!the!role!of!water!project!operations,!NMFS!and!DWR!jointly!initiated!the!South!Delta!Salmonid!Research!Collaborative!(SDSRC)!in!early!2013!(prior!to!the!formation!of!CSAMP!and!CAMT)!with!input!and!participation!of!Reclamation,!U.S.!Fish!and!Wildlife!Service!(USFWS),!California!Department!of!Fish!and!Wildlife!(DFW),!State!Water!Contractors,!Westlands!Water!District,!and!Delta!Stewardship!Council.!The!SDSRC!was!convened!as!an!open!technical!forum!bringing!together!researchers!and!managers!to!focus!on!improving!the!understanding!of!juvenile!salmonid!survival!in!the!south!Sacramento"San!Joaquin!Delta.!!

!

While!the!SDSRC!was!not!formed,!or!directed!by!CAMT,!CAMT!has!looked!to!the!work!of!the!SDSRC!to!inform!the!development!of!its!workplan!(see!Section!3).!The!sections!below!provide!

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highlights from the SDSRC work to date. A more complete description of the SDSRC and its activities can be found in Attachment A.

Beginning with its initial meeting in January 2013, the SDSRC adopted a stepwise strategy and aggressive timeline to design, peer review, and implement new research focused on increasing the understanding of the role of water project operations on juvenile salmonid survival. The SDSRC developed a series of technical products, including:

- A conceptual model of south Delta salmonid migrational survival (see Figure 4-8);
- An analysis of statistical power for a 1-year-through-Delta survival study of steelhead and fall Chinook (Appendix M in Attachment A);
- Identification of potential effect size differences that may be important biologically for the purposes of experimental design development and scientific inquiry;
- Fourteen hypothesis-based concept proposals for research improving the understanding of south Delta salmonid survival (Appendix G in Attachment A);
- Guidelines for concept proposal evaluation (Appendix H in Attachment A);
- A review of the ongoing 6-year steelhead survival study (RPA Action IV.2.2), to include identification of inflow-export conditions that have not yet been tested (Appendix L in Attachment A);
- Identification of opportunities and constraints to enhance learning from the 6-year steelhead study in 2014 (Section 4.4 in Attachment A);
- Identification of a new "Desktop Survival Study" (still in review) for implementation in as early as 2014 that includes additional analysis or meta-analysis of data from previously conducted studies of the survival and movement of tagged salmonids (Appendix J in Attachment A).

The SDSRC has proven to be a productive forum for exchanging views and exploring different approaches to new scientific efforts targeting management-relevant questions. In addition to developing a conceptual model and associated research proposals focusing on key research pathways, the group has had technical discussions about a wide range of topics, including what levels of effect are biologically relevant, the statistical power and experimental conditions needed to detect a particular effect, the potential ambiguities in interpreting results from acoustic tag data, the kinds of covariates that would ideally be measured during any experiment, and the various specific hydrodynamic cues that fish may be responding to.

South Delta Salmonid Survival Conceptual Model and SDSRC Study Proposals

Figure 4-8 below shows the current conceptual model being used by the SDSRC as a framework for development of hypotheses and concept proposals relating to south Delta salmonid smolt survival. Because this model includes extra-regional drivers affecting mechanistic relationships in the model, such as tidal forcing, and incorporates endpoints related to the fuller life cycle, such as juvenile condition and timing of ocean entry, it accommodates a wide range of hypotheses regarding the major factors influencing South Delta migration survival and population outcomes. Figure 4-8 also highlights (in white text) how the fourteen research proposals developed by the SDSRC relate to specific elements of the conceptual model. The numbers shown below each element refer to specific research proposals, as listed in Table 4-7.

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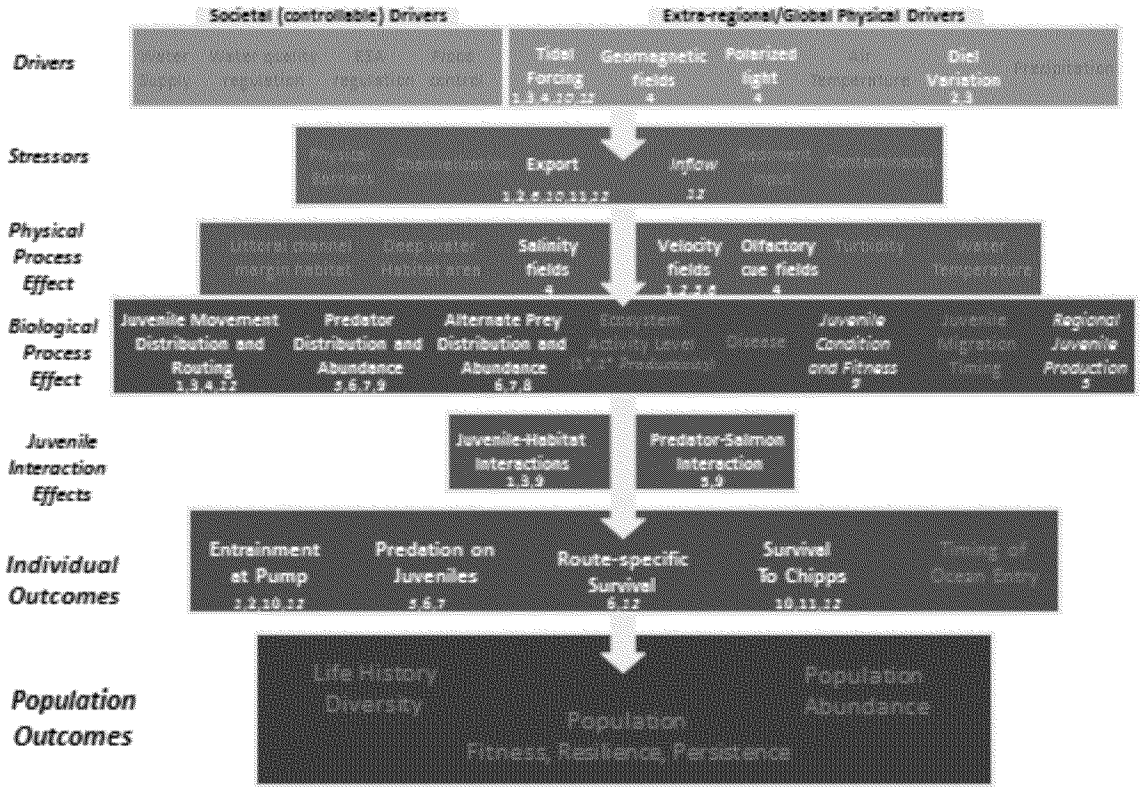

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Figure*4K8*Conceptual*Model*for*South*Delta*Smolt*Survival*(reflecting*scope*of*SDSRC*proposed*studies)*

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Table 4 (7 DSRC Study Proposals

!	Title	Conceptual Model Links		Study Questions
!	*Physical Drivers and Processes*			
1	**Influence of tides and exports on movement of smolts in Old River**	*Drivers:* *Stressors:* *Physical Process:* *Biological Process:* *Interaction Effect:* *Individual Outcome:*	**Tidal forcing** **Export** **Velocity fields** **Juvenile Movement** **Juvenile Habitat Interactions** Entrainment at Pumps	*How does OMR in combination with spring/neap tidal phase affect net movement of smolts along Old River?* *What is general movement behavior of smolts in relation to tidal stage?*
2	**Shifting Clifton Court fill rate and fill time to minimize smolt entrainment**	*Drivers:* *Stressor:* *Physical Process:* *Individual Outcome:*	**Diel variation** **Export** Velocity Field **Entrainment at Pump**	*Does a reduced fill rate or a shift to nighttime filling reduce juvenile salmonid entrainment into Clifton Court Forebay?*
3	**Diel and tidal effects on fine scale movement and habitat use in freshwater tidal environment**	*Drivers:* *!* *Physical Process:* *Biological Process:* *Interaction Effects:*	**Tidal forcing** **Diel variation** Velocity Fields **Juvenile Movement/Dist/Routing** **Juvenile Habitat Interactions**	*Does juvenile salmonid holding versus active migration behavior differ according to tidal stage or time of day in freshwater tidal environment?* *What habitat type do juveniles prefer during holding and during migration, or during day and night?*
4	**Juvenile salmonid navigation cues in a freshwater tidal environment**	*Drivers:* *!* *!* *Physical Process:* *!* *Biological Process:*	**Tidal forcing** **Geomagnetic fields** **Polarized light** **Salinity fields** **Olfactory cue fields** **Juvenile Movement/Dist/Routing**	*How do juvenile salmonids determine migration direction in a tidal environment?* *Are changes in water quality parameters over the tidal cycle associated with active migration versus holding behavior?* *Are juveniles predisposed to migrate in a fixed compass direction, and does this direction differ between northern and southern stocks from the Central Valley?* !

!	Title	Conceptual Model Links		Study Questions
!	*Biological Process: Predation*			
5	**Predator (prey dynamics in a tidal environment: a modeling study**	*Biological Process:* *Interaction Effects:* *Individual Outcome:*	Predator Dist/Abund Regional Smolt Production **Predator (Salmon Interaction** Predation on Juveniles	*Can the activity patterns of predators and prey be understood as the outcome of coupled games played in the physical setting of the estuary?*
6	**Reach (specific influence of hydrodynamics on predation and factors affecting predation on steelhead**	*Stressor:* *Physical Process:* *Biological Process:* *Individual Outcome:*	Export Velocity Fields **Predator Dist/Abund** **Alternate Prey Dist/Abund** **Predation on Juveniles** **Route (specific Survival**	*Is survival related to predator density?* *Is predator density related to alternative prey density or net flow?* *Is survival, or predator and prey densities, related to proximity to CVP/SWP pumping facilities?*
7	**Prey base of dominant predators on juvenile salmonids**	*Biological Process:* *Individual Outcome:*	**Predator Dist/Abund** **Alternate Prey Dist/Abund** **Predation on Juveniles**	*What are the dominant predators on juvenile salmonids in the South Delta?* *What are the primary prey species that support these predators throughout the year?*
8	**SAV indirect support of dominant predators by support of alternative prey**	*Biological Process:*	**Alternate Prey Dist/Abund**	*Does submerged aquatic vegetation (SAV) support high densities of small centrarchids that potentially serve as alternative prey to predators on juvenile salmonids?*
9	**Habitat (associated predation risk and food availability**	*Biological Process:* *Interaction Effects:*	**Predator Dist/Abund** Juvenile Condition **Juvenile (Habitat Interactions** **Predator (salmon Interactions**	*Does predation risk or food availability for juvenile salmonids differ between freshwater tidal habitat types?*

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	Title	Conceptual Model Links		Study Questions
	Individual Outcomes			
10	**Survival change detectability under extreme high(low export treatments**	*Drivers:* *Stressors:* *Individual Outcome:*	Tidal Forcing **Export** **Entrainment at Pumps** **Survival to Chipps**	*Can a clear export effect on survival be detected using extreme and sustained high and low export treatments?* *Is detectability different during spring versus neap tide conditions?*
11	**CVP/SWP pumping ratio on survival of entrained salmonids**	*Stressor:* *Individual Outcome:*	Export **Survival to Chipps**	*Can shifting SWP pumping to CVP increase survival of entrained juvenile salmonids?*
	Other (focus to be determined)			
12	**Reanalysis of existing acoustic tag study data**	*Drivers:* *Stressors:* *Biological Process:* *Individual Outcome:*	*Tidal Forcing* *Export and Inflow* *Juvenile Movement/Dist/Routing* *Route Specific Survival* *Entrainment at Pump* *Survival to Chipps*	*Can data from previous acoustic tag studies be reanalyzed to address important questions regarding juvenile salmonid route selection, migration rate, and survival not addressed in original reports?*

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5.0 Other Relevant Science Activities

The following sections briefly describe ongoing science activities that are not being directed by CAMT (most of the activities pre-date the formation of CAMT), but are relevant to the CAMT priority topic areas and the development of revised Delta Smelt and Salmonid Biological Opinions. Many of these activities have had little or no involvement by water agency or NGO representatives; however, the CAMT is exploring opportunities to improve collaboration on some of these in the future and the agencies are committed to greater stakeholder involvement.

5.1 The Fall Outflow Adaptive Management Plan (FOAMP)

The Biological Opinion required that Reclamation establish and conduct an adaptive management program to address uncertainties about the efficiency of the Fall X2 Action. The Biological Opinion requires that the adaptive management plan include "a clearly stated conceptual model, predictions of outcomes, a study design to determine the results of actions, a formal process for assessment and action adjustment, and a program of peer review…." (BiOp p. 369.) Reclamation worked with other federal and state agencies to develop and implement the Fall Outflow Adaptive Management Plan (FOAMP). The FOAMP is intended to effect adaptive management of the 2008 fall outflow RPA element, as well as inform development of future Biological Opinions.

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As part of the FOAMP, a set of conceptual models was developed by an interagency team with the assistance of a few academic scientists. The team subsequently identified specific studies and and a written monitoring plan. The plan was informed by advice from a National Research Council panel that independently evaluated the biological opinions in a report published in 2010 (http://www.nap.edu/catalog.php?record_id=12881).

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After over a year of development under Reclamation's supervision, the FOAMP investigations began in August of 2011 in cooperation with the Interagency Ecological Program (IEP), which is a research consortium of state and federal agencies, including California Department of Fish and Wildlife, California Department of Water Resources, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, and NOAA Fisheries Service. Individual studies were designed to answer questions about the ecology and dynamics of low-salinity habitat (LSH) in the San Francisco Estuary (SFE) and, specifically, the role of LSH in the biology and ecology of Delta Smelt. Because of the broad range of questions being explored by these studies, Reclamation, in cooperation with the IEP, perceived the need for a broad synthesis of the fall habitat studies, ongoing IEP monitoring and research, ongoing research funded by other entities, and previous studies in the San Francisco Estuary. The Fall Low Salinity Habitat, or "FLaSH" Report (Brown et al. 2013), is the first such synthesis, and regular updates are expected in the future as part of the annual AMP cycle. The FOAMP studies are summarized in the *Overview of Study Efforts* section below.

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Subsequent to the release of the FlaSH Report, an IEP Modeling and Synthesis Team (MAST) conducted additional integrative analysis of fall habitat study results and has been preparing its findings in a document known as the MAST Report. In addition to synthesizing information on the

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effects of flow and other environmental drivers on Delta Smelt, the MAST has taken additional steps in refining the conceptual models underlying the FOAMP. The MAST conceptual models are now being used as a point of departure for both the FOAMP and the new CAMT studies.

The FOAMP was designed from the start to be subjected to independent scientific review on an ongoing basis. A standing independent expert science panel was created by the Delta Science Program in 2011. The panel reviewed an initial draft FOAMP in 2011, and then reviewed a more complete FOAMP and initial study results in 2012. Both reviews are available from the Delta Science Program website (http://deltacouncil.ca.gov/science"program/long"term"operations"biological"opinions"annual"science"review). The FOAMP expects to conduct another review with the panel in 2014 or 2015. The timing will depend on progress integrating stakeholder science priorities into the development process that will result in an updated FOAMP workplan in 2014.

5.2 FLaSH Studies in the IEP Workplan

The FLaSH studies fall broadly into several categories: 1) population estimation and support for interpretation of ongoing Delta Smelt monitoring programs; 2) environmental and hydrodynamic covariate sampling and interpretation; 3) nutrient source, fate, dynamics, and role in food web support; 4) phytoplankton dynamics, zooplankton dynamics, and Delta Smelt prey sampling; 5) Delta Smelt growth rate estimates and otolith micro chemistry interpretation; 6) histopathological characterization of Delta fishes and indicators of individual health; 7) smelt culture and genetics characterization, 8) bivalve biology and behavior, and; 9) contaminants and harmful algal bloom detection and effects characterization. Table 5"1 below provides a summary listing of the ongoing FLaSH studies.

5.3 Delta Smelt Lifecycle Modeling Studies (Newman et al., USFWS)

A Delta Smelt life cycle model to be used as a management decision support tool is under development. The initial modeling objective is to use the model to assess and to predict the effects on the Delta Smelt population of water manipulations in the central and south Delta during the winter and spring months. In particular the focus is on the effects of various levels of reverse Old and Middle River (OMR) flows, which are primarily a function of water inflows, water export levels, and the tides, on fish survival and reproductive success while accounting for water turbidity and the spatial distribution of the fish population. Effects of fall outflow strategies will be examined in future applications of the model and supporting data sets.

The underlying statistical framework is a state space model (SSM). A SSM is a technique for modeling two parallel time series, one describing the underlying population dynamics (the "state" process) and another describing the available fish survey and environmental data (the "observation" model). The current state process formulation has a monthly time step and splits the Bay"Delta into four regions. The population dynamics include explicit definition of survival, reproduction, and movement processes. The effects of OMR flows enters into the model via the adult fish survival probabilities, particularly for fish present in the south and central Delta, and via hydrological partical tracking model predictions (DSM"2 PTM) of the entrainment of larvae and post"larvae. The model is being fit to data from several fish monitoring programs (e.g., 20mm, Summer Townet, Fall Midwater Trawl, Bay Study Midwater Trawl, and Spring Kodiak Trawl

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surveys)!and!incorporates!other!bioitic!data,!e.g.,!Environmental!Monitoring!Program's!
zooplankton!survey,!and!abiotic!data,!(e.g.,!water!conditions!such!as!tidal!velocity,!turbidity,!etc.).!
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Table 3(1 LaSH Studies Being Conducted by EP

Investigation!	Relevance!	Investigative Approach !	Responsibility!	Schedule!
Population Estimation and support for interpretation of ongoing Delta Smelt Monitoring programs				
1. #89!Directed!Field! Collections!"!Supplements! to!long"term!population! abundance!surveys.! Collection!support! analyses!including!smelt! health,!otolith,!gut! content,!food!web! investigation!!	Raw!data!to! address! hypotheses!	Field!collection! associated!with!FLaSH!	DFW"POD!(Existing! effort)!(Baxter)!	TBA!
2. #208!Smelt!life!cycle! model!"!State"space!model! construction!and!estimate! Delta!Smelt!population! abundance!	Model! construction!	2!phased!effort!to! develop!life!history! model!of!Delta!Smelt! and!multiple!single! species!life!history! models/or!single! integrated!multispecies! life!history!model!	USFWS!(Existing! effort)!(Newman)!	Manuscripts!in! progress.! Data!needed!for! model!fitting!are! nearly!complete!!
3. #130!Towed!imaging! System!!Testing!of!video" based!towed!abundance! sampling!for!application!to! Delta!Smelt!and!longfin!	Raw!data!to! address! hypotheses!! ! ! !	!	USBR!(Existing!effort)! (Portz)!	Complete.! Publication!Feyrer!et! al.!2013!
4. #131!Acoustics!to! estimate!trawl!openings"! Supports!gear!efficiency!	Tool! Development"! support!gear!	!	DFW!(existing!effort)! (Baxter)!	!

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	evaluation and interpretation of catch effort	efficiency			
5.	#182 Develop Acoustic transmitter suitable for use in Delta Smelt	Tool for population estimate of Delta Smelt	Tool Development	UCD (Existing effort) (Loge)	Complete. Final report available
Environmental and Hydrodynamic covariate sampling and interpretation					
6.	#205 Delta Sediment measurements and #206 boundary condition monitoring - Measurement and calibration of particle-size binned sediment dynamics at the Delta Boundaries	Raw data to address hypotheses	Collect field monitoring data Data used to support development, calibration and validation of numerical models of sediment transport and turbidity	USGS (Wright)	3rd year of 4 year agreement
7.	#230 Suspended sediment and X2 in Suisun Bay and the confluence during fall, 1994-2011 Sediment dynamics time series	Data collection and analysis to address hypotheses	Analysis of historical Data	USGS (Existing effort) (Schoellhammer)	4th year of 5 year agreement
8.	#180 Hydrodynamics and Particle Tracking modeling of Delta Smelt Habitat and Prey - Support for the individual-Based model published by Rose et al.	Individual-Based Model Support and understand variability of physical fish habitat with Fall X2 and population dynamics of	Modeling and analysis of lab data	SFSU (Existing effort) (Kimmerer)	Contract ended 12/31/13 - 3 manuscripts in prep

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	Calanoid copopods!!			
9. #232!Suisun!Bay! Hydrodynamics:!Flows,! salt!fluxes!and!X2! dynamics!during!the!IEP! fall!X2!study!	Modeling!to! address! hypotheses!	Hydrodynamic!modeling! and!mapping!!	Stanford!(Existing! effort)!(Monismith)!	Ongoing!
10. #207!3D!simulation!of! Delta!Smelt!hatchling! distribution!and!mortality!	Modeling!to! address! hypotheses!	Mechanistic!modeling!	RMA!Associates! (Gross)!	Ongoing.!! Draft!expected!spring! 2014!
11. #236!Sample!Processing! for!nutrients,!suspended! solids,!and!chlorophyll! concentrations!for!fall!X2! work.!!	!	!	UC!Davis!(Existing! effort)!(Dahlgren)!	2nd!year!of!5!year! agreement!
Nutrient*source,*fate,*dynamics,*and*role*in*food*web*support				
12. #175!Effects!of!Seasonal! variation!in!flow!on!the! spatial!and!temporal! variations!of!nutrients,! organic!matter,!and! phytoplankton!	Raw!data!to! address! hypotheses!	Analysis!of!existing!data! and!new!modeling!work!	USGS!(Kendall)! !	Ongoing!
13. #179!Causes!of!Seasonal! and!spatial!!seasonal! variation!in!variation!in! NH4!sources,!sinks,!and! contribution!to!algal! productivity!using!a!multi" isotopic!approach!	Raw!data!to! address! hypotheses!	New!multiple!stable! isotope!approach!to! analyze!existing!and! new!data!!	USGS!(Kendall)!	Ongoing!
14. #234!Residence!time!as!an! aid!to!interpret!nutrient!	Raw!data!to! address!	!	USGS!(Kendall)!	4th!year!of!5!year! agreement!

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dynamics and other habitat characteristics in Suisun, SJR confluence and Cache Slough complex	hypotheses			
15. #235 Enhanced fall habitat characterization using a multi-fingerprinting approach	Raw data to address hypotheses	Extend and enhance ongoing IEP Investigations Analysis of previously collected samples	USGS (Kendall)	4th year of 5 year agreement
16. #173 Distribution, concentrations, and fate of ammonium in the Sacramento River and the low salinity zone (phytoplankton uptake and bacterial nitrification rates)	Raw data to address hypotheses	Lab experiment	SFSU (Dugdale)	Extended to 12/31/13
17. #174 Influence of elevated ammonium on phytoplankton physiology in the SFE during Fall	Raw data to address hypotheses	Lab assessment of primary productivity and ammonium uptake	Cal Maritime (Parker)	Extended to 12/31/13
18. #229 Supplemental Nutrient and phytoplankton monitoring in Suisun Bay			Cal Maritime (Parker)	Ends 12/31/13
Phytoplankton dynamics, zooplankton dynamics, and Delta Smelt prey sampling				
19. #169 Delta Smelt feeding and food web interactions. Ongoing studies of smelt feeding	Data need to define habitat of Smelt	Field and experimental work	SFSU (Existing effort) (Kimmerer)	Extended to 12/31/13 Sample processing to

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behavior under varying conditions of prey density and predators				continue through 2014 2 manuscripts submitted 6 manuscripts in prep
20. #62 Fish Diet and condition, See FLaSH report (2013)			FLaSH report (Existing effort)	
Delta Smelt growth rate estimates and otolith micro chemistry interpretation				
21. Interdisciplinary studies on Delta Smelt and longfin smelt. Otolith microchemistry analyses and life history reconstructions of Delta Smelt			UCD (Hobbs)	Completed. Publication status unknown
Histopathological characterization of Delta fishes and indicators of individual health				
22. #228 Estimation of survival, growth, and reproductive fitness of Delta Smelt	Raw data to address hypotheses		UCD (Teh)	Completed
Smelt culture and genetics characterization				
23. #108 Delta Smelt culture facility	Source of Fish for Lab and Field Experiments	Lab culture of fish	UCD (Existing Effort) (Lindberg)	Continuous
24. #135 Delta Smelt genetics	Development of new lab techniques	Development of 69 SNP markers to replace microsatellite markers	UCD (May)	

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Bivalve biology and behavior				
25. #231 Bivalve effects on the food web supporting Delta Smelt and recruitment patterns of bivalves with varying freshwater flow	Raw data to address hypotheses	!	USGS (Thompson)	4th year of 5 year agreement ! Manuscript expected Summer 2014
Contaminants and harmful algal bloom detection and effects characterization				
26. #177 Medabolic responses to variable sensitivity environments in field acclimatized *Corbula amurensis*	Raw data to address hypotheses	Lab experiment	UCD (Stillman)	Extended to 12/31/13 ! 1 publication in MEPS ! 2 manuscripts in prep
27. Regarding environmental stresses associated with pollutants and changing turbidities	Raw data to address hypotheses	Lab experiment	UCD (Connon)	!
28. #171 Remote sensing mapping and monitoring of Microcystis and turbidity in the upper SFE." low resolution study (30 meter pixel) as proof" of "concepts for monitoring Microsystis	!	!	UCD (Ustin)	Complete
Other Studies				
29. Delta Smelt Lifecycle Modeling Study	Life cycle model to be used as a management	!	USFWS (Newman)	!

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	decision!support! tool.!Particular! focus!on!the! effect!of!various! levels!of!reverse! OMR!flows!on! fish!survival!and! reproductive! success.!!			
30. Trawl!Gear!Efficiency! evaluation!	Estimates!of!gear! efficiencies!for! Delta!Smelt! survey!data!for! calculating! absolute!Delta! Smelt!abundance! over!particular! interval!!	!	DFW!and!USFWS! (Baxter)!	!
31. Smelt!Survey!Review! Study!	Evaluation!of! existing!sampling! programs!and! interpretation! efforts,! describing! explicit! management! driven! information!need! and!anticipated! data!gaps!	!	UCD!(Emilio!Laca)!	!

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5.4 Trawl Gear Efficiency Evaluation

This study will provide estimates of gear efficiencies for Delta Smelt survey data for calculating absolute Delta Smelt abundances over particular intervals, and to support models of smelt population dynamics using integrated data (including gear efficiency estimates) from several of the existing IEP surveys. The objective is to more completely understand how current and historical surveys reflect actual Delta Smelt populations, locations, and densities. Current estimates do not include estimates of error, and therefore are unsatisfactory to assess real smelt abundance, or to measure smelt response to management inputs. This project is expected to generate more accurate data in the future that will be used to inform Delta Smelt population models under construction by members of the IEP and others (see, for example, Newman et al.). The study is being led by the California Department of Fish and Wildlife.

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Below is a brief list of work plan elements included in the evaluation:

- *Understand logistical requirements and develop coordinated IEP scheduling*
  - Assemble California Department of Fish and Wildlife (DFW) and IEP employees to discuss and characterize logistical items for coordination and planning purposes, specifying constraints, safety issues, vessel coordination, gear redundancy needs, equipment, and deployment choreography and responsibilities.
- *Conduct pilot scheduling and testing*
  - Execute whatever trial sampling and deployment rehearsals necessary to de"bug and fail"safe data collection procedures. Establish vessel responsibilities, generate crew requirements and identify temporary staff hiring needs. Determine crew and sampling safety requirements.
- *Execute targeted gear deployments and repeated surveys*
  - Collect controlled and targeted information on the volume sampled at various depths by various gear types. Determine the depth and lateral distributions of Delta Smelt by life stage and/or gear type.
- *Evaluate gear performance, prepare reports*
  - Calculate the relative gear efficiencies for different IEP fish surveys, emphasizing those focused on Delta Smelt (e.g., Spring Kodiak Trawl survey, 20mm survey, Summer Townet, Fall Midwater Trawl survey), and adding important additional surveys if possible (e.g., Chipps Island Survey, Bay Study Midwater Trawl). Prepare analysis and interpretation as reports on gear performance to the IEP and to the various modeling teams using survey data as input information to understand Delta Smelt life cycle and population variability over time and space.

5.5 Smelt Survey Review Study

This study is critically evaluating existing sampling programs and interpretation efforts, describing explicit management"driven information needs and anticipated data gaps, and will propose updated or alternative protocols to match needs, sampling/collection schemes, and interpretation constraints. The study is being conducted by Professor Emilio Laca at the University of California, Davis with funding provided by the FWS.

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Below!is!a!brief!list!of!work!plan!elements!included!in!the!Smelt!Survey!Review!Study:!

- *Conduct)Scoping)Workshop)*
  - ! Assemble!Agency!(IEP)!representatives!for!the!purpose!of!identifying!available!programmatic!materials!for!review,!identifying!available!support!personnel,!finalizing!project!timelines!and!specifying!deliverables!under!general!contract!terms.!Ongoing!Juvenile!Fish!Monitoring!Program!and!Juvenile!Salmon!Survivorship!Study!review!planning!shall!be!used!as!a!guide!for!finalizing!work!priorities!and!deliverables.!
- *Understand)and)characterize)current)aims)and)protocols*
  - ! Collect!background!on!purpose!and!requirements!for!surveys.!Understand!current!field!protocols!and!equipment!limitations.!Become!familiar!with!past!and!current!needs!for!data!and!information,!management!questions,!and!water!operations!recommendations.!Provide!context!for!IEP!regulatory!requirements,!special!studies!demands,!and!Workplan!formulation.!
- *Evaluate)statistical)validity)of)collection)and)interpretation)protocols)and)procedures;)propose)alternative)methods)if)necessary)*
  - ! Examine!temporal!and!spatial!aspects!of!sampling!routines!in!light!of!long"term!collection!aims!and!newer,!near"term!data!interpretation!needs.!Incorporate!updated!collection!and!interpretation!methods!where!warranted.!Provide!contrast!between!past,!present,!and!proposed!protocols!for!illustration.!Describe!shortcoming!and!strengths!of!existing!sampling!schemes!given!existing!infrastructural!and!programmatic!limitations.!
- *Devise)implementation)plan/change)scheme)and)provide)oversight)for)modification)efforts)(as)needed)*
  - ! Using!current!IEP!sampling!programs!as!a!basis!for!recommendation,!provide!updated!or!modified!sampling!plan,!if!needed.!Oversee!data!conversion!where!necessary.!Provide!archive/conversion!services!as!needed!to!avoid!"orphan"!data!sets.!Provide!guidance!regarding!change"over!to!newer!or!modified!data!collection!and!interpretation!schemes.!

5.6 Central Valley Chinook Life Cycle Model

The!NMFS!Southwest!Fisheries!Science!Center!is!leading!a!team!developing!a!Central!Valley!Chinook!Life!Cycle!Model!(CVC"LCM)!that!tracks!the!production,!movement,!survival,!and!development!of!monthly!cohorts!of!winter"run!Chinook!salmon!through!five!distinct!habitats:!River,!Delta,!Floodplain,!Bay,!and!Ocean.!Hydrodynamics!and!water!quality!in!the!River!and!Delta!play!a!key!role!in!determining!the!probability!that!salmon!will!survive!through!the!different!stages!of!their!life!cycle.!For!example,!water!flow!and!velocity!drives!the!movement!of!salmon!through!their!ecosystem,!which!influences!their!ultimate!survival!and!ability!to!reproduce.!In!addition,!salmon!survival!is!affected!by!the!availability!of!highly "productive!floodplain!habitat!that!is!generated!by!flows!of!sufficient!magnitude!to!overtop!weirs!in!the!Central!Valley.!!

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A!variety!of!water!management!decisions,!such!as!reservoir!releases,!water!diversions,!pumping!schedules,!etc.,!influence!the!hydrodynamics!of!the!River!and!Delta!habitats.!Initial!modeling!will!use!existing!models!(CALSIM!II,!HEC"RAS!and!DSM2)!to!describe!the!physical!environment!under!

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various!hydrological!and!operational!scenarios.!Later!versions!of!the!model!will!use!a!modified!DWR!Particle!Tracking!Model!(PTM)!to!include!fish"like!behaviors,!to!predict!salmon!survival!under!different!conditions!in!the!Delta.!!

5.7 Enhanced PTM

As!described!in!the!summary!of!the!CVC"LCM!above,!the!LCM!development!team!expects!to!incorporate!a!modification!of!the!DWR's!PTM!module!in!later!versions!of!the!CVC"LCM!that!will!model!how!particles!with!fish"like!behaviors!respond!to!hydrodynamic!conditions!in!the!Delta.!Development!of!this!tool!will!allow!evaluation!of!RPA!actions!that!affect!within"delta!hydrodynamic!conditions.!
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5.8 Other Studies Pertaining to Juvenile Survival in the South Delta

Juvenile!salmonid!migrational!behavior!and!survival!in!the!south!Delta!has!been!the!subject!of!considerable!research.!Table!5"2!provides!a!summary!listing!of!proposed,!ongoing,!and!recently!completed!studies!pertaining!to!salmon!survival!in!the!south!Delta.!
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5.9 IEP Studies Relevant to OMR and Delta Smelt Entrainment

Tables!5"3,!5"4,!and!5"5!provide!summary!of!some!of!the!2014!and!2105!IEP!studies!that!help!to!address!specific!questions!and!hypotheses!regarding!OMR!and!Delta!Smelt!entrainment.!!These!tables!illustrate!how!many!IEP!studies!directly!address!data!needs,!hypotheses,!and!questions.!The!tables!summarize:!!studies!planned!for!2014!(Table!5"3);!likely!studies!to!be!added!in!2014!(Table!5"4);!and!additional!relevant!work!that!is!being!considered!for!2015!(Table!5"5).!It!should!be!clear!from!the!tables!that!multiple!surveys,!data!sets,!and!studies!will!likely!be!necessary!to!address!the!questions!and!hypotheses!outlined!in!Section!4.2.!!
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Table 5(2 Ongoing or Completed Studies Related to South Delta Salmonid Survival

&	Title	Conceptual Model Links		Study Questions	Study Lead	Status
&	*Biological(Process:(Smolt(Routing!*					
1&	**2012 Steelhead Stipulation Study**	*Stressors:(* *Biological(Process:(* *Individual(Outcome:* !!	Inflow!and!Exports ! **Juvenile Movement/Distribution**!! Survival!to!Chipps!	*What(are(the(effects(of(April/May(OMR(flows(on(steelhead(survival(and(migration?(* *How(do(tidal(conditions(and(OMR(flows(affect(route(entrainment?(*	Kevin!Clark,! DWR!	Final!Report! pending!
2&	**Barrier Studies at Georgiana Slough**	*Stressors:(* *(* *Physical(Process:(* *Biological(Process:(* *Individual(Outcome:(* *(* *(* *(*	**Barriers (physical))non-physical)** Inflow!and!Exports ! **Velocity Fields** **Juvenile Movement/Routing** Entrainment!at!Pump! Predation!on!Juveniles! Route!Specific!Survival! **Survival to Chipps(**	*How(does(fish(distribution(at(junctions(and(hydrodynamics(affect(route(selection?(* *How(do(non-physical(barriers(affect(route(selection?(* *What(are(route(specific(survival(rates(to(Chipps(Island?(*	Jacob! McQuirk,! DWR!	Completed;! Additional!work! proposed!for! 2014!
3&	**Six(Year Acoustic Tagging Study**	*Stressors:(* *Biological(Process:(* *Individual(Outcome: (* *(* *(*	Inflow!and!Exports ! **Juvenile Movement/Distribution** **Entrainment at Pumps** **Route Specific Survival** **Survival to Chipps**	*What(is(the(survival(of(steelhead(from(tributaries(to(the(SJR,(through(SJR,(and(the(Delta?(* *How(does(survival(vary(among(individual(reaches(and(salvage? (* *What(is(the(influence(of(flow(and(exports(on(steelhead(distribution(and(survival?(*	Joshua!Israel,! USBR!	Ongoing!
4&	**Smart(particle modeling of juvenile route selection, travel time, and survival**	*Stressors:(* *Physical(Process:(* *(* *(* *(* *Biological(Process:(* *Individual(Outcome: (*	**Physical Barriers** Salinity! **Velocity Fields** Turbidity! Water!Temperature! **Juvenile Movement/Dist/Routing** **Predation on Juveniles**	*Can(hydrodynamic(fields,(non-physical(barrier(operation(and(water(quality(factors(explain(route(choice,(travel(time,(and(survival(of(juvenile(salmonids?(*	Xiaochun! Wang,!DWR!	Ongoing!

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&	Title&	Conceptual&Model&Links&		Study&Questions&	Study&Lead&	Status&
!	*Biological(Process:(Predation!*					
5&	**Head&of&Old&River& Fish&Studies&**	*Drivers:(* *Stressors:(* ((*Physical(Process:(* *Biological(Process:(* ((*Individual(Outcome:(* ((	Diel!Variation! **Barriers&(physical)&)non-physical)&** Inflow! Water!Temperature! **Velocity&Fields&** **Juvenile&Movement/Routing&** **Predator&Distrib/Abund&** Alternate!Prey!Distrib/Abund! Predation!on!Juveniles! Route!Specific!Survival! Survival!to!Chipps(	*How(does(smolt(distribution(at(junctions(and(hydrodynamics(affect(route(selection?(* *How(do(non-Physical(barriers(affect(route(selection?(* *How(do(barriers(affect(predation(on(salmon(and(steelhead?(* *How(do(environmental(variables(affect(predator(density,(habitat(use,(residence(time(and(predation(on(juvenile(salmonids(in(vicinity(of(barrier?!*	Jacob!McQuirk,!DWR!	Synthesis!report!thru!2013!pending;!2013!data!yet!to!be!analyzed!
6&	**Clifton&Court& Forebay&Predation& Studies&**	*Biological(Process:(* *Individual(Outcome:(*	**Predator& Distribution/Abundance& Predation&on&Juveniles&**	*What(is(the(predator(behavior(in(CCF,(before(and(after(installation(of(proposed(fishing(facility?(* *What(is(the(survival(of(salmonids(in(CCF,(before(and(after(installation(of(proposed(fishing(facility?(*	Kevin!Clark,!DWR!	Ongoing!
7&	**2013&&2015& Predator& Manipulation&Study&**	*Physical(Process:(* *Biological(Process:(* *Interaction:(* *Individual(Outcome:(*	Velocity!Fields! **Predator& Distribution/Abundance&** Predator"Salmon!Interaction! **Predation&on&Juveniles&**	*How(does(predator(density(affect(predation(rate?(* *Is(transit(time(or(transit(distance(a(better(predictor(of(predation(risk(and(survival?(*	Sean!Hayes,!NOAA!Fisheries!	Ongoing!
&	*Outcomes!*					
8&	**San&Joaquin&Fall(run& Salmon& Outmigration&**	*Stressors:(* *Biological(Process:(* *Individual(Outcome:(* ((	**Inflow**!and!Exports! Juvenile!Routing! **Entrainment&at&Pumps&** Route"specific!Survival! **Survival&to&Chipps&**	*How(does(fall-run(survival(vary(across(managed(inflow((i.e.,(VAMP)(and(export(conditions?(* *How(does(survival(vary(between(natural(outmigration(and(salvage(at(the(pumping(plants?(*	Patricia!Brandes,!UWFS!	Ongoing!

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&	Title	Conceptual Model Links		Study Questions	Study Lead	Status
9	**NMFS Winter run Life Cycle Model**	*Stressors:*	Export and Inflow	*Given relationships based on best available science between environmental variables and juvenile salmon migration behavi or, predation risk, and ocean survival: how do water supply management decisions and proposed habitat restoration actions affect year to year survival, long term population growth, and life history diversity of winter run Chinook Salmon?*	Steve Lindley, NOAA Fisheries	Ongoing
		Physical Process:	Littoral Channel Margin Habitat			
			Deep Water Habitat Area			
			Velocity and Salinity Fields			
			Water Temperature			
		Biological Process:	Juvenile Movement/Distrib/Routing			
			Predator Distribution/Abundance			
			Regional Juvenile Production			
			Migration Timing			
		Interaction Effects:	Juvenile Habitat Interactions			
			Predator Salmon Interaction			
		Individual Outcome:	Entrainment at Pump			
			Predation on Juveniles			
			Route specific Survival			
			Survival to Chipps			
			Timing Ocean Entry			
		Pop Outcome:	**Life History Diversity**			
			Population Abundance			
			Population Fitness/Resilience			

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Table 3(3 Planned IEP Studies to support CAMT Entrainment Effort

Investigation	Key Question(s)	Relevance	Investigative Approach	Responsibility	Schedule
1. Environmental Monitoring Program (IEP)	3a, 4a"c, 5b"c H1"H5	Raw data to address hypotheses	Field monitoring data	DWR (Existing effort)	Monthly
2. Delta Flow Measurement and Database Management	4a"c, 5b"c H1"H5	Raw data to address hypotheses	Field monitoring data	USBR, DWR (Existing effort)	Monthly
3. Smelt Culture Facility	Many potential applications	Source of fish for possible lab and field experiments	Lab culture of fish	UCD (Existing effort)	Continuous
4. Physical Processes Influencing Smelt Migration	1c, 3a, 4a"c	Migration is key component of entrainment conceptual model	Analyses of field data collected in Sacramento and San Joaquin Rivers	UCD & BOR (Existing effort)	Ongoing through 2014
5. Data Management and Utilization	1a"b, 2a"b, 3a, 4a"c, 5a"c H1"H5	Data management system for effort	Data storage and management	DWR (Existing effort)	Continuous
6. 20 mm Delta Smelt Survey	2a"b, 5a"c H4"7	Raw data to address hypotheses	Field monitoring data	DFW (Existing effort)	Monthly
7. Gear efficiency in Support of Delta Smelt Modeling	1a"b, 2a"b, 3a, 4a"c, 5a"c H1"H5	Raw data to address hypotheses	Field monitoring data	DFW, FWS (Existing effort)	Variable
8. Delta Sediment Measurements	3a, 4a"c, 5b"c H1"H5	Raw data to address hypotheses	Field monitoring data	USGS, DWR (Existing effort)	Monthly

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9. Fall!Midwater! Trawl!Survey!	3a! H1,!H6"8!	Raw!data!to! address! hypotheses!	Field!monitoring! data!	DFW!(Existing!effort)!	Monthly!(fall)!
10. Spring!Kodiak! Trawl!	1a,!4a"c! H1"3,!H6"8!	Raw!data!to! address! hypotheses!	Field!monitoring! data!	DFW!(Existing!effort)!	Winter"Spring!
11. Summer!Townet! Survey!	2a"b,!5a"c! H4"8!	Raw!data!to! address! hypotheses!	Field!monitoring! data!	DFW!(Existing!effort)!	Summer!
12. Upper!Estuary! Zooplankton! Monitoring!	3a,!4a"c,!5b"c! H1"H5!	Raw!data!to! address! hypotheses!	Field!monitoring! data!	DFW!(Existing!effort)!	Monthly!
13. Delta!Smelt! Sampling! Protocols!and! Ecological! Interpretation!	1a,!2a,3a,4a"c,5a"c! H1"8!	Evaluation!of! survey!methods! and!data!quality!	Analysis!of!existing! data!!	FYS!(Existing!effort)!	Variable!
14. Delta!Smelt!Life! Cycle!Model!	H6"8!	Need!to!evaluate! population! effects.!	Modeling!	FWS!(Existing!effort)!	Continuous!
15. Physiological! Mechanisms!of! Environmental! Tolerance!in!Delta! Smelt!	3a,!4a"c,!5b"c! H1"H5!	Study!on!habitat! needs!of!Delta! Smelt!	Lab!Experiment!	UCD!(Existing!effort)!	Seasonal!
16. Suspended! Sediment!and!X2! in!Suisun!Bay!and! the!Confluence!	3a,!4a"c,!5b"c! H1"H5!	Study!on!pre" movement! conditions!and! possible!triggers! to!movement.!	Data!analysis!	USGS!(Existing! effort)!	Variable!

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17. Evaluation!of! Natural!Marking! in!Delta!Smelt!	1a"d,!2!a"d!	Tool!for!field! studies!on! entrainment!	Tool!development!	FWS?!(Existing! effort)!	Variable!
18. Operation!of! Thermograph! Stations!	3a,!4a"c,!5b"c! H1"H5!	Raw!data!to! address! hypotheses!	Field!monitoring! data!	USBR,!DWR!(Existing! effort)!	Monthly!
19. Bay"Delta! Integrated! Database!	1a"b,!2a"b,!3a,!4a" c,!5a"c! H1"H5!	Data! management! system!for!effort!	Data!storage!and! management!	Multiple!agencies! (Existing!effort)!	Continuous!
20. Otolith!Analyses! of!Pelagic!Fish!	4b,!6c! H8!	Data!on! movement! patterns!of!smelt!	Analysis!of!historical! otoliths!	UCD!(Earlier!Effort)!	Report!due!in!2014!
21. Estimation!of! Pelagic!Fish! Population!Sizes!	1a,!2a,!6a"b,!d! H6"H8!	Needed!to! evaluate! population! effects!	Analysis!of!historical! data!	FWS!(Earlier!Effort)!	Report!due!in!2014!
22. Feeding!and! Growth!of!Delta! Smelt!	! 3a,!4a"c,!5a"c! H1"8!	Data!needed!to! define!habitat!of! smelt.!	Analysis!of! laboratory!data!	RTC!(Earlier!Effort)!	Report!due!in!2014!
23. Patterns!of! Predation!on! Delta!Smelt!	2"b,!5b"c,!6a"b,d! H4"8!	Information! needed!to! evaluate! mortality!of! larval!smelt.!	Analysis!of! laboratory!and!field! data.!	DWR,!UCD!(Earlier! Effort)!	Report!due!in!2014!
24. Monitoring!Inter" Annual!Variability! of!Delta!Smelt! Contingents!and! Growth!	1a"d,!2a"d,!3a,!4c,! 5c,!6c! H5"8!	Needed!to! evaluate!effects! on!life!history! diversity.!	Analysis!of!historical! field!samples!	UCD!(Earlier!Effort)!	Report!due!in!2014!
25. Delta!Smelt! Feeding!and!Food! Web!Interactions!	3a,!4a"c,!5a"c! H1"8!	Needed!to!define! habitat!of!Delta! Smelt.!	Analysis!of!field!and! lab!data!	RTC!(Earlier!Effort)!	Report!due!in!2014!

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26. Longfin !and !Delta! Smelt! Bioenergetics!	3a,!4a"c,!5a"c! H1"8!	Needed!to!define! habitat!of!Delta! Smelt.!	Analysis!of!lab!data!	UCD!(Earlier!Effort)!	Report!due!in!2014!
27. TFCF!Efficiency! Evaluation!for! Delta!Smelt!	1a"d,!2!a"d!	Needed!for! entrainment! estimates!	Analysis!of! experimental!data!	USBR!(Earlier!Effort)!	Report!due!in!2014!
28. Juvenile!Salmon! and!Adult!Delta! Smelt!Salvage! Efficiency!During! VAMP!at!TFCF!	1a"d,!2!a"d!	Needed!for! entrainment! estimates!	Analysis!of! experimental!data!	USBR!(Earlier!Effort)!	Report!due!in!2014!

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Table 3(4 Potential Additional 2014 IEP Studies to Support CAMT Entrainment Effort

Investigation	Key Question(s)	Relevance	Investigative Approach	Responsibility	Schedule
29. SmeltCAM!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	USBR,!DWR,!DFW,! Others!(New!effort)!	TBA!
30. Increased!Survey! Effort!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	DFW,!FWS!(New! effort)!	TBA!
31. Increased!Spatial! Coverage!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	DFW,!FWS!(New! effort)!	TBA!

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Table 3(5 Potential Additional 2015 IEP Studies to Support CAMT Entrainment Effort

Investigation	Key Question(s)	Relevance	Investigative Approach	Responsibility	Schedule
32. Shadow!Trawling!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	DFW,!FWS!(New! effort)!	TBA!
33. Random!Sampling!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	DFW,!FWS!(New! effort)!	TBA!
34. Mark"Recapture! Efficiency,! Recapture,!and! Loss!Experiments!	1d,!4e,!5d!	Raw!data!to! address! hypotheses!	IEP!!	DFW,!FWS?!(New! effort)!	TBA!

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Attachment)A:)Progress)Report)South)Delta)Salmonid)Research) Collaborative!(provided!under!separate!cover))

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