ROBERT G. DREHER, Acting Assistant Attorney General
United States Department of Justice
Environment & Natural Resources Division
SETH M. BARSKY, Chief
S. JAY GOVINDAN, Acting Assistant Chief
BRADLEY H. OLIPHANT, Trial Attorney (Cal. Bar. No. 216468)
Wildlife and Marine Resources Section
999 18th St., South Terrace, Ste. 370
Denver, CO 80202
T: 303-844-1381 | F: 303-844-1350
ROBERT P. WILLIAMS (D.C. Bar No. 474730)
Trial Attorney
Benjamin Franklin Station, P.O. Box 7369
601 D. Street, NW, Room 3028 (20004)
Washington, D.C. 20044-7369
T: (202) 305-0216 | F: (202) 305-0275

Attorneys for Federal Defendants

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF CALIFORNIA
FRESNO DIVISION

THE CONSOLIDATED DELTA SMELT CASES	Lead Case: 1:09-cv-407-LJO-DLB Member Cases: 1:09-cv-422-LJO-DLB 1:09-cv-631-LJO-DLB 1:09-cv-892-LJO-GSA Partially Consolidated With: 1:09-cv-480-LJO-GSA 1:09-cv-1201-LJO-DLB **DECLARATION OF MARIA REA**
THE CONSOLIDATED SALMONID CASES	Lead Case: 1:09-cv-1053-LJO-DLB Member Cases: 1:09-cv-1090-LJO-DLB 1:09-cv-1378-LJO-DLB 1:09-cv-1520-LJO-DLB 1:09-cv-1580-LJO-DLB 1:09-cv-1625-LJO-SMS **DECLARATION OF MARIA REA**

I, Maria Rea, declare as follows:

1. I am the Assistant Regional Administrator, California Central Valley Area Office of the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS), West Coast Region. I previously submitted a declaration dated March 14, 2013 (Salmon Doc. 731-3) for the Supplement Brief in Support of the Joint Motion to Extend the Remand Schedule (Salmon Doc. 731). That declaration followed on the December 7, 2012 declaration of Rodney R. McInnis (Salmon Doc. No. 713-5) in support of Federal Defendants' and the Department of Water Resources' (DWR) joint motion for a continuance of the deadlines in the remand schedule. In my March 14, 2013 declaration, I provided additional details explaining: how circumstances had changed in significant, unforeseen ways since the judgments in the *Consolidated Salmonid Cases* and *Delta Smelt Cases* were entered; how the changed circumstances made compliance with the remand schedule contrary to the public interest; and how the requested continuance was tailored to the changed circumstances. Salmon Doc. 731-3.

2. I have reviewed the Court's April 9, 2013 Memorandum Decision and Order Regarding Motion to Extend Remand Schedule (Order) and I submit this declaration to address the Court's questions raised in that Order (Smelt Doc. 1106; Salmon Doc. 739). Specifically, my declaration will explain: the progress made in connection with the Collaborative Science and Adaptive Management Program (CSAMP); details about CSAMP's future activities; and how any results from this collaborative effort will be incorporated into the consultation process. This information provides support for the Movants' request for another yearlong extension of the remand schedules in the *Consolidated Salmonid Cases* and *Delta Smelt Cases*. Additionally, this declaration provides additional information on 2014 operations and the California drought state of emergency. While not directly related to the request for an additional extension (other than perhaps delaying studies that rely on the release of Delta water), NMFS wanted to take this opportunity to inform the Court about several pertinent decisions.

//

//

Progress Made in Connection with the CSAMP

3. As I explained in my March 2013 declaration, the CSAMP process calls for the establishment of a Collaborative Adaptive Management Team (CAMT). Salmon Doc. 731-3 ¶ 11. That has occurred. Following the issuance of the Court Order, a two-tiered organizational structure was established to implement the CSAMP program: (1) a Collaborative Science Policy Group ("Policy Group") made up of agency directors and top-level executives from the entities involved in the litigation; and (2) the CAMT, a working group comprised of designated managers and scientists functioning under the direction of the Policy Group. A true and correct copy of the Progress Report to the Collaborative Science Policy Group from the CAMT (Progress Report) is attached hereto as Exhibit A.

4. I also explained in my March 2013 declaration that CAMT will likely utilize an adaptive management approach akin to the nine-step approach described in the draft Delta Plan developed by the Delta Stewardship Council. Salmon Doc. 731-3 ¶ 11. As detailed in Section 2 of the attached Progress Report, the CAMT science process will be "broadly consistent with the adaptive management process described in the DOI [Department of Interior] Adaptive Management Technical Guide and the Delta Science Plan." Progress Report at 5.

5. As the Progress Report explains, the first steps in that process consist of developing conceptual models, identifying uncertainties and disagreements, formulating hypotheses or questions that address the uncertainties and disagreements, testing those hypotheses or answering those questions using appropriate scientific techniques, and evaluating alternative actions to achieve the goals and meet the objectives, thereby dealing with the problems. Progress Report at 5. Following group discussions, CAMT agreed to focus on three priority areas in 2013:

- Old and Middle River (OMR) Flow Management and Entrainment
- Fall Outflow Management for Delta Smelt
- South Delta Salmonid Survival

As I explained in my March 2013 declaration, it was also anticipated that the CAMT would provide a role in synthesizing and overseeing ongoing Delta science efforts. Salmon Doc. 731-3 ¶ 12. This anticipated role for CAMT has also occurred, though synthesis of information is still ongoing. Over the past approximately ten months, CAMT oversaw the initiation and staffing of technical subgroups for the first two topic areas. And, rather than convene a third subgroup to address issues related to south delta salmonid survival, CAMT agreed to defer technical work on those issues to the existing South Delta Salmonid Research Collaborative (SDSRC), which was established jointly by NMFS and DWR, with input and participation from the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, the Delta Stewardship Council, and Plaintiffs State Water Contractors and Westlands Water District, as an outgrowth of the 2012 Joint Stipulation for Central Valley Project (CVP)/State Water Project (SWP) operations (Salmon Doc. 660). The Progress Report (Exhibit A) provides a full discussion of CAMT/CSAMP progress on the three topic areas identified above. The first two topics have been evaluated in the context of delta smelt; below I highlight our progress on the third topic of salmonid survival in the south Delta.

6. As it specifically relates to salmonid issues, the ESA-listed species over which NMFS has jurisdiction, the primary CSAMP highlight from 2013 is the work done by the SDSRC collaboration. The SDSRC (or its technical working group, the SDSRC Science Working Group, or SSWG) has been meeting since late January 2013 to explore research opportunities that would reduce the scientific uncertainties about the effects of San Joaquin River inflow and SWP and CVP water exports on south Delta hydrodynamics, and the effects of hydrodynamics on factors affecting migration behavior and survival of juvenile salmonids. Since the January 29, 2013 kickoff meeting, the full SDSRC has convened on four additional occasions: February 27, May 6, June 7 (call), and July 15. These sessions were generally designed as briefings by the SSWG to promote understanding of progress, challenges, next steps, and necessary decisions by managers. The SSWG has convened either in person or by conference call 11 times: February 22, March 25, April 8, April 22, May 30, July 15, August 20, September 3, September 25 and 26, and October 25. Representatives of the SSWG separately

briefed a core group of agency managers on two occasions during this period, and work group representatives also briefed the CAMT on two occasions.

7. This yearlong collaboration among technical representatives, including representatives from parties to the litigation, has resulted in the development of a series of technical products, including:

- A conceptual model of south Delta salmonid migrational survival;
- An analysis of statistical power for a 1-year through-Delta survival study of steelhead and fall-run Chinook salmon;
- 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;
- Guidelines for concept proposal evaluation;
- A review of the ongoing 6-year steelhead study (RPA Action IV.2.2), to include identification of inflow-export conditions that have not yet been tested;
- Identification of opportunities and constraints to enhance learning from the 6-year steelhead study in 2014; and
- Identification of a new "Desktop Survival Study" (still in review) for implementation 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.

8. A full description of the SDSRC participants, process, and progress in 2013 is provided in the SDSRC progress report, which is attached as Exhibit B. NMFS and CAMT support the continued work of the SDSRC.

//

CSAMP's Future Activities

9. Consistent with my previous declaration, the first year granted by the court in our request for a three-year extension has been used to form the CAMT and develop conceptual models in order to identify key questions and inform what tasks will be included, and with what priority, in the workplan for 2014. The second year of the extension, should it be granted, will allow implementation of the proposed near-term priority work elements identified by CAMT for implementation in 2014. (*See* Section 3.0 (CAMT Workplan) of the Progress Report, Exhibit A, at 10-31). The anticipated third year of the extension request will allow continued development of syntheses initiated in 2014 and implementation of any new studies/monitoring suggested by the efforts carried out in 2014.

10. CAMT has decided to continue work on south Delta salmonid issues through the SDSRC, with the understanding that (a) SDSRC will work within an expanded scope that includes indirect ecological effects of south Delta water operations, and (b) the SDSRC will periodically report progress to the CAMT. The Delta Science Program (DSP) will also be providing assistance towards implementation of the elements of the workplans for each topic area, including the salmonid workplan. DSP assistance will include: guidance on scientific methods; identification of technical experts for specific investigations; identification of subject-related experts to assist with scoping and coordination tasks; and management of the independent review process for CAMT science proposals, study plans, and results. Progress Report at 11. Specific to the priority topic area relating to south delta salmonid survival, CAMT's highest priority workplan elements for 2014 (*See* Table 3-3 (CAMT South Delta Salmonid Survival Workplan) of the Progress Report, Exhibit A, at 24-30) include:

a. Synthesis of literature and data in context of conceptual model: SDSRC will convene a series of working sessions to: (a) review and potentially refine the current SDSRC conceptual model; (b) identify, screen and document published reports and empirical data, as linked to the conceptual model; (c) identify key information gaps; (d) identify key scientific agreements and disagreements, (e) review questions submitted by CAMT members in this context; and (f) develop a collaboratively produced report. *[Schedule: Status* *updates April, June, and August of 2014; Draft report September 2014; Final report November 2014]*

b. Briefing on NMFS-Southwest Fisheries Science Center (SWFSC) Life-Cycle Model (LCM): NMFS will schedule a briefing for interested and knowledgeable parties on the status and structure of the NMFS-SWFSC LCM. *[Schedule: Briefing to be scheduled no later than April 2014]*

c. Data synthesis and meta-analysis: Synthesis of data from previous Delta salmonid tagging studies may be useful in addressing some key questions/uncertainties about the direct and ecologically indirect effects of exports on salmonid survival in the Delta. In 2014, SDSRC will establish a working group to: (1) plan and oversee the strategy for identification and meta-analysis of existing data; (2) identify initial questions to address and identify relevant data sets; and (3) conduct preliminary analyses. *[Schedule: Revise written proposal by April 2014; Progress report March 2015; draft report by November 2015; manuscript completed for publication by June 2016.]*

d. Investigation of alternative metrics for management of south Delta water operations: SDSRC will convene a working group to (a) synthesize and evaluate existing data to identify potential alternative metrics for managing south Delta water operations and (b) evaluate their benefits and limitations. *[Schedule: Status check in June 2014; Progress Report in November 2014]*

e. Re-charter the SDSRC: The SDSRC will be required to periodically report its progress to the CAMT, but will continue to use the existing facilitator.

11. In addition to providing the benefits of additional work time for the CAMT subgroups, an additional one year extension provides returns from efforts concurrent with the CAMT/CSAMP and CAMT subgroup activities. A second (and potentially third) year of extension on the remand timeline would allow for more information from these efforts to be considered in the remand process. For example, year four of RPA Action IV.2.2, the 6-year

steelhead study, will be implemented this spring. Because of the time required to process massive datasets of acoustic telemetry data (the specific challenges and processing time depend on both the specific tag technology and the degree of automation available for analyzing the data), results from the first three years of the study are not yet available. Reports from the 2011 and 2012 study years are anticipated from Reclamation by the summer of 2014, with 2013 results expected by December of 2014.

12. In addition to field studies such as the 6-year acoustic steelhead study and the 2012 Stipulation Study, an important investment is being made in the development of a LCM that tracks the production, movement, survival, and development of monthly cohorts of winter-run Chinook salmon. The NMFS Southwest Fisheries Science Center is leading the team developing this LCM which will be responsive to a variety of water management decisions, such as reservoir releases, water diversions, pumping schedules, *etc*., that influence the hydrodynamics of the Sacramento River and Delta habitats. Initial modeling will use existing models (CALSIM II, HEC-RAS and DSM2) to describe the physical environment under various hydrological and operational scenarios. Later versions of the model will use a modified DWR Particle Tracking Model (enhanced PTM) that gives fish-like behaviors to the particles, to predict salmon survival under different conditions in the Delta.

13. Preliminary results from the initial version of the LCM are expected by June 2014; results from the model version linked with the enhanced PTM are expected to be available by December 2014; scenario analysis using a version of the LCM for spring-run Chinook salmon is expected to be available by May 2015.

14. In Paragraph 22 of my March 2013 declaration, I noted some key milestones for each of three phases. Key milestones and updates of progress toward those milestones in Phase 1 (collaborative science development and implementation) are:

a. Completion of new experimental designs by January 1, 2014: The SDSRC did, by January 2014, produce 14 hypothesis-based concept proposals, and further developed two of those proposals – one study relating to fish movement in response to hydrodynamic cues in south delta channels and another study focused on synthesis and meta-analysis of existing acoustic telemetry data.

b. Implementation of an experiment by June 30, 2014 during the first year of extension: The fish movement study mentioned above did not progress to a final experimental design because of concerns regarding the limitations of current technology with respect to distinguishing the behavior of tagged study fish from the behavior of predators that have recently eaten a tagged study fish. Completion of an analysis plan for the synthesis and meta-analysis of existing data, which can build on the existing draft proposal for data synthesis, is one of the three top priorities identified by CAMT for the south Delta salmonid survival topic area.

c. Based on discussions by CAMT and the workplans developed by CAMT in coordination with the topic area subgroups, the plan to implement a second year of the experiment and complete analysis and reporting of the first and second year results by June 30, 2015 and June 30, 2016, respectively, if a second one-year extension is granted, has been replaced by the salmonid workplan described in ¶11.

15. The key milestone identified in Phase 2 [Reclamation's New Project Description and Biological Assessment (BA) and National Environmental Policy Act (NEPA) phase] was "submission of a final consultation package and BA, including any new project description and/or RPA actions, to NMFS by December 31, 2015." Because the court granted a one-year, rather than three-year, extension, that milestone was necessarily moved to an earlier date. Currently, NMFS expects to receive a draft consultation package and BA in April, 2014; this date might be shifted if the Court grants another extension.

16. Finally, the key milestones identified in Phase 3 (NMFS BiOp phase) were: "issuance of a draft BiOp to Reclamation on October 1, 2017; independent peer review of the draft BiOp and responding to peer review in a revised BiOp by September 11, 2018; and section 7 review, clearance, and issuance of the final BiOp by February 1, 2019." This timeline was modified in response to the Court's granting of a single extension year; per the Court's April 9,

2013 Order, the draft BiOp would be issued by October 1, 2015 and the final BiOp would be issued by February 1, 2017. NMFS is on target to meet these deadlines if no further extension is granted.

17. Without an additional extension, NMFS will not have the resources to participate in the CAMT under the CSAMP. Additionally, NMFS will be required to redirect resources currently funding the SDSRC to preparing the biological opinion.

Incorporation of Collaboration Results into the Consultation Process

18. As noted in my March declaration, "…it takes more time initially to collaboratively define goals and develop models to describe linkages between goals and actions." The first year of our requested three-year extension was to develop the CAMT process and some conceptual models to serve as a framework for decisions about which issues should take priority. The parties have made worthwhile progress on developing conceptual models and identifying many key questions; work remains on establishing final priorities and developing detailed workplans tailored to the proposed near-term priority work elements identified by CAMT. Thus, at the end of year one, while the CAMT process itself has not yet produced significant final results that can be incorporated into the consultation process, it *has* provided the framework for more substantive progress in future extension year(s). Without an extension, NMFS will need to begin working on the BiOp immediately; staff limitations mean that further collaboration and information from the CSAMP process would cease.

19. NMFS will use recent data relevant to evaluating the effects of CVP/SWP project operations, whatever the remand timeline. With an extension, NMFS expects to have access to an additional year of information from the 6-year steelhead study as well as the potential to use information from a variety of studies planned in the delta (see summary of delta-relevant studies in Table 5-2 (Ongoing or Completed Studies Related to South Delta Salmonid Survival) in the CAMT Progress report. Exhibit A at 81-83.

20. We expect a draft LCM for winter-run Chinook salmon by June of 2014, and a draft LCM for spring-run Chinook salmon by May 2015. While those models will need review, we may be able to use some of the preliminary results from the winter-run Chinook LCM in our

analysis for the draft BiOp, currently due on October 1, 2015. An extension to the remand timeline provides more opportunity to review the model internally and with other agencies and stakeholders. With time for additional model review and development, we may be able to use the models for both winter-run and spring-run Chinook with more confidence in our analyses for the final BiOp, currently due on February 1, 2017. The results from this modeling effort and other science developed through the collaborative process will inform the ESA consultation process and improve the short and long-term protection of the listed species. To the extent there is consensus among some or all stakeholders, the results from this collaborative effort could help reduce the risk of continued or future litigation.

Additional Information Regarding 2014 Operations and Drought State of Emergency

21. While not directly related to the request for an additional extension, NMFS did want to take this opportunity to inform the court about several discussions NMFS is engaged in with regard to 2014 operations, specifically in the context of the extremely dry conditions we have experienced since 2013 and the Drought State of Emergency declared by Governor Brown on January 17, 2014.[1]

22. First, NMFS has been discussing options to use the routing/timing of potential water transfers as a way to improve in-river conditions for fish or to provide stable, targeted flow conditions that may enhance the value of experiments planned for spring 2014 (such as the planned releases of acoustically-tagged steelhead and Chinook in the lower San Joaquin River in spring 2014). However, the drought conditions may severely limit these types of options in 2014.

23. Second, NMFS recently coordinated with Reclamation and other agencies on a drought contingency plan pursuant to RPA Action I.2.3.C of the NMFS BiOp. Action I.2.3.C requires Reclamation to develop and submit to NMFS a drought contingency plan if forecasts indicate that either the Clear Creek temperature compliance point or end-of-September storage of at least 1.9 million acre-feet in Shasta Reservoir is not achievable. The January forecast indicates that end-of-September storage in Shasta Reservoir will be 0.453 million acre-feet.

[1] http://gov.ca.gov/news.php?id=18379

Because the drought contingency plan also required coordination with the State Water Resources Control Board (SWRCB), the drought contingency plan was submitted to the SWRCB as a Temporary Urgency Change Petition, and also to NMFS. Reclamation's drought contingency plan is provided as Exhibit C; the NMFS response is included as Exhibit D. NMFS concluded that the drought contingency plan submitted by Reclamation, as modified by the more specific Delta Cross Channel Gate closure criteria included in enclosure 2 of the NMFS response (see Exhibit D) is consistent with Action I.2.3.C and meets the specified criteria for a drought contingency plan. NMFS made this finding based on both the real-time physical and biological data and monitoring information attached to Reclamation's letter (Exhibit C), our supplemental rationale for DCC gate operational triggers (*see* enclosure 2 of Exhibit D), and the underlying analysis of the CVP/SWP Opinion which concluded that implementation of the RPA is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, the Southern Distinct Population Segment of North American green sturgeon, and the Southern Resident killer whales, and will not result in the destruction or adverse modification of their designated critical habitats. Furthermore, the best available scientific and commercial data indicate that implementation of this plan will not exceed levels of take anticipated for implementation of the RPA specified in the CVP/SWP Opinion.

24. NMFS anticipates that the DCC gate operational triggers will continue to be refined throughout the month of February as more real-time data are made available through the extensive monitoring program. That information will be continuously analyzed for changes in risk to species and risk to water quality. In addition, the drought contingency plan will be reviewed and updated based on data gathered through the monitoring efforts to ensure implementation of the plan continues to meet all ESA requirements.

25. In my declaration of March 2013, I stated that CSAMP could potentially break the cycle of litigation, improve scientific understanding over the long term, and provide useful new information to implement and adaptively manage the RPA actions within the existing BiOps and inform development of the new BiOps. The CAMT (and larger CSAMP) process has already facilitated discussions on three highlighted topic areas of disagreement. After reviewing the

conceptual models and research questions developed for each topic area by technical working groups in 2013, CAMT has proposed a set of ambitious near-term priority work elements that can be pursued in 2014 only if another extension is granted by the Court. I deeply appreciate the efforts of all CSAMP and CAMT members, and designees, to work together effectively during this first extension year and I continue to believe that addressing our scientific disagreements through this collaborative CSAMP effort is more productive than addressing those disagreements in court.

I declare under penalty of perjury under the laws of the State of California and the United States of America that the foregoing is true and correct to the best of my current knowledge.

Dated this 14th day of February, 2014

Maria Rea

Maria Rea
Assistant Regional Administrator,
California Central Valley Area Office
National Marine Fisheries Service

EXHIBIT A

Progress Report to the Collaborative Science Policy Group

Prepared by:

The Collaborative Adaptive Management Team (CAMT)

February 14, 2014

[Version 6.1 FINAL]

CSAMP Policy Group

Jim Beck……………………………………………………………Kern County Water Agency
Thomas Birmingham……………………………………… Westlands Water District
Charlton "Chuck" Bonham…………………………….. CA Department of Fish and Wildlife
Mark Cowin……………………………………………………. CA Department of Water Resources
Zeke Grader……………………………………………………. Golden Gate Salmon Association
Ren Lohoefener……………………………………………… U.S. Fish and Wildlife Service
Jeff Kightlinger………………………………………………. Metropolitan Water District of Southern California
David Murillo…………………………………………………. U.S. Bureau of Reclamation
Bill Phillimore………………………………………………... Coalition for a Sustainable Delta
Dick Pool……………………………………………………… Water4Fish
Kate Poole……………………………………………………..Natural Resources Defense Council
William Stelle……………………………………………….. National Marine Fisheries Service
Jay Ziegler……………………………………………………..The Nature Conservancy

Collaborative Adaptive Management Team (CAMT)

Gary Bobker…………………………………………………. The Bay Institute
Frances Brewster…………………………………………… Santa Clara Valley Water District
Mike Chotkowski……………………………………………. U.S. Fish and Wildlife Service
Valerie Connor, Co-Chair……………………………….. State and Federal Contractors Water Agency
Sue Fry………………………………………………………….. U.S. Bureau of Reclamation
Lauren Hastings……………………………………………… Delta Science Program
Steve Lindley………………………………………………….. National Marine Fisheries Service
Laura King Moon………………………………………….CA Department of Water Resources
Anke Mueller-Solger………………………………….. Interagency Ecological Program
Maria Rea…………………………………………………….National Marine Fisheries Service
Carl Wilcox………………………………………………….. CA Department of Fish and Wildlife
Leo Winternitz, Co-Chair……………………………….The Nature Conservancy

Table of Contents

List of Tables

List of Figures

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.

Mission Statement

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

> 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:

- **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.

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.

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.

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)

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

- 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.

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 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 1-2).

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.

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.

2.0 Process Framework

Introduction

In addition to focusing on the development of individual workplans for the priority topic areas presented in Table 1-2, CAMT members participated 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.

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 1080-1, 2)

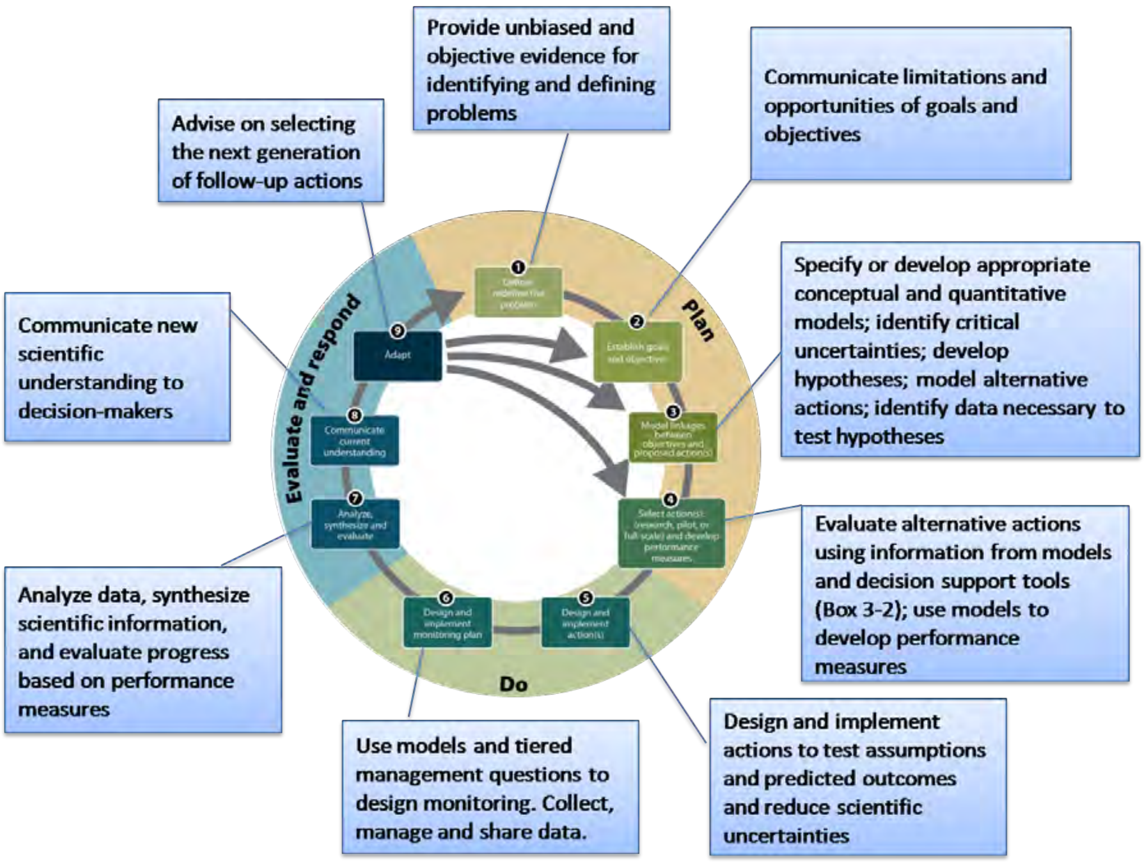
More specifically the Court Order, quoting from the declaration of Lohoefner, stated:

> 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.

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 2-1).

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

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.



(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.

In the CAMT process, the results of these initial steps have identified some disagreements and better defined the uncertainties. As shown in Figure 2-1, a key initial step of the science effort is the development of CSAMP conceptual models for the priority topics listed in Table 1-2. 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 2-1) 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:

- 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 2-1, the CSAMP process can be viewed in four distinct phases: (1) the initial nine-month 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 long-term future following the completion of the revised BiOps. The final schedule will be determined by court decisions from the district and appellate courts.

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	Long-Term	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 long-term program of collaborative science and adaptive management requires a credible and legitimate framework and process that ensures broad-based 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 policy-makers.

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 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 court-ordered 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.

3.0 CAMT Workplan

Tables 3.1 through 3.3 outline proposed near-term 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.

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 co-chairs, and approved by CAMT, who provide additional skills, subject area knowledge and experience. The CAMT co-chairs 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 plans. 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 subject-related 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 decision-making authority of the Delta Lead Scientist. Additional review may come from the Delta Independent Science Board (DISB), if deemed appropriate by the CAMT.

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.

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

- Well-stated 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, well-documented methods for data collection
- Analytical rigor and sound logic for analysis and interpretation
- Clear documentation of methods, results, and conclusions
- Publication of results in peer-reviewed scientific journals or reports

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.

Specific analyses and experiments designed to address key questions and hypotheses listed in Tables 3-1, 3-2, and 3-3 will be developed in Phase 2 of the CAMT process (see Table 2-1). 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.

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 large-scale adaptive management experiments (i.e. active adaptive management) and associated field data collections, monitoring and studies associated with non-experimental (passive) adaptive management, and smaller-scale field and laboratory studies.

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

Finally, this workplan reflects a good-faith 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 third-party investigators has not been confirmed; and uncontrollable circumstances, such as the drought, may impose new priorities that may impact schedules.

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

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

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

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

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

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

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.

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

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

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

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

Table 3-3 CAMT South Delta Salmonid Survival Workplan

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

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 identifi-cation 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

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.	

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.

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

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.

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)

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.

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:

- 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.

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.

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.

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.

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.

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 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.*

(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 4-2

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 areal 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.*

(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.

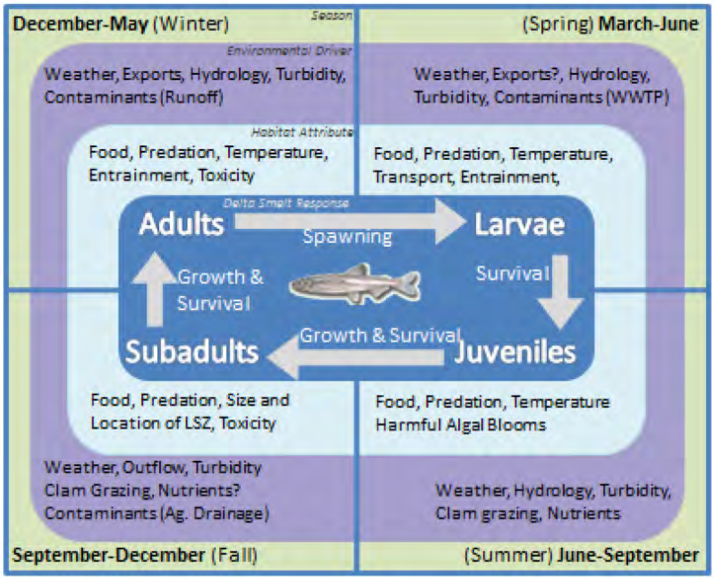


Figure 4-1 Revised Conceptual Model for Delta Smelt

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).

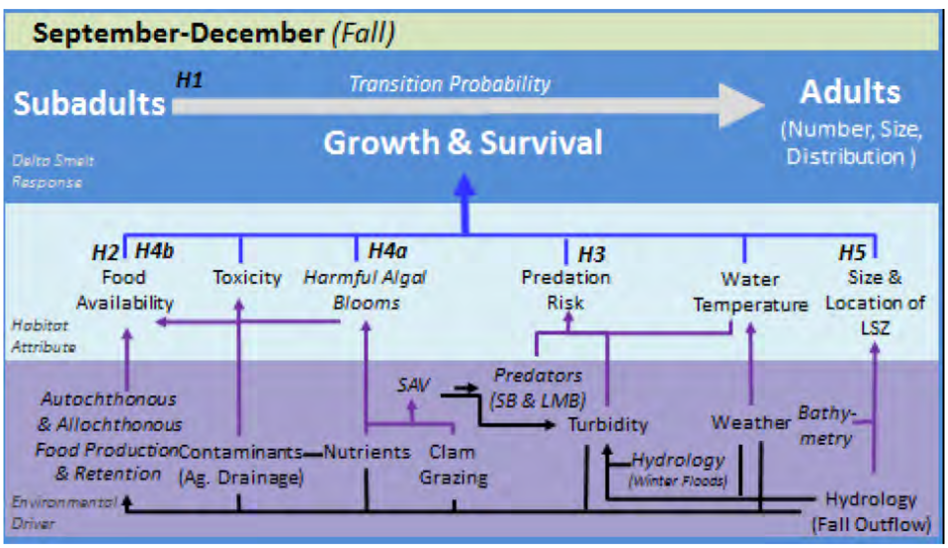


Figure 4-2 Conceptual Model for Transition from Delta Smelt Subadults to Adults - Source: (MAST 2013)

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.

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.

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.

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 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.

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.

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. (2013 a, 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).

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 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.

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 4-3

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

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,

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" (i.e. 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?

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?

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.

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.

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.

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

---

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

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 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 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 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 & 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 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 (e.g., 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.

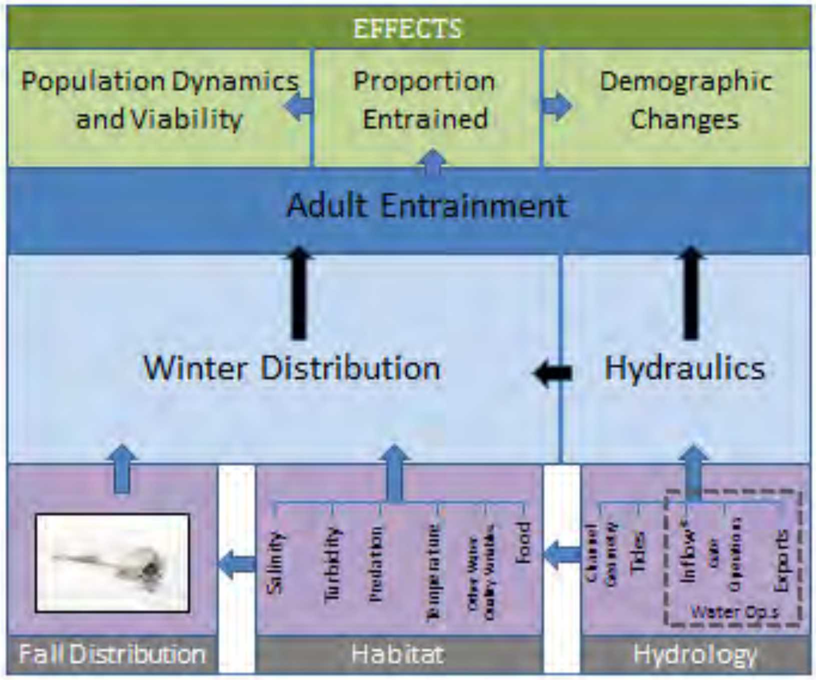


Figure 4-3 Mechanistic Entrainment Model for Adult Delta Smelt

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

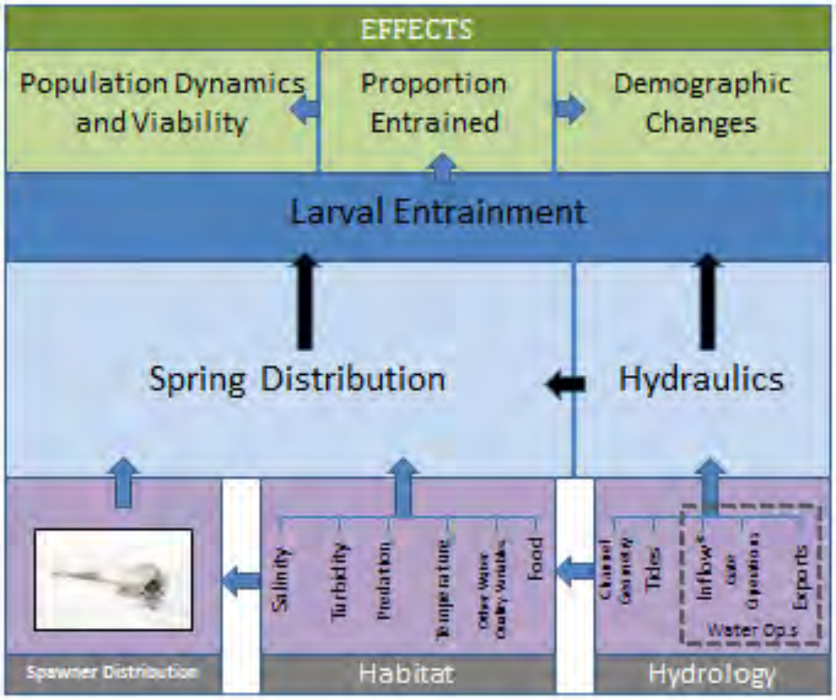


Figure 4-4 Mechanistic Entrainment Model for Larval Delta Smelt

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.

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).

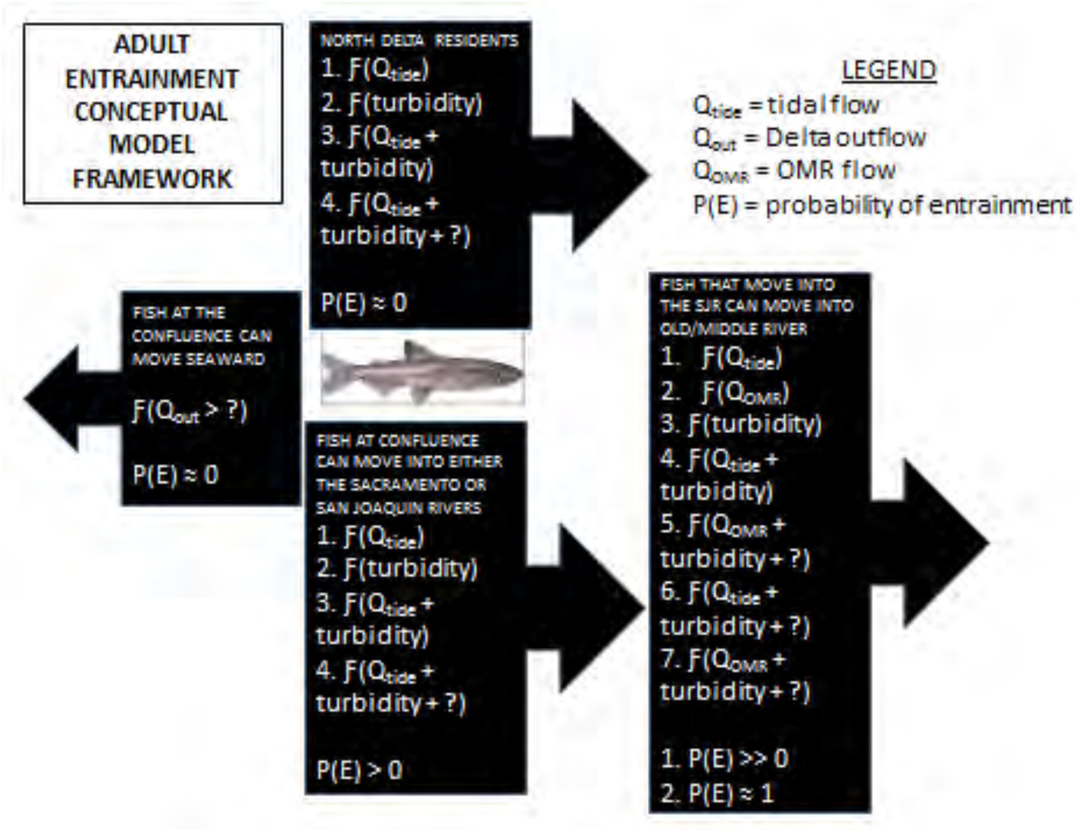


Figure 4-5 Hypothesis-Driven Entrainment Model for Adult Delta Smelt

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.

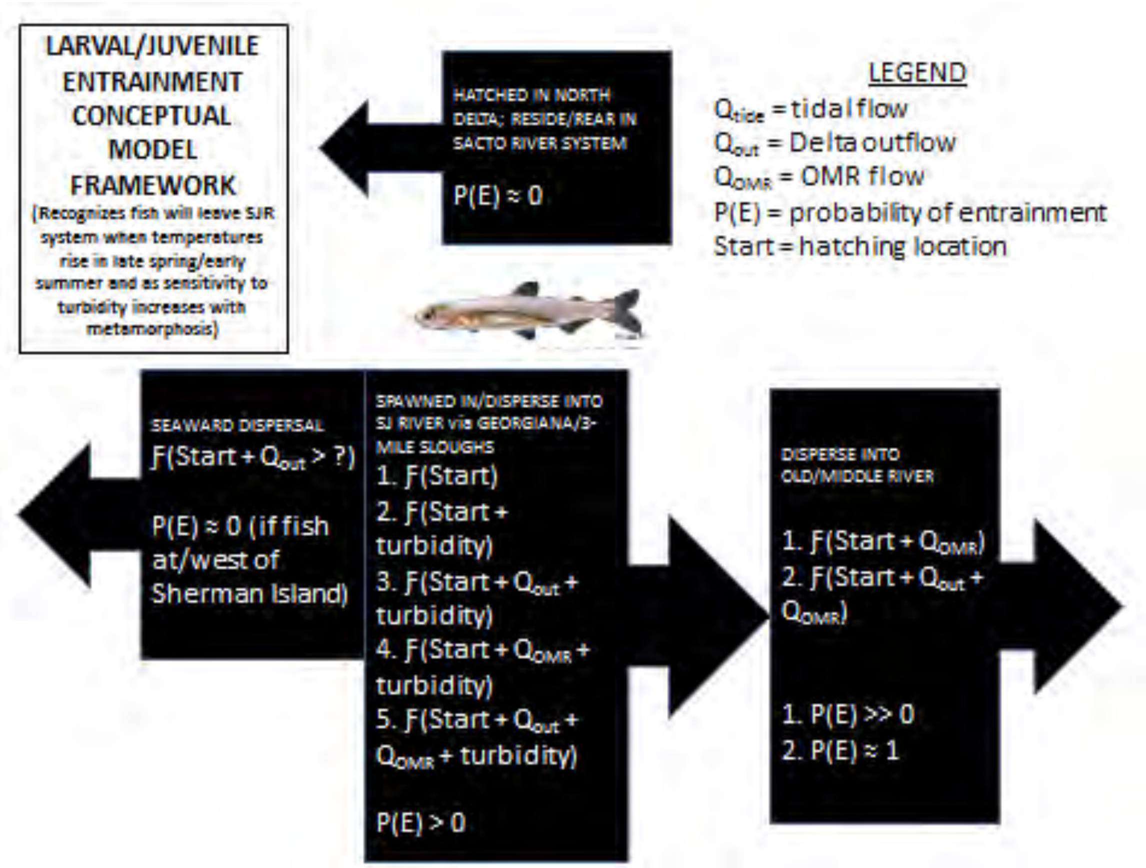


Figure 4-6 Hypothesis-Driven Entrainment Model for Larval and Post-Larval Delta Smelt

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 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.

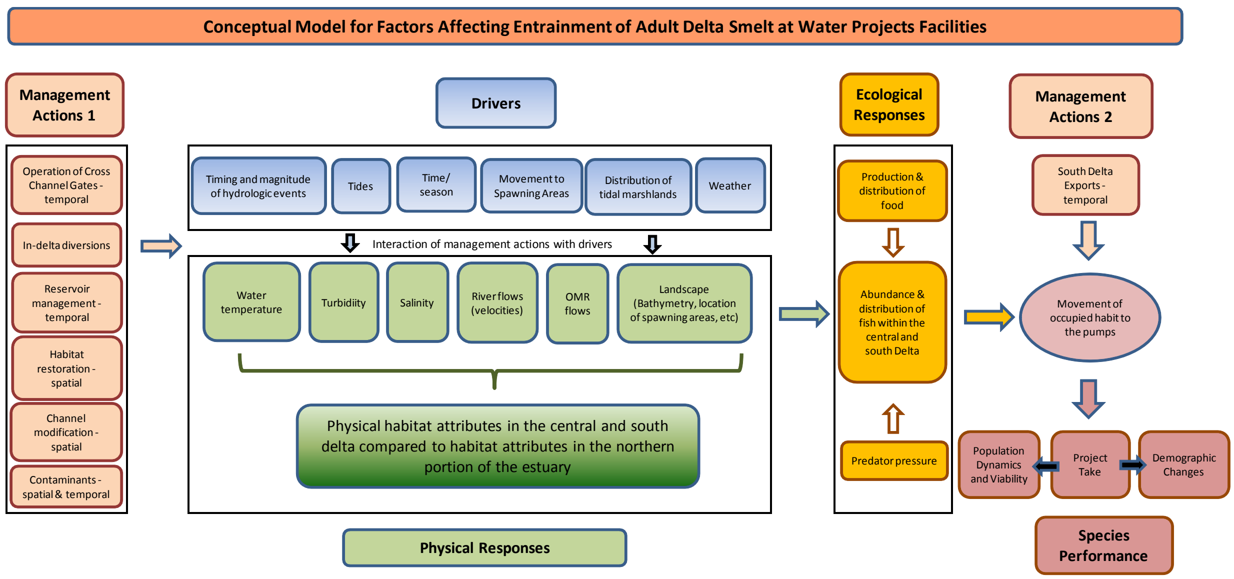


Figure 4-7 Management Action Entrainment Model for Adult Delta Smelt

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.

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 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.

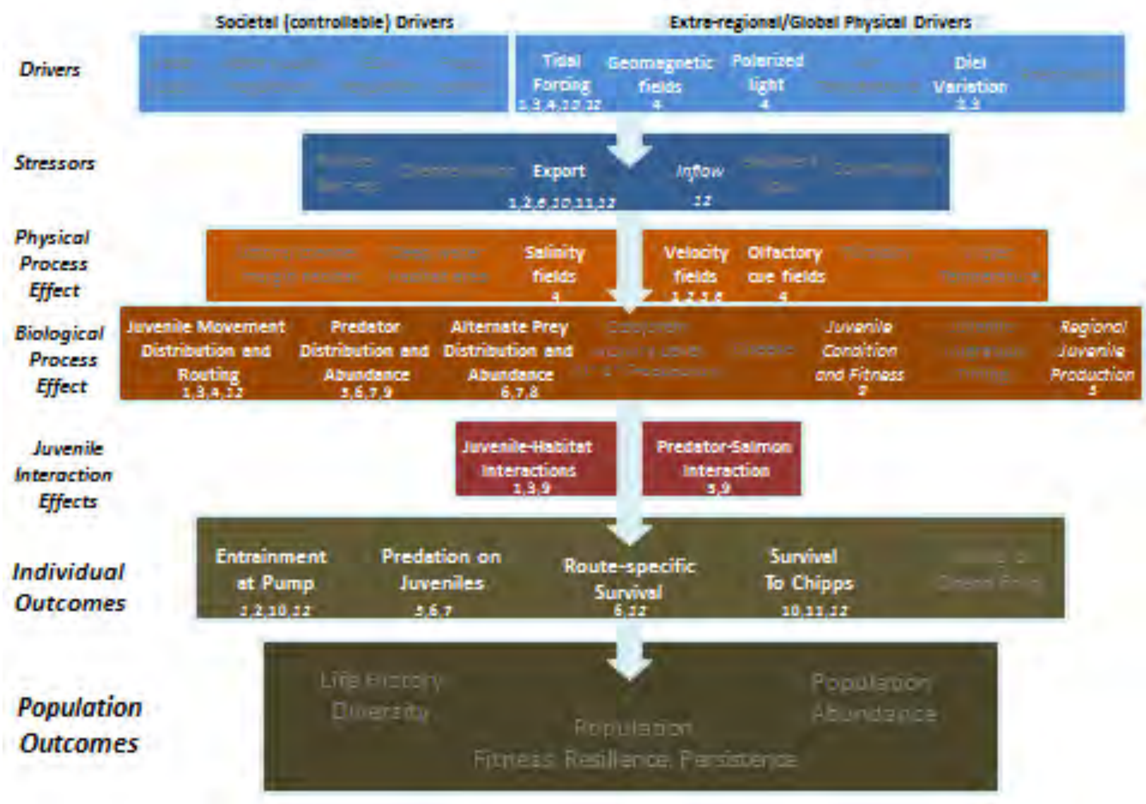


Figure 4-8 Conceptual Model for South Delta Smolt Survival (reflecting scope of SDSRC proposed studies)

Table 4-7 SDSRC 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?*

	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?*

References Cited

Allendorf, F.W., PR. England, G. Luikart, P.A. Ritchie, N. Ryman. 2008. Genetic effects of harvest on wild animal populations. Trends in Ecology and Evolution 23(6): 327-337.

Baxter, R. et al. 2013. An updated conceptual model for delta smelt: our evolving understanding of an estuarine fish. Draft Interagency Ecological Program (IEP) report by the Management, Analysis, and Synthesis Team (MAST), July 2013. Available at: http://www.water.ca.gov/iep/docs/mast_draft_7-21-13.pdf

Bennett, W.A., J.A. Hobbs, and S.J. Teh. 2008. Interplay of environmental forcing and growth-selective mortality in the poor year-class success of delta smelt in 2005. Final report: "fish otolith and condition study 2005". Prepared for the POD Management Team of the Interagency Ecological Program for the San Francisco Estuary.

Bergamaschi, B. A., K. M. Kuivila, and M. S. Fram. 2001. Pesticides associated with suspended sediments entering San Francisco Bay following the-first major storm of water year 1996. Estuaries 24: 368-380.

Castillo, Gonzalo; Morinaka, Jerry; Lindberg, Joan; Fujimura, Robert; Baskerville-Bridges, Bradd; Hobbs, James; et al.(2012). Pre-Screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California. San Francisco Estuary and Watershed Science, 10(4). Jmie_sfews_11175. Retrieved from: http://escholarship.org/uc/item/28m595k4http://escholarship.org/uc/item/28m595k4

Delta Science Program. 2013. Report of the 2013 Independent Review Panel (IRP) on the Long-term Operations Biological Opinions (LOBO) Annual Review.

Feyrer F, Portz D, Odum D, Newman KB, Sommer T, et al. (2013) SmeltCam: Underwater Video Codend for Trawled Nets with an Application to the Distribution of the Imperiled Delta Smelt. PloS ONE 8(7): e67829. Doi:10.1371/journal.pone.0067829

Fisch, K.M., Henderson, J.M., Burton, R.S., and May B., 2011, Population genetics and conservation implications for the endangered delta smelt in the San Francisco Bay-Delta: Conservation Genetics, v. 12, p. 1421–1434.

Grimaldo LF, Sommer T, Van Ark N, Jones G, Holland E, Moyle PB, Smith P, Herbold B. 2009a. Factors affecting fish entrainment into massive water diversions in a freshwater tidal estuary: Can fish losses be managed? North American Journal of Fisheries Management 29:1253-1270.

Hauser, L., G.J. Adcock, P.J. Smith, J.H. Benal Ramirez, and G.R. Carvalho. 2002. 2002. Loss of microsatellite diversity and low effective population size in an overexploited population of New Zealand snapper (Pagrus auratus). PNAS 99 (18): 11742-11747.

Hobbs JA. 2010. Otolith Growth and Microchemistry to Determine Variability in Recruitment Success of Delta Smelt. Research Summaries, California Sea Grant College Program, UC San Diego. http://escholarship.org/uc/item/4d10m0d9#page-1

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

Hobbs JA, Bennett WA, Burton J, Gras M. 2007. Classification of larval and adult delta smelt to nursery areas by use of trace elemental fingerprinting. Transactions of the American Fisheries Society 136:518–527

Houde, E. 1987. Comparative Growth, Mortality, and Energetics of Marine Fish Larvae: Temperature and Implied Latitudinal Effects. Fishery Bulletin, U.S. 87:471-495.

Kimmerer, W.J., Burau, J.R. and Bennett, W.A., 1998. Tidally-oriented vertical migration and position maintenance of zooplankton in a temperate estuary. Limnology and Oceanography, 43:1697-1709.

Kimmerer WJ. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 6, Issue 2, Article 2.

Kimmerer, Wim J.(2011). Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science, 9(1). Jmie_sfews_11028. Retrieved from: http://escholarship.org/uc/item/0rd2n5vb.

Kimmerer, W.J., Bennett, W.A. and Burau, J.R., 2002. Persistence of tidally-oriented vertical migration by zooplankton in a temperate estuary. Estuaries, 25:359-371.

Kimmerer, Wim J. and Matthew L. Nobriga. 2008. Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta Using a Particle Tracking Model. San Francisco Estuary and Watershed Science. Vol. 6, Issue 1 (February), Article 4.

Mac Nally, R., Thompson, J.R., Kimmerer, W.J., Feyrer, F., Newman, K.B., Sih, A., Bennett, W.A., Brown, L., Fleishman, E., Culberson, S.D., Castillo, G., 2010, An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR): Ecological Applications, v. 20, p. 1417–1430.

Maunder MN, Deriso RB. 2011. A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (Hyposmesus transpacificus). Canadian Journal of Fisheries and Aquatic Sciences 68(7):1285-1306.

Merz JE, Hamilton S, Bergman PS, Cavallo B. 2011. Spatial perspective for delta smelt; a summary of contemporary survey data. California Fish and Game 97(4):164-189.

Miller, William J.(2011). Revisiting Assumptions that Underlie Estimates of Proportional Entrainment of Delta Smelt by State and Federal Water Diversions from the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science, 9(1).

Miller, William J., Bryan F. J. Manly, Dennis D. Murphy, David Fullerton, Rob Roy Ramey. 2012. An Investigation of Factors Affecting the Decline of Delta Smelt (Hypomesus transpacificus) in the Sacramento-San Joaquin Estuary. Reviews in Fisheries Science 20(1): 1-19.

Mount et al. 2013. Panel review of the draft Bay Delta Conservation Plan. Prepared for the Nature Conservancy and American Rivers.. *http://mavensnotebook.com/wp-content/uploads/2013/09/FINAL-BDCP-REVIEW-for-TNC-and-AR-Sept-2013.pdf.*

Moyle PB. 2002. Inland Fishes of California. University of California Press, Berkeley.

Murphy, Dennis Daniel; & Hamilton, Scott A.(2013). Eastward Migration or Marshward Dispersal: Exercising Survey Data to Elicit an Understanding of Seasonal Movement of Delta Smelt. San Francisco Estuary and Watershed Science, 11(3). Jmie_sfews_15805.

National Research Council. 2010. A scientific assessment of alternatives for reducing water management effects on threatened and endangered fishes in California's Bay–Delta, Washington, D.C.: National Academies Press.

National Research Council. 2012. Sustainable Water and Environmental Management in the California Bay-Delta. Washington, DC: National Academies Press.

Newman, KB. 2008. Sample design-based methodology for estimating delta smelt abundance. San Francisco Estuary and Watershed Science 6: http//repositories.cdlib.org/jmie/sfews/vol6/iss3/art3.

Rose KA, Wim J. Kimmerer, Karen P. Edwards & William A. Bennett. 2013a. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: I. Model Description and Baseline Results. Transactions of the American Fisheries Society Volume 142: 1238-1259

Rose, K. A., Kimmerer, W. J., Edwards, K. P. and Bennett, W. A. 2013. Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: II. Alternative baselines and good versus bad years. Transactions of the American Fisheries Society, 142: 1260–1272.

Secor, D. H. 1999. Specifying divergent migrations in the concept of stock: the contingent hypothesis. Fisheries Research 43:13-34.

Sommer T, Mejia F, Nobriga M, Feyrer F, Grimaldo L. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science (2011) 9 (2), 16 pages.

Sommer, Ted, and Francine Mejia, 2013, A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper San Francisco Estuary, San Francisco Estuary and Watershed Science 11(2), 27 p.

Sommer, Ted, William C. Harrell, Frederick Feyrer. 2013. Large-bodied fish migration and residency in a flood basin of the Sacramento River, California, USA. Ecology of Freshwater Fish 2013. Doi: 10.1111/eff.12095.

Sweetnam, D.A. 1999. Status of delta smelt in the Sacramento-San Joaquin Estuary. California Fish and Game 85:22–27.

Thomson, J.R., Kimmerer, W.J., Brown, L.R., Newman, K.B., Mac Nally, R., Bennett, W.A., Feyrer, F., and Fleishman, E., 2010, Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary: Ecological Applications, v. 20, p. 1431–1448.

USBR 2012. Draft 2012 Plan for Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability. http://deltacouncil.ca.gov/science-program/review-materials-and-supporting-information.

USFWS (United States Fish and Wildlife Service). 2008. Formal Endangered Species Act consultation on the proposed coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP).

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.

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).

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.

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 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 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.).

Table 5-1 FLaSH Studies Being Conducted by IEP

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)	

	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

	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

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

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)	

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 I 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)	

	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)

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.

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.

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.

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 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.

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.

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.

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

	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

	Title	Conceptual Model Links		Study Questions	Study Lead	Status
9	**NMFS Winter-run Life Cycle Model**	*Stressors:* *Physical Process:* *Biological Process:* *Interaction Effects:* *Individual Outcome:* *Pop Outcome:*	Export and Inflow Littoral Channel Margin Habitat Deep Water Habitat Area Velocity and Salinity Fields Water Temperature Juvenile Movement/Distrib/Routing Predator Distribution/Abundance Regional Juvenile Production Migration Timing Juvenile-Habitat Interactions Predator-Salmon Interaction Entrainment at Pump Predation on Juveniles Route-specific Survival Survival to Chipps Timing Ocean Entry **Life History Diversity** **Population Abundance** Population Fitness/Resilience	*Given relationships based on best available science between environmental variables and juvenile salmon migration behavior, 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

Table 5-3 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

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

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

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

Table 5-4 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

Table 5-5 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

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

EXHIBIT B

PROGRESS REPORT
SOUTH DELTA SALMONID RESEARCH COLLABORATIVE

Prepared for

National Marine Fisheries Service

California Department of Water Resources

Prepared by

Anchor QEA, LLC
720 Olive Way, Suite 1900
Seattle, Washington 98101

January 2014

PROGRESS REPORT
SOUTH DELTA SALMONID RESEARCH COLLABORATIVE

Prepared for

National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento, California 95814

California Department of Water Resources
1416 9th Street, Room 1115
Sacramento, California 95814

Prepared by

Anchor QEA, LLC
720 Olive Way, Suite 1900
Seattle, Washington 98101

January 2014

PREFACE

This is a progress report on the work of the South Delta Salmonid Research Collaboration (SDSRC) since January 2013, primarily through a smaller work group of the SDSRC primarily composed of scientists and researchers from multiple agencies and organizations (called the SDSRC Science Working Group or SSWG for purposes of this report). The status report was prepared at the request of the Collaborative Adaptive Management Team (CAMT). It is the product of multiple authors, reviewers, and editors from among the diverse membership of the SSWG. A complete list of regular SSWG participants can be found in Appendix C of this report. Without limiting the contributions of any individual, those primarily involved in preparing this report included a diverse group of federal and state agency scientists, water contractor staff and consultants, and environmental organization staff who participated in SDSRC meetings and contributed to the products compose this progress report (see list below). The regular participants in the SSWG and their affiliations are listed in Appendix C.

This progress report was prepared at the request of the CAMT and was compiled from text prepared by multiple participants which was reviewed and edited by a subgroup of the SSWG that included:

Pat Brandes	U.S. Fish and Wildlife Service
Rebecca Buchanan	University of Washington
Barbara Byrne	National Marine Fisheries Service
Louise Conrad	California Department of Water Resources
Sheila Greene	Westlands Water District
Chuck Hanson	Consultant, State Water Contractors
Mike Harty	Kearns & West (facilitator)
Brett Harvey	California Department of Water Resources
Sean Hayes	National Marine Fisheries Service
Matt Holland	Delta Stewardship Council
Josh Israel	U.S. Bureau of Reclamation
Mike Schiewe	Consultant, Anchor QEA, LLC
Jeff Stuart	National Marine Fisheries Service

TABLE OF CONTENTS

List of Figures

List of Appendices

LIST OF ACRONYMS AND ABBREVIATIONS

CAMT	Collaborative Adaptive Management Team
cfs	cubic feet per second
CSAMP	Collaborative Science and Adaptive Management Program
CVP	Central Valley Project
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
ESA	Endangered Species Act
I/E	San Joaquin inflow to Delta export
IEP	Interagency Ecological Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OMR	Old River and Middle River
PIT	passive integrated transponder
Reclamation	U.S. Bureau of Reclamation
RFID	Radio Frequency Identification
RPA	Reasonable and Prudent Alternative
SAR	smolt to adult
SDSRC	South Delta Salmon Research Collaborative
SSWG	SDSRC Science Working Group
SWP	State Water Project
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan

1 INTRODUCTION

This report summarizes progress of the South Delta Salmon Research Collaborative (SDSRC) since the group was convened in January 2013. The report begins with a brief summary of events leading to creation of the SDSRC. This summary is not intended to be exhaustive but rather to provide context for the SDSRC's purpose and scope. The bulk of the report focuses on describing the group's agreements on a process and some specific activities and products since January 2013. The report is intended to document SDSRC discussions during 2013 and to assist decision-makers in understanding important choices that require attention as part of a collaborative research program focusing on south Delta salmonid survival.

The content in this draft Progress Report was compiled from the input of multiple contributors who actively participated in the SDSRC and volunteered to prepare draft sections. The contributors and other Science Working Group participants jointly reviewed the content and accuracy of this report.

1.1 ESA Listings, Biological Opinions, and Litigation

Endangered Species Act (ESA) listings of multiple populations of Central Valley salmonids began in 1989 with the listing of Sacramento winter-run Chinook salmon, which was followed by the additional listings of Central Valley spring-run Chinook salmon and California Central Valley steelhead in the 1990s. Subsequent Biological Opinions on the long-term operations of the Central Valley Project (CVP) and State Water Project (SWP) have been the subject of legal challenges in federal court, which have resulted most recently in the remand, without vacatur,[1] of the Biological Opinion issued by the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) in June 2009, and an order to submit a revised Biological Opinion by February 1, 2016. Since many of the legal claims were related to scientific uncertainties or disagreements about whether or how water operations affect listed salmonids or about how estimated impacts affect population growth rates, the federal defendants (NMFS and the U.S. Bureau of Reclamation [Reclamation]) and parties to the litigation (including the California

[1] A subset of actions in the Reasonable and Prudent Alternative of the Biological Opinion were challenged; a subset of challenged actions were the basis for the remand of the Biological Opinion; "without vacatur" means that ***all*** actions are still in effect until the new Biological Opinion goes into effect.

Department of Water Resources [DWR], CVP and SWP water contractors, and environmental organizations) discussed options for addressing these scientific uncertainties in a more collaborative framework rather than engaging in another adversarial "battle of the scientists" in court. Federal defendants and DWR requested a 3-year extension of the remand schedule in order to allow for the development of a collaborative science process that would help to inform the new Biological Opinion. In April 2013 federal Judge Lawrence O'Neill granted an initial one-year extension of time for NMFS to submit a draft Biological Opinion and to establish a Collaborative Science and Adaptive Management Program (CSAMP), with further extensions contingent on a showing of substantial progress (language from the Court's order provided for background only; see Appendix A for the complete order):

> *On or before February 15, 2014, the parties shall submit a joint status report to the Court detailing progress that has been made in connection with the CSAMP as well as providing additional information about CSAMP's future activities and how any results will be incorporated into the consultation processes.*

1.2 SDSRC

The SDSRC was established jointly by NMFS and DWR in early 2013, 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. All of these federal and state agencies were interested in supporting a more collaborative approach to pursuing research into the effects of San Joaquin inflows and delta water exports on salmonid survival in the south Delta. It 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 and its relationship to flow and exports. It was specifically designed to create a collaborative forum for thoughtful, extended information exchange and discussion involving complex scientific issues with significant policy and management implications. Participants included parties that had previously been at odds over the importance of San Joaquin inflows and water exports in survival of juvenile salmonids in the south Delta, including participants from the above-noted agencies and groups as well as selected environmental organizations and consultants for state and federal water contractors.

1.3 Scope

The charge to the SDSRC is to explore opportunities to conduct research that would reduce the scientific uncertainties about the effects of CVP/SWP project operations and San Joaquin River inflow to the Delta on the migration routing and survival of San Joaquin salmonids. The scope, which was established by the convening agencies, was as follows: the effects of [San Joaquin] inflow and exports on south Delta hydrodynamics, and the effects of hydrodynamics on factors affecting migration behavior and survival of juvenile salmonids. This scope was established to ensure a SDSRC focus on the operation of the CVP and SWP projects, which are in turn the long-term operations subject to ESA Section 7 consultation and the focus of the current litigation. Although the SDSRC focused primarily on San Joaquin-origin salmonids, discussions also considered the influence of south Delta hydrodynamics on listed Sacramento-origin juvenile salmonids.

1.4 SDSRC Purpose and Approach

The initial SDSRC meeting on January 29, 2013, was attended by a wide range of stakeholders with an interest in how CVP and SWP operations are managed for the protection of listed species, including federal and state agencies, public water agency representatives, and environmental advocates (a sign-in sheet from the meeting is included in Appendix B). The diversity of the attendees was consistent with the openness and transparency intended by the initiating agencies. Written guidelines for the initial meeting characterize the SDSRC as "designed for thoughtful, extended information exchange and discussion involving complex scientific and technical topics." The SDSRC process is "open to any participant with relevant scientific or technical expertise and information interested in participating consistent with the guidelines." All participants are expected to adhere to the guidelines in order to promote the kind of constructive scientific collaboration that can be fostered outside the context of litigation.

The SDSRC, while a scientific collaboration, does not rely on consensus for decision-making. The expectation is that individual researchers and other qualified participants will contribute their knowledge and perspectives. To the extent there are agreements, these are captured in this progress report; points of disagreement during 2013 have also been noted and, during 2014, the SDSRC will work to document the reasons for those disagreements.

1.5 Science Working Group

At the initial SDSRC meeting, a small group of participants volunteered to form a work group (hereafter referred to as the SDSRC Science Working Group; SSWG) in order to promote efficiency and progress toward desired objectives. The SSWG was also open to qualified and interested participants, and has operated consistent with the SDSRC meeting guidelines (i.e., relying on individual perspectives and knowledge rather than on consensus decision-making). The SSWG participants are responsible for most of the progress described in this report. The SSWG briefed the larger SDSRC at multiple points during 2013 and also briefed a smaller group of agency managers and the Collaborative Adaptive Management Team (CAMT) on several occasions. A list of SDSRC and SSWG meetings can be found in Section 3. Regular participants in the SSWG effort are listed in Appendix C.

2 RESEARCH FORMULATION STRATEGY

Beginning with its initial meeting in January 2013, the SDSRC adopted a step-wise 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 target date for implementation was as early as spring 2014, with the understanding that research potentially would span multiple years in order to generate meaningful results.

Toward that end, the SSWG began by compiling and quickly reviewing descriptions of ongoing research projects in the south Delta and developing a conceptual model for salmonids in the south Delta. The next step was development of a suite of testable hypotheses and linked concept proposals for internal work group review, followed by prioritization for further development. The last planned step was external peer review and, if necessary, a "fix-it" loop. At this point, the SSWG has not agreed to move any study forward to external peer review. The strategy also included agency decision-maker input both before and after external peer review. The rationale for this strategy is to make sure that projects subjected to peer review were addressing an information need of high value to management. The plan was to submit those projects receiving high marks through the external peer review process to agency decision-makers to consider for implementation.

2.1 Ongoing Research

Summaries of selected ongoing south Delta research projects were provided by NMFS, USFWS, Reclamation, and DWR. The most current version of that project list is provided in Appendix D. In general, the projects were narrow in scope, focusing on specific questions involving predator-prey interactions and fish behavior and route selection at migration junctions. Only two projects investigated through-Delta salmonid survival. One was a USFWS-led investigation of through-Delta survival of acoustically tagged fall-run Chinook salmon that had been conducted since 2010 (and represented the continuation of a long-term study effort on through-Delta salmon survival using coded-wire-tagged study fish). The other project was a 6-Year Steelhead Survival Study, which was required by Reasonable and Prudent Alternative (RPA) IV.2.2 in the 2009 Long-term Operations Biological Opinion. Reclamation is the lead agency for this study.

2.2 Conceptual Model

Conceptual models typically use diagrams, narratives, and/or tables to describe a set of relationships in a simplified manner. They are often used to develop, refine, and document understanding of ecosystems, including hypotheses about possible effects from potential actions. Conceptual models can provide a framework for incorporating new information as knowledge of the system improves.

SSWG participants developed five separate conceptual models depicting factors affecting juvenile salmonid survival in the south Delta (Appendix E). These ultimately were combined into a single, simplified conceptual model (Figure 1) that provided a framework for development of hypotheses and concept proposals. Based on the group's continued discussions, the SSWG participants refined the conceptual model (Figure 2).

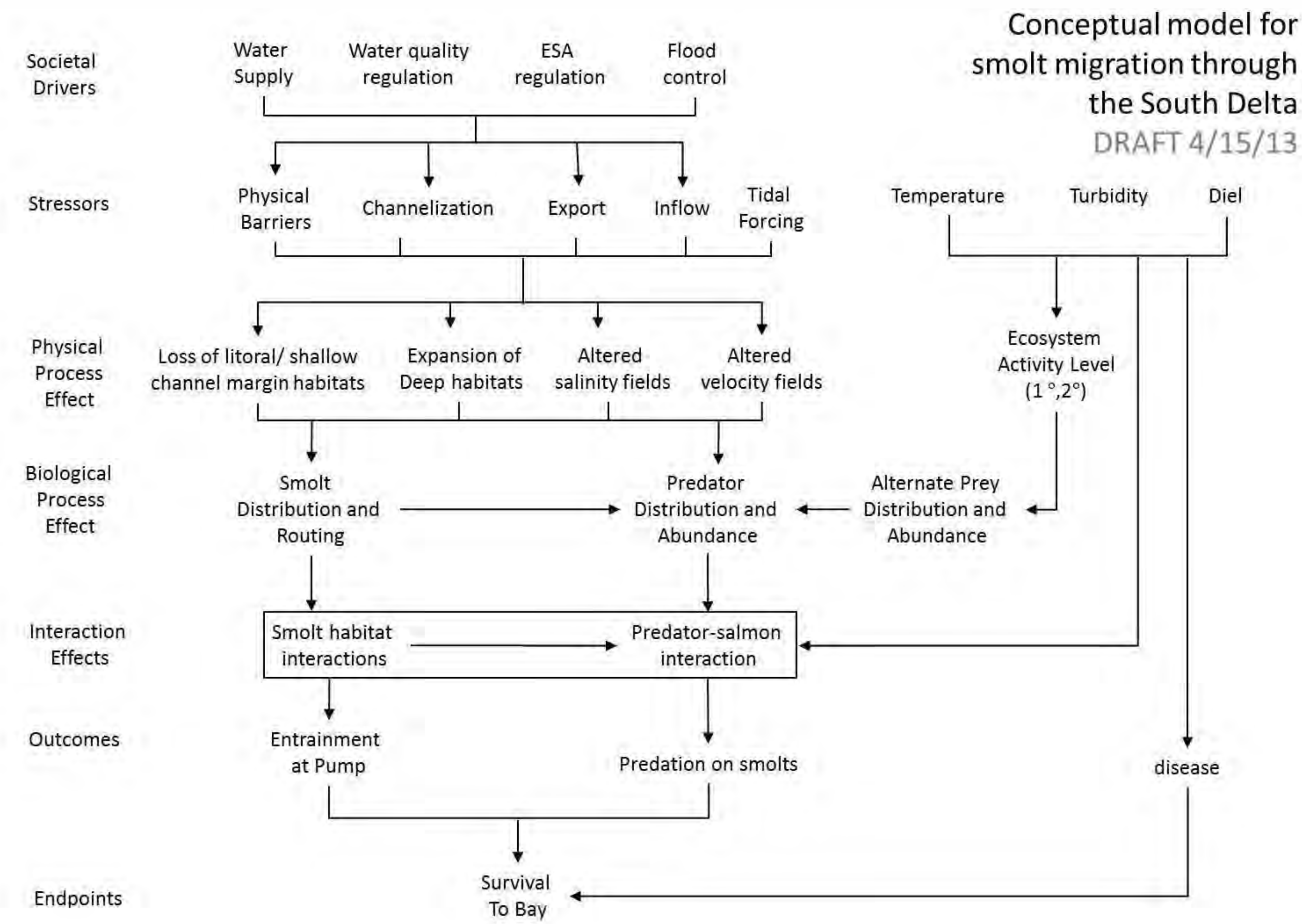


Figure 1

Simplified Conceptual Model for Through-delta Salmonid Survival

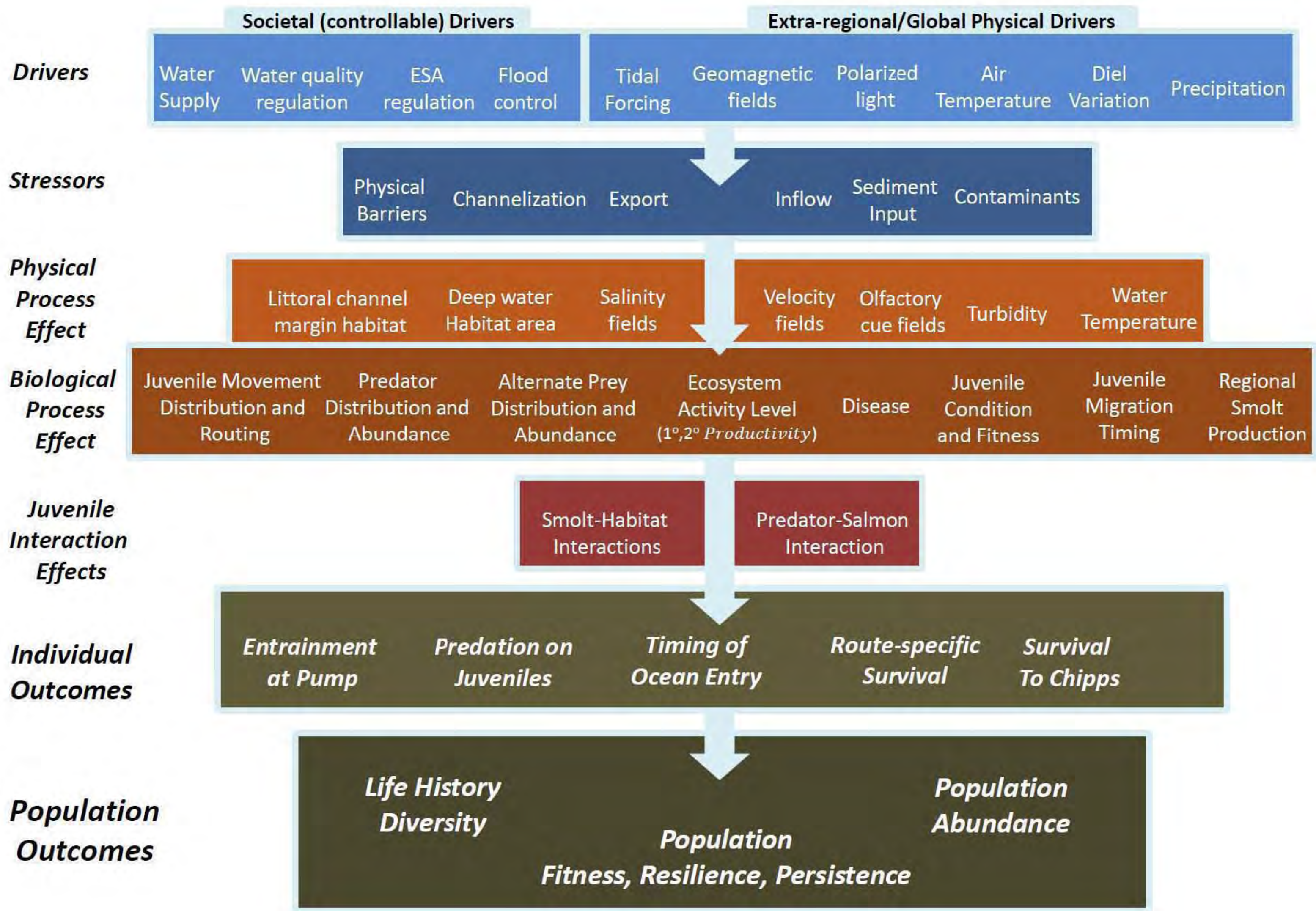


Figure 2

Current Version of the Conceptual Model for South Delta Salmonid Smolt Survival

The initial approach the SSWG took in developing a conceptual model was a "driver-linkage-outcome" approach that draws on deterministic models of ecosystem components linked together with cause-and-effect relationships of interacting variables and outcomes, using the following definitions:

- **Drivers** are physical, chemical, or biological forces that control the species or system of interest.
- **Linkages** are cause-and-effect relationships between drivers and outcomes.
- **Outcomes** are response variables (such as reproductive success, growth, and mortality) that the conceptual model is attempting to explain.

However, the current structure of the conceptual model (Figure 2) is hierarchical with major drivers and stressors at the top of the hierarchy (e.g., export and channelization), cascading through interacting physical and biological linkage mechanisms (e.g., water velocity fields, habitat area, and predator distribution), with outcomes and endpoints at the bottom of the hierarchy (e.g., entrainment, predation, and survival). Specific linkages between elements were not delineated because nearly every element in the conceptual model is linked in some way to most elements at the same or adjacent hierarchical levels; consistent delineation of all linkages would have resulted in an incomprehensible "spaghetti" diagram. In the future, as hypotheses are developed around relationships between specific elements in the conceptual model, more refined sub-models can be developed to express those relationships.

Because the scope of the SDSRC was limited to a single life stage (juvenile) in a defined region (south Delta), the conceptual model is not explicitly tied into a full life-cycle model for anadromous salmonids. However, the 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. Because the efforts of the SDSRC have been largely focused on direct effects of water inflow and export on salmonid survival, there is strong interest among some SSWG participants in expanding the focus in the coming year to include indirect[2] effects of project operations relevant to ESA section 7 consultations. Some factors mediating the effect of operations on

[2] Throughout this document, the term "indirect" is used in an ecological context and should not be interpreted with the regulatory meaning of the term in the context of ESA.

juvenile survival may be responding to indirect effects of Delta operations that can better be detected using longer term experimentation and observation.

Developing a conceptual model that was deemed satisfactory by all SSWG participants was an important accomplishment. Organizing many interacting factors that potentially affect south Delta salmonid survival was an essential starting point for formulation of meaningful research. This conceptual model was the foundation from which the SSWG built the testable hypotheses and conceptual study proposals.

2.3 Testable Hypotheses and Concept Proposals

After general agreement on a simplified conceptual model, individual SSWG participants were invited to develop hypothesis statements consistent with the scope and associated concept proposals that outlined an experimental approach to testing each hypothesis. Most of the concept research proposals were brief, one-page outlines based around testable hypotheses, although several were more fully developed (see the template for concept proposals in Appendix F). The proposal exercise was intended to highlight key uncertainties regarding relationships in the conceptual model in the form of testable hypotheses. After an initial distribution, proposals were revised to incorporate opportunities for integration with other concept proposals. The result was the development of 14 concept proposals that varied in temporal and spatial scope. These formed the pool from which studies would be selected for further development, management review, and (eventually) submittal to the external peer review process. The concept proposals are included in Appendices G, J, and K.

2.4 Internal Workgroup Review

Over the course of several sessions, the SSWG developed guidelines for reviewing the merits of each of the submitted hypotheses and concept proposals. These guidelines included explicit consideration of: 1) relevance to scope; 2) scientific merit; 3) logistic and environmental uncertainties; and 4) potential policy flags. Each SSWG participant reviewed the full set of hypotheses and concept proposals using the concept proposal evaluation guidelines outlined in Section Ia of the document provided in Appendix H. All participants were encouraged to consider the guidelines but were also free to use alternative approaches or criteria for their input. Work group participants subsequently shared their reviews as part of a process of identifying a subset of proposals meriting further development and assessed the potential for further integration of proposals.

2.5 External Peer Review

A hallmark of rigorous science is the process of external peer review. The SSWG participants identified a multidisciplinary pool of well-published scientists covering a range of disciplines relevant to the studies expected to fall within the SSWG's focus. The peer reviewers would be asked to evaluate a full proposal on the basis of: 1) scientific merit and technical quality; 2) proposed research plan; 3) resources; and 4) team qualifications (Section II of the document provided in Appendix H). For each full proposal moving forward to this step, three to four reviewers would be identified covering the range of relevant expertise. For example, review of an acoustic telemetry study investigating water export effects on near-field migrational behavior and survival would require review by scientists with expertise in experimental design and statistical analyses, acoustic tag-based survival studies, hydrodynamics, and salmon ecology. Following peer review, any recommendations to improve the study would be addressed in a fix-it loop. To encourage participation in the review process and timely responses, the external scientists participating in the process would be compensated for their time.[3]

2.6 Manager Review and Recommendation for Funding

Decision-makers would be involved in proposal selection both before and after the external peer review. As described in Sections Ib and III, respectively, of the guidelines document (Appendix H), key criteria to be considered by decision-makers would be relevance to the ESA consultation on water project operations, feasibility of implementing needed experimental conditions given existing regulations and demands on the system, and feasibility in terms of expected funding and staff-time availability.

[3] The research proposals developed by the work group have not yet been submitted for peer review.

3 SDSRC MEETINGS AND GUIDELINES

The full SDSRC has convened on four additional occasions, either in person or via conference call, since the January 29, 2013, kickoff: February 27, May 6, June 7 (call), and July 15. These sessions were generally designed as briefings by the SSWG to promote understanding of progress, challenges, next steps, and necessary decisions by managers. The SSWG has convened either in person or by conference call 11 times: February 22, March 25, April 8, April 22, May 30, July 15, August 20, September 3, September 25 and 26, and October 25. Representatives of the SSWG separately briefed a core group of agency managers on two occasions during this period, and SSWG representatives also briefed the CAMT on two occasions.

The SDSRC meeting guidelines can be found at Appendix I.

4 OUTCOMES

4.1 Overview

Considering the diverse agency and stakeholder group representation within in the SSWG, there was an immediate and surprising level of consensus among SSWG participants at the first meeting on four key points:

- The large-scale survival studies that primarily track survival between Mossdale and Chipps Island have not yet provided a clear answer to the primary question, "How do combinations of export and inflow rates affect juvenile salmonid survival?"
- The full range of conditions targeted in the Vernalis Adaptive Management Plan (VAMP) study design for assessing survival of Chinook salmon was not achieved with the observed hydrology during the VAMP years. The full range of conditions potentially testable in the 6-year Steelhead Survival Study required in the NMFS Biological Opinion have not yet been achieved over the past three years; there are 3 years remaining for this study.
- If a large-scale survival approach is continued, the best chance of detecting an export effect on juvenile salmonid survival in the south Delta is to apply "treatments" of extreme export and inflow levels that are held constant over the time necessary for a tagged-fish release to transit the south Delta, a period of approximately 2 to 3 weeks. The group also acknowledged that under some conditions, relatively large numbers of fish may be needed for experimental releases to account for predation and other losses while having a sufficient sample size to effectively estimate survival (e.g., statistical power). Implementing these more extreme treatments is expected to increase the signal-to-noise ratio, yet it was recognized by the group that a single replicate, no matter how extreme, may still not allow broad inference. Additionally, using study fish from the specific population of management importance (steelhead, winter-run Chinook salmon), rather than from a surrogate population such as fall-run Chinook salmon, provides direct information on the influence of unique behaviors and life histories of those populations on survival instead of requiring additional inference regarding surrogacy.
- Export operations influence juvenile salmonid survival through direct entrainment at the pumps and through indirect "linkage" mechanisms such as migration route

selection, juvenile residence time in the south Delta, and numerous other factors involved with predation risk.

Most SSWG participants agree that understanding indirect effects and longer term effects of project operations is relevant to the ESA Section 7 consultation on those long-term operations, and that the SSWG's efforts need not be limited to hypotheses related to direct effects of Delta operations.

During its initial 10 months, the SDSRC has generated several key accomplishments including:

- Melding of draft conceptual models into a single simplified conceptual model of south Delta salmonid survival (Appendix E and Figure 1)
- Agreement on the high value of evaluating the statistical power of a study based on a biologically relevant effect size as part of study planning
- Development of a suite of hypotheses and associated concept research proposals
- Ongoing discussions among a diverse set of participants with a range of perspectives

4.2 Proposals and Studies

Fourteen proposals were produced (Appendices G, J, and K), ranging in focus from large-scale, through-Delta survival studies, to meso-scale predation and migration behavior studies, to fine-scale migration behavior and habitat use studies. Approaches ranged from simulation modeling, to field observation, to manipulative experimentation. Three of these studies (two ongoing multi-year studies of through-delta survival of steelhead and Chinook salmon, and one predation study funded for 2014) already had funding and were presented to the SSWG for recommendations of potential study modifications to improve or augment research approaches and objectives. For example, could the proposed studies be modified to leverage resources (e.g., tagged fish, receivers, and estimation of environmental covariates) from concurrent studies? In addition, two of the newly proposed studies (without funding) were identified for priority implementation in 2014, pending further development of the study design and identification of funding sources.

The following section lists ongoing and proposed studies for 2014 that were discussed by the SSWG or SSWG subgroups.

4.2.1 Funded Studies Planned for 2014

Three studies that will be implemented during 2014 are particularly relevant to the SDSRC's scope of understanding linkages between project operations and salmonid survival in the south Delta:

- Survival of steelhead smolts during outmigration in the San Joaquin River and Delta (6-Year Steelhead Study)
- Survival of Chinook salmon smolts during outmigration in the San Joaquin River and Delta (Chinook Salmon Survival Study)
- Testing the effects of manipulated predator densities and prey transit time on juvenile salmonid survival at the San Joaquin and Old River confluence

4.3 New Studies Proposed by SDSRC

Based on the SSWG review of the 14 concept proposals, and in consideration of the studies already planned for implementation in 2014, SSWG identified two proposals with high potential for implementation in 2014 for further development:

- Collaborative hypothesis testing based on additional or meta-analyses of existing survival studies of tagged salmonids in the delta ("Desktop Survival Study," see Appendix J).
- Movement behavior of juvenile Chinook salmon in the Old River channel under the influence of tidal patterns and export operations ("Field Movement Study," see Appendix K).

The "Desktop Survival Study" (Appendix J) proposes additional analysis or meta-analysis of data from previously conducted studies of the survival and movement of tagged salmonids (including coded-wire-tag, radio tag, or acoustic tag technologies). This study proposal is currently under revision.

The "Field Movement Study" is a field study designed to monitor both fine-scale and meso-scale movement of acoustically tagged juvenile salmonids under a range of Old River and Middle River (OMR) flows in the Old River channel to the north of the export facilities. The main purpose of this study is to establish the effects of exports on migration rates, entrainment probability, and residence time in the Old River corridor for salmonids originating from both the Sacramento and San Joaquin rivers. A SSWG subgroup met on June 17 to further develop the study design and determine the logistical requirements. At the June 17 meeting, this team identified a technical roadblock described below that has postponed further steps toward study implementation.

Current telemetry equipment and analyses cannot identify with high accuracy whether an acoustic tag-detection represents a free-swimming juvenile salmonid or a juvenile that has been consumed by a predator. Therefore, presumed juvenile behavior based on tag movement may actually represent predator behavior. Algorithms have been developed to identify predator-like behavior of tags. However, the confounding effect becomes more severe at higher predation rates because a greater proportion of tag detections are likely predators. Even if the algorithms had a high rate of accuracy in identifying predated tags, in the presence of low salmonid survival a large proportion of the tags considered to be smolts might actually be predators. Computer algorithms are considered more accurate over larger spatial scales, because tags must pass multiple tag-detecting receivers, providing multiple opportunities to discern smolt-like versus predator-like movement behavior. Therefore, through-Delta survival estimates for ongoing studies are considered adequately robust to tag predation, even at very low survival rates, while estimates of survival rate and migration routing for smaller reaches within the South Delta are less reliable. For this reason the subgroup recommended postponing further development of the newly proposed field study investigating export effects on movement behavior in the Old River until the confounding of study results by tag predation can be adequately controlled or better understood.

To address the confounding effects of predation on acoustic telemetry studies, several measures have been proposed or are in development. Two tag manufacturers are currently developing predation-detecting acoustic tags in collaboration with DWR, with one tag model showing promising results in lab tests and proceeding to field trials as early as 2014. Predation-detecting tags will be most useful for medium- to large-scale studies, but because of a lag time between the actual predation event and triggering of the detection mechanism, these tags may be less useful for studies tracking short temporal-scale movement. Although the SSWG opted to postpone small-scale studies reliant on acoustic telemetry, this topic is currently under further discussion by the SSWG.

4.4 Modification of the 6-Year Steelhead Study

To maximize opportunities for data collection in 2014, the SSWG considered options for modifying the ongoing 6-Year Steelhead Survival Study to enhance the value of the information the study was generating. One early suggestion was to add an additional release group in February to increase the range of operational conditions tested within a single year. Another modification considered was to specifically target the inflow and export conditions that had not yet been tested during the first 3 years of the study (Appendix L). Yet another potential modification was to transition to a hypothesis-testing approach that would compare through-Delta survival under conditions of extremely high and low inflow, and extremely high and low export. This latter approach would maximize the signal of inflow and export to increase the power to detect an effect; these treatments would also represent conditions not previously tested.

At an early November 2013 briefing of agency decision-makers regarding possible modifications, SSWG representatives reported that they were continuing to discuss both potential modifications and that each modification had its supporters. While the two approaches are not mutually exclusive, they do represent two types of analytical approach. The high-low approach can be viewed as a statistical testing of the difference between two treatment conditions; whereas, obtaining survival estimates under a range of conditions is a multivariate regression-based approach.

4.5 Ability to Detect a Significant Export Effect on Survival

A topic that repeatedly came up during SSWG sessions was that of identifying a survival difference between inflow/export conditions that is biologically meaningful. Identifying the desired minimum effect size (the estimated magnitude of a response to a variable of interest) is needed to assess the statistical power of an experiment. The ability to detect a change in survival in response to changes in export or inflow relies, in part, on both the sample size of tagged fish and the range of export and inflow levels that occur across different release groups of acoustically tagged fish. To better understand the effect of sample size on the ability to discern a doubling of through-Delta survival rate for Chinook salmon or a 10% increase in survival rate for steelhead, a power analysis was conducted by SSWG participant Rebecca Buchanan (Appendix M) at the request of the Field Movement Study subgroup of the SSWG. For the purposes of this analysis, the subgroup identified a doubling of Chinook salmon survival, e.g., from 5% (based on recent estimates) to 10%, as a reasonable effect size. Steelhead survival through the south Delta has been much higher in the first year of results available (38% to 69%), such that a 10% proportional increase in survival rate, e.g., from 50% to 55%, was deemed biologically relevant for the purposes of this exploratory power analysis.

The power analysis indicated that a Chinook salmon sample size of around 200 tagged juveniles for each "treatment level" of exports would likely be adequate to detect a meaningful increase in survival rate during years with survival of 10%, compared to 2,000 tagged juvenile steelhead necessary to detect a meaningful increase in steelhead survival. During low survival years (i.e., dry water years) sample size for each export level would need to be around 1,500 for Chinook salmon and 6,000 for steelhead. The higher sample size required for steelhead is due to the smaller proportional increase in survival rate necessary to be considered meaningful, only a 10% increase compared to a 100% increase for Chinook salmon. These sample sizes are logistically achievable for Chinook salmon, especially considering that sample sizes can be broken into replicates to achieve similar statistical power. However, according to this analysis, the sample sizes indicated for steelhead will be more challenging and costly to achieve.

Another approach to increase the chance of detecting an export effect on survival is to force a larger range in survival rates between different releases, either by increasing the highest survival rate, lowering the lowest survival rate, or both. This could theoretically be achieved by releasing tagged fish during extremely high and low inflow: export combinations. With this in mind, a separate analysis was conducted to estimate the range of inflow and export levels observed during tagged-steelhead releases over the first 3 years of the 6-Year Study (Appendix L). This analysis found that over the distribution of spring inflows and exports that have occurred over the past 10 years, tagged steelhead have not been released during the most extreme "high-low" combinations of inflow to export, mainly because these combinations are relatively rare and have not occurred in the last 3 years.

Together, these analyses suggest for the identified effect size and level of significance, large sample sizes and extreme inflow/export treatments will be necessary to determine whether exports exert a meaningful direct and immediate influence on through-Delta survival rates. These measures would also maximize the ability to detect inflow and export effects on routing and other migration behavior. Alternatively, releases may be made at less extreme combinations of inflow and export in accordance with the current RPA standards, bearing in mind that many years of replicate releases may be necessary to have even a modest chance of detecting a meaningful export effect on survival rate.

5 SUMMARY OF RANGE OF VIEWS

As noted in Section 4, there was general agreement among SWG participants on several substantive issues, including the importance of:

- Pursuing opportunities to leverage large-scale, through-Delta studies in coordination with other studies
- Prescribing stable experimental conditions
- Designing experiments with explicit consideration of statistical power and biologically relevant effect sizes
- Acknowledging the complex ecosystem context in which multiple interacting covariates must be considered

Participants have differing views on other key questions. While it was not an explicit goal of the SDSRC to systematically document the contrasting views and their technical basis, this section summarizes preliminary discussions of these issues.

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. The RPA of the NMFS 2009 Biological Opinion on long-term operations of the CVP and SWP includes two key actions that fall within the scope of SDSRC, in that they link Delta project operations (and associated hydrodynamic conditions) to through-Delta outmigration success of salmonids:

- Action IV.2.3 – Requires OMR flows to be no more negative than -5,000 cubic feet per second (cfs); less negative levels are required when salmonid salvage at the export facilities exceeds specified triggers
- Actin 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.

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.

6 FUTURE CONSIDERATIONS AND DIRECTIONS

6.1 Future of the SDSRC

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.

A collaborative approach with a wide range of parties is not the fastest way to develop a study, but it is productive in that the resulting study will have been subject to the scrutiny of a diverse set of perspectives. This approach should reduce future disagreements about the inferences that may be drawn from a particular study.

The SSWG has not formally discussed its future potential roles or objectives, or documented individual views on these topics. However, many SSWG members have expressed interest in continuing to work collaboratively on the issues discussed in this report.

6.2 Expansion of SDSRC Focus

Several SSWG participants expressed concern that studies selected for implementation may be limited in focus to studies examining the immediate effects of inflow and exports on juvenile salmonid route-selection and migration rate or on survival, without identifying the mechanisms underlying those effects, particularly mechanisms of potential indirect effects or non-immediate (i.e., longer term) effects. In addition, several SSWG members expressed the opinion that limiting the research scope to responses directly linked to immediate hydrodynamic conditions in the south Delta region, and to the geographic region of the south Delta in general, does not allow a full exploration of hypotheses of how various factors may interact with Delta hydrodynamic conditions to affect salmonid through-Delta survival. As presented in the initial January 29, 2013, SDSRC meeting, the scope of the proposed study (or studies) was to determine effects of inflow/export on south Delta hydrodynamics and the effects of hydrodynamics on factors affecting behavior and survival of salmonids. This scope was chosen by co-conveners NMFS and DWR in order to focus scientific efforts towards resolution of one of the most contentious (because of high water cost in combination with some uncertainties) issues raised during litigation—implementation of the San Joaquin River inflow/CVP/SWP export ratio, which is described in the RPA action IV.2.1 in the 2009 NMFS Biological Opinion. Although this scope does not preclude investigation of indirect effects or non-immediate effects, comments on study proposals during the internal review process characterized such studies as being outside the SSWG scope if study design did not explicitly link response variables to immediate changes in inflow or exports, suggesting a restatement of scope from the SDSRC (or CAMT) would be helpful to clarify the boundaries of research focus.

Participants in the SSWG discussed the merits of broadening the focus of the recommended studies to include multiple levels of ecological processes over a much broader geographical and temporal range. Such an expansion could include a range of topics. The SSWG did not attempt a definitive list of such topics, but possible avenues raised in discussions or research concepts included:

- Predator movement and behavior in relation to Delta environmental conditions and habitats
- Interaction of predator abundance with salmonid behavior
- Salmonid behavior and survival in different habitats, under different environmental conditions (salinity, turbidity, and water velocity) and in response to distributions of salmonid (and predator) forage bases
- Influence of salmonid origin (hatchery versus wild or wild tributary origin) on behavioral responses and survival

These types of studies necessitate a multi-year approach that is integrated with co-occurring studies in the Delta and tributary watersheds. Although SSWG members had different opinions regarding the relevance of these studies to the scope of the SSWG, participants generally agreed that such studies could provide relevant information to agency managers to inform key operational and regulatory decisions.

6.3 Potential Future Efforts

In October 2013, a few SSWG participants summarized some future efforts to pursue should the SDSRC continue during 2014. Preliminary descriptions and development of some of the "to-do" list (not yet approved by or prioritized by the SSWG) are provided in Appendix N.

7 SUMMARY AND CONCLUSIONS

The SDSRC has been meeting once to twice per month since late January 2013 to explore research opportunities and design of experiments to broaden the understanding of the effects of San Joaquin inflow and SWP and CVP water exports on south Delta hydrodynamics and survival of migrating juvenile salmonids. The SSWG, with periodic review and input by the full SDSRC, developed a series of technical products, including:

- A conceptual model of south Delta salmonid migrational survival (Figure 2)
- An analysis of statistical power for a 1-year through-Delta survival study of steelhead and fall Chinook (Appendix M)
- 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)
- Guidelines for concept proposal evaluation (Appendix H)
- A review of the ongoing 6-year steelhead study (RPA IV.2.2), to include identification of inflow-export conditions that have not yet been tested (Appendix L)
- Identification of opportunities and constraints to enhance learning from the 6-year steelhead study in 2014 (Section 4.4)
- Identification of a new "Desktop Survival Study" (still in review) for implementation 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)

An important, yet easy to overlook, accomplishment of the SDSRC was the establishment of a technical forum for scientists from DWR, DFW, Reclamation, USFWS, NMFS, and technical staff and consultants for water contractors and non-government organizations to work collaboratively exploring ideas for new research, discussing interpretations of previously conducted research, and repairing relationships that had been stressed by years of litigation. The SDSRC was a "meeting space" where scientists were encouraged to discuss and challenge interpretation of technical information from an individual technical perspective, not from the perspective of presenting an agency position. Moreover, the breadth of the concept proposals highlights that the SDSRC is certainly not short of new and innovative research ideas. If the SDSRC scope changes or broadens, the SSWG would consider developing additional concept proposals or reprioritize existing proposals to reflect that new scope. Continuing the SDSRC under an expanded scope is strongly supported by many SSWG participants.

APPENDIX A
EXTENSION OF REMAND TIMELINE

UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

THE CONSOLIDATED DELTA SMELT CASES	Lead Case: 1:09-cv-00407 LJO BAM Member Cases: 1:09-cv-00422 LJO GSA 1:09-cv-00480 LJO GSA 1:09-cv-00631 LJO DLB 1:09-cv-00892 LJO DLB Partially Consolidated With: 1:09-cv-01201-LJO-DLB MEMORANDUM DECISION AND ORDER RE MOTION TO EXTEND REMAND SCHEDULE (Doc. 1080)
THE CONSOLIDATED SALMONID CASES	Lead Case: 1:09-CV-01053 LJO BAM Member Cases 1:09-CV-01090 LJO DLB 1:09-CV-01378 LJO SMS 1:09-CV-01520 LJO SMS 1:09-CV-01580 LJO DLB 1:09-CV-01625 LJO SMS MEMORANDUM DECISION AND ORDER RE MOTION TO EXTEND REMAND SCHEDULE (Doc. 703).

I. <u>INTRODUCTION</u>

The final amended judgment in the *Consolidated Delta Smelt Cases* requires the U.S. Bureau of Reclamation ("Reclamation") and the U.S. Fish and Wildlife Service ("FWS") to complete a revised Biological Opinion ("BiOp") under the Endangered Species Act ("ESA") regarding the impact of proposed operation of the Central Valley Project ("CVP") and State Water Project ("SWP") on the threatened delta smelt, as well as to conduct certain related analyses under the National Environmental

Policy Act ("NEPA"), by December 1, 2013. 1:09-cv-00407 ("*Smelt*") Doc. 884. The final judgment in the *Consolidated Salmonid Cases* requires Reclamation and the National Marine Fisheries Service ("NMFS") to complete a BiOp analyzing the impact of CVP and SWP operations on five aquatic species, including three salmonid species, and a related NEPA analyses, in accordance with a schedule that calls for issuance of a Record of Decision by Reclamation by April 29, 2016. 1:09-cv-01053 ("*Salmonid*") Doc. 655. The schedules embodied in these judgments were modeled largely after schedules suggested by Federal Defendants, over numerous objections to the length of the remand period. *Smelt* Doc. 877-1; *Salmonid* Doc. 653.

Federal Defendants from these two sets of consolidated actions, as well as Plaintiff Intervenor in both cases, the California Department of Water Resources ("DWR"), (collectively, "Movants") jointly move to extend the respective remand schedules by three additional years. *Smelt* Doc. 1090; *Salmonid* Doc. 713. Defendant-Intervenors objected. *Smelt* Doc. 1092; *Salmonid* Doc. 722. After reviewing the initial pleadings, the Court concluded that Movants had not yet met their burden under Fed. R. Civ. P. 60(b), which governs amendment of the judgments in question. *Smelt* Doc. 1098; *Salmonid* Doc. 728.

Upon the Court's invitation and pursuant to a stipulated two-week continuance, Movants filed supplemental support for the requested extension on March 15, 2013. *Smelt* Doc. 1101; *Salmonid* Doc. 731. Various Plaintiffs filed statements of non-opposition, *Smelt* Doc. 1103 (Metropolitan Water District of Southern California, State Water Contractors, Kern County Water Agency, and Coalition for a Sustainable Delta), *Salmonid* Doc. 733 (same), or joinders, *Smelt* Doc. 1104 (San Luis & Delta Mendota Water Authority, Westlands Water District, Family Farm Alliance), *Salmonid* Docs. 734 (same) & 735 (Oakdale Irrigation District, South San Joaquin Irrigation District, Stockton East Water District). Defendant-Intervenors filed a supplemental opposition. *Smelt* Doc. 1105 (San Luis & Delta Mendota Water Authority, Westlands Water District, Family Farm Alliance), *Salmonid* Doc. 738.

Having considered all of the relevant submissions, the Court concludes that the issues are well defined and that oral argument is not necessary. The matter is therefore decided on the papers pursuant to Local Rule 230(g) and the following decision rendered.

II. DISCUSSION

A. Legal Standard.

Fed. R. Civ. P. 60(b) provides:

> On motion and just terms, the court may relieve a party or its legal representative from a final judgment, order, or proceeding for the following reasons:
>
> (1) mistake, inadvertence, surprise, or excusable neglect;
>
> (2) newly discovered evidence that, with reasonable diligence, could not have been discovered in time to move for a new trial under Rule 59(b);
>
> (3) fraud (whether previously called intrinsic or extrinsic), misrepresentation, or misconduct by an opposing party;
>
> (4) the judgment is void;
>
> (5) the judgment has been satisfied, released or discharged; it is based on an earlier judgment that has been reversed or vacated; or applying it prospectively is no longer equitable; or
>
> (6) any other reason that justifies relief.

In their initial pleadings, Movants relied on Rule 60(b)(5), asserting application of the respective judgment "prospectively is no longer equitable." *Smelt* Doc. 1095 at 9-10; *Salmonid* Doc. 726 at 7. A party invoking Rule 60(b)(5) must satisfy a two-prong standard. *United States v. Asarco, Inc.*, 430 F.3d 972, 979 (9th Cir. 2005) (citing *Rufo v. Inmates of Suffolk County Jail*, 502 U.S. 367 (1992)). First, "[t]he moving party must satisfy an initial burden of showing a significant change either in factual conditions or in the law warranting modification of the [judgment]." *Id.* (citing *Rufo*, 502 U.S. at 384). Next, "the proposed modification [must be] suitably tailored to resolve the problems created by the changed factual or legal conditions." *Id.* (citing *Rufo*, 502 U.S. at 391). If the movant can point to "significantly changed factual conditions, … it must additionally show that the changed conditions make compliance with the [judgment] 'more onerous,' 'unworkable,' or 'detrimental to the public interest.'" *Id.* (citing *Small v. Hunt*, 98 F.3d 789, 795 (4th Cir. 1996) and quoting *Rufo*, 502 U.S. at 384).[1]

In their supplemental brief, Federal Defendants cite *Federal Power Commission v.*

---

[1] *Rufo* and *Asarco* concerned the modification of consent decrees entered in cases involving institutional reform. The Ninth Circuit has confirmed that the standards set forth in *Rufo* provide a "general, flexible standard for all petitions brought under the equity provision of Rule 60(b)(5)." *Bellevue Manor Associates v. United States*, 165 F.3d 1249, 1255 (9th Cir. 1999) (emphasis added); *see also Conservation Cong. v. U.S. Forest Serv.*, 2010 WL 3636142 (E.D. Cal. Sept. 14, 2010) aff'd, 489 F. App'x 151 (9th Cir. 2012) (applying *Rufo* in Administrative Procedure Act case).

Transcontinental Gas Pipe Line Corporation, 423 U.S. 326, 333 (1976), for the proposition that where a federal administrative agency seeks to define "the methods, procedures, and time dimension of the needed inquiry" on remand, the agency retains discretion to determine how it "may best proceed to develop the needed evidence and how its prior decision should be modified in light of such evidence as develops." The Supreme Court's reasoning in *Transcontinental* suggests that a reviewing court should not normally interfere with an agency's determination about how long remand would take to complete:

> At least in the absence of substantial justification for doing otherwise, a reviewing court may not, after determining that additional evidence is requisite for adequate review, proceed by dictating to the a the results to be reported to the court without opportunity for further consideration on the basis of the new evidence by the agency. Such a procedure clearly runs the risk of "propel(ling) the court into the domain which Congress has set aside exclusively for the administrative agency." *SEC v. Chenery Corp.*, 332 U.S. 194, 196 (1947). "The Court, it is true, has power 'to affirm, modify, or set aside' the order of the [agency] 'in whole or in part.' . . . But that authority is not power to exercise an essentially administrative function." *FPC v. Idaho Power Co*., 344 U.S. 17, 21 (1952).

Id. (emphasis added).

Yet, recent Ninth Circuit precedent clearly permits imposition of deadlines upon the remand process. *See, e.g., Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv*., 524 F.3d 917, 937 (9th Cir. 2008) ("*NWF v. NMFS*" (finding a court has discretionary authority to impose deadlines on remand proceedings and that requiring regular status reports during remand is "clearly permissible"); *Nat'l Org. of Veterans' Advocates v. Sec'y of Veterans Affairs*, 260 F.3d 1365, 1381 (Fed. Cir. 2001) (setting 120–day deadline for rule-making, while permitting agency to move for a reasonable extension if rule-making could not be completed within this timeframe). The Ninth Circuit's precedent is not in conflict with *Transcontinental*. For example, although the district court in *NWF v. NMFS* acknowledged that *Transcontinental* prohibits a reviewing court from dictating to an administrative agency "the methods, procedures, and time dimension" of the remand in the absence of "substantial justification," the agency's history of failing to comply with the ESA in that case constituted "substantial justification for a process that is somewhat detailed and monitored by the court." *NWF v. NMFS*, 2005 WL 2488447 (D. Or. Oct. 7, 2005) *aff'd*, 481 F.3d 1224 (9th Cir. 2007) *opinion amended and superseded*, 524 F.3d 917 (9th Cir. 2008) and *aff'd*, 524 F.3d 917 (9th Cir. 2008).

B. <u>Application of the *Asarco/Rufo* Standard.</u>

1. <u>Significant Change in Factual Conditions.</u>

To justify relief under Rule 60(b)(5) on the ground that a judgment "prospectively is no longer equitable," a party must first "satisfy [an] initial burden of showing a significant change either in factual conditions or in the law warranting modification of the [judgment]." *Asarco*, 430 F.3d at 979 (citing *Rufo*, 502 U.S. at 384). Here, Movants do not suggest that the law has changed. Rather, they argue that the process by which the relevant agencies and (at least some of the) interested stakeholders plan to develop scientific information relevant to the remand process has undergone a paradigm shift justifying the requested schedule modification.

a. <u>General Description of the CSAMP Process.</u>

Movants seek an extension from the remand schedules in both cases to allow staff from the relevant federal and state agencies to participate in a Collaborative Science and Adaptive Management Process ("CSAMP") described in a Proposal attached to the Supplemental Declaration of Ren Lohoefener. *Smelt* Doc. 1101-2, Att. 1.[2] The stated goal of the CSAMP is to "develop a robust science and adaptive management program, with collaboration of the scientists and experts from the Public Water Agencies (PWAs) and the NGO community, that will inform the development and implementation of the BiOps, [the Bay Delta Conservation Program ("BDCP")], and other programs." *Id*. at p. 11 of 15. Movants believe that implementation of CSAMP "will result in a halt to the counter-productive litigation cycle through the development of common understandings of the science, joint fact-finding, increased transparency through information sharing, and a commitment to work together so that parties develop trust and no longer use the courts to solve disputed scientific and technical issues." *Id*. 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;

[2] The remainder of this memorandum decision and order largely cites documents for which identical copies have been filed in both the *Smelt* and *Salmonid* cases. In such cases, only the *Smelt* citation is provided.

> (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.

Id.

Movants do not provide a great deal of detail about what the CSAMP will undertake and what it is likely to achieve. Movants explain that because it is intended to be a "collaborative" process, the details must be worked out in a collaborative manner after the process has begun. Supp. Lohoefener Decl. ¶ 20; Decl. of Maria Rea, Doc. 1101-3, ¶ 11. However, Movants do explain that CSAMP will follow standardized and generally-accepted protocols for a collaborative science process, *id.*, which will likely involve a nine-step protocol developed by the Delta Stewardship Council, *see* Rea Decl. ¶ 11 (explaining that these nine steps fall into the three broader categories of "plan," "do," and "evaluate and respond") & Ex. 1.

b. <u>Foreseeability of Changed Factual Conditions.</u>

"Ordinarily … modification should not be granted where a party relies upon events that actually were anticipated" at the time judgment was entered. *See Rufo*, 502 U.S. at 385; *see also Labor/Community Strategy Ctr. v. Los Angeles Cty. Metro. Transp. Auth.*, 564 F.3d 1115, 1120 (9th Cir. 2009) (noting that moving party must demonstrate the change was not anticipated at the time judgment was entered). "[W]here a party relies upon events that actually were anticipated at the time" judgment was entered, "modification should be granted only if the party satisfies the heavy burden of convincing the court that it agreed to the [judgment] in good faith, made a reasonable effort to comply, and should be relieved of the undertaking under Rule 60(b)." *Rufo*, 502 U.S. at 385.

Declarations filed in support of the pending motion to modify the judgment have universally indicated that circumstances related to collaborative scientific action have changed significantly since entry of judgment:

- Ren Lohoefener, Regional Director of FWS's Pacific Southwest Region, declares that while FWS staff was focusing on the increasingly adversarial litigation concerning the 2008 Smelt BiOp, many parties were focusing on the BDCP as a way to develop more collaborative solutions. However, "negotiations were impacted by the adversarial and time-consuming nature of the litigation ... making collaborative solutions extremely difficult." Supp. Lohoefener Decl. ¶ 4. "Since the litigation has ended, many parties have focused their efforts on BDCP and on fostering communication between the formerly adversarial parties." *Id.* at ¶ 5. This has led to movement in the BDCP effort as well as increased communication between formerly adversarial parties concerning implementation of the 2008 Smelt BiOp's RPA this past winter. *Id.* In sum, "there is no way the Federal Defendants could have predicted that the agencies and stakeholders could have come to the table in the way described in the [CSAMP] Proposal at the time the Amended Judgment was issued. The current circumstance is the result of many hundreds of hours spent meeting with stakeholders and fostering communication." *Id.* at ¶ 6.
- Maria Rea, NMFS's Central Valley Area Office Supervisor, echoes these sentiments, explaining that "the years of litigation on NMFS's 2009 salmonid [BiOp] created a very polarized atmosphere between NMFS and the litigants, including [DWR], with very different perspectives on what constitutes best available science." Rea Decl. ¶ 3. When she submitted a previous declaration proposing a schedule for remand that eventually led to the current remand schedule, Ms. Rea "did not anticipate" that a new collaborative science process would be proposed, nor that DWR would take a co-leadership role in the new South Delta Salmonid Research Collaborative ("SDSRC"), a smaller scale collaborative science project that the parties view as a subgroup of the larger CSAMP. *Id.* at ¶¶ 3, 25.

- Eileen Sobeck, Deputy Assistant Secretary for Fish and Wildlife and parks for the U.S. Department of the Interior and the point person for negotiation of the CSAMP Proposal, concurs that there has been a "significant change" in the parties' entrenched litigation positions since summary judgment was entered. Sobeck Decl., Doc. 1101-5, at ¶¶ 1, 3, 7.
- Dale Hoffman-Floerke, Chief Deputy Director of DWR, agrees that there has been a "significant breakthrough" in development of the BDCP, which in turn triggered an intensive collaboration between the state and federal agencies. Hoffman-Floerke Decl., Doc. 1101-1 at ¶ 2. In "recent months," the increasingly collaborative nature of discussions in connection with the BDCP has "spilled over" into discussions of the implementation of the RPAs. *Id*. at ¶ 3. As a result, Hoffman-Floerke too believes there has been a "paradigm shift." *Id*.

Defendant Intervenors dispute that the development of the CSAMP is a "new fact," pointing out that expanded stakeholder input was explicitly contemplated by earlier filings with this Court. *Smelt* Doc. 1092 at 6. For example, a September 20, 2011 stipulation regarding deadlines for submission of a revised draft smelt BiOp stated: "Federal Defendants and some of the parties have discussed greater participation in the consultation process for a new delta smelt BiOp." *Smelt* Doc. 1060 at ¶ 5. While this indicates that some collaboration might have been contemplated prior to the entry of judgment, the record amply demonstrates that the level of collaboration contemplated by the CSAMP is much more intense and potentially far-reaching than any previously-described collaborative efforts. The Court is satisfied that Movants have met their burden to demonstrate there has been a change in circumstances that was not anticipated at the time judgment was entered. Therefore, the additional "heavy burden" standard set forth in *Rufo* does not apply here.[3]

---

[3] For the same reason, there is no merit to Defendant Intervenors' objection that the motion to extend the remand schedule is untimely. *See Smelt* Doc. 1092 at 4-5. Fed. R. of Civ. P. 60(c)(1) provides that "[a] motion under Rule 60(b) must be made within a reasonable time." "What constitutes a reasonable time depends upon the facts of each case, taking into consideration the interest in finality, the reason for the delay, the practical ability of the litigant to learn earlier of the grounds relied upon, and prejudice to the other parties." *Lemoge v. United States*, 587 F.3d 1188, 1196 (9th Cir. 2009) (internal quotations and citations omitted). Here, Movants' evidence demonstrates a fairly recent, marked increase in collaboration between previously adversarial parties. The present motions, initially filed in late December 2012, were made within a "reasonable

2. Public Interest.

Movants must also "show that the changed conditions make compliance with the [judgment] 'more onerous,' 'unworkable,' or 'detrimental to the public interest.'" *Asarco*, 430 F.3d at 979 (citing *Small,* 98 F.3d at 795 and quoting *Rufo*, 502 U.S. at 384). Movants do not suggest that the changed factual conditions render compliance with the existing deadline "more onerous" or "unworkable." In fact, they acknowledge that staff is on target to meet the existing deadlines. *See* Supp. Lohoefner Decl. ¶ 14; Rea Decl. ¶ 8. Rather, Movants maintain that it will be detrimental to the public interest to continue on the current schedule because the CSAMP has the potential to break the cycle of litigation and to make the scientific underpinnings of both BiOps more robust. However, Movants explain that these advantages cannot be realized without an extension, as the respective agencies cannot dedicate staff to both efforts (i.e., the remand and the CSAMP) simultaneously.

a. Breaking the Litigation Cycle.

The Court takes judicial notice of the undisputed and undisputable fact that efforts to protect listed fish species in the Delta have been embroiled in nearly constant litigation for more than a decade. Movants' declarants emphasize the counterproductive effects of this state of affairs. Supp. Lohoefener Decl. ¶ 8 ("[E]ffective collaboration and litigation are fundamentally incompatible. Continued litigation stalls constructive efforts to improve the health of the Delta and its species."); Rea Decl. ¶ 7 ("Breaking this litigation cycle is in the public interest, as we will be able to focus our limited resources in ways that are most effective for the short and long-term protection of [ESA] listed species."). Movants believe that greater collaboration in the development of scientific information related to these species will reduce the likelihood of further litigation in the future. There is some evidence to support this belief. For example, Mr. Lohoefener credits "increased communication between the formerly adversarial parties [that] occurred this winter" for the fact that "[d]espite the fact that exports have been constrained to low levels from mid-December 2012 through mid-February 2013, no litigation has ensued." Supp. Lohoefener Decl. ¶ 5.

---

time" after these new circumstances came about.

However, as Defendant-Intervenors point out, no party has committed to refraining from seeking interim injunctive relief against the implementation of the BiOps' RPAs during any extended remand period. *See Smelt* Doc. 1093 at 2; *Salmon* Doc. 734 at 2 (indicating that the CSAMP process allows any party to pursue injunctive relief during remand).[4] Therefore, according to Defendant Intervenors, "the relationship remains adversarial." *Smelt* Doc. 1105 at 2. The fact that Defendant Intervenors have not joined in this motion to extend the remand schedule is evidence that the relevant stakeholders have yet to resolve many fundamental issues.

Nevertheless, on balance, the Court believes Movants' interest in pursuing the CSAMP process represents a solid step away from the pattern of litigation that has burdened the parties in recent years. If successful in this respect, CSAMP would advance the public interest. The Court is loath to cut off such a possibility before it is given a chance to develop, especially given the universal and enthusiastic interest in this approach expressed by all declarants.

b. <u>Advancement of Relevant Science.</u>

One of Movants' primary arguments in favor of the extension is their belief that the CSAMP process will "advance[e] the state of scientific understanding," thereby allowing the BiOps to be "made more robust." Rea Decl. ¶ 9 (discussing NMFS's work on the salmonid BiOp); *see also* Supp. Lohoefener Decl. ¶ 14 (indicating that while FWS "could issue a new smelt BiOp that meets the ESA's best available science requirement according to the existing remand schedule.... ," CSAMP is a means to "advance the state of science regarding some of the more contentious fish protective actions").

Movants' supplemental filings discuss in general terms the types of issues CSAMP may endeavor to address in a collaborative manner. Several declarants mention that a particularly fertile area for collaborative science is model development. Both this Court and multiple peer review bodies have identified a lack of quantitative life cycle models as a major shortcoming in development of the 2008 Smelt BiOp. *San Luis & Delta-Mendota Water Auth. v. Salazar*, 760 F. Supp. 2d 855, 881-85 (E.D. Cal.

---

[4] Defendant Intervenors also point out that DWR continues to challenge the science underlying the remanded BiOps on appeal. *Smelt* Doc. 1105 at 2. The Court does not believe this is indicative of anything other than DWR's long-standing disagreement with some of the scientific methods used and conclusions reached in the previous BiOps.

2010); *In re Consol. Salmonid Cases*, 791 F. Supp. 2d 802, 834-45 (E.D. Cal. 2011); Supp. Lohoefener Decl. ¶ 16. Mr. Lohoefener indicates that CSAMP "offers the opportunity to work with the parties to use existing models that they have developed and to further develop those and other models." Supp. Lohoefener Decl. ¶ 16. Likewise, Dr. Michael Schiewe, a fish biologist formerly employed by NMFS and now retained as a consultant by the agency, believes that a three-year extension will permit NMFS a much better opportunity to take advantage of a salmonid life cycle model currently being developed by NFMS. Schiewe Decl., Doc. 1101-4, ¶ 22 ("[D]eveloping quantitative life cycle models is an iterative process that involves testing and validating ... over multiple generations and years. I would expect each additional year made available by the 3-year extension to significantly improve the utility of the [NMFS] model. This is especially the case in the first few years after a new model is released."). Dr. Schiewe believes that "[p]erhaps more relevant to the specific question of improving Delta survival of salmonids" is the development of a behavioral model that will help predict how migrating juvenile salmon will respond to Delta conditions. *Id*. at ¶ 23. This issue was litigated extensively in connection with the 2009 Salmonid BiOp. *See Consol. Salmonid Cases*, 791 F. Supp. 2d at 899-904. Dr. Schiewe states that a three-year extension will provide time to begin development of a suite of models designed to better predict the effects of Delta operations on salmon migration behavior and survival. *Id*. at ¶24.

CSAMP is also anticipated to benefit the development of actions to protect spawning delta smelt and their progeny. Supp. Lohoefener Decl. ¶ 18. It is believed that smelt populations may move in response to changing turbidity conditions. *See San Luis*, 760 F. Supp. 2d at 923-24. Models of the movement of turbid zones and smelt responses to local hydrology may help to inform how the Delta should be operated to minimize smelt entrainment in the State and Federal pumping facilities. *See* Supp. Lohoefener Decl. ¶ 18.

CSAMP does seem to offer a potential mechanism to advance collaboratively scientific understanding in areas that have previously been the subject of intense dispute. Defendant Intervenors do not refute this. Rather, they argue that it is unlawful to delay the remand process in order to seek additional studies or information. In support of this proposition, Defendant Intervenors cite a previous decision in the Consolidated Delta Smelt Cases, *San Luis*, 760 F. Supp. 2d at 871, which in turn relied upon *Center for Biological Diversity v. Rumsfeld*, 198 F. Supp. 2d 1139, 1154-56 (D. Ariz. 2002), for the general rule that "[a] decision about jeopardy must be made based on the best science available at the time of the decision; the agency cannot wait for or promise future studies."

A close examination of *Rumsfeld* reveals that it should not serve as a bar to the requested extension. *Rumsfeld* concerned a biological opinion that concluded the Army's continued operations at Fort Huachuca, Arizona would not cause jeopardy to listed species that relied on flows from the Upper San Pedro River, even though rapid development in the area and uncontrolled groundwater pumping at the Fort posed threats to the species. *See generally id*. at 1143-44. The "no jeopardy" finding was premised on several required mitigation measures. First, the Army had to develop and implement an on-base plan to protect and maintain populations of listed species and habitats, *id*. at 1148, although the on-base plan was not designed to address the underlying problem of diminishing flows in the San Pedro River, *see id*. at 1153. Second, the Army was required to develop a regional water resources plan, sufficient to maintain flows in the San Pedro River to sustain the protected species and their habitats. *Id*. at 1148. The biological opinion acknowledged that the Army had no authority over the implementation of the regional plan and was only required to participate along with other stakeholders. *Id*. at 1153. Third, the Army had to monitor progress and report on the implementation of the various projects. *Id*. at 1149. Fourth, the biological opinion assumed the operation of a water recharge facility designed to temporarily delay the impact of groundwater overdraft, which the *Rumsfeld* court acknowledged was "subject to substantial uncertainty." *Id*. at 1145. *Rumsfeld* found it unlawful for FWS to "sidestep[] its obligation to make an accurate 'no jeopardy' decision based on the best available evidence" by seeking to assign this responsibility to other stakeholders through the requirement that they develop a regional water resources plan.

Movants' interest in further developing the relevant body of science in a collaborative manner during an extended remand is distinguishable from the situation in *Rumsfeld*. *Rumsfeld* concerned an unlawful "no jeopardy" determination that permitted development activities to proceed on the uncertain promise of future corrective action. Here, in contrast, the agencies seek to delay making a decision as to the existence of jeopardy and/or any required mitigation measures in order to develop better scientific information. Movants are trying to make a more robust (and possibly less contentious) jeopardy determination. The Court is unaware of any authority that prohibits affording agency decision makers a reasonable amount of time to engage in such a process.

c. Inability to Pursue CSAMP and Current Remand Schedules Simultaneously.

The final piece of Movants' public interest argument is their assertion that the parties cannot pursue CSAMP while simultaneously working to complete new BiOps according to the existing remand schedule. This is because CSAMP and the remand processes would involve largely the same key staff members from the state and federal agencies. *See* Supp. Lohoefener Decl., ¶¶ 11-12; Rea Decl. at ¶ 8 ("If the Court does not grant the requested extension, NMFS will adhere to the schedule previously ordered ... but will be unable to commit to the CSAMP process), ¶ 31.[5]

Although Defendant Intervenors are correct that "insufficient" funding is generally not considered a valid justification for delaying compliance with the ESA, *see Ctr. for Biological Diversity v. Norton*, 304 F. Supp. 2d 1174, 1179-80 (D. Ariz. 2003), the situation here cannot be fixed by merely reallocating funds and/or staff. As Deputy Assistant Secretary of the Interior Sobeck indicates: "Adding inexperienced or new staff will not significantly expand the agencies' capacity to undertake all of theses efforts at the same time." Sobeck Decl. at ¶ 8.

d. Implementation of the RPAs during the Remand Period.

The Court is mindful of Defendant Intervenors' concern that recent filings suggest intent to use CSAMP to modify and refine the BiOps' RPA actions. *See, e.g.*, Smelt Doc. 1080-1 at 3 ("The RPAs will be evaluated and refined through the collaborative science and adaptive management program and may be modified through administrative action or judicial approval as appropriate."). As all parties are

---

[5] Movants also note that the ongoing remand/consultation process is preventing agency staff from fully participating in other, ongoing collaborative efforts, including the BDCP. While this arguably is detrimental to the public interest, this has not been considered in the public interest calculus because, as was discussed in this Court's January 30, 2013 Order, *Smelt* Doc. 1098, the possibility of simultaneously pursuing reconsultation and the BDCP was at least partially anticipated by the relevant agencies prior to entry of the judgments in these cases.

undoubtedly aware, the existing BiOps have not been vacated. Any "modifications" to the RPAs must be made consistent with procedures required by law. Absent lawful modifications,[6] the CVP and SWP are required to operate in compliance with the existing RPAs. Defendant Intervenors' fears that the protections of the BiOps will be weakened will not come to pass. With this in mind, any delay engendered by pursuit of CSAMP process poses no additional, independent threat to the continued existence of the species covered by the BiOps.

In sum, allowing CSAMP to proceed has the potential to advance significantly the public interest, while proceeding on the current schedule appears likely to reverse recent moves designed to steer the parties away from endless litigation, which has been extraordinarily burdensome on the parties and the Court.

3. <u>Suitably Tailored.</u>

The remaining question is whether the proposed modification is "suitably tailored" to the changed factual conditions. *See Asarco*, 430 F.3d 979 (citing *Rufo*, 502 U.S. at 391). Movants have generally explained why the CSAMP needs three years to bear fruit, *see* Rea Decl. ¶¶ 18-24, and that "it makes sense to pursue that effort" before proceeding in earnest with the remand, Sobeck Decl. ¶ 8.

NFMS provides a somewhat more specific timeline describing target dates for CSAMP and incorporation of its results into the consultation process. Rea Decl. at Ex. 3. According to this timeline, it will take until January 1, 2014 for CSAMP to form and develop key questions and experimental designs. *Id*. This will be followed by two years during which scientific experiments will be performed and those experiments will be analyzed and written up. *Id*. The close of the first year of scientific research is targeted for June 30, 2015, with the second year closing on June 30, 2016. *Id*. Reclamation (the action agency) will integrate the results of this scientific work into the its "consultation package," which may take the form of a biological assessment, to be transmitted to NMFS by the end of 2015, after which NMFS anticipates it will take slightly more than three additional years to complete its own work on a biological opinion, which it anticipates will issue February 1, 2019. *See id.*

[6] The Court does not, at this time, express any opinion as to how such modifications might be accomplished.

The Court has not located an equivalent timeline for an adjusted *Smelt* remand, but presumes that the target dates Ms. Rea provides for the CSAMP are universally applicable. Obviously, the timing of integration of any research produced by CSAMP would differ in the smelt case, as the extension they are requesting will extend the current deadline of December 2013 to December 2016, rather than early 2019.[7]

Because the CSAMP process has not yet begun and its exact processes are to be developed in a collaborative manner, Movants are unable at this time to provide details of the CSAMP process, what it is likely to accomplish, and how those accomplishments will be brought to bear on the respective consultation processes. *See* Sobeck Decl. ¶ 14. This lack of detail provides the Court with little assurance that CSAMP will proceed as envisioned, let alone that CSAMP will actually result in scientific progress, as opposed to "collaborative" gridlock. Therefore, rather than granting Movants a three-year blank check, during which time CSAMP could stagnate or entirely fall apart, the Court will grant a staged extension as described below.

III. CONCLUSION AND ORDER

Given that the CSAMP is targeted to form and develop key questions and experimental designs by January 1, 2014, approximately nine months from now, all deadlines in both the *Smelt* and *Salmonid* cases are extended by one year. On or before February 15, 2014, the parties shall submit a joint status report to the Court detailing progress that has been made in connection with the CSAMP as well as providing additional information about CSAMP's future activities and how any results will be incorporated into the consultation processes. As part of any such submission, the Court expects to see detailed schedules describing how CSAMP and the consultation processes in both cases will proceed. Concurrent with the filing of the joint status report, the Court will entertain a request to extend the remand schedule by an additional year, with the understanding that if substantial progress has been made

[7] It is notable that FWS already has completed and transmitted to Reclamation a draft revised Smelt BiOp, *see Smelt* Doc. 1069, and Reclamation has begun the related scoping process under NEPA, *see* 77 Fed. Reg. 18,858 (Mar. 28, 2012). Nevertheless, FWS's Mr. Lohoefener is concerned that issuing the BiOp according to the current schedule does not leave sufficient time to build consensus and "stakeholder buy-in" and therefore "will lead to further litigation." Supp. Lohoefener Decl. ¶ 9. According to Deputy Assistant Secretary Sobeck, this will "send all parties back to their litigation corners, which will severely limit further efforts at collaboration" and "will not help foster long-term solutions." Sobeck Decl. ¶ 6.

along the lines outlined by Movants, such an extension will be granted. The opposite is equally true. If substantial progress has not been made, further extensions will be nonexistent. Extension of the deadlines by a third year will require a similar showing at the end of the second year.

IT IS SO ORDERED.

Dated: **April 9, 2013**

/s/ Lawrence J. O'Neill
UNITED STATES DISTRICT JUDGE

APPENDIX B
SIGN-IN SHEET FROM 1/29/13 SDSRC MEETING

Date 1/29/13 Event South Delta Research Location CFD Capitol Mall, Huntington

Name	Organization	e-mail
Kevin Clark	DWR	kclark@water.ca.gov
Pat Brandes	FWS	Pat_Brandes@fws.gov
Leigh Bartoo	FWS	aondrea_bartoo@fws.gov
Paul Bergman	CFS	pbergman@fishsciences.net
GARWIN YIP	NMFS	GARWIN.YIP@NOAA.GOV
Alice Low	CDFW	alice.low@wildlife.ca.gov
GEORGE ISAAC	DSP	gisaac@deltacouncil.ca.gov
Jenny Melgo	CFS	jennym@fishsciences.net
Barbara Byrne	NMFS	
Brett Harvey	DWR	Brett.Harvey@water.ca.gov
Maria Rea	NMFS	maria.rea@noaa.gov
Dale Hoffman-Floerke	DWR	dalehf@water.ca.gov
Roger Fujii	USGS	rfujii@usgs.gov
Heidi Rooks	DWR	hrooks@water.ca.gov
LIZ KITECK	USBR	ekiteck@usbr.gov
Mike Schiewe	Anchor QEA / NMFS	mschiewe@anchorqea.com
Chuck Hanson	Hanson Env / SWC	chanson@hansonenv.com
Jeff Stuart	NMFS	J.Stuart@noaa.gov
Barb Byrne	NMFS	barbara.byrne@noaa.gov
CHAD DIBBLE	CDFW	chad.dibble@wildlife.ca.gov
Doug Obegi	NRDC	dobegi@nrdc.org
Sue Fry	Reclamation	sfry@usbr.gov
David van Rijn	"	dvanrijn@usbr.gov
Terry Erlewine	State Water Contractors	terlewine@swc.org
Sheila Greene	Westlands Water District	sgreene@westlandswater.org
Brad Cavallo	CFS/DWR	bcavallo@fishsciences.net
Josh Isreal		
Sean Hays		
Steve Lindley (phone line)		
Dave Fullerton (phone)		
Rebecca Buchanan (phone)		
Carl Wilcox (phone)		

APPENDIX C
ACTIVE SSWG PARTICIPANTS

Active participants in the SDSRC Science Working Group

California Department of Fish and Wildlife
Alice Low

California Department of Water Resources
Michael Cane
Kevin Clark
Louise Conrad
Brett Harvey
Jacob McQuirk
Javier Miranda

Consultants
Brad Cavallo, Cramer Fish Sciences, representing the state water contractors
Sheila Greene, Westlands Water District, representing the federal water contractors
Chuck Hanson, Hanson Environmental, representing the state water contractors
Mike Schiewe, AnchorQEA, representing NMFS
Mike Harty, Kearns & West, facilitator

Delta Stewardship Council
Sam Harader
Matt Holland

National Marine Fisheries Service
Barbara Byrne
Jeff Stuart

NOAA Southwest Fisheries Science Center (Santa Cruz)
Sean Hayes
Steve Lindley

Reclamation
Josh Israel

U.S. Fish and Wildlife Service
Pat Brandes

APPENDIX D
ONGOING AND PLANNED RESEARCH ON SOUTH DELTA SALMONID SURVIVAL

<u>Studies that are "recently completed, underway or planned" which will add to the Department's understanding of project operational impacts on listed fish and inform remanded BiOps</u>

Studies Recently Completed with Reports Pending

1. **<u>2012 Stipulation Study</u>** *(Steelhead)*
   The 2012 Stipulation Study monitored the movement patterns and survival of acoustically tagged steelhead released during April and May in tidal reaches of the San Joaquin River downstream of Stockton and in channels leading into the interior Delta. In addition to providing information about the effects of Old and Middle River (OMR) flows on route selection and survival of steelhead in the South Delta, the stipulation study piloted an alternative approach to manage water export risks to ESA listed salmonids. A report describing this study, analyzing the resulting data and assessing the effectiveness of the study as an operations management tool will be completed by December 2013.

2. **<u>Barrier Studies at Georgiana Slough</u>** *(Salmon)*
   A full-scale field study of a non-physical barrier (NPB) at Georgiana Slough was completed in 2011 and 2012. The study was conducted at the divergence of Georgiana Slough from the Sacramento River. This study is consistent with RPA Action IV.1.3, and was completed to investigate potential engineering solutions to reduce the diversion of emigrating juvenile salmonids to the interior and southern Delta. This non-physical barrier utilized bio-acoustic fish fence™ (BAFF) technology; which combines acoustics and a strobe-lit sheet of bubbles to create an underwater wall of light and sound intended to repel juvenile Chinook salmon and discourage out-migrating salmon smolts from entering Georgiana Slough. The objective is to keep the smolts in the Sacramento River system where their chance of survival is considered greater.

   The results of the 2011 work suggest this technology was effective at providing a 2/3 reduction in juvenile salmon entrainment into Georgiana Slough. The final report on the 2011 study is complete. 2012 data is being processed and analyzed, but preliminary analyses suggest a measureable reduction in entrainment in 2012 as well. A final 2012 report will be available in spring 2013. 2011 and 2012 had very different hydrological conditions thus allowing evaluations of barrier effectiveness under a wide range of flows. These results are important for understanding the utility of this specific technology; however, one of the most important things that was observed in the 2011 and 2012 GSNPB studies was that the across-river fish distribution and local hydrodynamics are the major controlling factors for juvenile salmon route selection. In 2011, and it appears that 2012 analysis will support this as well, the efficiency of the BAFF was primarily explained by one or both of these factors.

   Rather than a BAFF, there may be simpler and less expensive ways to alter across-river fish distributions that will prevent fish from being entrained in Georgiana

Slough. Floating guidance wall structures have been used with some success in the Pacific Northwest area, and we believe they may offer a relatively simple solution for altering fish distributions that from a bulk flow perspective is flow neutral.

Based on the analyses and observations of the 2011 and 2012 studies, we hypothesize that by manipulating the distribution of fish prior to the fish entering a junction their route selection can be manipulated. By then properly selecting the junctions to perform this manipulation, an engineering solution will lead to an increase in population level survival through the delta. This hypothesis would require field testing. A third study to test this hypothesis at Georgiana Slough is being considered, but has not been approved, for 2014. This study would look at a new technology to deter fish from Georgiana Slough as well as further evaluate route entrainment and reach specific survival. Results from a 2014 study would not be available for scientific review until late 2015.

3. **Divergence Hydrodynamics** *(Basic hydrodynamic information, not fish specific.)*
Detailed hydrodynamic measurements using stationary Acoustic Doppler Current Profilers (ADCP) were completed in 2011 and 2012 at Georgiana Slough and in 2012 at the Head of Old River. These measurements and analysis of the related data provide detailed hydrodynamic mapping of the areas. This work is essential to both understanding fish movement and flow dynamics. This work would also serve to calibrate multi-dimensional computational fluid dynamic models. The multi-dimensional computational fluid dynamic models can be combined with individual-based fish behavior models to better understand fish behavior under different hydrodynamic conditions and would be valuable for analyzing planned project alternatives.

DWR is preparing a contract with the US Army Corps of Engineers to be executed in 2013 to model engineering solutions like the BAFF at various Delta locations including the Head of Old River and Georgiana Slough. Also, a proposal to collect hydrodynamic data at the divergences described in the NMFS BiOp RPA Action IV.1.3 is being considered by Reclamation and would be conducted by USGS. ADCP's would be deployed at the divergences and complete velocity field data would be collected to better understand divergence hydraulics.

4. **Develop Screen Criteria** *(Sturgeon)*
Reclamation directed a series of laboratory experiments through UCD to determine the swimming performance and behavior of young green sturgeon and white sturgeon, including effects of positive barriers (screens), passive barriers (louvers), and behavioral deterrent devices (near-field vibrations and strobe-light flashes). Data is currently being analyzed and a report should be drafted soon afterward.

5. **Collection, Handling, Transportation and Release (CHTR) Studies**

The CHTR studies are a collective group of Interagency Ecological Program coordinated studies collaboratively conducted by DFW, DWR, Reclamation, and UCD with the intent of evaluating the survival of listed fish, specifically delta smelt, through the CHTR phase of the salvage process. The goal of these studies is to document existing conditions and fish survival through the CHTR phase, while developing recommendations for improving or modernizing the process to increase survival. Results from these studies will aid with assessing the effects of the fish salvage process on delta smelt and other sensitive fish species. Experimentation and data collection for these various studies was conducted from 2004 through 2008.

In 2010, DWR published two technical reports describing the effects of the "Release" phase including (1) salvaged fish injury and mortality and (2)release site predation. Three more reports (all in final review) are expected from DFW in 2013 including:

- Stress response of delta smelt in the CHTR phase of the fish salvage process
- Acute mortality and injury of delta smelt associated with the CHTR phase of the fish salvage process
- Fish Predation in the CHTR phase of the fish salvage process.

6. **Head of Old River Fish Studies**

A temporary rock barrier is historically installed in the spring at the Head of Old River (HOR) at the confluence of the San Joaquin River. Installation of the physical barrier was prohibited by court order in 2008 because it reduces flow in Old River which increases reverse flows in the central Delta. Reverse flows are considered a threat to Delta smelt due to an increased probability of entrainment in the south Delta CVP and SWP pumping facilities.

In 2009 and 2010, DWR worked in coordination with the San Joaquin River Group Authority and the US Bureau of Reclamation (Reclamation) to design, implement and monitor a non-physical barrier or Bio Acoustic Fish Fence (BAFF) at the HOR. The BAFF was designed to deter salmonids from moving into Old River without effecting river flows and consequently was considered Delta smelt friendly. The BAFF was deployed in the San Joaquin River immediately upstream of the HOR. The 2011 BAFF was not installed due to high San Joaquin River flows.

In 2012, due to criteria under the "Joint Stipulation Regarding CVP and SWP Operations in 2012" approved by United States District Judge Lawrence J. O'Neill, a physical rock barrier was installed at the HOR. To address Delta smelt concerns, more flow in Old River was provided by installing additional culverts in the rock barrier.

For many years, tagged fish studies have been conducted at the HOR to monitor the effectiveness of the non-physical barrier and the physical rock barrier in keeping out-migrating salmon in the main stem of the San Joaquin River rather than entering

Old River. In 2011 and 2012 detailed studies of predatory fish behavior were conducted at the HOR. Data on the abundance, distribution, and composition of predatory fish as well as the two-dimensional movement of salmonid smolts and predatory fish has been collected. A comprehensive analysis of the 2009-2012 salmonid and predator studies conducted at the HOR and a synthesis report is being prepared by consultants under contract to DWR. The final synthesis report is expected in late 2013.

In 2013, a predatory fish study is planned which will look at predatory fish composition, diet, and movement through Reclamation's extensive 6-Year Steelhead Study acoustic monitoring network. AECOM Technical Services, Inc. (AECOM) and subcontractor Fisheries Foundation of California will conduct the 2013 study of predatory fish at the HOR under a DWR contract. This work is being completed in coordination and partnership with the Reclamation and NMFS. Fisheries Foundation of California will collect predatory fish data, capture predatory fish, and acoustically tag up to 30 predatory fish. This field work will take place on the San Joaquin River and Old River in the vicinity of the HOR. AECOM will manage the work, prepare the technical deliverables, and procure required equipment.
The objectives of this study are:

- Procure required acoustic tags and associated equipment.
- Capture predatory fish, collect related data, and acoustically tag predatory fish as directed by DWR and in coordination with Reclamation's 6-Year Steelhead Study.
- Prepare a technical report summarizing efforts, delivering data, and providing recommendations for application and integration of data and any future study recommendations.

A report summarizing the 2013 work in will be available in late 2013.

Studies Underway

7. <u>San Joaquin Fall-run Salmon Outmigration</u> *(Salmon)*

Outmigrating fall-run salmon are monitored as they migrate down the San Joaquin River, past the divergence with Old River and other distributaries, to eventually reach the junction with the Sacramento River at Chipps Island. These studies were initiated in 2000 as part of the Vernalis Adaptive Management Plan (VAMP), a large-scale, long term (12-year), experimental-management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta.

Salmon survival studies were conducted using Coded Wire Tags from 2000-2006 and Acoustic Tags from 2007-2011. The HORB was not installed in 2005, 2006, 2008 and 2011 and a non-physical barrier (Bio-Acoustic Fish Fence) was tested and used in 2009 and 2010. The VAMP ended in 2011 but annual outmigration monitoring occurred in 2012 and will be conducted in 2013.

Recent analysis of the data concludes that survival of outmigrating fall-run salmon through the Delta is better if they are salvaged at the facilities at the CVP Jones Pumping Plant and trucked and released at the release sites near the western edge of the Delta.

8. **<u>Six Year Acoustic Tagging Study</u>** *(Steelhead)*
This study will assess behavior of outmigrating salmonids in lower San Joaquin River and the Delta. The Temporary Barriers Study (TBS) and the Six Year Acoustic Tagging Study (SYAT) were combined in 2011 and DWR staff served as the project lead for the TBS. In 2012, TBS and SYAT were managed as two distinct projects with staff providing technical assistance to the federal project lead (Bureau of Reclamation). The following goals for the SYAT however, were consistent for both 2011 and 2012:
    - Determine survival of emigrating smolts from tributaries into mainstem of San Joaquin River, the mainstem San Joaquin River downstream into the Delta, and the Delta to Chipps Island.
    - Reach specific mortality and/or export loss of tagged fish.
    - Determine influence of flow and exports on survival and route entrainment in these migratory reaches.
    - Test effectiveness of experimental technologies on route entrainment and selection by tagged fish.
    - Year 6 of this study is in Spring 2016

9. **<u>Real Time Coded Wire Tag (CWT) Monitoring</u>** *(Salmonids)*
This monitoring is designed to provide real-time processing of salmon salvaged at the Skinner Fish Facility to improve in-season management of salmonids and SWP operations. Staff successfully implemented real-time processing of CWT salmon salvaged at the Skinner Fish Facility. The data from the extracted tags is used to inform in-season management and State Water Project water operations.

10. **<u>Skinner Evaluations/Improvements</u>** *(Salmonids, sturgeon & longfin smelt)*
The goal of this project is to evaluate the salvage efficiency and performance of the Skinner Fish Facility for listed salmonids and sturgeon, and to maximize salvage and survival of longfin smelt. The results of studies and evaluations will be used to develop and implement improvements to the facility infrastructure and operational procedures. Goals include 1) Developing estimates for salvage efficiency of steelhead and various size classes of Chinook salmon during FY 12-13 through FY15-16; 2) Evaluating predator management practices within the facility during FY 13-14 though FY 15-16; 3) Evaluating methods for improving smelt survival through salvage during FY 11-12 to 15-16; and 4) implementing recommended improvements in a timely manner based on the results of the aforementioned evaluations. This project is intended to comply with the requirements outlined in NMFS RPA Action IV.4.2, IV.4.3, NMFS T&C2a, and DFG ITP6.2.1 and 8.5.

2011-2012 Accomplishments

- In collaboration with DFW, developed a revised draft report examining the stress response of delta smelt in the Collection, Handling, Transport, and Release (CHTR) process at the Skinner Fish Facility.
- Conducted 6 additional releases of tagged fish at the Skinner Fish Facility to improve preliminary estimates of salvage efficiency for late-fall run (winter run surrogate) Chinook salmon and to refine study methods for a full scale evaluation.
- Initiated planning to implement improvements to the Skinner Fish Facility based on the recommendations of the CHTR reports including procurement of new buckets, improvements to the debris conveyor, and improvements to the holding tanks.
- Coordinated with Reclamation, NMFS, Cramer Fish Sciences, and other DWR staff to conduct a sensitivity analysis on the loss equation developed by a NMFS consultant in 2011. The results of the sensitivity analysis will be used to prioritize research activities at the facilities

11. <u>DIDSON Studies of Adult Green Sturgeon</u> *(Sturgeon)*

The DIDSON studies examine passage success, distribution, habitat usage, residence time and the influences of environmental variables (i.e., flow, temperature, substrate and depth). In the upper Sacramento River and the lower Feather River, the DIDSON is used to estimate the annual abundance of adult green sturgeon. The studies also help determine if there are adult migration barriers and determine potential spawning grounds which can be target areas for egg and larval surveys. DIDSON studies are also being conducting in the Yolo Bypass to evaluate sturgeon stranding within the major ponds of the floodplain and to determine which flow stages influence migration into and out of the system. These studies can provide data to make management decisions concerning future monitoring programs, operational changes to the water projects, and habitat enhancement needs and modifications (i.e., Fremont Weir).

12. <u>Sturgeon Acoustic Tagging Studies</u> *(Sturgeon)*

These projects provide presence, movement, and general habitat-use information for sturgeon in the various Central Valley river systems and the Yolo and Sutter Bypasses. Acoustic tagging data which addresses both temporal and spatial information such as holding, migration, and spawning behavior for sturgeon will help identify key habitat features and better document factors inhibiting accessibility to upstream habitats (e.g. flow regime, passage barriers). Current and future tagging projects in the Sacramento and the San Joaquin river basins and the bypasses will focus on a more detailed investigation of habitat use which can be used to guide habitat restoration and management efforts.

13. <u>Juvenile Green Sturgeon Movements and Identification of Critical Rearing Habitat</u> *(Sturgeon)*

Reclamation directs a study by UCD to determine the rearing habitat of juvenile green sturgeon within the river, delta and bay. Acoustic telemetry will be used to record their movements and periods of residence within different regions, some of which are natural and others that are altered by the construction of levees and disposal of dredging materials. This information can be used for restoration and for water operations management decisions.

14. **Laboratory Studies** *(Sturgeon)*

UC Davis has multiple lab studies being conducted and analyzed through 2013 that would provide additional information that has bearing on project effects on green sturgeon. They include: 1) juvenile green sturgeon temperature and salinity preference; 2) larval and juvenile sturgeon fish screen and louver experiments; 3) incision suture type/method effects on sturgeons; 4) sturgeon swimming energetics; 5) unscreened diversion effects on larval and juvenile sturgeons; and 6) downstream displacement velocity versus substrate experiments. Investigations of life history and contaminant effects on white sturgeon in the Sacramento-San Joaquin Bay-Delta, conducted by the University of Georgia, will provide baseline date for feasibility of age and growth study with non-lethal sampling. The contaminants survey may lead to hypothesis testing for the effects of certain contaminants on sturgeon growth, development, behavior, and reproduction.

15. **Linking habitat to native fish predation in the North Delta** (*Salmon, steelhead, delta smelt, longfin smelt)*

This project examines predator consumption rates of native fish species, including Chinook salmon, steelhead, delta smelt, and longfin smelt, across seasons, habitats and regions of the North Delta. Predatory fishes (largemouth bass, Sacramento pikeminnow, smallmouth bass, spotted bass, and striped bass) are caught via trammel netting and their stomach contents are subjected to highly sensitive genetic assays to determine presence of target prey species' DNA. The data will be used in conjunction with the Delta Passage Model (Cramer Fish Sciences) to estimate and compare consumption rates of winter, spring, and fall run Chinook salmon across migration routes of the North Delta. Fieldwork for this project began in December 2012 and will continue in the months of December, April, and June through June of 2014. Data analyses and reports will be completed in January 2015. This information will be informative to habitat characteristics and features that may attract predators and should be avoided in future restoration projects. It will also highlight potential corridors that may be problematic for salmon migration through the North Delta.

16. **Evaluation of juvenile Chinook salmon use of the Yolo Bypass** (*Chinook salmon)*

This study builds on research and monitoring work in the Yolo Bypass that has been in place since 1998. This research has already shown improved survival and growth rates of juvenile salmon that rear in the Yolo Bypass during inundation and current work will update and build upon past analyses. In addition, this study makes use of recent progress in telemetry, genetic, and isotopic tools to generate more information about how salmon use the Yolo Bypass. Four avenues of study will generate information that can be used specifically for Yolo Bypass restoration plans:

- Analysis of historical data of Yolo Bypass food web and Chinook salmon use of the Bypass. These analyses will include evaluation of factors affecting growth, residence time, and survival of Chinook salmon in the Yolo Bypass. A synthesis of empirical and modeled data will examine potential thresholds for flow and/or inundation period that support enhanced productivity and food web response on the floodplain.
- Run composition of juvenile Chinook sampled in the Yolo Bypass and Sacramento River will be compared using genetic analyses.
- Juvenile salmon (hatchery origin) residence time and survival will be assessed using acoustic telemetry.
- The potential for a unique isotopic signature of residence in the Yolo Bypass will be investigated. If a unique signature is present, many retrospective analyses will be possible to compare survival (e.g., adult return rates, smolt emigration rates) and growth of fish in the Yolo Bypass and main river channels.

This study began in February of 2012. Reports will be completed by January 2015.

Studies Planned

17. <u>Clifton Court Forebay Predation Studies</u> *(Salmonids)*

The Clifton Court Forebay (CCF) Predator Study was designed in 2011 to gather as much information as possible, pre- and post installation of the proposed CCF Fishing Facility. Project implementation will begin with a pilot study in spring 2013 (approximately two years prior to the construction of the CCF Fishing Facility), and continue through the end of 2017. This will allow the behavior and population demographics of predatory fish and birds, and salmonid survival to be more thoroughly documented, and can be used to evaluate the impacts of the CCF Fishing Facility on fish populations, pre-screen loss and predator-prey dynamics. Results of these studies can also guide future management decisions to assist in further reducing pre-screen loss at CCF.

18. <u>Green Sturgeon Laboratory Studies</u> *(Sturgeon)*

This study will examine juvenile green sturgeon swimming behavior near louvers and screens in order to improve their survival at the Skinner Fish Facility. (NMFS IV.4) Staff continues to collaborate with DFW, USBR, and NMFS in determining an appropriate surrogate for the green sturgeon and how to best implement the study(ies). The goals of the current study are to:

- Determine the time spent in different sections of the flume to assess the fish's response to screens and louvers.
- Determine the frequency of contact or impingement on the screens and louvers.
- Determine the passage rate of sturgeon through or past the louver array.

19. <u>Gut Evacuation Study</u> *(Salmon and steelhead)*

This study will collect data on the rate at which striped bass digestively pass acoustic tags that were inside predated salmon. This information will assist researchers with evaluation and interpretation of data on survival and movement of salmon and steelhead throughout the Central Valley of California, with probable application to other systems. Staff is in the process of developing a study plan and implementation is scheduled for 2013. The goals of the study are to:

- Assist researchers in evaluating and interpreting data on survival and movement of salmon and steelhead throughout the Central Valley of California by monitoring acoustically tagged salmon.
- Quantify the rate at which striped bass digestively pass acoustic tags that were inside predated Chinook salmon and steelhead.
- Evaluate the role of fish size with respect to the rate at which striped bass digestively pass acoustic tags that were inside predated Chinook salmon and steelhead.
- Evaluate the role of water temperature with respect to the rate at which striped bass digestively pass acoustic tags that were inside Chinook salmon and steelhead.

20. Fish Release Site Predation Monitoring *(All salvaged fish, action is directed by NMFS BO.)*

This project is to evaluate and document the predation reduction and/or improvements to salvaged fish survival attained with construction of new release sites and modified fish release operations. The goals of this project include: 1) Collecting baseline information on the abundance of predatory fishes at or near the location of proposed new salvaged fish release sites; 2) Evaluating the efficacy of improvements to the Curtis Landing Release Site infrastructure to ensure complete pipe flushing and other operational parameters; 3) Evaluating the predation reduction and/or changes in salvaged fish survival due to construction of two new release sites. This project is intended to comply with the requirements outlined in NMFS RPA Action IV.4.3. This project is the monitoring component of the Curtis Landing Fish Release Site Modification and New Release Site Projects. It is contingent upon modifications to the Curtis Landing Fish Release Site and construction of two new release sites.

The implementation schedule (based on the current estimate for construction activities) is:

- Monitoring Plan Development — FY 2014/2015
- Curtis Landing Evaluations — FY 2014/2015
- Baseline Monitoring — FY 2015/2016
- Post-construction Monitoring — FY 2016/2017 through FY 2017/2018

21. 2013-2015 Predator Manipulation Study *(Salmonids)*

NMFS has proposed to quantify and manipulate predator densities at the HOR to evaluate the effects on juvenile salmonid survival. DWR has agreed to fund the work and facilitate a multi-agency team to plan and develop the study beginning with preliminary planning and field surveys in 2013 followed by full studies in 2014 and 2015. The study will test the hypothesis that predation is a major factor contributing to the observed low survival of juvenile salmonids in the south Delta. Final results of the study will not be available until 2016.

22. **<u>Contaminants, Age, and Growth Study for Sturgeon</u>** *(Sturgeon)*

The purpose of these studies is to identify the effects of contaminants on sturgeon populations, assess current age-and-growth characteristics, identify spawning and rearing locations, and spawning periodicity of white sturgeon. Effects of contaminants on sturgeon and habitat use information will assist with focusing future restoration actions for sturgeon in the San Joaquin River and the Sacramento-San Joaquin Delta. Habitat restoration actions designed for white sturgeon are likely to provide benefit for green sturgeon as well. These studies are expected to be conducted through 2015.

23. **<u>Factors affecting Mississippi silverside predation of larval smelt</u>** (*delta smelt)*

Mississippi silverside are known predators of larval delta smelt and are increasingly abundant in the Delta; however, the extent of their impact on the smelt population is unknown. This study will examine the threat of silversides as predators from several angles:

- Retrospective analyses of factors influencing the distribution and abundance of silversides in the Delta since their original invasion in the mid-1970s.
- Complete analysis of silverside diet composition in Liberty Island, a known haven for delta smelt that also has high and consistent silverside abundance.
- Bioenergetic model of silverside consumption of larval delta smelt in Liberty Island
- Laboratory experiments to determine the influence of increasing turbidity on silverside predation rates on larval smelt. Prior fieldwork has indicated lower incidence of predation as turbidity increases, but laboratory trials are necessary to determine turbidity levels at which predator efficiency is affected.

This study will begin in May 2013 and will be completed by June of 2014. The information can be used to evaluate Liberty Island as a potential model for restored freshwater habitat targeted for delta smelt nursery habitat, as well as inform restoration planners as to environmental factors that may encourage high silverside abundance and larval smelt predation.

24. **<u>Yolo Bypass Knaggs Ranch Experimental Agricultural Floodplain</u>** (*Chinook salmon*)

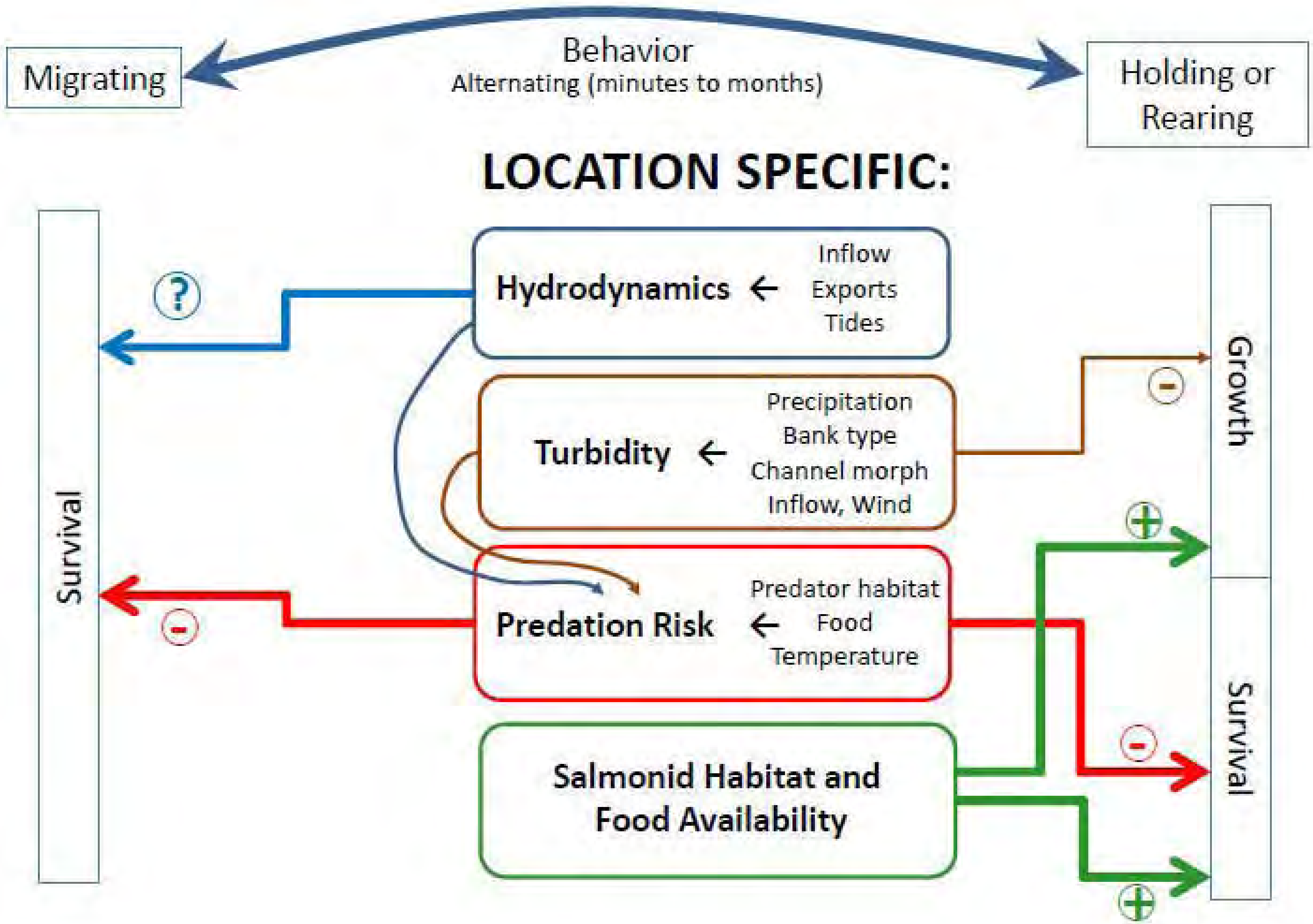
This project will evaluate the use of a managed, agricultural floodplain as seasonal habitat for Chinook salmon. Dual use of land for agriculture and wildlife habitat is a possible scenario for meeting salmon habitat restoration requirements of the NMFS BO, but the habitat value of agricultural land needs to be evaluated. This project will take place on the Knaggs Ranch property in the Yolo Bypass and will compare juvenile salmon survival and growth rates between fallow, rice stubble, and disked land. Approximately 50,000 coded-wire-tagged, hatchery origin fish (Feather

River Hatchery) will be planted in a series of 2-acre fields containing one of the three possible substrates. For comparison purposes, paired releases, also of 50,000 fish, will be carried out in the Sacramento River and Yolo Bypass Tule Canal. This will allow a comparison of survival to adult return between the three release locations. In addition, salmon habitat preference will be evaluated by tracking PIT-tagged juvenile salmon on a smaller field where all three habitat types are available. Finally, a small group of natural-origin juvenile Chinook will also be planted on the experimental floodplain in order to compare the growth response between hatchery and wild fish.

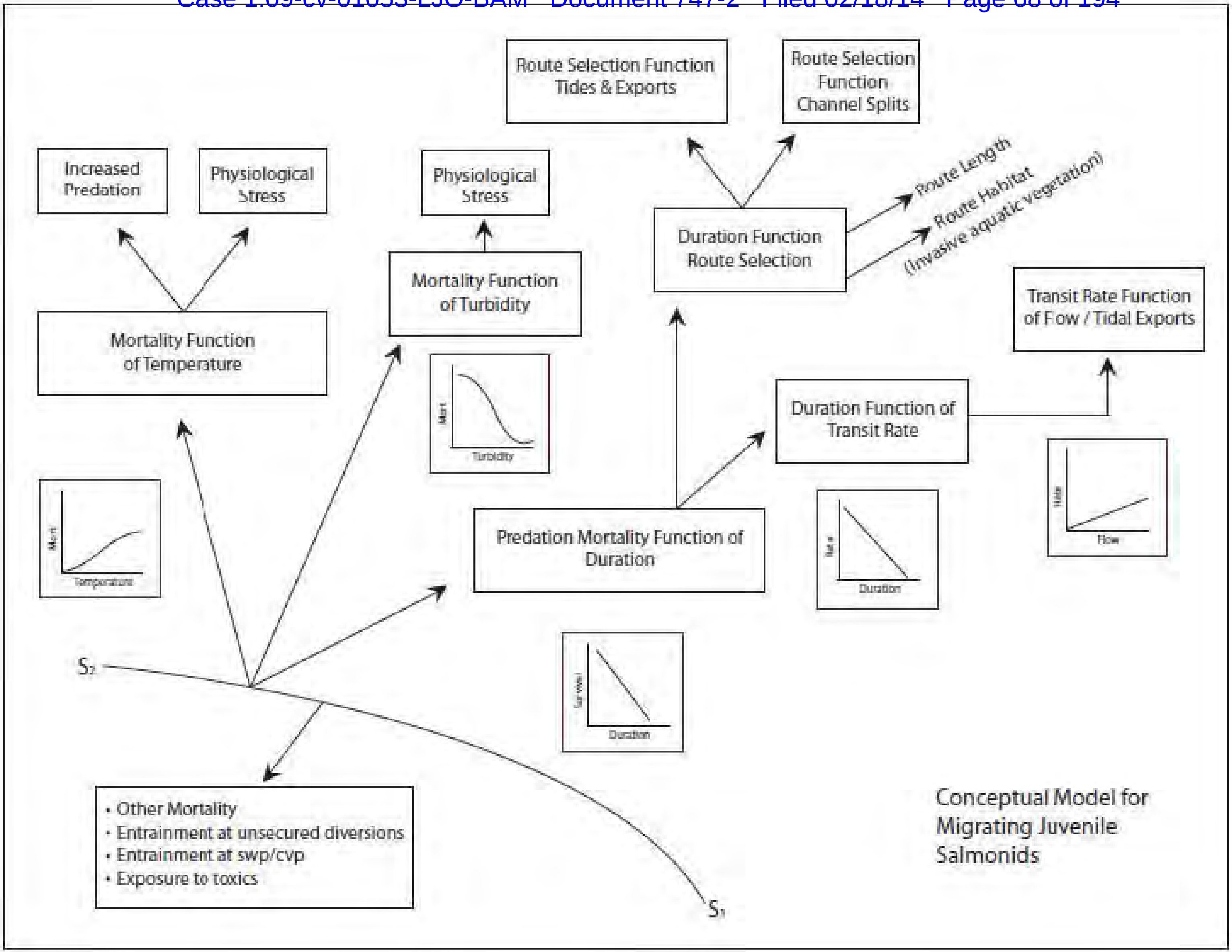
This study is planned for February – April of 2013, with a likelihood of continued study in subsequent years.

APPENDIX E
FIVE PRELIMINARY CONCEPTUAL MODELS

Delta Juvenile Salmonid Conceptual Model (fry, parr or smolt)



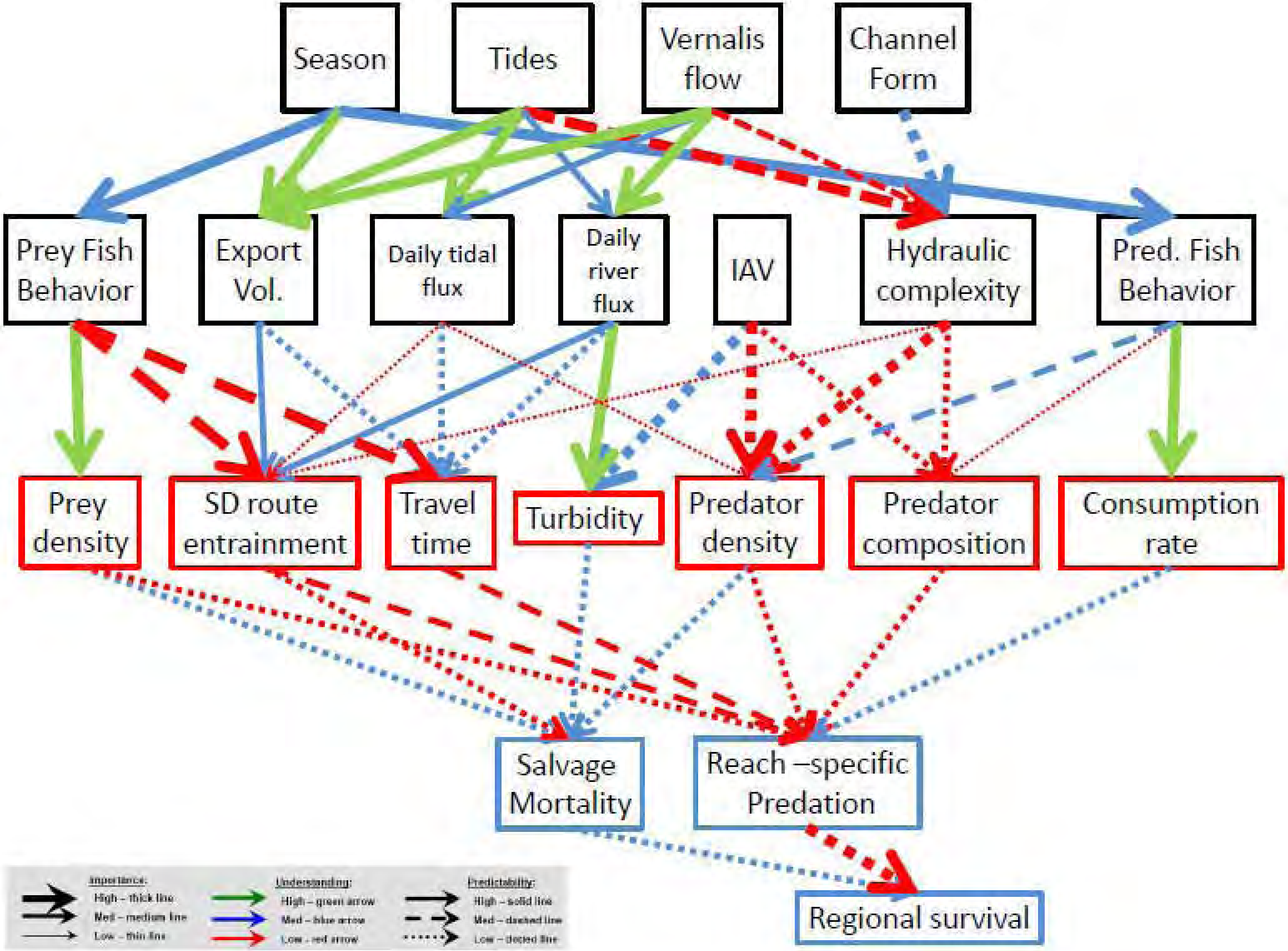
From Brad Cavallo, Cramer Fish Sciences



From Chuck Hanson, Hanson Environmental

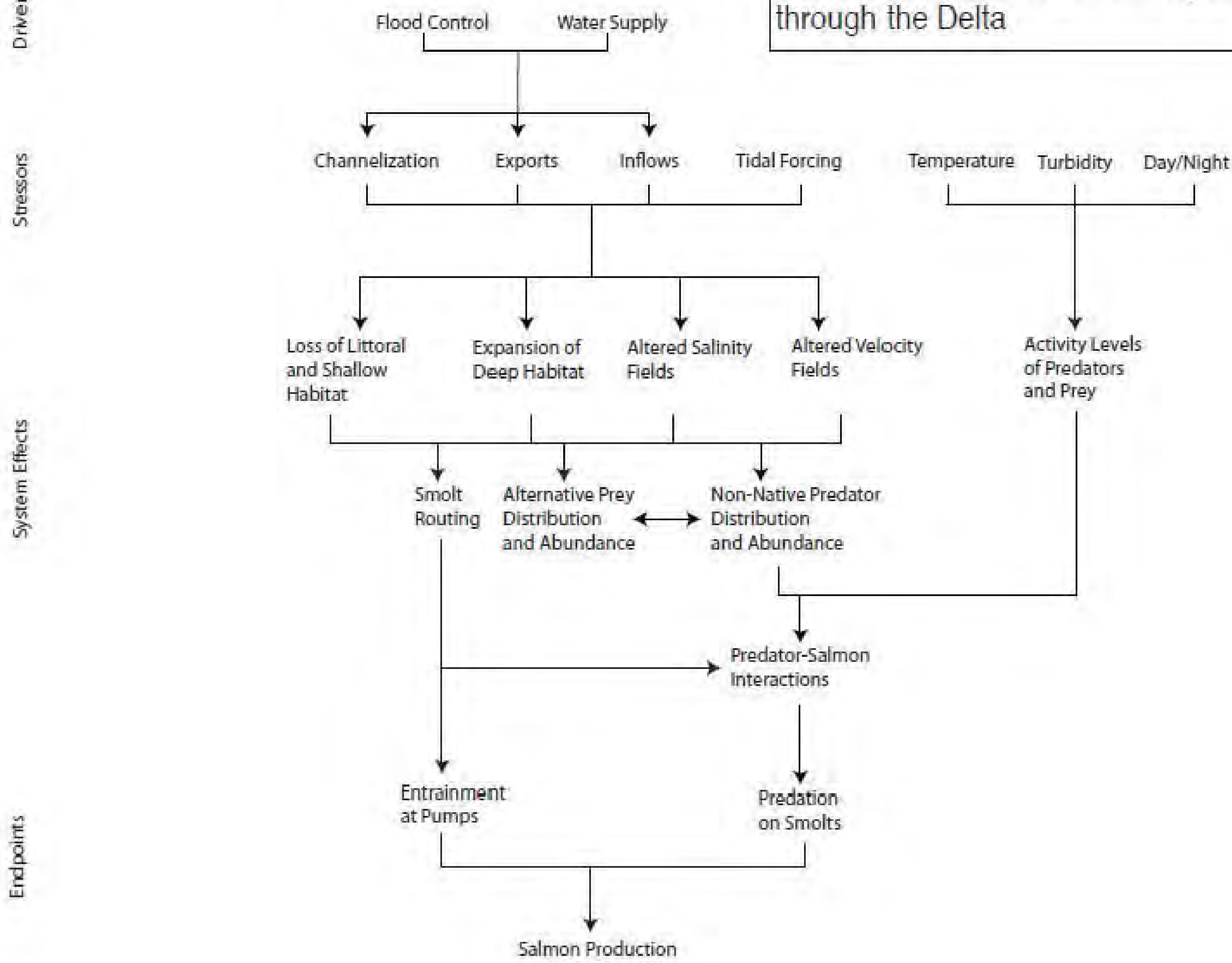
				APPLICABLE TO SPECIES? (Y or N)		APPLICABLE TO LIFE STAGE? (Y or N)			APPLICABLE TO BEHAVIOR? (Y or N)	
DRIVER	ANY "SUB-DRIVERS"?	INKAGE (+,-, or ?	OUTCOME	*O. mykiss*	Chinook	FRY	PARR	SMOLT	Holding/Rearing	Migrating
Hydrodynamics	Inflow, Exports, Tides, Operation of Barriers	?	Survival	Y	Y	Y	Y	Y	N	Y
Water Quality	Temperature, toxics, turbidity (influenced by air temperature, input of toxics (point and non-source point), flow, bank type, channel morphology, wind)		Survival & growth	Y	Y	Y	Y	Y		
Predation	Predator habitat (including artificial instream structures), food supply, temperature, introduced predator species	-	Survival	Y	Y	Y	Y	Y	N	Y
Food Availability	Primary and secondary productivity (affected by introduced species, alteration of habitat)	+	Survival & growth	Y	Y	Y	Y	Y	Y	N
Entrainment	In-Delta diversions, SWP/CVP diversions (including CCF)		Survival	Y	Y	Y	Y	Y		
Physical Habitat Availability	Levee construction, bank protection, loss of wetlands (including tidal marsh, riparian, and shallow water habitat)		Survival & growth							

From Alice Low, California Department of Fish & Wildlife



From Josh Israel, Reclamation

Conceptual model for smolt migration through the Delta



From Steve Lindley, NOAA Fisheries -- Southwest Fisheries Science Center

APPENDIX F
TEMPLATE FOR CONCEPTUAL RESEARCH PROPOSALS

***Draft*--1 Mar 2013**

Template for hypotheses and concept proposals (one-pagers; no more than two)

Hypothesis: State the hypothesis to be tested.

Background and Purpose: A few sentences (short paragraph at the most) describing the context; what do we know about the importance of the issue being addressed? What don't we know and why is it important? How does it link to our conceptual models?

Experimental Approach: A few sentences about the experimental design and tools (e.g., radio tracking of smolts in selected reaches varying in distant from the export facilities coupled with fine-scale hydrodynamic monitoring over multiple tidal cycles).

Methods (including statistical analysis plan): Radio tracking of hatchery smolts, deployment of hydraulic instrumentation; etc.

Experimental challenges: For example, will special conditions be required that may be difficult to achieve (e.g., water year, health and safety issues, permits, etc.)

Application of Findings to Management: Do the findings have direct or indirect application or implications for managing south Delta inflow/export and improving salmonid survival through the Delta?

Technology Transfer: Method of reporting findings and schedule

Other useful information to weave into the narrative:

> If site specific, to what degree can the findings be applied generically to a broader area? To other reaches?
>
> Can the hypothesis be tested by modifying or enhancing an existing study?
>
> Others?

APPENDIX G
COMPILATION OF ALL CONCEPTUAL RESEARCH PROPOSALS

Predator-prey dynamics in a tidal environment

Jim Anderson (U Washington) and Steve Lindley (NMFS)

Hypothesis: The activity patterns of predators and prey can be understood as the outcome of coupled games played in the physical setting of the estuary, which is characterized by oscillatory water movement.

Background and Purpose: Salmon exhibit a diversity of migratory behaviors as they move through estuaries (defined as the region under tidal influence between the coastal ocean and the river). The diversity includes moving during the day or night, active swimming or drifting with the tide, and selective tidal stream transport. Salmon also tend to suffer high mortality in estuaries. Some insights into the causes of this diversity and mortality might be gained by considering the evolutionary problem facing salmon—how to move through an unfamiliar and potentially hostile environment that links a rearing environment advantageous to eggs and small fish (the river) and a feeding environment suitable for larger fish (the coastal ocean). Salmon smolts will have the best chance of survival upon ocean entry if they have high energy reserves, but must of course survive the migration. This suggests there are trade-offs between conserving energy and minimizing predation risk. Estuarine predators have a different problem—how to acquire food in a dynamic environment. Predators might sit and wait for prey (conserving energy), or actively search for them (at some higher energetic cost). Which predator strategy pays best may depend on the behavior of prey, and vice versa. A deeper understanding of these dynamics should help us predict responses to variations in predator and prey abundance and identify environmental criteria (residual vs. tidal flow, turbidity, vegetation and other visibility factors, etc.) that favor predator foraging or prey passage.

Experimental Approach and Methods: We propose using game theory and predator-prey encounter theory to understand the dynamics of coupled games played by predators and prey. Game theory, in the context of evolution, seeks to understand behavior as the result of repeated contests between individuals employing different strategies. An unbeatable strategy (termed an evolutionarily stable strategy or ESS) is one that renders a population using that strategy immune to invasion by rare mutants employing a different strategy. Typically, game theory is employed to study the behavior of organisms within a population. Encounter theory characterizes the probability of predator-prey encounters based on their movements and environmental conditions.

Our application of game and encounter theories is unusual (unique? need to dig deeper) in that we are considering two simultaneous and dynamic games where the outcome of one game depends on the state of the other, and vice versa. In spite of this complexity, in the simplest case, where predators and prey may drift or hold position according to the tide and illumination level, preliminary analysis suggests that ESSs may be found analytically. At some point, as complexity is added (more realistic behaviors, alternative prey, foraging by prey), it may be necessary to move to numerical solutions.

The resulting models will predict behaviors of predators and prey, and prey survival, as a function of the abundance of predators and prey, turbidity, prevalence of submerged vegetation, the strength of tidal and residual velocities, the availability of alternative prey, and the length of the estuary. These predictions will be compared qualitatively and quantitatively to observed behaviors and survival of salmon smolts in the San Francisco Bay Delta, the Columbia River and other salmon systems for both Pacific and Atlantic salmon populations.

Experimental challenges: The proposed study does not rely on any new field work.

Application of Findings to Management: The model will predict the effects on smolt survival of altering flow regimes, visibility factors, and the abundance of predators and prey, all actions under consideration by water and fishery managers. We expect to identify environmental criteria favoring predators (high smolt mortality) and prey (rapid smolt migration and low mortality). We anticipate the study also will provide insight into predator-prey interactions of other species resident in tidal estuaries such as delta smelt and longfin smelt.

Establishing effects of environmental conditions on the predator-prey balance will be useful for identifying locations of predator prey studies and developing efficient and informative tidally-coordinated monitoring protocols. We anticipate that modifications of ongoing and planned predator-prey studies will provide evidence to test and refine the model.

Technology Transfer: A paper describing the development of the theory and its testing with data will be published in a journal such as The American Naturalist. A two-year project period is envisioned.

Other useful information to weave into the narrative:

> If site specific, to what degree can the findings be applied generically to a broader area? To other reaches?
>
> Can the hypothesis be tested by modifying or enhancing an existing study?
>
> Others?

South Delta Salmon Research Group

Estimating survival through the San Joaquin Delta - Brandes 3/22/13

Hypotheses: Survival through the San Joaquin Delta is the combination of survival in each reach and the proportion of the population entering each reach (see specific hypotheses by reach below, Appendix 1). Survival in each reach is a function of travel time and travel time is a function of velocity. Velocity is a function of flow, exports, tides and channel bathymetry – with the role of each of these variables and their influence on velocity, different in different channels. Survival is also a function of water temperature, although it needs to be accounted for, it is not being tested.

The survival in each reach and the proportion of the population in each reach is a function of velocities, which is the overall effect from flows, exports, tides and channel bathymetry. Velocities define the habitat and affect residence times that determine survival in each specific reach. We know that velocities determine the proportion of fish splitting into the various routes of the Delta (SJRGA in press, Perry, 2010). There is also some evidence that flow increases survival in some reaches (SJRGA in press, Perry, 2010), and the proportion of the tagged fish that were detected in predators were less in 2011 compared to 2010 (SJRGA in press). We also know that mortality is high in CCFB, outside the CVP, in the Stockton deepwater ship channel, and between Medford Island and Jersey Point (SJRGA in press). More data is needed to determine route and reach specific survival throughout the Delta at extremes of flows and exports to evaluate their effect on travel times and survival and to detect the signal from within the noise and variability of the environment.

Experimental approach: The experimental approach is a series of nested experiments. The first step is to measure survival through the Delta (Durham Ferry to Chipps Island) multiple times at different flows and exports, within a year and for three years (using both acoustic tags and CWT's). The second step is to pick specific focus reaches (8) and determine if travel time of acoustically tagged fish within a specific reach is related to the velocity in the reach. If there is a relationship between travel time and velocity, the third step would be to determine if there is a relationship between travel time and survival.

Methods: Release four groups of 500, acoustically tagged salmon and steelhead and estimate survival though the Delta and by reach using the 6 year study acoustic array of receivers throughout the Delta. Use a VAMP/6 year model framework to estimate reach and route specific survival under a various sets of hydrodynamic conditions for three years. Release CWT fish at Mossdale and Jersey Point to get independent estimates of survival through the Delta between Mossdale and Jersey Point. If necessary, augment sample sizes of acoustic or radio tagged fish released within a reach and potentially add receivers to estimate travel time within a confined reach. Collect information on water temperature, velocity, SAV, habitat type and the proportion of detected tags leaving the site in predators as an estimate of predation within the focused reaches. The criteria for selecting the specific reaches are: 1) areas of high mortality 2) likely affected by flows and exports 3) likely affected by exports more than flow 3) likely affected by flows independent of exports. The eight focused reaches include: 1) the Stockton Deepwater ship channel, 2) Turner Cut, the 3) San Joaquin River between Medford Island and Jersey Point, 4) in Old River outside the CVP, 5) in Old River outside of CCFB, 6) between Banta Carbona and Mossdale and 7) Lathrop to Stockton and 8) Old River to the CVP, SWP and Old River at Hwy 4. Although it is expected if survival is related to travel time, the relationship will be unique to each specific reach.

Experimental challenges: The experimental challenge is to be able to detect the export and flow signals from within the environmental noise. One approach to being able to detect the signal from the noise is to experiment at flow and export conditions that are on either ends of the extreme or sufficiently different, while other conditions known to affect survival, but not being evaluated such as water temperatures, are similar.

Application of findings to management: Information of survival through the Delta is needed to put whatever information is generated in the nested reach specific survival study into perspective. Not knowing how a specific reach survival compares to overall survival through the Delta will limit our understanding and perspective on the more specific reach and route specific survival estimates. Once it is understood what is responsible for the low survival in the Delta appropriate measures can be adopted to improve survival.

Technology transfer: information will be written up in reports, and manuscripts. Data will be publically available. The study will be conducted in multiple years (at least three) and results will be reported within 12-18 months of the study. An additional report and manuscript will summarize the three years of data. Also, data from 2011-2013 will be used and added to that obtained in 2014, 2015 and 2016 as appropriate. A power analyses will be conducted to assure sample sizes are adequate, while assessing the need to augment sample sizes at release sites downstream to improve the precision. Additional information from the 2012 stipulation study may also be used to test the hypotheses if possible.

Appendix 1: Specific hypotheses and potential mechanisms by reach.

Ho: Survival between Durham Ferry and head of Old River is a function of river inflow – The higher the flow the higher the survival

Potential mechanisms- Higher flows decrease water temperature, increase turbidity, increase migration rate, dilute pollutants which in turn decreases mortality from time exposure to predation, disease, and toxics. Higher flows also increase the food supply from floodplains.

Ho: The proportion of fish diverted at HOR (without a barrier) is related to velocity (flows, exports). The higher the San Joaquin River flow at Vernalis, and the lower the exports, the greater the proportion of fish that enter the San Joaquin River. At low flows, and at high exports, most of the flow and fish enter Old River.

Potential mechanism: Fish go with the flow. The higher the flow the further downstream the tidal prism. At low flows (and consequently further upstream tidal prism) and at higher pumping more water will enter Old River – thus more fish enter Old River.

Ho: Survival in Old River between the head of Old River and the fish facilities is a function of flow and exports - as flows and exports increase survival increases in that reach.

Potential mechanisms: Reduced residence time in Old River, higher flow reduces water temperature and decreases the metabolism of predators, and exports decrease the residence time in Old River.

Ho: Survival from predation is high at the CVP trashracks, just outside the facility.

Potential mechanisms: Predation is high at the CVP trashracks due to regularity of food for predators and disorientation by juvenile salmonids and other prey items when they encounter the change in velocities and structures associated with the facility.

Ho: Survival between the CVP and Chipps Island is a function of exports, the higher the velocities the higher the survival of salvage to some maximum. Also how often fish are trucked back to the Delta and the condition of the pipes at the release sites affect survival from the CVP to Chipps.

Potential mechanisms are due to shorter residence times through the facility, decreasing predation, although still high, and increased efficiency of the screens. Also included is loss through the screens when removed for cleaning, fish getting into the Delta Mendota Canal.

Ho: Survival between the CCFB to SWP and Chipps is close to zero in all cases due to predation outside of CCFB, and inside CCFB.

Potential mechanisms: Fish don't make it to the SWP to be salvaged. Increased pumping would decrease residence time in CCFB and increase survival by some low amount through CCFB. Opening the gates allow predators to move in and out and result in a concentration of predators residing in CCFB due to the constant influx of food supply and disorientation of prey moving into CCFB from the main San Joaquin River.

Ho: Survival in the San Joaquin River to the Stockton deepwater ship channel is a function of flow, as flow increases survival increases.

Potential mechanisms: Increased flow increases survival, and exports decrease survival in this reach. Increased flows move the tidal prism downstream, increases the migration rate, dilutes ammonia from the Stockton wastewater treatment plant, reduces temperatures, decreases predation due to increased turbidity and reduced water temperatures.

Ho: Survival from the deepwater ship channel to Turner Cut is a function of flow.

Potential mechanism: Once in the deepwater ship channel survival is a function of travel time. Increased flows decrease travel time although not as much as upstream.

Ho: Proportion of fish entering Turner Cut, Columbia Cut, Old and Middle Rivers is a function of the flow entering the channel.

Potential mechanism is from the interaction between flows and tidal cycle and possibly exports and when the fish reach the channel.

Ho: Survival of fish entering the interior Delta from Turner Cut, Columbia Cut, Old and Middle Rivers is a low and a function of flows, tides, exports.

Potential mechanism is exports which results in the net flow towards the pumps. The fish follow the net flow and are delayed or misdirected and do not find their way to the western Delta. They follow the net flow which takes them to the pumping plants and mortality is high across the Delta to the fish facilities and many never make it to either the pumping plants or out to Chipps. The increased travel time across the Delta to the fish facilities or to Chipps increases the residence time of fish trying to migrate downstream thus increasing the time they are vulnerable to predation and other mortality factors (agricultural diversions).

Ho: Survival in the San Joaquin River downstream of the deepwater ship channel is a function of how many fish are diverted into the interior Delta as they migrate downstream and the survival of fish staying on the mainstem San Joaquin River. Survival in the mainstem is a function of the strength of the ebb tide relative to the flood tide which is a function of outflow and exports

Potential mechanism: Survival for fish entering the interior Delta is low, because they do not find their way to Chipps or the fish facilities and are lost to predation due to increased residence time. The survival on the mainstem San Joaquin River is a function of the strength of the ebb tides (with increased flow increasing the strength of the ebb tide relative to that of the flood tide).

Survival for fish moving from the mainstem San Joaquin River to the interior Delta at all channels that connect to the interior Delta is affected by the tides which is a function of how much flow is moving into the interior Delta. Fish that move into the interior Delta on tidal flows, that encounter net flows towards the pumps do not move back into the San Joaquin River and the increased residence time in the interior Delta increases mortality from predation. Without pumping the fish would move back into the mainstem San Joaquin River at some point and make it Chipps Island. With pumping they aren't moving back into the San Joaquin River or towards Chipps Island once they are diverted into the interior Delta by the combination of the tide and net flows towards the pumps. Mechanism is increased residence time with pumping, and more prone to non-native predation as residence time increases. Submerged aquatic vegetation has increased the habitat for non-native predators, increasing their numbers. Increased water temperatures have increased the metabolism of predators increasing predation rates, thus we have a combination of more predators (due to more habitat) and higher predation of those predators (due to higher water temperatures increasing metabolic rates). Survival is a function of conditions at the time the fish reach specific junctions as to whether they are diverted into the interior Delta or stay on the mainstem San Joaquin River. The underlying mechanisms should be similar to those experienced in the Sacramento River, but will be different in magnitude.

Diel Migration Patterns and Entrainment into Clifton Court Forebay

Hypothesis:

H_0: Salmonid smolt entrainment into CCFB is not affected by diel cycles.

Background and Purpose:

Research suggests that smolt survival through Clifton Court Fore Bay (CCFB) is extremely low (37%-39% in USGS, 2009; 26%, Clark et al., 2009; 37%-1%, Gingras, 1997) and that fish entering the interior south Delta overwhelmingly survive through the delta via salvage (100%, USGS, 2009; 100%, SJRGA, 2010; 92.3%, pers comm. R. Buchanan, 2012). The Tracy Fish Facility (TFF) has no fore bay and, therefore, smolts that are salvaged at TFF may have higher through-delta rates of survival than smolts travelling through the SFF. Acoustically tagged Chinook salmon smolts have been shown to be more likely to be detected on hydrophones during daylight hours (USGS, 2009) which may imply that the smolts migrate more during the day and hold/ feed at night.

Experimental Approach:

This study should be conduct in conjunction with the 6-year study steelhead releases and VAMP-like salmon releases, however, additional releases would likely be required. Entrainment of juvenile salmonids into CCFB would be analyzed to understand if CCFB entrainment could be minimized by selectively opening the gates only at certain diel periods (e.g. day, crepuscular, night).

Methods:

This study would be in conjunction with the 6-year study steelhead releases and VAMP-like salmon releases and would compare entrainment rates into CCFB during three diel periods (Day, Crepuscular and Night). Using data from 2011, 2013 and other future years an analysis could determine if diel cycles effect smolt entrainment into CCFB. The data would further be analyzed by taking flow rates into CCFB to determine how radial gate flow rates affect Salmonid entrainment during these same diel periods. If enough samples are not available from the data collected during these years additional manipulation could occur as follows:

Groups of 120 acoustically tagged juvenile steelhead and 120 acoustically tagged Chinook salmon smolts will be released upstream (location TBD) from the CCFB radial gates over a 24 hour period (e.g. 5 Salmon and 5 steelhead released per hour). For each 240 fish group the radial gates would be operated such that flow/gate positions would be consistent during each flood tide for the 5 days following release. Subject groups would be tested with the radial gates fully open (@ 100%), mostly open (@ 50-80%) and mostly closed (@ 20-50%).

	Gate Operation at flood tides for 5 days
Release Group 1 (120 Chinook and 120 Steelhead)	Gates remain fully open
Release Group 2 (120 Chinook and 120 Steelhead)	Gates remain mostly open
Release Group 3 (120 Chinook and 120 Steelhead)	Gates remain mostly closed

Experimental/Regulatory Challenges:

-Lower levels of pumping at SWP during certain release group periods.

-Inflows must be kept consistent for study periods regardless of Water Quality and other restrictions.

-CVP pumping should remain consistent throughout this study regardless of ESA take.

Application of Findings to Management:

-This study could provide input on adaptive management practices for operation of the radial gates.

-In conjunction with the findings of the Export Ratio Study this could be utilized to increase Salmonid smolt survival during spring pumping operations.

-Results could be utilized to dictate use patterns of the SWP pumping during spring salmon outmigration periods.

Obtaining Significant Increases in Survival of Salmonid Smolts through Facilities Operational Changes

Hypothesis:

H_0: SWP and CVP pumping ratios from March to May have no effect on salmonid smolt survival in the South Delta.

Background and Purpose:

Research suggests that smolt survival through Clifton Court Fore Bay (CCFB) is extremely low (37%-39% in USGS, 2009; 26%, Clark et al., 2009; 37%-1%, Gingras, 1997) and that fish entering the interior south Delta overwhelmingly survive through the delta via salvage (100%, USGS, 2009; 100%, SJRGA, 2010; 92.3%, pers comm. R. Buchanan, 2012). The Tracy Fish Facility (TFF) has no fore bay and, therefore, smolts that are salvaged at TFF may have higher through-delta rates of survival than smolts travelling through the SFF. Furthermore, TFF and SFF salvage efficiencies have been shown to be correlated to pumping rates as under certain flow conditions screen efficiency is improved (Haefner and Bowen, 2001) and survival through CCFB may be improved if travel times can be lowered through increased SWP pumping rates.

Experimental Approach:

This study should be conduct in conjunction with the 6-year study steelhead releases and VAMP-like salmon releases over three years. In essence, the pumping operations would be altered after monthly releases in order to test if south Delta survival can be improved by adjusting pumping rations between SWP and CVP facilities. Total south Delta pumping rates will not be affected by this study. Inflows and exports need not be the same for all years and should be determined by the expected Water Year Type (determined before the February release), however, within each year monthly inflows/exports must be kept consistent. Pulsed flows could be utilized in this study, as long as flow regimes were consistent for each of the 3 months of each year.

Methods:

This study would be in conjunction with the 6-year study steelhead releases and VAMP-like salmon releases over three years and would add to these releases in order to ensure that monthly salmon and steelhead releases occur from February to May. Each of these releases would occur at the beginning of each month and water exports would be adjusted following this table:

	Year 1		**Year 2**		**Year 3**	
	CVP Pumping	**SWP Pumping**	**CVP Pumping**	**SWP Pumping**	**CVP Pumping**	**SWP Pumping**
March	0-20%	80-100%	50%	50%	80-100%	0-20%
April	80-100%	0-20%	0-20%	80-100%	50%	50%
May	50%	50%	80-100%	0-20%	0-20%	80-100%

Analyses would be conducted to gain an understanding if south Delta Chinook and Steelhead survival can be improved by altering pumping ratios.

Experimental/Regulatory Challenges:

-Obtaining Chinook salmon large enough to tag in February may not be feasible.

-Determining WYT in February may not be possible.

-HOR Barrier must not be placed in any years as tagged salmonids would not reach the facilities.

-Ag Barrier construction would likely begin in May and could influence hydrodynamics.

-Inflows/Exports must be kept consistent for each year regardless of Water Quality, ESA take, and other restrictions.

Application of Findings to Management:

-This study could provide input on adaptive management practices in the spring export ratios that could positively influence smolt survival through the south Delta.

I:E Ratio and Juvenile Steelhead Survival

K. Clark

Hypothesis:

H_0: Lowering the I:E ratio does not change steelhead survival within the reaches of the San Joaquin River and the interior Delta. (Higher export rates do not decrease steelhead survival)

H_a: Lowering the I:E ratio does change steelhead survival within the reaches of the San Joaquin River and the interior Delta. (Higher export rates do decrease steelhead survival)

Background and Purpose:

Understanding the response of salmonid survival within the channels of the South Delta to the I:E ratio is critical to implementing management decisions to protect ESA listed salmonid species. Several studies have attempted to evaluate the relationship between I:E and salmonid survival within the reaches of the San Joaquin River and the interior Delta. The results of those studies have been inconclusive. However, these previous studies had little or no control over inflow or export rates and the range of I:E tested was severely limited. We propose a new study to evaluate salmonid survival in response to two extreme export rates (high and low).

Experimental Approach:

We propose to manipulate I:E ratio on the San Joaquin river to maintain two I:E ratios by changing export rate and keeping inflow as stable as possible. Each ratio of I:E would be maintained for 14 consecutive day periods (Table 1) and each period would began at the start of either a spring or neap tidal cycle. Weekly releases (8 releases) of 500 acoustic tagged steelhead would be conducted at Durham Ferry on the San Joaquin River and tracked on an acoustic tag receiver array.

Table 1: Experimental Periods

1st 14 day period	2nd 14 day period	3rd 14 day period	4th 14 day period
High Export Rate (TBD)	High Export Rate (TBD)	Low Export Rate (1500 cfs)	Low Export Rate (1500 cfs)

In order to meet the study objectives, NMFS, USFWS, and DFG would need to agree that if take limits for salmonids and delta smelt were exceeded at the CVP and SWP export facilities, then no action would occur to alter export rates during the duration of the study period. In addition, the California State Water Resources Control Board may need to approve a variance from D1641.

Data Analysis:

Statistical analysis of reach-specific survival and overall survival for acoustically tagged steelhead would be consistent with the analytical methods used for survival estimation in the Six-Year Acoustic Tag steelhead study being performed in the South Delta.

One of the major technical challenges in analyzing results of acoustic tagging studies using acoustic tag technology is determining whether a juvenile salmonid has been preyed upon by a larger predatory fish and subsequently detected moving past a receiver. Given the uncertainty of all current methods of differentiating predator from juvenile salmonid behavior, statistical analyses would be performed using all tag detections (assuming all detections are juvenile salmonid detections and no predator bias).

New technology is being currently evaluated by DWR that may discern when acoustic tagged salmonids have been consumed by predatory fish. If this new technology is deemed reliable, the new technology would be utilized and would allow for predator filtering of the dataset.

Linkage to Other Studies:

This study should be linked and coordinated with the Six Year Acoustic Tag Study and to the extent possible. Equipment (tags and receivers) tagging and release operations and data collection should be coordinated with the Six Year Acoustic Tag Study.

This study could also serve as a backbone for other studies to be added. All studies looking to evaluate fish behavior or survival under controlled export rate conditions should be integrated with this larger scale study.

How Study Results Will be Used

The results of the study will be used to add to the understanding surrounding the use of I:E as an appropriate metric and management tool for increasing steelhead survival through the San Joaquin River and interior Delta.

Experimental Challenges

Detecting differences in salmonid survival from within the environmental noise could be difficult. Our approach seeks to reduce this issue by using extreme export conditions or using export conditions that are sufficiently different, while other conditions known to affect survival, but not being evaluated such as water temperatures, are similar.

Adequate control over export conditions, as there are several factors that control export rates, could be problematic. There would need to be a high level of coordination between all of the entities that control export rates in order to achieve the experimental conditions prescribed.

Predation rates within the South Delta may be so high as to completely mask any differences in salmonid survival attributable to the I:E ratio, even under extreme export conditions.

Collaborative Hypothesis Testing Based on Analyses of Existing Acoustic Tag Study Results

Chuck Hanson April 7, 2013

Hypotheses: The conceptual model of juvenile salmonid survival in the south Delta (Figure 1) identifies a number of null hypotheses regarding the drivers-linkages-outcomes that can be tested statistically using data collected as part of past and current acoustic tag experimental investigations. The hypotheses include, but are not limited to:

- Juvenile salmonid survival through specific reaches (reach-specific survival) in the lower San Joaquin River and Delta is independent of the duration that a juvenile salmonid resides in the Delta during emigration. The risk of predation mortality is independent of reach-specific residence time
- The rate of juvenile salmonid emigration through a reach is independent of average river and tidal flow and velocity during the period that a fish is migrating through the reach
- The duration of residence of a juvenile salmonid within a reach is independent of flow and migration rate
- Juvenile salmonid survival is independent of route selection and route length. Route selection is independent of river flow, export rates, OMR reverse flow, and tidal flow within the reach and at channel junctions
- Juvenile salmonid survival within a reach is independent of habitat conditions including SAV
- Juvenile salmonid survival is independent of water clarity and turbidity within a reach
- Juvenile salmonid survival within a reach is independent of average water temperatures
- Juvenile salmonid survival is independent of fish length
- Juvenile Chinook salmon survival within a reach is not significantly different than that for juvenile steelhead
- Juvenile salmonid survival is independent of location of tagged fish release location

Background and Purpose: Acoustic tagging studies have been designed and implemented over the past decade as part of the NMFS north Delta survival studies, academic graduate studies, USGS north Delta studies, Georgiana Slough 2011 and 2012 non-physical barrier investigations, Freeport intake evaluations, Sacramento Regional Wastewater evaluation, VAMP, 2012 Stipulation Study, Head of Old River evaluations, USBR Six-year steelhead survival study, and others. Additional studies are currently being designed and implemented. Results of these studies, however, have not been systematically analyzed to test many of the hypotheses that exist regarding the movement and survival functions for juvenile Chinook salmon and steelhead during their emigration through the south Delta. In addition, these existing data sets can be used to test the effects of various experimental design elements that can then be used to inform the design and implementation of survival studies in the future. For example, results of past studies can be used to assess the sample size and statistical power of future experimental investigations and alternative release strategies, as well as to identify key environmental covariates for inclusion in subsequent investigations. Re-analysis of existing study results is an efficient and cost-effective method to assess many of these factors and to develop a more robust experimental and analytical framework for the design and analysis of subsequent studies. The data re-analysis would be done collaboratively with the original investigators.

Experimental Approach: The approach to the data re-analysis would include a compilation of acoustic and radio tag studies conducted in the Bay-Delta. For each previous study an assessment would be made of the instrumentation and receiver deployment related to the potential use of various data sets to address specific hypotheses (some data sets may be useful for assessing reach-specific survival while others may be useful of examining fish migration characteristics, others may be determined to not be appropriate for inclusion in the analyses, etc.). The study objectives, methods, and results of analyses of each of the original study would be reviewed and critiqued for use in this analysis. Based on the receiver arrays and release locations specific reaches would be selected for inclusion in the analysis. Data from the original receiver detections, in addition to data from other sources on river flows, tidal hydrodynamics (including simulation model results), water temperature, turbidity, and habitat conditions would be compiled. The data set would then be analyzed statistically using univariate and multivariate techniques to address specific hypotheses.

Methods: An interdisciplinary team of fishery biologists, biostatisticians, hydrologists, modelers, and the original investigators will be assembled to perform the analyses. The data sets compiled for each of the selected studies discussed above would be reviewed for quality control prior to analysis. The data sets would include information on tagging, release, tag detection, and covariates linked both geographically and temporally to each of the fishery studies. Statistical analyses would then be performed and documented for each of the hypotheses being tested. Results of the analyses will be documented in a draft and final technical report as well as summarized in presentations and briefings for managers. An independent group of three scientists will serve as an advisory committee to help oversee the data selection, analyses, and critically review technical documentation as part of the project.

Experimental Challenges: Challenges for the project include the lack of synoptic data collected on the response of acoustically tagged salmonids and the corresponding water temperatures, turbidity levels, river flows, and tidal hydrodynamics needed to test one or more of the hypotheses. Additional challenges include studies that were designed and conducted to achieve objectives other that those to be addressed as part of this investigation, lack of data documentation or missing data, confounding environmental covariates, and the uncertainty in determining if, when, and where a juvenile salmonid was preyed on or lost as a result of some other factor (e.g., entrained into an unscreened diversion). A specific set of metrics will be used to assess the likelihood that a predation event had occurred based on examination and analysis of data such as the Georgiana Slough and HORB studies where predators and prey were monitored using 2- or 3-dimensional tag detection technology.

Application of Findings to Management: Results of the re-analysis of existing data will provide managers with new insights into the experimental design considerations of future studies (e.g., sample size and statistical power, detection array deployment, release strategies, development of interdisciplinary studies that include detailed water quality, habitat, and hydrodynamic measurements, etc. The study will also help to identify data gaps from previous investigations. Results of hypothesis testing will help inform development of the functional relationships (drivers-linkages-outcomes) shown in the conceptual model as well as addressed in development of salmonid lifecycle models. Study results will help identify specific functional relationships that affect juvenile salmonid survival and form part of an improved technical foundation for future study designs and potential management actions (e.g., consideration of modification of river flow to reduce predation mortality, effects of exports and tidal conditions on route selection and subsequent risk of mortality, etc.).

Technology Transfer: Results of this investigation will be used to improve the experimental design of future juvenile salmonid survival studies as well as the design of monitoring programs to evaluate the effectiveness of future management actions.

Identifying dominant predators of seasonally migrating juvenile salmonids in the South Delta and the alternative prey that support them year round?

Hypothesis: Ha1: A small subset of potential predators in the South Delta are responsible for the majority of actual predation on juvenile salmonids. Ha2: Juvenile salmon are rare in dominant predator diets and these predators are primarily supported by alternative prey.

Background and Purpose: Although flow and exports are the proximal drivers of interest, the ultimate response of interest regarding juvenile salmonids is survival, which is likely strongly influenced by predation rates. To model, mitigate or simply understand the influence of physical drivers on predation, it is necessary to understand predator behavior, and thus the dominant predator species. For instance, predation risk along a migration route can be framed either as a function of travel distance or travel time, depending on whether primary risk is from relatively mobile predators (striped bass) that follow juveniles over the length of the migration route, or immobile predators (largemouth bass) that juveniles must pass one-by-one. Juvenile salmonids are likely a minor and only seasonal component of their dominant predators's diets in the South Delta. Therefore densities of these predators are likely supported by year-round presence of alternative prey. This experiment will determine the most common predators of juvenile salmonids in the South Delta, as well as the most common prey of these predators at different times of the year.

Experimental Approach: This study will use DNA analysis of potential predator gut contents to detect presence/absence of prey items. An additional manipulative component could be added: measure survival of acoustically tagged juvenile salmon along experimental reaches with two predator density manipulation treatments (BACI or adjacent treatment-control reaches): T1) block and gill nets to selectively remove striped bass from experimental reach, T2) electrofish to remove largemouth bass from experimental reach.

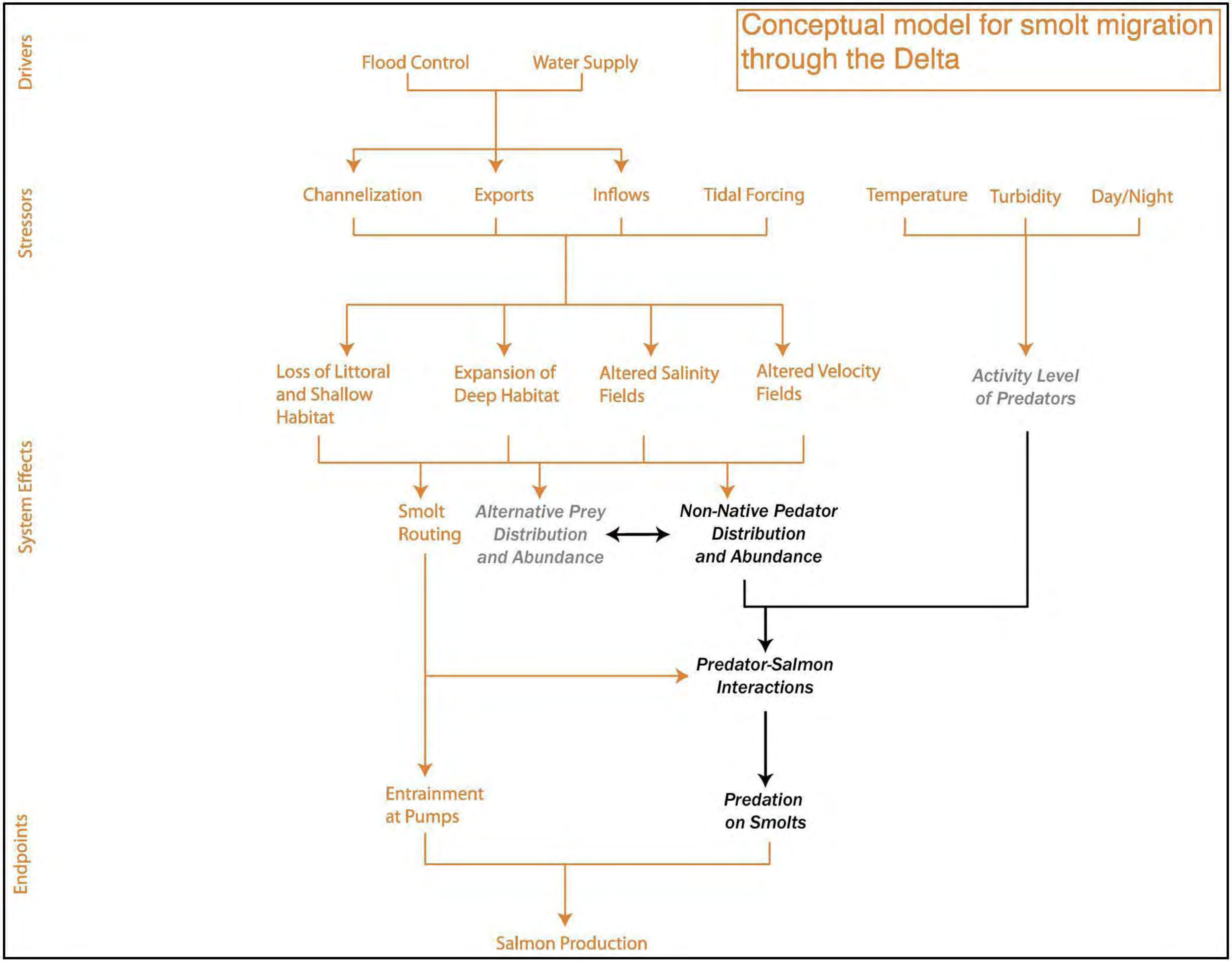
Methods (including statistical analysis plan): Potential predators of juvenile salmonids will be lethally sampled at least four times over a year by gill net, trammel net, electrofishing, and/or in conjunction with other predator removal experiments. Gut tracts will be removed and gut contents will be analyzed for presence/absence of DNA from juvenile salmonids and other common South Delta species using techniques and genetic panels that have been rigorously tested over three field seasons for appropriate sampling method and detection rate variation (dependent on both consumption volume and time since consumption).

Experimental challenges: Bycatch of sensitive species.

Application of Findings to Management: Predator control is a potential option for improving survival of juvenile salmonids in the South Delta. Accurate targeting of predator control measures will benefit from an understanding of the dominant predators of juvenile salmonids. Following on the example described above of a stationary vs mobile dominant predator, with stationary predators the goal would be to guide juveniles down the shortest migration route and to reduce predator numbers along that route (e.g. removal, habitat modification), while with mobile predators the objective would be to speed juveniles along the migration route (e.g. pulse flows and reduced water exports). In addition, a fuller understanding of dominant predator diets will provide the opportunity to apply control measures that suppress conditions fostering alternative prey of these dominant predators.

Technology Transfer: Update communications, presentations, reports, journal publications.

Other useful information to weave into the narrative: This study will capitalize on recently developed genetics technology at UC Davis (currently in use in the North Delta). This study can run partly in conjunction with predator removal studies.


Conceptual model for smolt migration through the Delta
Drivers
Stressors
System Effects
Endpoints
Flood Control
Water Supply
Channelization
Exports
Inflows
Tidal Forcing
Temperature
Turbidity
Day/Night
Loss of Littoral and Shallow Habitat
Expansion of Deep Habitat
Altered Salinity Fields
Altered Velocity Fields
Activity Level of Predators
Smolt Routing
Alternative Prey Distribution and Abundance
Non-Native Pedator Distribution and Abundance
Predator-Salmon Interactions
Entrainment at Pumps
Predation on Smolts
Salmon Production

What are the dominant environmental cues for juvenile salmonid fine-scale movement behavior and navigation in the South Delta?

Introduction: This proposal outlines a set of related study modules that examine the possible relationship between juvenile salmon navigation and movement behavior and a suite of environmental cues.

Hypotheses:
Module 1: Meso-scale navigation behavior and water quality gradient cues.
H_A: Juvenile Chinook salmon longitudinal movement direction along a channel (e.g. north vs. south) in the South Delta tidal environment is guided by juvenile reaction to:
H_{A1}) salinity concentration changes over the tidal cycle (Eulerian temporal salinity gradients).
H_{A2}) changes over the tidal cycle of concentration changes of chemical signatures that are indicative of upstream olfactory signatures the juvenile experienced along the migration route.
H_{A3}) changes over the tidal cycle of concentration changes of chemical signatures that were imprinted in the river system where the juvenile reared and smolted.
[dual Sac/SJ basin juvenile releases with meso-scale 1D or 2D acoustic tag monitoring and 1D water quality measurements over tidal cycles in Old River and in SJ below Head of Old River]

Module 2: Meso-scale navigation and celestial/geomagnetic cues.
H_A: Juvenile Chinook salmon longitudinal movement direction along channels and route selection at junctions in the South Delta is guided by an inherent tendency to travel in a single compass direction (most likely based on celestial and geomagnetic cues).
H_A: Juvenile Chinook salmon of northern Central Valley stocks differ from juveniles of southern Central Valley stocks in their inherent compass travel direction.
[dual Sac/SJ basin juvenile releases with prerelease tank experiment and 1D or 2D acoustic tag monitoring in channels with variety of compass orientations]

Module 3: Fine-scale movement behavior and navigational cues.
H_A : Juvenile Chinook salmon movement behavior (holding vs. unidirectional swimming), longitudinal movement direction along a channel (e.g. north vs. south), orientation across the channel (left side vs. right side, margins vs. center, bottom vs. top water), and related route choice at junctions in the South Delta tidal environment are guided by:
H_{A1}) salinity concentration changes over the tidal cycle (Eulerian temporal salinity gradients).
H_{A2}) changes over the tidal cycle of concentration changes of chemical signatures that were imprinted immediately upstream along the migration route.
H_{A3}) changes over the tidal cycle of concentration changes of chemical signatures that were imprinted in the river system where the juvenile reared and smolted.
H_{A4}) inherent compass travel direction.

[dual Sac/SJ basin juvenile releases with fine-scale 3D acoustic tag monitoring and 2D/3D water quality measurements over tidal cycles in channel reaches leading to and exiting a freshwater tidal and estuarine tidal junction with juvenile releases in all three arms]

Module 4: Fine-scale movement behavior at junctions, route selection, water velocity fields and channel junction geomorphology.

H_A : Juvenile Chinook salmon orientation across the channel (left side vs. right side, margins vs. center, bottom vs. top water), and related route choice at junctions in the South Delta tidal environment are guided by:

H_{A1}) active positioning according to water velocity fields in relation to flow-split streamlines leading up to the junction.

H_{A2}) inherent compass travel direction in relation to flow-split streamlines leading up to the junction.

H_{A3}) active positioning according to geomorphic features (e.g. inside bend vs. outside bend) in relation to flow-split streamlines leading up to the junction.

H_{A4}) random positioning in relation to flow-split streamlines leading up to the junction.

Background and Purpose: Understanding the environmental cues that allow a juvenile salmon to successfully migrate toward the Ocean through freshwater, tidal environments is likely a critical step toward understanding the effects of water project infrastructure and operations on juvenile route choice and residence time within the South Delta channel matrix. Adult salmon bound for their natal streams are known to navigate by electromagnetic fields in the open ocean and by chemical cues once they near their home river based on imprinted memory of their ocean-bound juvenile migration. Less is known about how ocean-bound juveniles successfully navigate through freshwater tidal environments never before encountered. Studies have found that sockeye salmon smolts from different lakes have an inherent (possibly genetic based) tendency to travel in the compass direction of the outlet from their lake, and that this directional navigation is guided by a combination of geomagnetic and celestial cues (Quinn and Brannon, 1982). Similarly, chum salmon smolts have an inherent tendency to travel in the direction that will lead them through river inlets to the ocean (Quinn and Groot, 1983), and that demonstration this directional tendency is more pronounced at higher water velocities (Quinn and Groot, 1984). Another possible navigational cue are tidally driven changes in salinity or in the concentration of chemical signatures from the juvenile's natal stream or chemical signatures of water encountered immediately upstream. These temporal changes in salinity or chemical concentration gradients could provide behavioral cues causing the juvenile to hold or go with the flow. In addition, either celestial/geomagnetic or chemical cues may influence juvenile orientation across the channel, which could influence route selection at junctions by positioning juveniles in relation to flow-split streamlines leading up to junctions. However, cross-sectional orientation of juveniles in the channel may simply reflect preference for particular hydrodynamic or geomorphological features of channels leading up to junctions (e.g. cross-sectional orientation in relation to water velocity fields or channel bends).

Regardless of the dominant navigational mechanism used by emigrating salmon juveniles, infrastructure (barriers, cross channels) or operations (pumping, agricultural discharge) may confuse, delay or misdirect migrating juveniles. However, predicting or mitigating these effects will require a better mechanistic understanding of juvenile navigation cues in the South Delta. Also of concern is the possibility that past and planned South Delta studies using juvenile salmon from northern Central Valley stocks are subject to the confounding effect of juveniles following: compass cues that are not appropriate for southern Central Valley stocks and lead them in a south-westerly direction toward the water project export facilities.

Experimental Approach: For modules 1-3, paired releases of juveniles from north and south Central Valley stocks will be made in south Delta channels and their movement will be compared. All modules will require study locations with tidal influence.

<u>Module 1</u>, comparing movement behavior to water quality gradients at the meso-scale uses 1D or 2D acoustic tag monitoring of juveniles and 1D water quality monitoring along the longitudinal profile of study channels. To isolate the influence of salinity versus other chemical signatures, a study channel within and upstream of detectable salinity intrusion is necessary. This module could piggy-back on the Stuart study on the Old River, the Hayes study downstream of the Head of Old River, or any other meso-scale acoustic tag monitoring study.

<u>Module 2</u>, comparing movement behavior and celestial/geomagnetic cues, has two components. Just prior to release of acoustically tagged juveniles from paired north/south stocks, test fish are placed in circular tanks similar to those used in Quinn and Groot (1983). Tanks have numerous openings evenly spaces around perimeter allowing fish to exit (without reentry) into adjacent holding tanks. Any directional tendency of salmon movement detected in the holding tanks is compared to directional movement of salmon stocks along channels and at junctions to determine if celestial/geomagnetic cues (as determined by tank experiment) influences route choice. This module could piggy-back on the same studies as Module 1 and could be conducted in conjunction with Module 1.

<u>Module 3</u>, fine-scale movement behavior and navigational cues, requires fine-scale 3D acoustic tag monitoring of juveniles and fine-scale 2D/3D water quality monitoring/measurements over at least one tidal cycle. This study could piggy back on virtually any study releasing acoustically tagged juveniles in tidally influenced reaches. However, in order to examine movement behavior at a junction, channel reaches leading to and exiting from a junction should be monitored, ideally with juvenile releases in all three arms of the junction.

<u>Module 4</u>, fine-scale movement behavior at junctions, route selection, water velocity fields and channel junction geomorphology, is similar in approach to Module 3 as far as acoustically tagged juvenile fish monitoring. However, instead of fine-scale water quality, this study relies on fine scale hydrodynamic monitoring and modeling of water velocity fields in channels leading to a

junction. In addition, fish movement is compared to pre-defined and surveyed geomorphological features to examine potential influence of these features on fish orientation upon approach to junctions.

Methods (including statistical analysis plan):
Field:Statistical subjects are the juveniles and treatment groups are individual channel reaches (i.e. no attempt at replication). Experimental goal is not to project conclusions beyond experimental sites (which would require random site selection). Rather, the goal is to accurately describe and compare juvenile behaviors in several contrasting channel types. Reasonable hypotheses regarding drivers of juvenile behavior should explain movement across multiple channel types (riverine vs cross-channel, high vs low export influence). Fine-scale GPS habitat mapping defining areas of predetermined habitat types (SAV, littoral, open channel) will provide additional information beyond the direct objectives of the study modules. Fine-scale (sub-meter) juvenile Chinook movements will be monitored with 2D or 3D acoustic telemetry. Water quality data loggers and ISCE's will take water samples at fixed locations along and across channels over regular time intervals throughout the study for detailed chemical analyses.

Analysis: Juvenile activity (moving vs holding), longitudinal velocity and direction of movement, and time spent in predetermined habitat types (GPS layer overlay) during activities will be compared during set intervals in the tidal cycle to establish whether juveniles exhibit a consistent response to tidal velocity. 1D water quality gradients along channels will be interpolated between ISCE sampling points and sampling times to the finest scale possible and then converted into Lagrangian temporal gradients from the perspective of individual juveniles. The direction of Lagrangian temporal gradients (increasing vs decreasing vs stable) will be compared to juvenile activity to determine if there is a consistent behavioral response to water quality cues. Directional tendencies in tank experimental will be based on statistical methods described in Quinn and Groot (1983).

Modeling: DSM2 "finger-printing" will be modified to model historical spatio-temporal concentration gradients of "upstream" water at select junctions and channel reaches in the South Delta. DSM2 particle tracking will be modified so that particles reflect hypothetical behavioral responses to 1D tidal driven flow and/or concentration of "upstream" water. Particle paths will be compared to migration paths of juveniles from larger-scale acoustic telemetry studies.

Experimental challenges: Obtaining experimental fish from appropriate geographic regions may be a challenge. Another challenge will be defining appropriate length of experimental channel reaches and detecting predation of tagged juveniles. This experiment does not require special conditions except that reaches must be subject to tidal flows and some reaches must be have detectable salinity concentrations.

Application of Findings to Management: A detailed understanding of juvenile movement in relation to hydrological flow and mixing patterns, tidally driven changes in water quality, and habitat types within experimental reaches will allow structuring of models that can test relevance to larger scale migration patterns in existing data sets. This will open the door for explaining route choice and migration rate based on output of existing hydrological models. Since existing models are capable of describing hydrological changes caused by water project operations and infrastructure, information from this study will indirectly inform possible consequences of different water project management options. Detailed movements will also allow better understanding of habitat use during different behaviors (holding, movement) that will elucidate potential interactions with sedentary versus mobile predators and inform mitigation efforts to reduce predation risk.

Technology Transfer: Progress reports and presentations, final report and journal publications. Raw data made available upon request.

Other useful information to weave into the narrative: Modules could be combined with a before/after predator removal, SAV removal, or any other experimental approach that relies on fine scale tracking of juvenile movements in a tidal environment over several tidal cycles. QUALITY will be far more informative than QUANTITY, where quality refers to the ability to more specifically define the movement behavior of juvenile salmon in South Delta water ways, and quantity refers to larger spatial scales or increased replication. Useful information derived from other large scale migration/survival studies will be minimal without information from high quality, fine scale descriptions of juvenile behavior that can help us understand larger scale migration patterns.

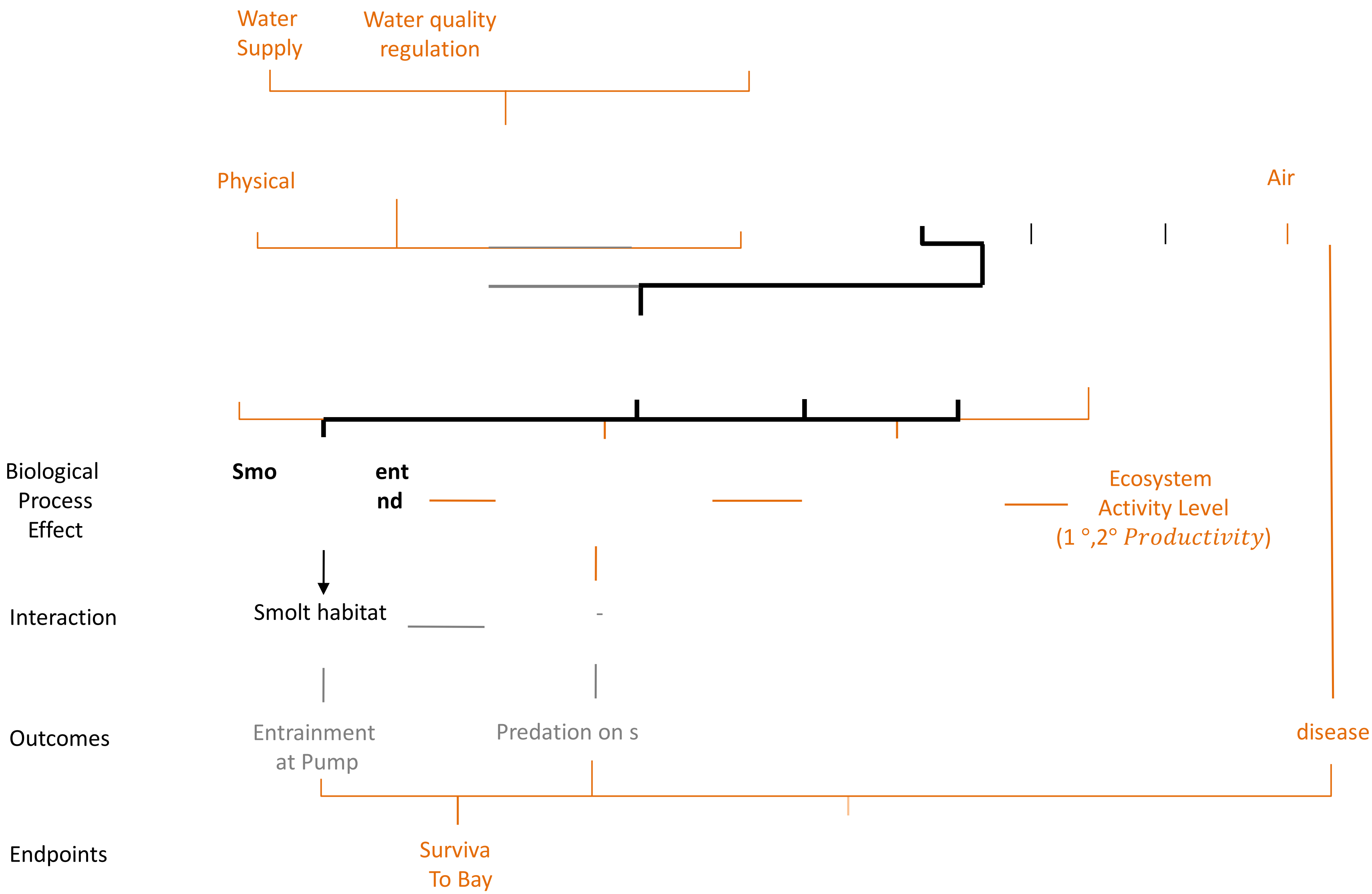
References:

Quinn, T.P. and E.L. Brannon. 1982. The use of celestial and magnetic cues by orienting sockeye salmon smolts. *Journal of Comparative Physiology A* **147**:547-552.

Quinn, T.P. and C. Groot. 1983. Orientation of chum salmon (*Oncorhynchus keta*) after internal and external magnetic field alteration. *Canadian Journal of Fisheries and Aquatic Sciences* **40**:1598-1606.

Quinn, T.P. and C. Groot. 1984. The effect of water flow rate on bimodal orientation of juvenile chum salmon, *Oncorhynchus keta*. *Animal Behavior* **32(2)**: 628-629.

Juvenile salmonid ues in tidal environment - Harve



Juvenile salmonid use of SAV as holding and rearing habitat in South Delta

Hypothesis:

H_{A1}: Juvenile salmonids use SAV (when available) as holding habitat while migrating through the South Delta.

H_{A2}: SAV provides higher densities of available food to juvenile salmonids relative to alternative habitat types such as rip-rap or muddy shoals.

Background and Purpose: Little is known regarding fine-scale habitat use by juvenile salmonids in the Delta. SAV has proliferated in the South Delta in recent decades. Although not found to be associated with adult largemouth bass, SAV has been associated with largemouth YOY, thus providing recruitment habitat that likely benefits the establishment of local adult populations. In addition, SAV provides habitat for other centrarchids and cray fish, that are common prey of largemouth bass and possibly striped bass, and therefore SAV may support high densities of these predators year-round. On the other hand, SAV may also support invertebrate food resources and provide refuge from predators for juvenile salmonids migrating through the South Delta. For this reason, it is unclear whether establishment of SAV in South Delta channels is a net benefit or detriment for juvenile salmonid survival. An initial step toward answering this question is to determine: i) whether migrating juveniles use or even prefer SAV habitat during migration through the South Delta, particularly while holding, and ii) whether SAV provides benefits for juvenile salmon, such as abundant food.

Experimental Approach: Monitor movement of acoustically tagged juvenile salmon released in channel reaches with and without SAV and overlay movement on detailed SAV map. Define whether SAV is used regularly in channels with SAV and whether SAV use is related to tidal phase, solar irradiation (day/night, overcast), turbidity or possibly predator densities (if study ran in conjunction with predator removal study, some information may also be gleaned as to the influence of SAV on juvenile predation risk). Survey food densities in SAV and adjacent alternative habitat types. Possibly collect and analyze juvenile gut contents, or conduct enclosure studies to determine diet composition, consumption rate and growth of juvenile salmonids in SAV and alternative habitat types.

Methods (including statistical analysis plan): Conduct fine scale survey of SAV (and other predefined habitat type) coverage in experimental reaches using GPS. Release acoustically tagged juveniles into experimental reaches and map 2D or 3D movement. Over set time intervals, define dominant juvenile activity and habitat use. Compare overall habitat use to predetermined physical variables using appropriate statistics. Survey juvenile salmon diet (or diet of other similar-sized fish) inhabiting SAV and other habitat types. Conduct predator-free enclosure experiments in representative habitats, monitoring diet (gut contents), and growth.

Experimental challenges: Determining predation events in acoustic studies. Boat traffic interference with acoustic receiver arrays.

Application of Findings to Management: Elevated flows and stable freshwater conditions are thought to be major contributors to the proliferation of SAV in the South Delta. This study will determine the extent to which juvenile salmon use SAV and whether SAV appears to offer beneficial holding habitat during migration through the south Delta. It will also inform whether SAV removal may have negative consequences for juvenile survival.

Technology Transfer: Presentations, reports, publications.

Other useful information to weave into the narrative: This study could be run in conjunction with the study of fine scale juvenile navigation in relation to tidal cycle and chemical gradients in order to capitalize on a highly instrumented channel. It could also be run in conjunction with a predator removal study to determine whether predators influence juvenile SAV use and possibly offer some insight as to whether SAV availability enhances juvenile survival during migration in the presence of predators.

SAV support of alternative prey for dominant predators of juvenile salmonids in the South Delta.

Hypothesis: SAV is associated with higher densities of alternative prey that support dominant predators of juvenile salmonids (striped bass, largemouth bass) in the South Delta.

Background and Purpose: Juvenile salmonids are a minor and only seasonal component of potential prey for their dominant predators in the South Delta, striped and/or largemouth bass. Therefore high densities of these predators are likely supported by year-round presence of alternative prey. SAV has proliferated in the South Delta in recent decades, and though not associated with adult largemouth bass densities, SAV has been associated with YOY largemouth bass densities, thus providing indirect benefits for the establishment of adult populations as recruitment habitat and prey habitat (largemouth are canabalistic). SAV likely supports higher densities of other prey for largemouth bass and possibly striped bass that may support these predators year-round. Coupled with predator diet studies using gut content DNA analysis (see prospectus: "Harvey_Dominant predators and their alternative prey prospectus"), this study would provide a more comprehensive understanding of the conditions that support high predator densities in the South Delta.

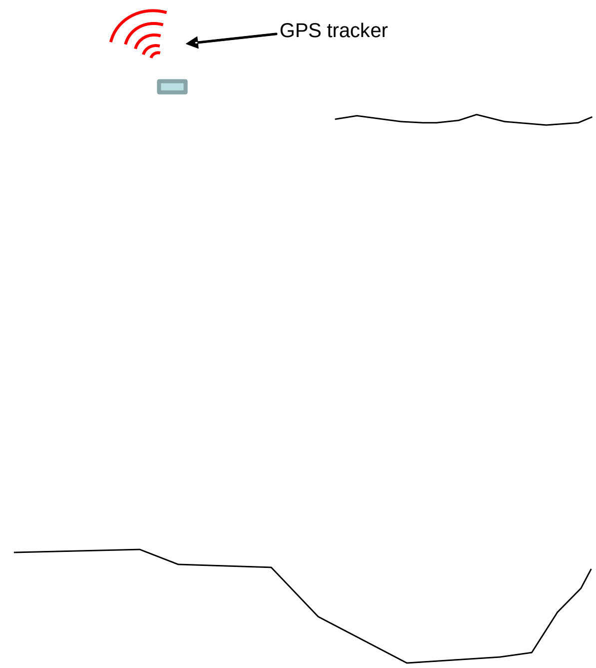
Experimental Approach: Analyze existing datasets of centrarchid surveys in association with different levels of SAV density. Compare recent surveys with surveys conducted prior to the year 2000 to describe dominant changes in alternative prey composition and density.

Methods (including statistical analysis plan): Stats: TBD based on structure of available data.

Experimental challenges: Limited to what is available in existing datasets.

Application of Findings to Management: Do the findings have direct or indirect application or implications for managing south Delta inflow/export and improving salmonid survival through the Delta? As elevated flows and stable freshwater conditions are thought to be major contributors to the proliferation of SAV in the South Delta, this analysis will allow a better understanding of the indirect impacts of flow/salinity management on densities of alternative prey that support year-round abundance of dominant predators.

Salmonid Tethering to assess effects of IE ratio on predation rate



This method was originally proposed as part of the 'predator removal' study to test effects of relative change in predation rates at various predator densities.

In concept it could be applied to ask 'how does relative predation rate change in a reach (say roughly~50-100m) as a function of I:E ratio. This relates to how we have proposed to use it in the predator removal study to address something we refer to as the **Prey Transit Time Hypothesis**- which is that *the survival of juvenile salmonids passing through a reach will be a function of transit time and path through the reach* regardless of predator density and manipulations, the movement path and velocity of tethers through each reach relative to the rate at which they are predated upon can be compared both within and across tether deployments in both experimental and control reaches (and across flows associated with different IE Ratio)

The intent of this method is not to quantify absolute predation rates, given the biases associated with increased susceptibility to predation with the tether, but rather to provide a relative comparison of predation rate in treatment and control reaches for the Predator Density Hypothesis and relative predation rates relative to tether movement path and velocity for the Prey Transit Time Hypothesis. The SWFSC has been using the tethering method to assess predation rates around water diversion on the Sacramento River (including Freeport, City of Sacramento, and the City of Redding Pump House #1). Methods were developed based on studies in the literature incorporating standard tethering techniques used in other riverine habitat studies (Gregory and Levings 1998) and hook-timers developed for assessing long-line fisheries (Somerton and Kikkawa 1995, Sigler 2000). Previous experience with these method indicates bottom mounted tethers are most effective in stable current systems. Due to potential changes in current directions and slack tides, we intend to use unmoored tethers and allow them to drift through the experimental and control reaches. In addition, previous studies were designed to assess predation around a specific structure, whereas this study will be comparing average predation rates in control versus experimental reaches and relative to reach flow dynamics, so the drifting within a reach will not affect experimental design. In this task, small floats with juvenile hatchery fall-run Chinook salmon (or steelhead) tethered below by a small hook with pull timer will be deployed at 10 m spacing (n = ~20) across the river channel at the 'up-flow' section of each reach (direction potentially dependent upon tide and pumping) and allowed to drift down-current through the reach and collected at the far end, where tethers will be recovered and evaluated for predation. Each float will have a GPS unit that records its position every 5 seconds providing path and point to point velocity. These units also transmit location to a base station in real-time which facilities unit recovery and negates having to download 30 receivers after each deployment. We typically conduct these experiments at dawn and dusk, and potentially midnight and midday (although public fishing pressure often precludes midday experiments). The protocol will be expanded to address tidal and flow changes as well. We intend to conduct pilot tether releases in the spring 2013 while conducting surveys at other study sites, to establish practical hook-depth settings, modify for GPS package and determine the number of drifters that can be practically managed. This could be delayed until fall 2013, but practical considerations including availability of hatchery fish in spring and deployment under normal spring flow conditions are desired. Also the primary complication associated with tether deployments is tangling of the live fish with the tether gear, so experiments with unbaited hooks or artificial lures are less valuable for testing efforts in 2013. In addition, despite the increased susceptibility of smolts to predation, past experience indicates 100% predation rates rarely occur. As such preliminary measures of predation rates in 2013 will be used to conduct a power analysis for the total number of tethers required to achieve a measurable effect for work in 2014-2015.

As above, the purpose of this experiment is not to achieve a perfectly accurate measure of salmon mortality/predation, but rather to evaluate the relative differences observed between treatment and control reaches both before and after removal efforts and ‘survival’ relative to transit time. Biases associated with the tether increasing susceptibility to predation are not of concern as those measures of true reach survival are made with the acoustic tagging study (Task 4 below). Hook timers have three-fold purposes. In the event that there is 100% predation, the timer allows the relative quanitification of how quickly this occurred in each reach. More commonly, the timer also provides an assessment of whether a predation event truly occurred (hook-timer pulled) vs the salmon smolt simply escaping the hook (timer not pulled). Finally when synced with the GPS unit- the timer will enable us to determine the location of the tether when it was predated upon (ie. in the middle of the HOR scour hole, versus 500 m away in mid-channel or along a bank).

Annual cost for two boat teams deploying tethers are 10 rotating locations throughout the delta for 2 months
sample size ~ 40-60 tether deployments per location/day

Personnel Costs				**Fall 2013**	
Salary	**Description**			**Year 1**	
	Position	*Hourly rate (year 1)*	*monthly*	*Hours/yr*	Salary
	Title: Post-doctoral Scholar	$24.33	4,217	520	12,650.00
	Title: Post-doctoral Scholar	$24.33	4,217	520	12,650.00
	Title: Staff Research Associate II	$20.64	3,578	320	6,605.54
	Title: Lab Assistant III	$18.40	3,189	320	5,887.38
	Title: Lab Assistant II	$16.17	2,802	320	5,172.92
	Title: Lab Assistant II	$16.17	2,802	320	5,172.92
				Subtotal	**48,138.77**
Benefi		Benefit Rate			Benefits
	Title: Post-doctoral Scholar	0.38			4,807.00
	Title: Post-doctoral Scholar	0.38			4,807.00
	Title: Staff Research Associate II	0.46			3,038.55
	Title: Lab Assistant III	0.65			3,826.80
	Title: Lab Assistant II	0.45			2,327.82
	Title: Lab Assistant II	0.45			2,327.82
				Subtotal	**21,134.98**
				UCSC Overhead (26%)	**18,011.17**
				Total Personnel costs	**87,284.92**
Equipment					
No	**Description**	**Unit Price**		**Quantity**	**Total**
1	Garmin Tether GPS tracking system	500		100	50,000
2	Tether parts- floats, weights, line, glow sticks, hooks				5,000
3	Misc Supplies				5,000
4	Laptop for GPS tracking tethers	2000		4	8,000.00
5	fluff				50,000
				Equipment total	**118,000**

Travel	**Description**				
Federal Employees (Hayes, Demer, Lindley etc)		Rates	# persons	Travel days	
Lodging	Daily rate (Stockton CA)	83	3	10	2,490.00
M&IE	Daily rate	56	3	10	1,680.00
Non-Federal Employees- Funds to UCSC (overhead required)					
Lodging	Daily rate (Stockton CA)	83	6	31	15,438.00
M&IE	Daily rate	56	6	31	10,416.00
	Indirect costs on UCSC Staff (26%)				6722.04
		monthly rate	# vehicles	# months	
Federal Vehicle lease		278	2	5	2,780.00
		rate		# miles	
GSA Mileage ($0.40/mile)		$0.40		6500	$2,600.00
Boat Usage					7,400
Trailer maintenance					1,500
				Total	**51,026.04**
		Annual Cost			**256,310.96**

Project title: Testing the effects of manipulated predator densities and prey transit time on juvenile salmonid survival at the San Joaquin and Old River Confluence.

Sean Hayes, Steve Lindley, Cyril Michel, Megan Sabal, David Demer- NOAA SWFSC

Summary:
To test the hypothesis that predation is a major factor contributing to the observed low survival of juvenile salmonids in the south Delta, the SWFSC proposes a predator survey and removal experiment to be done in collaboration with DWR, DFW, and USBR. The proposed study site will be centered on the divergence of the San Joaquin River with Old River where reach specific mortality rates of 10-40% were documented during the Vernalis Adaptive Management Program (VAMP) studies (SJRG 2011). This location will include a 4.5 km experimental reach to be divided into three 1.5 km sub-reaches, with the center reach being the site of experimental removal and the adjacent reaches being used to track sink/source predator dynamics. Two more full control reaches (length =1.5 km) will be located roughly10 km away to avoid source/sink issues associated with the removal and surrounding 'partial control' reaches at the HOR divergence. This study is designed to work with OMR flow manipulations, but not dependent upon that for full results.

Experiments will be conducted to evaluate two hypotheses (which are likely interactive rather than alternative/ mutually-exclusive):

1. **Predator Density Hypothesis-** The survival of juvenile salmonids passing through a reach will increase with the removal of predators (predator removal manipulation experiment)
   a. Downstream compensatory mortality effects will be measured to determine the effective distance over which within-reach survival enhancements propagate.
2. **Prey Transit Time Hypothesis-** The survival of juvenile salmonids passing through a reach will be a function of transit time and path through the reach (drifting tether experiments)

Methods:

1. Acoustic surveys with split &/or multibeam echosounders and DIDSON cameras to quantify: fish densities/sizes (before/after removal), bathymetry, and possibly aquatic vegetation
2. Acoustic tagging/tracking of predators, Chinook smolts (and steelhead from 6yr study)
3. Predator removals- combined netting and efishing efforts to remove from 1500m reach.
4. Tether work- drift ~30 GPS tagged floats with live salmon smolts through reaches with a) before and after manipulated densities, b) through control reaches and c) repeat at various flow rates.
5. Predator diet analysis- genetics and/or scope ID

Predictions:

1. If predator density affects predation- this will be reflected by reduced predation of acoustically tagged Chinook and steelhead (6-yr study), as well as reduced predation on baited drifting tethers, compared to rates measured prior to removal efforts and in control reaches
2. If prey transit time affects predation- this will be reflected by the reduced predation on baited tethers that move through reaches faster than those that move slower- both within and between deployments and at different flows.

Reach-specific influence of hydrodynamics and predation on steelhead survival

Hypotheses: Predation mortality is higher adjacent to the SWP and CVP (i.e. Grant Line Canal and Old River) than in other freshwater reaches of the South Delta and San Joaquin River Salmonid migration corridors.

The distibution and abundance of alternate prey is greater along Grant Line Canal and Old River than in other freshwater sections of the South Delta salmonid migration corridor.

Reach specific survival along Grant Line Canal and Old River is not significantly affected of migration speed.

Reach specific survival along Grant Line Canal and Old River is significantly related to alternate prey densities in this reach.

Background and Purpose: How changes in water operations influencing stressors (i.e. inflow, export, barriers) affect steelhead routing, predator distribution and abundance, and alternate prey distribution is poorly understood. While route entrainment of steelhead at junctions has been evaluated in the past and will continue to be studied as a factor in survival(6 Year Study 2011-2013), less focus has been placed on interactive effects between species (i.e. predators, alternative prey, salmonids) and hydrodynamics. This study would evaluate how inflow, exports, and barrier configuration influence abundance and distribution of alternate prey and predators in habitat closely associated with the CVP and SWP, and how these factors may impact salmonids survival close to the facilities. This information is critical to determining the spatial and temporal scales of salmonid survival enhancement management actions that can be taken in the South Delta associated with open habitats outside the CVP and SWP.

Recent regional investigations (VAMP 2010, 2011 studies) found higher survival through the South Delta than the San Joaquin River Corridor, but also significantly higher predation (higher densities of shed tags) along Grant Line canal and near the facilities than any location along the mainstem San Joaquin River route. There is building agreement that travel time is a principal factor influencing survival through the San Joaquin and South Delta outmigration corridors, yet the relationship between higher survival and faster travel times appears to breakdown in open channels adjacent to the CVP and SWP. This study aims to investigate the hypothesis that this high mortality adjacent to the facility is related to prey densities being greater in these areas due to the increased volume of water transitting this area around the CVP/SWP pump facilities.

Experimental Approach: This study would run concurrent with the steelhead telemetry study releases between March and June occurring as part of the NMFS BO's RPA IV.2.2 between 2014-2016. The 6 year study will include fish pathology/disease testing, battery life studies, and fish condition studies to rule out these mechanisms as sources of mortality for thes releases of steelhead. The spatially- dependent survival estimates along the South Delta and San Joaquin River corridors made by the study will be assumed to represent only predation mortality if these other studies do not show impacts from disease, experimental effect, or condition. Measurements of alternate prey and predator periodicity and abundance will be covariates to consider as biologically relevant factors influencing survival. Other factors will include measures of travel speed, inflow, exports, habitat, and barrier configuration.

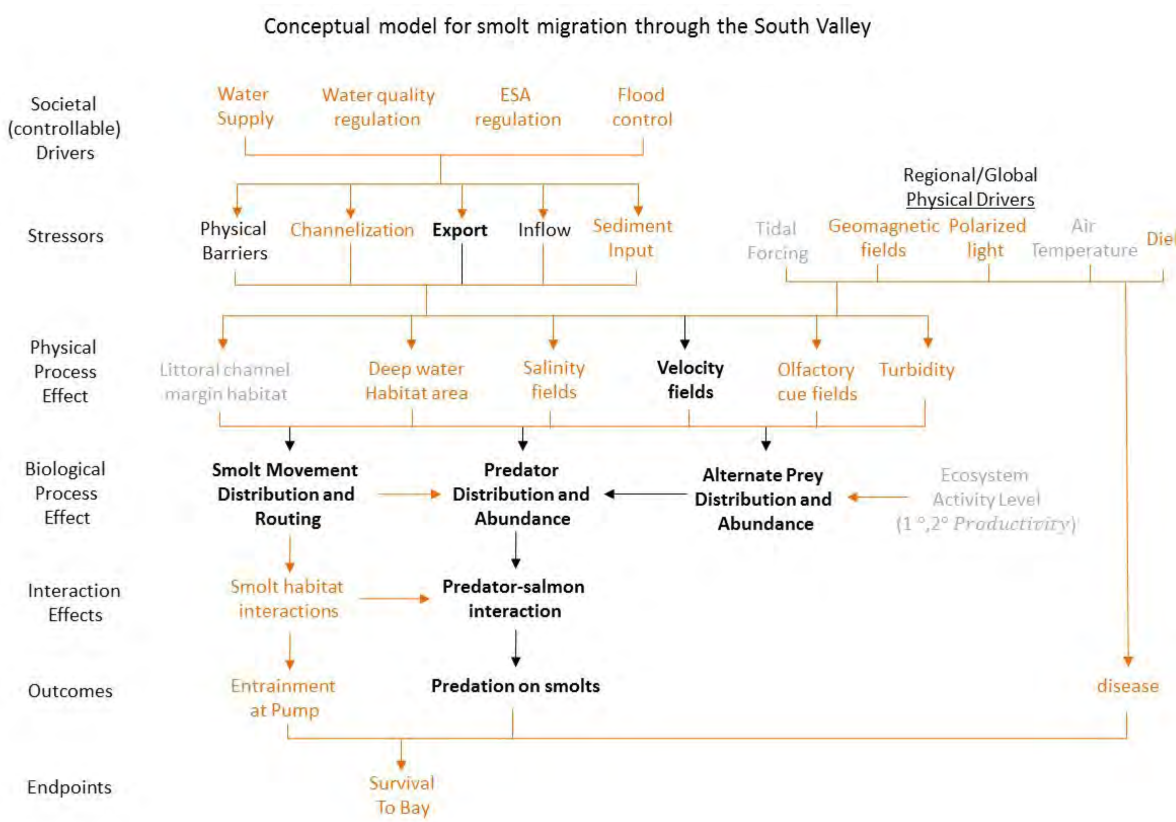
Methods (including statistical analysis plan): The focus on this study will be to collect empirical data to examine regional steelhead survival modeling interpretation. Measurements of a temporally relevant (i.e. monthly) and spatially discrete (i.e. every 5km at representative habitats) index of abundance of predators along the South Delta corridor and hydrodynamically similar segment of the San Joaquin River corridor will provide baseline data to evaluate if predator abundance varies in time and space along these corridors. Measurements of catch per unit volume of larval and young-of-year fishes from the CVP/ SWP facility count records (surrogate for Grant Line Canal and Old River), Mossdale Trawl expanded experimental trawl for these fish, and an added experimental trawl in a hydrodynamically similar location as Grant Line Canal along the San Joaquin River Corridor will provide baseline data to evaluate in alternate prey abundance varies with inflow, export, or barriers. This study requires concurrent acoustic telemetry studies of steelhead (will be occurring as part of RPA IV.2.2 during 2014-2016). Monthly releases from the 6 Year Study with acoustically-tagged steelhead will provide monthly estimates of survival. Mobile surveys for defecated tags will provide an additional measure of mortality associated with predators along the San Joaquin River and South Delta migration corridors. Measurement of daily tidal flux would benefit from deployment of hydraulic instrumentation adjacent to study sites, but considerable information may exist that would provide for modeling of this parameter already. These measurements of tidal flux will incorporate the daily mean flow through a reach, as well as the change in daily flow due to tidal forcing.

These reach-specific data can be used with associated travel time and reach length data to interpret results from predator-prey interaction and regional survival models. General linear modeling will use reach-specific results (travel time, predator density, and alternate prey density) with environmental results (i.e. reach length, tidal flux, temperature) to evaluate predictors of reach-specific steelhead survival independently and regionally. Results from such a temporally and spatially comparative study are necessary to gain understanding about balancing management strategies involving hydrodynamics and predator control for increasing steelhead survival through the South Delta.

Experimental challenges: Predator and prey densities can be measured noninvasively using similar to that in the the NMFS Science Center's predator study. These methods will be able to enumerate densities of predator and prey fish targets in littoral and deep water habitats. This study would use these methods in a location that is of management importance due to the very high predator mortality observed there in the past two reported VAMP studies and their locations close to the CVP and SWP.

Application of Findings to Management: The temporal and spatial components of this study are designed to evaluate the variation in species interacting in the ecology of outmigrating steelhead, and potentially salmon. Since this study will explore steelhead mortality in reaches under different levels of hydrodynamic influence of the CVP/SWP export facilities, it will provide results to understand how proximity to the facility may influence predator and alternate prey periodicity and abundance. The influence of hydrodynamics affected by exports on reach-specific number of predators and alternate prey is essential to understanding the scale of relative stressors (predation, altered hydrodynamics) and the potential for fish and water management strategies to influence steelhead survival through the South Delta.

Technology Transfer: Data would be collected starting in 2014, and results reported during the following year through an interim annual report as part of the series of reports developed through the South Delta Collaborative Salmonid Research Work Group. Results utilizing acoustic telemetry study results will be discussed in the interim reports, not the acoustic telemetry study report occurring biennially as part of NMFS BO RPA IV.2.2. To ensure utility to agency science and management staff, a final report will be prioritized over publication of results in the peer-reviewed literature. Once the multiyear study is completed, a peer-reviewed publication will be developed.



How do exports and inflows affect the survival of migrating smolts in the Delta?
Steve Lindley, 22 Feb 2013.

Hypothesis 1: Travel time alteration. In the presence of mobile predators, survival of smolts migrating through a reach will depend on residence time within the reach. High inflow will tend to reduce residence time in tidal reaches, increasing survival. This effect may be augmented by increased turbidity. Increasing exports may have a more complex effect, depending on the context of the reach and the scale of the observation. At some scales, the velocities induced by the pumps may reduce travel time over certain reaches, possibly enhancing survival at this scale. At the larger scale of a channel network, pump-induced alterations in velocity fields may confuse migrating salmon or entrain them into reaches where travel time is slower, reducing survival as exports rise.

Hypothesis 2: Water quality variability. Controlling exports and inflows to maintain low salinities in the interior Delta may boost populations of non-native predators and prey. A more variable hydrologic regime would favor species adapted to variable conditions (e.g., native fish) and suppress non-natives that require low salinity (non-native fish, invasive aquatic vegetation). Under this hypothesis, the direction of effects of inflow and exports would vary seasonally: high inflow and low exports would be beneficial to salmonids in the winter and spring, while low inflow and high exports would be beneficial in the summer. These effects on salmon are indirect; the direct effects are on other organisms. The effect on salmon would only be seen after the effects on predator, alternative prey and SAV populations play out, which would probably take one to several years.

APPENDIX H
CONCEPT PROPOSAL EVALUATION GUIDELINES

DRAFT

1 May 2013

Research Proposal Evaluation Criteria

The following is a proposed process for screening, technical review, and principal/management selection of south Delta studies addressing the effects of San Joaquin River inflow and CVP and SWP exports on south Delta hydrodynamics, and the effects of hydrodynamics on factors affecting salmonid migration behavior and survival. The process involves several steps, including (1) a screening step to narrow the list to those studies most likely to contribute important new information for managing south Delta inflow/exports, and is divided into (a) a technical ranking of all research concepts to be conducted by the Small Science Group participants, (b) review of the rankings with the Large Group, and (c) a management review and selection for peer review; (2) an external peer review of the short-listed proposals identified in Step 1; and (3) a management-level selection process and agreement to execute one or more studies beginning in WY2014.

The following are some suggested approaches, trigger questions, and criteria for the three steps.

Ia. Project ranking by the Small Science Group -- The following are trigger questions to guide the Small Science Group in ranking concept proposals. The questions are divided into 4 categories: Relevance to Project Scope; Scientific Merit; Logistic and Environmental Uncertainties; and Policy Flags. This initial step is for the purpose of ranking all proposals to support management consideration and selection of one or more proposals—or combinations of proposals—for further development and submission for scientific peer review. No research proposals will be eliminated at this step: all results will be presented to the management reviewers. To assist in ranking, each question will be scored as High, Medium or Low, and rolled up to a category score of High, Medium, or Low. The "Relevance to Project Scope" category will be treated as a threshold issue, and a low score will automatically lead to a low ranking. Each Small Science Group participant will conduct individual rankings of the proposals as a first process step; participants will then discuss their individual rankings as a group to evaluate the results of individual scoring and identify opportunities to combine or improve proposals. Based on results of these two steps participants will review the rankings with the Large Group and decide whether further adjustment of the rankings would be useful for management review and selection.

A. Relevance to Project Scope

a. Does the study address an important aspect of south Delta hydrodynamics or salmonid survival that has implications for managing south Delta inflow/export (i.e., RPA IV.2.1)? Specifically, does it reduce uncertainty about salmonid responses to delta conditions?

b. Does the study directly link to key uncertainties in Driver-Linkage-Outcomes described in the conceptual models?
c. Does the study provide information relevant for life-cycle, survival, or behavioral modeling?
d. Can the study be implemented in Water Year 2014?

B. Scientific Merit

a. Does the concept proposal include well-articulated and testable hypotheses?
b. Does the concept proposal take into account previous research and scientific reviews, such as the 2012 Independent Review Panel review on Long-Term Operations that included a review of the 2012 Stipulation Study?
c. Does the concept proposal include proposed methods, and are the methods appropriate for addressing the hypotheses?
d. Does the concept proposal include sample sizes, and are they realistically obtainable?
e. Does the concept proposal include an appropriate plan for statistical analysis of the results?
f. Are the results of the study likely to be of sufficient quality to be publishable in a peer-reviewed scientific?
g. Does the new knowledge gained from the research and its potential application to improving south Delta survival of salmonids justify the cost, staff time, and any potential short-term risk to fish?

C. Logistic and Environmental Uncertainties

a. What is the likelihood that experimental conditions can be met, and is the likelihood dependent on ambient environmental conditions such as water year? If the research is water year-dependent and conditions are not met, does the research still provide valuable information?
b. If required, are study fish available? If so, does the study require fish from specific hatchery and are they likely available?
c. Does the study require the construction or installation of physical barriers, and if so are the structures likely to be permitted?
d. Do the proposed study methods require any special permits, and are they likely obtainable considering the timing of the proposed research and lead time?
e. Can the study be conducted efficiently as an extension or component of an existing study (thus facilitating permitting and potentially minimizing cost)?

D. Policy Flags

a. If conducted during April-May, are study conditions expected to provide conditions equal to or greater than the protections afforded by RPA IV.2.1 for San Joaquin steelhead?
b. Does the research require a waiver or modification of water quality or quantity regulations during the experimental period? If so, and if regulatory restrictions are not relaxed or waived, does the experiment still provide valuable information?

Ib. Management Review and Selection for Peer Review

1. Relevance for/technical contribution to BiOp remand
2. Addresses critical management/operational uncertainty, etc.
3. Small Science Group ranking

II. External Peer Review: Suggest three reviews of each screened proposal, with reviewers selected based on the relevance of their expertise in the proposed investigation. All proposals will be reviewed for adequacy of a statistical analysis plan.

The following technical review format is an adaptation of the process used by the National Institute of Health for their extramural science program

Scientific Merit and Technical Quality of the Proposed Research (60%)

Does the proposal clearly state the study goal, objectives, and hypotheses to be tested?

Does the proposal adequately explain how the study would contribute to answering the research question?

Does the proposal present an understanding of current state of knowledge or practices and deficiencies in current understanding of the subject?

Does the proposal address why and how the proposed methods/approaches are optimal for achieving the scientific objectives? Is the approach feasible?

Does the proposal acknowledge potential problems and consider alternative approaches or methods?

Does the proposal include a scientifically sound and detailed plan for statistical analysis?

Does the proposal include an appropriate plan for reporting and technology transfer?

Proposed Research Plan (10%)

Are the research tasks organized logically?

Are study objectives achievable?

Is the schedule realistic?

Resources (15%)

Does the proposal clearly describe the availability of resources (both scientific expertise and materials), contributed by each team member/collaborator and how this will accomplish the research results identified in the proposal?

Is the proposed budget reasonable and appropriate?

Team Qualifications (15%)

Does the proposal clearly and succinctly describe the capabilities of the principal investigator and key team members/collaborators?

Is the team technically competent to undertake the study?

Does the proposal explain how each team member/collaborator will be participating?

Based on team qualifications and study design, will the results be worthy of publication in a scientific journal?

Technical Review Criteria Used for Individual Peer Reviews of Science Proposals and Instructions to Reviewers

Instructions to reviewers:

Please provide a brief written summary of your review findings for each review criterion listed below. Please provide an overall numerical rating of the proposal based on your review. Use the rating definitions below to determine your overall rating. Please do not report numerical ratings with greater than two significant figures. Please provide a brief written justification for your overall rating.

Rating	Definition
5 – 5.9 (Superior)	All aspects of the proposal are clear and well described. All technical review criteria are affirmatively met and there is a high probability of success. No substantive flaws are noted, although some minor errors or omissions may be noted.

4 – 4.9 (Good)	All aspects of the proposal are clear and well described. A majority of the technical review criteria are affirmatively met, although there may be some minor questions related to some aspects of the proposal. Reviewers may identify one substantive flaw, but there is a clear resolution to that flaw. Some minor errors or omissions also may be noted.
3 – 3.9 (Average)	The proposal is sound overall, but some deficiencies are noted. Reviewers may identify up to two substantive critical flaws, and at least half of the technical review criteria are affirmatively met.
2 – 2.9 (Below Average)	The proposal presents a cogent description of the project but serious deficiencies are noted. Reviewers may identify three or more substantive critical flaws, and less than half of the technical review criteria are affirmatively met.
1 - 1.9 (Inferior)	The proposal does not present a cogent description of the project and serious deficiencies are noted. Reviewers may identify three or more substantive critical flaws, and less than half of the technical review criteria are affirmatively met.

III. Management-level selection

1. Does the study rate "Good" or higher based on scientific peer review?
2. Do the principals agree that the study addresses a key scientific uncertainty that has direct implications for balancing San Joaquin inflow/Delta exports?
3. Does the study directly link to uncertainties described in the conceptual model?
4. Can the study conditions be met, and the required permits obtained considering the lead time?
5. If proposed as *in lieu* of RPA IV.2.1, is it likely to provide protection for San Joaquin steelhead equal to or greater than RPA IV.2.1/IV.2.3 +?
6. Is the project implementable (funds, staff, water, fish protection)?

   Will the results be available in time to influence operations within one calendar year?

APPENDIX I
SDSRC MEETING GUIDELINES

DRAFT Meeting Guidelines for the South Delta Salmonid Research Collaborative Process January 29, 2013

The following meeting guidelines are intended to support the broad purpose of the South Delta Salmonid Research Collaborative Process (SDSRCP): *To bring together lead researchers and agency staff to review and discuss questions related to salmon survival and hydrologic conditions in the South Delta, to discuss conceptual theories and need for ongoing analyses of existing data sets, development of modeling related tools, and discuss new management-driven research needs for experimental design to be implemented in Spring 2014*. In particular, these guidelines are intended to promote the respectful and constructive exchange of technical and scientific information and ideas related to salmonid research in the South Delta. *All SDSRCP participants are expected to adhere to these guidelines as a condition of their participation.*

Respectful interaction. SDSRCP participants will interact in ways that consistently demonstrate respect for individuals despite differences in professional views, values, or interests. This includes:

- Using appropriate language
- Allowing speakers to finish
- Foregoing personal attacks
- Sharing available time
- Ensuring humor is not at the expense of other participants

Focused participation. SDSRCP participants will focus presentations, comments, and interactions with others on agenda topics and will honor requests to stay "on track." This commitment includes maintaining a focus on technical and scientific topics and taking individual responsibility for keeping current.

Good faith. SDSRCP participants are expected to support the purpose for the SDSRCP through their participation. This contribution includes listening before evaluating and taking responsibility for the reliability of information offered for consideration by others.

Consistent Attendance. The SCSRCP will benefit from consistent attendance at scheduled meetings in order to meet its ambitious timeline. It is designed for thoughtful, extended information exchange and discussion involving complex scientific and technical topics. The process will remain open to any participant with relevant scientific or technical expertise and information interested in participating consistent with these guidelines.

Cell phone/Smart phone. Participants will refrain from disruptive cell/smart phone use during meetings. Cell phones and other electronic communications devices will be turned off or set to "silent" mode; important calls or messages will be addressed outside the meeting venue.

Recording. Participants agree to refrain from audio or video recording, or the taking of photographs, during SDSRCP meetings.

Meeting Summaries. NMFS plans to prepare written summaries of SCSRCP meetings, and will circulate a draft summary following each meeting for input by participants.

Interaction with the Media. SDSRCP participants will not attribute views, positions, or statements to other participants outside the SDSRCP process, including but not limited to communications with members of the media. This limitation does not extend to discussions about the SDSRCP process within a participant's organization.

APPENDIX J
DESKTOP SURVIVAL STUDY

Collaborative Hypothesis Testing Based on Analysis of Existing Remote Sensing Fish Migration and Survival Studies in the Sacramento – San Joaquin Delta

Prepared by:

South Delta Collaborative Data Analysis Team
September 18, 2013

Introduction

Over the past 15 years more than two dozen remote sensing (e.g., acoustic and radio tagging) experimental studies on fish migration have been conducted in the Sacramento River, San Joaquin River, many upstream tributaries, and within the Delta. There have also been a number of coded wire tag (CWT) mark-recapture studies conducted in the rivers and Delta that provide additional results that can be used to further identify and test various hypotheses in conjunction with results of acoustic and radio tag studies. These studies include, but are not limited to, studies in the north Delta at the Delta Cross Channel and other channel junctions (Perry et al. 2010), releases near Red Bluff (McFarland et al. 2009, Michel 2010, Hayes pers com.), Georgiana Slough non-physical barrier investigations (DWR 2012, 2013, Perry et al. 2012), and the north, central, and south Delta (e.g., Vogel 2002, 2004). In addition, acoustic tag studies have recently been conducted as part of the U.S. Army Corps of Engineers levee bank evaluations, the Sacramento Municipal Sewage Treatment plant outfall evaluation, Freeport Regional Water Project intake evaluation, and others. Studies have also been conducted in the south Delta as part of the Vernalis Adaptive Management Program (VAMP) (SJRGA 2013, Buchanan et al. 2013, Vogel 2010, 2011), Head of Old River investigations (Bowen and Bark 2012, Bowen et al. 2012, DWR 2013), and others. The East Bay Municipal Utilities District (Setka pers. Com.) has conducted remote sensing studies for juvenile salmonids on the Mokelumne River. These and other studies have generated hundreds of millions of individual tag detections and present a wealth of information that can be used for further testing and evaluation of alternative hypotheses, as well as providing guidance on the development of the experimental design and analysis of future remote-sensing experimental studies. Advantages of the data re-analysis include maximizing the use and value of prior studies, no requirements for permits or regulatory approvals, no equipment purchases, tagging, field deployment and logistic support for field data collection efforts, collaborative interdisciplinary approach to establishing a robust data management framework and technical foundation for future experimental studies and the identification of potential management actions designed to improve the survival of juvenile salmonids during migration through the lower rivers and Delta. Additionally, some fish telemetry studies in the Delta have been conducted, but the data have not yet been analyzed.

Many of these studies were originally designed to test specific hypotheses and issues, such as the experimental evaluation of guidance performance of a non-physical barrier located in the Sacramento River and Georgiana Slough, but also provide information that can be used to test additional hypotheses. Results of many of the remote-sensing studies can be integrated with additional information currently available on environmental covariates such as water velocities, turbidity or light levels, water temperature conditions, or other factors that were not originally included in the basic experimental design, that can be used in an integrated interdisciplinary fashion to further evaluate the effects of various environmental and biological factors on results of remote-sensing studies. In addition, opportunities exist to integrate results among a variety of experimental studies to expand the geographic area, sample sizes, and range of environmental variation that allows more robust hypothesis testing than can be conducted with individual study results alone. The synthesis of findings across a variety of interdisciplinary studies provides an opportunity to test and evaluate various hypotheses and to strengthen the overall analytical framework available for evaluating the response of juvenile Chinook salmon, steelhead, and other fish species to conditions that occur within the Sacramento and San Joaquin River systems and Delta in response to factors such as seasonal variation in river flows, export operations from the State Water Project (SWP) and Central Valley Project (CVP) on hydrodynamic conditions occurring within the central and southern regions of the Delta (e.g., Old and Middle River (OMR) reverse flow magnitude, QWest, tides, or other hydrodynamic and water quality conditions) and the interaction between hydrologic conditions occurring at channel junctions on route selection, reach-specific survival as a function of various environmental conditions, overall survival of juvenile salmonids migrating through the Bay-Delta estuary, and the identification of potential management actions that could be used to improve the level of survival and the contribution of juvenile production to adult population abundance.

In addition, opportunities exist within the existing data sets to further evaluate the effects of factors such as release location, size and origin of experimental animals, tagging techniques and individual tagger effects, variation in detection array deployment and operations, tag detection efficiencies as a function of tag size, channel configurations, and detection array deployment, as well as other experimental factors that influence the overall experimental design for future remote monitoring studies. Analysis of the wealth of information currently available from these prior remote-sensing field studies also provides a foundation for developing improved algorithms for detecting predation on tagged fish, the potential for automated tag processing and analysis, and the ability to improve and refine the overall experimental design (i.e., better definition of variation in migration rates and route-specific survival rates that influence sample size and subsequent power of field experiments) of future studies. The synthesis of information across these various interdisciplinary studies will provide a stronger and more robust framework for developing the experimental design, identifying testable hypotheses, improving analytical procedures, and identifying existing information that can be used to address specific hypotheses and further advance the scientific understanding of factors affecting migration rates, fish behavior, route selection, seasonal variation in predation, and reach specific and overall survival rates of juvenile salmonids migrating from the Sacramento and San Joaquin River systems through the Bay-Delta estuary. Results of this investigation will be used to improve the experimental design of future juvenile salmonid survival studies, identification of management actions, as well as the design of monitoring programs to evaluate the effectiveness of future management actions. This will also serve as a proof of concept for the application of "Big Data" analytical tools in fisheries management. A database management platform (Palantir described below) has been identified for use in the data re-analysis to organize and access specific data from various sources for use in the analysis as well as developing a multiparameter documented database of studies compiled as part of this project that would be available to other investigators and interested parties for further analysis and as a framework for compiling data from ongoing and future studies.

Background/Purpose

Radio- and acoustic fish tagging studies have been designed and implemented over the past 15 years as part of studies conducted in the Sacramento and San Joaquin Rivers and Delta by a variety of investigators including the US Bureau of Reclamation (USBR), California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), US Fish and Wildlife Service (USFWS), University of California, Davis (UCD), US Army Corps of Engineers, (ACOE), National Marine Fisheries Service (NMFS), San Joaquin River Group Authority (SJRGA), Sacramento Municipal Waste Water Treatment Plant, US Geological Survey (USGS), East Bay Municipal Utilities District (EBMUD), and others. Additional studies are currently being designed and implemented. Results of these studies, however, have not been systematically analyzed to test many of the hypotheses that exist regarding the movement and survival functions for juvenile Chinook salmon and steelhead during their emigration through the tributary rivers and Delta. Further, results of many of these studies have not been integrated with other available environmental data and data from other studies in an attempt to identify relationships and correlations not discernible in the data from individual studies alone. In addition, these existing data sets can be used to test the effects of various experimental design elements that can then be used to inform the design and implementation of fish migration and survival studies in the future. For example, results of past studies can be used to assess the sample size and statistical power of future experimental investigations and alternative release strategies, as well as to identify key environmental covariates for inclusion in subsequent investigations. Re-analysis of existing study results is an efficient and cost-effective method to assess many of these factors and to develop a more robust experimental and analytical framework for the design and analysis of subsequent studies.

The data re-analysis would be done collaboratively with the original investigators, using a recently developed "Big Data" analytical platform that facilitates easy integration of disparate data sets, a fast collaborative workflow across multiple investigators, and knowledge management through the explicit digital capture of original data, assumptions, and analyses. The integration and analysis of results from multiple studies would also serve to increase sample sizes and statistical power of the analyses.

Analytical Approach

The approach to the data re-analysis would include a compilation of acoustic- and radio-tag studies conducted in the Bay-Delta. For each previous study an assessment would be made of the instrumentation and receiver deployment related to the potential use of various data sets to address specific hypotheses (some data sets may be useful for assessing reach-specific survival while others may be useful of examining fish migration characteristics, others may be determined to not be appropriate for inclusion in the analyses, etc.). The study objectives, methods, and results of analyses of each of the original studies would be reviewed and critiqued for use in this analysis, and stored for easy reference in the analytical platform. Based on the receiver arrays and release locations, specific reaches would be selected for inclusion in the analysis. Data from the original receiver detections, in addition to data from other sources on river flows, tidal hydrodynamics (including simulation model results), water temperature, turbidity, and habitat conditions would also be compiled.

This re-analysis would begin with collaborative data exploration that would allow all investigators to evaluate and analyze their data alongside the results of other acoustic- and radio-tag studies, as well as the array of related environmental data that could be related to survival. This initial data exploration will allow investigators to identify and focus on the most important areas of correlation, and the resulting data sets describing these important relationships would then be analyzed statistically using univariate and multivariate techniques to address specific hypotheses. Dr. Manly and other scientists on the assessment team will assist in identifying appropriate statistical tests, validating underlying assumptions, and interpreting the significance and applicability of test results.
Based on the scope of individual remote-sensing studies and the available data, a data management plan will be developed that identifies data from various studies that will be used to analyze and evaluate specific hypotheses and elements of the experimental design. The data analysis plan will also identify other sources of data, such as data on channel velocities developed by USGS, turbidity monitoring, results of water temperature monitoring, data on river channel flows, water quality monitoring results for electrical conductivity and other constituents, information on channel configuration and bathymetry, information on submerged aquatic vegetation (SAV), SWP and CVP export rates, and other relevant information that will be used in combination with results of the remote-sensing studies as part of the overall integrated multidisciplinary data analysis framework. The source and resolution of each of the individual data sets will be evaluated to determine opportunities and constraints for integrating information among various studies and data sources. Information on time scales, data resolution, and other parameters applicable to the use of individual or multiple data sets to test specific hypotheses will be evaluated within the framework of statistical hypothesis testing. The data analysis plan will include consideration of descriptive statistics, classical statistical analysis, the use of general linear modeling (GLM), application of reach-specific modeling techniques, as well as the potential application of hydrodynamic and water quality simulation modeling as part of the overall analysis of individual data sets and hypotheses. The proposed data analysis team includes interdisciplinary expertise in the analysis and interpretation of remote-sensing data sets, hydrodynamics and water quality conditions within the lower rivers and Delta, statistical and analytical approaches, and the

application of various alternative data analysis techniques that may be applicable to inclusion in the data analysis plan. The data analysis plan will serve as the overall framework and guidance for directing and prioritizing subsequent analyses, documentation of data sets and analytical methods, as well as identifying key findings resulting from each of the individual analyses as well as additional hypotheses that can be tested using one or more of the data sets compiled as part of this project.

Objectives

The objectives of the re-analysis of existing data from remote-sensing experimental investigations conducted within the Bay-Delta estuary include two fundamental elements. The first element is hypothesis testing in which a variety of hypotheses have been identified that can be tested and evaluated utilizing one or more of the existing experimental study data sets and the integration of both biotic and abiotic covariates as part of the hypothesis testing approach. The second major element is a synthesis of information and findings from both the hypothesis testing as well as review of technical documentation on prior studies (e.g., meta-analyses), discussions with principal investigators, and the identification and synthesis of information across studies that serves as a basis for further refining the technical foundation for the experimental design, implementation, and analysis of future remote-sensing studies. The hypothesis testing and refined experimental design elements of the proposed project are briefly identified and discussed below.

Hypothesis Testing

The conceptual model of juvenile salmonid survival in the south Delta (Figure 1) identifies a number of null hypotheses regarding the drivers-linkages-outcomes that can be tested statistically using data collected as part of past and current radio- and acoustic-tag experimental investigations. The highest priority hypotheses to be evaluated in the data re-analysis focus on the effects, if any, of river and tidal flows, SWP and CVP export rates, OMR reverse flow, on migration rate, route selection, and survival include, but are not limited to:

Ho: Juvenile salmonid survival through specific reaches (reach-specific survival) in the lower Sacramento and San Joaquin rivers and Delta and throughout the region (survival to Chipps Island) is independent of river and tidal flows, OMR reverse flow, SWP and CVP export rates, and/or the duration that a juvenile salmonid resides in the Delta during emigration.

Ho: Juvenile salmonid survival is independent of route selection and route length.

Ho: Route selection is independent of river and tidal flows, SWP and CVP export rates, OMR reverse flow, within the reach and at channel junctions.

Ho: Survival, migration rate, and route selection are not significantly different between juvenile steelhead and Chinook salmon.

Ho: The rate of juvenile salmonid emigration through a reach is independent of river and tidal flows, SWP and CVP export rates, OMR reverse flow, and tidal flow during the period that a fish is migrating through the reach.

Second priority hypotheses to be evaluated, and in some cases results of previous analyses replicated and validated, based on available data and schedule, that will help in evaluating and refining guidance for future studies include but are not limited to:

Ho: Route selection is independent of proportional flow splits.
Ho: Survival is uniform among all reaches (riverine and tidal).
Ho: Migration rates are uniform among all reaches (riverine and tidal).
Ho: Survival rate, behavioral response to channel junctions and route selection are independent of release location.
Ho: Migration rates and migration timing are independent of day and night.
Ho: The duration of residence of a juvenile salmonid within a reach is independent of river and tidal flows, SWP and CVP export rates, OMR reverse flow.
Ho: Juvenile salmonid survival within a reach is independent of habitat conditions including SAV (note that information is available on SAV in many Delta channels from aerial photographs and remote sensing but may not be available for specific years or seasons when acoustic or radio tag studies were conducted. In addition, the response of tagged fish to habitat complexity on a site-specific scale and specific habitat features cannot be assessed with existing data, however, general habitat characteristics such as average channel width, average depth, presence of riprap, presence of SAV, and other metrics will be compiled and used as covariates in the analyses.
Ho: Juvenile salmonid survival is independent of water clarity and turbidity within a reach.
Ho: Juvenile salmonid survival within a reach is independent of average water temperatures.
Ho: Juvenile salmonid survival is independent of fish length, age, hatchery source, tagging, transport, and release locations and strategies.

Refined Experimental Design Elements

Over the past 15 years a number of remote-sensing and studies have been designed, implemented, and analyzed utilizing both juvenile salmonids, as well as tagging potential predatory species. Through development of these prior experimental studies information has been gained on a variety of elements of the experimental design that can be used to further develop a robust technical foundation for future study efforts. Information from these prior studies will be reviewed and evaluated to serve as a framework for identifying areas of refinement in future experimental designs. In addition, information from prior remote-sensing studies, evaluated in context with information from other monitoring programs such as those on water velocities, river flows, channel junctions morphology, water quality conditions, and other factors, will also be used in helping to refine guidance for the design, implementation, and analysis of future remote-sensing studies. Some of the areas that will be specifically examined for use in refining future experiments are briefly described below.

Environmental Variation – one of the complexities in conducting field experimental evaluations within the Delta and tributary rivers includes variation in a variety of environmental parameters associated with both natural variation (e.g., seasonal and daily variation in water temperatures, hydrology, etc.) and operational variation (e.g., variation in gate operations, export rates, etc.). These parameters may include variation in river flows, tidal conditions, turbidity, seasonal and daily variation in water temperature and salinity, variation in SWP and CVP export rates and associated variation in OMR reverse flows, and other factors. The degree of variation within key parameters used in the analysis has a direct influence on the power of the resulting analyses to detect meaningful relationships between specific environmental parameters and the response of tagged salmonids and other fish. In some investigations, the degree of variation in specific environmental parameters such as San Joaquin River flow and SWP and CVP export rates as part of the VAMP studies have been regulated to provide relatively uniform conditions over the duration of the test. In other studies, such as the Six-year steelhead survival studies, no control over parameters such as San Joaquin River flow or SWP/CVP export rates has been exercised. Operational variation in factors such as reservoir releases and resulting instream flows, gate operations, OMR reverse flows, and export rates can be reduced and managed with varying degrees of success if included as part of the experimental design and coordination with operations managers while natural variation is largely uncontrolled. Analyses of results from various investigations will be reviewed to assess the role of environmental variation in the power of the experimental design for detecting relationships between environmental conditions and associated responses of target fish species, as well as recommendations for the approach to addressing environmental variation in subsequent studies.

Environmental Monitoring – environmental monitoring associated with a number of remote-sensing experimental studies conducted in the Delta have relied on existing routine monitoring for parameters such as flow as reflected by USGS and DWR gauging station records, water temperature, electrical conductivity, and turbidity as measured by grab samples associated with specific individual fishery collection activities, and in some cases, such as the Georgiana Slough non-physical barrier and Delta Cross Channel investigations, detailed continuous monitoring of localized water velocities through the use of instrumentation such as acoustic Doppler profilers. Past studies will be reviewed to determine whether or not more detailed environmental monitoring associated with specific experimental tests would have contributed to improved data analysis and interpretation of results.

Application of Hydrodynamic and Water Quality Simulation Models – results of hydrodynamic and water quality simulation modeling has been used to predict time-specific environmental conditions at given locations. Results of comparisons between simulated environmental conditions and observed conditions at specific locations will be conducted to assess the applicability, opportunities, and constraints associated with applying model simulations for predicting environmental covariates.

Release Locations – there has been considerable debate regarding the effect of release location on the resulting behavior and survival of juvenile salmonids within the Bay-Delta estuary. In some studies, release locations have been established in relatively close proximity to the measurement locations of interest, while in other studies release locations have been tens or in some cases more than 100 miles upstream of the Delta. It has been hypothesized that locating release locations further upstream offers a longer opportunity for fish to acclimate to ambient conditions within the river system, reduce the potential effects of handling and tagging stress, and improve the response of fish to predators and other environmental conditions. In contrast, predation mortality has been observed to be a major factor affecting the survival and abundance of tagged fish migrating downstream within the tributary rivers and Delta. Locating release locations further upstream may contribute to greater predation losses and subsequently reduced sample sizes and reduced statistical power of remote-sensing experiments. Analyses will be performed to assess the potential relationship between alternative recent release locations and the subsequent response of tagged fish to treatment conditions.

Sample Size/Power Analysis – there exists a strong relationship between the number of tagged fish included in an experimental treatment, variation in the survival or migration response of the fish, and the statistical power of the resulting analyses to detect statistically significant changes in the behavioral response or survival of the tagged fish. In general, a larger sample size of tagged fish will produce greater statistical power for an experimental design to detect significant differences between treatment and control conditions. Increasing sample size, however, results in a substantial increase in both the logistic requirements for tagging and release as well as the cost associated with remote-sensing studies. Analyses will be performed for various types of experimental designs to utilize existing information in estimating the relationship between sample size and associated statistical power for various types of experimental designs and release locations.

Predator Tagging – a number of remote-sensing studies have included, as an experimental element, tagging and monitoring predatory fish (e.g., Vogel 2011, 2012). Tagged predators typically include striped bass, largemouth bass, pikeminnow, and catfish. Results of these studies will be reviewed to assess the information gained through predator tagging in understanding the role of predation as a factor influencing the survival of tagged fish such as juvenile salmonids. Information will also be assessed regarding the behavioral patterns of predatory fish and how information from these studies can be used in better defining predation events that may otherwise bias results of remote-sensing experimental studies. Predatory fish are known to prey on tagged salmonids and other fish, however under current conditions, there is no ability to specifically determine when a predation event has occurred. The current inability to determine whether or not a predation event has occurred represents a major source of potential uncertainty and bias in the interpretation and analysis of prior remote-sensing experimental study results.

Predator Filters – in an effort to improve the analysis and interpretation of results of remote-sensing experimental studies information on the behavior of predatory fish and how migration patterns change once a juvenile salmonid or other tagged fish has been preyed upon has been used in an effort to reduce the uncertainty associated with predation (Vogel 2009, 2010, Bowen and Bark 2012, Buchanan et al. 2013). These predation filters, or rules for determining when an individual tag should remain in the database identified as a target fish species versus identified within the analysis as a target fish preyed upon by a predatory fish, will be reviewed and evaluated. In addition, preliminary results of experimental investigations using alternative tag technologies designed to better identify predation events will also be considered as part of the assessment.

Remote-Sensing Tags/Application of Alternative Technologies – there are currently a number of alternative remote-sensing technologies that have been applied under various experimental conditions to studies within the Delta and upstream tributaries. These alternative technologies include various configurations of acoustic tags, radio tags, and the application of passive integrated transponder (PIT) tag technologies. Each of these alternative technologies has strengths and weaknesses. In addition, some vendors claim to have recently developed tags that can detect predation events. The assessment will include consideration of the application of various technologies as part of the experimental design for prior studies with recommendations for consideration of alternative tag technologies for future studies.

Tagging Method/Tagger Effects – remote-sensing tags require handling and, in most cases, surgical implantation of tags into the body cavity of the target fish species. These tagging techniques are stressful and invasive and may contribute to changes in fish behavior, ability to avoid predation, and other areas of uncertainty regarding the interpretation of remote-sensing tag results. In addition, individuals engaged in tagging fish have various levels of training and expertise that can influence the resulting survival or migration patterns for individual fish based on their tagging history. Information on the proposed standard operating procedures for conducting acoustic tagging developed by USGS (Liedtke et al. 2012) as well as monitoring the results for individual taggers and determining the effects of individual taggers on survival or migration behavior results will be considered as part of the evaluation. Since remote-sensing tags are individually identifiable, typical standard methods include the identification of individual taggers responsible for tagging individual fish. Variation in the results of survival estimates for groups of fish that were tagged by various individuals will be analyzed to determine whether or not there are statistically identifiable variations in survival or migration rates associated with the individuals engaged in fish handling and tagging. Results of the assessment will be used in recommending approaches to standardizing tagging methods, as well as analyses to determine whether or not tagger effects are a source of variation in the results of experimental studies.

Hatchery Surrogates – the vast majority of juvenile salmonids that have been used in remote-sensing experimental studies have been of hatchery origin. In many cases as a result of the size of acoustic tags late fall-run Chinook salmon, typically produced in the Coleman National Fish Hatchery, have been used for many experimental studies. Yearling steelhead produced in hatcheries have also been used frequently as part of survival studies. There is growing debate, however, regarding the applicability of hatchery-produced juvenile salmonids as representative surrogates for various species and lifestages of wild salmonids naturally produced within the Sacramento-San Joaquin system. Emerging studies are currently being conducted to provide information on the comparative relationship between migration behavior and survival for hatchery and in-river produced salmonids.

For example, NMFS initiated as study in 2013 that, in part, is designed to obtain comparative results of fish behavior and survival for wild and hatchery-produced juvenile salmonids (Hayes pers. Com.). Information available will be compiled and used as part of a preliminary assessment of the potential applicability of hatchery-produced salmonids as an appropriate surrogate for assessing the effects of various environmental conditions on the survival and migration of wild fish.

Fish Characteristics – variation in results of radio or acoustic tag studies may result from variation in the source of test fish, physiological state, age and size, fish handling, tagging, and release, and other factors. As part of the re-analysis of existing data opportunities will be identified that allow statistical tests and comparisons of factors such as migration rate and survival for test fish of various origins. Tests will be conducted based on available data of the independence of sources of test fish, independence among brood years and age, size, and physiological status of test fish, date and timing of release, tagger effects, and other factors that may affect test results.

Survival Models – a number of analytical approaches have been developed for quantifying reach-specific as well as overall survival of juvenile salmonids and other fish migrating downstream through the tributary rivers and Sacramento-San Joaquin Delta. Models have also been developed for quantitatively assessing route-specific migration behaviors and the associated confidence intervals for both reach-specific survival estimates as well as migration route selection. The available analytical models will be evaluated and compared as part of the assessment. The application of various modeling techniques for use in assessing survival estimates for various regions and specific reaches of the system, as well as the statistical relationship between survival or migration behavior and various environmental covariates through use of multiple regression models or the application of GLM modeling techniques will also be assessed. Recommendations will be developed for the application of specific analytical techniques associated with various hypotheses and experimental objectives.

Detection Arrays – a variety of remote-sensing detection array configurations have been used in Bay-Delta studies including one-dimensional, two-dimensional, and three-dimensional monitoring arrays, in addition to the application of dual detectors at specific locations to enhance the probability of detection of tagged fish migrating through a given reach or area of the experimental system. The potential application and information developed using alternative detection array deployment methods will be reviewed and assessed to support recommendations for the application of various techniques for improving detection probability and the resulting estimates of reach-specific survival or migration pathway selection, as well as reducing confidence intervals associated with tag detection probabilities.

Tag Life/Tag Size – manufacturers of remote-sensing technologies have utilized a variety of techniques over the past decade to reduce the size of remote-sensing tags, improve battery life and efficiency, and reduce the effects tag size as a factor influencing the overall health and condition of tagged fish. Consideration will be given as part of the assessment to evaluating the relationship between tag size, the distance and probability of tag detection, the duration of active tag life, how tag life studies can be used as an integral element of improving the overall experimental design and analysis of remote-sensing studies, and how tag life uncertainty is a factor affecting results of experimental studies. The analysis will include a discussion of the potential opportunities and constraints for the application of various tag sizes and technologies as they relate to the fundamental experimental design and objectives of remote-sensing studies.

Test Monitoring Duration – the assessment will include consideration of the potential duration for various types of experimental designs based on factors such as the location of release relative to the treatment or control locations, the effects of flow on migration and residency of tagged fish within a given area, the effects of seasonal water temperature and tidal conditions, and other factors that influence the planned duration for testing and monitoring following the release of tagged fish. The assessment will include analyses of the duration of passage for juvenile salmonids within various regions of the Bay-Delta estuary as a function of the distance upstream where the release occurs, the size of fish, the seasonal timing of releases, and other factors.

Replication – there is a need to develop improved statistical power and reliability of analyses of remote-sensing studies through replication of treatment effects. It is difficult to achieve statistical replication in field experiments as a result of variation in other factors such as seasonal water temperatures, river flows, variation and fish size, and other parameters. Consideration will be given as part of the assessment to evaluating the approach and resulting power developed through replicated experimental designs as part of remote-sensing studies. In addition consideration will be given to including a wide range of treatment effects (e.g., testing extreme conditions) as an experimental approach for improving the ability of remote-sensing experimental designs in detecting significant responses of tagged fish to environmental treatment effects.

Linkages to Mechanisms and Functional Relationships Included in Lifecycle Population Models – the development of survival models, models of fish migration, and overall lifecycle models for salmonids and other fish species is an important analytical tool for improving the overall understanding of the effects of various environmental factors on fish behavior and survival, as well as assessing the potential effectiveness of various alternative management actions for improving protection and enhancing habitat and other conditions for target fish species. Linkages between the results of remote-sensing studies and the refinement of experimental designs to provide information useful in developing functional relationships and mechanisms that can be included in survival, migration, and lifecycle models will be assessed as part of the overall foundation for developing future experimental designs.

Opportunities to Develop Automated Data Processing Algorithms and Functions that Expedite and Streamline Data Processing – remote-sensing studies generate a tremendous amount of information over a relatively short period of time. The large volumes of data generated by remote-sensing experimental designs have, in the past, resulted in substantial delays in the time required for data processing and analysis of results from individual tests. Opportunities exist through the analysis of prior remote-sensing studies to identify opportunities for employing specific computerized algorithms, analytical frameworks, and other procedures that would help facilitate improved and accelerated data processing and analysis of remote-sensing results. The assessment will include consideration of opportunities to employ computerized algorithms and other processes, in a large-scale database format, to facilitate and expedite data processing and analysis as part of future studies.

Detection of Upstream Migration by Juvenile Fish Following Release – the behavioral response of juvenile salmonids following release as part of an experimental remote- sensing investigation may include a variety of behaviors. Tagged fish may rapidly move downstream following release, may remain in a localized area for a period of time following release, or in some cases may actually migrate upstream away from the release location. Variation in the behavioral response of tagged fish following release is a factor influencing the analysis of migratory behaviors and, in some cases, may increase the uncertainty in results regarding reach-specific migration behavior and survival estimates. The migration behavior of fish encountering various structures, migrating differentially between day and nighttime conditions, fish size, the time of release (day/night, different tidal stages, etc.), water temperature at the time of release, and other factors may all influence fish behavior and the interpretation of experimental results from remote-sensing studies. The application of mobile monitoring to assess changes in fish distribution following release will be assessed. Information on the occurrence of tagged fish detected at monitoring locations upstream from the point of release for various species and size classes of fish will also be assessed as part of the investigation. The implications of fish behavior following release will also be discussed with respect to the duration of monitoring, the interpretation of results, and the influence of variation in fish behavior on factors such as reach-specific survival, estimation of migration rates as a function of various environmental conditions, and route selection.

Methods/Approach

An interdisciplinary team of fishery biologists, biostatisticians, hydrologists, modelers, and the original investigators has been assembled to perform the analyses. The data sets compiled for each of the selected studies discussed above would be reviewed for quality control prior to analysis. The data sets would include information on tagging, fish species, origin and size, release location and strategy, tag detection, and environmental covariates linked both geographically and temporally to each of the fishery studies. All relevant metadata associated with all of the investigations will be incorporated in the Palantir platform as well. The data sets would include information on tagging, release, tag detection, and covariates linked both geographically and temporally to each of the fishery studies. Hydrology, water quality, hydrodynamic, climate, and related biology data would be incorporated into the database platform as well. Statistical analyses would then be performed and documented for each of the hypotheses being tested. Results of the analyses will be documented in a draft and final technical report as well as summarized in presentations and briefings for managers and permanently recorded for easy replication in the Palantir platform. Scientists from the assessment team will serve as advisors to help oversee the data selection, analyses, and critically review technical documentation as part of the project.

Given the large number of studies, the diversity of data types and formats, and the need to collaborate across multiple investigators whose work spanned many years, this effort will be greatly enhanced through the use of recently available "Big Data" analytical tools. The Palantir platform provides a web-based, user-friendly suite of spatial, temporal, and statistical tools all linked through an advanced data integration, collaborative analysis, and knowledge management platform. Further, NewFields has already compiled a large database of related environmental data in the Palantir platform that would greatly accelerate this work.

Data Compilation/Transfer

Through discussions with the principal investigators involved in prior studies as well as review of technical documentation reports and information contained in individual prior project databases, specific data sets will be identified and compiled into the Palantir database management platform that can subsequently be used for further analysis of individual data sets as well as the integration and synthesis across data sets as appropriate for addressing specific elements of the proposed project objectives. Data transfer from the original principal investigators and supporting agencies into the compiled data management framework will be accomplished on an individual data set basis. For each of the individual data sets, metadata describing each of the individual data fields, units of measure, station identifications, and other relevant information will also be documented. In addition, as part of the data transfer and compilation process, data fields will be standardized, to the extent practicable, across data sets to allow for easier integration of data sets among a variety of studies as well as synchronization of data sets, based on date and time stamps, GPS locations, and other relevant information, that will facilitate the integration of information from remote-sensing studies and other environmental monitoring programs conducted within the lower rivers and Delta. In addition, information on the specific locations of individual tag detection arrays, monitor identifications, information on sentinel tags, tag detection calibration and validation, and information on the source and tagging history of individual fish used in each of the remote-sensing studies will also be documented as part of the information transfer.

Data Management Framework

As a result of the large-scale and interdisciplinary nature of data that will be compiled from various remote-sensing studies and other data sources as part of the proposed project, a data management structure has been identified and selected that will allow documentation of individual datasets, facilitate data queries and the identification of appropriate data sets for integration, provide easy access to subsets of the available database for subsequent focus statistical analysis, and modeling. Use of the Palantir data management platform will be an integral part of the overall success of the proposed data re-analysis program. The Palantir database management platform has been developed and tested under the direct supervision of Dr. Mark Tomkins.

Data QA/QC

As part to the initial compilation and transfer of information from various remote-sensing studies and other data sources, documentation will be maintained on quality assurance/quality control (QA/QC) of the data sets. Descriptive statistics, as well as a variety of graphical techniques, will be applied to various data sets and parameters to identify the distribution of information and potential data outliers. Evidence of instrument failure, miss-labeled data, or information that is outside of the normal range of recorded parameters will be identified as potential data outliers and documented in the event that they are excluded from subsequent analysis. One of the objectives of the data compilation and quality assurance checks is to develop a single, comprehensive, multifactorial data set that can be used as a platform for data analysis and integration among studies and for use as a framework for data management for future investigations. To help ensure the highest possible quality of data used in these analyses results of each of the individual data sets will be reviewed as part of the proposed project with subsequent discussions with the appropriate principal investigator in the event that there are questions or inconsistencies identified within or among individual data sets.

Data Challenges

Challenges for the project include the lack of synoptic data collected on the response of radio- and acoustic-tagged salmonids and the corresponding water temperatures, turbidity levels, river flows and velocities, and tidal hydrodynamics needed to test one or more of the hypotheses. Additional challenges include studies that were designed and conducted to achieve objectives other that those to be addressed as part of this investigation, lack of data documentation or missing data, confounding environmental covariates, and the uncertainty in determining if, when, and where a juvenile salmonid was preyed on or lost as a result of some other factor (e.g., entrained into an unscreened diversion). A specific set of metrics (e.g., predation filter rules) will be used to assess the likelihood that a predation event had occurred based on examination and analysis of data such as the Georgiana Slough and HORB studies where predators and prey were monitored using 2- or 3-dimensional tag detection technology.

Results

Integration of results on survival and migration of tagged fish in combinations with interdisciplinary information on other environmental covariates, will include presentation of descriptive statistics, the application of graphical summaries to depict various relationships, the application of various statistical models and statistical analysis techniques, including the development of point estimates and confidence intervals for various parameters, will be presented as part of the results of this investigation. Results of the investigation will also include results of various modeling techniques for survival and route selection, development of survival estimates, migration model estimates, and the potential application of results to lifecycle modeling will be discussed. Results of individual hypothesis tests will be presented along with a discussion of alternative hypotheses with respect to various functions and potential mechanisms. For each of the results, information will be documented on the source of data used in the analysis, analytical methods, the rationale for various approaches to data analysis, data transformations and statistical testing of the validity of underlying assumptions, as well as exploration of alternative approaches for data analysis and organization of results. For many of the results, information will also be presented and discussed regarding the implications of the resulting relationships or information developed through these analyses as they apply to improved understanding of the life history of tagged fish, the interactions and relationships between behavior, survival, and route selection and various environmental covariates, the effects of potential predation on resulting estimates of reach-specific survival and migration rates, and other information with respect to implications for identifying and evaluating potential management actions designed to improve and enhance conditions for Central Valley salmonids and other fish species. Areas of uncertainty with regard to the analyses and the interpretation of results, including such things as variation in environmental covariates or the effects of variation on sample size with respect to the power of a given experimental design to statistically detect a treatment effect, will be discussed.

Results of these analyses will provide a foundation for discussing various key elements to be considered in future experimental designs as well as compromises that may occur in developing an experimental design based on the number of replicates, the design of the treatment effects (e.g., identifying environmental extremes for purposes of testing response with the greatest likelihood of detecting significant differences), the effects on replication over time as it affects the analysis of trends and confidence in resulting relationships, the ability of hatchery produced salmonids and other fish to effectively represent, as surrogates, the behavior, route selection, migration rates, and survival of wild salmonids, and variation between fish sizes and life stages as a factor influencing the response of tagged fish to environmental conditions. These and other factors will be addressed and discussed as part of the results of this re-analysis in addition to factors affecting key elements in the experimental design decision process for future studies. Results of this re-analysis will also include development of a documented, large-scale, multifactorial database that will serve as an analytical framework for organizing information and facilitating future data analysis. Literature associated with the various studies will also be compiled in the form of an electronic reference library that will further provide useful information to investigators as they evaluate results of existing experimental studies and design remote-sensing studies to be implemented in the future.

Application of Findings to Management

Managers and other interested parties will have an opportunity to assist in identifying priorities for data analysis and hypothesis testing as part of the data re-analysis process. Results of the re-analysis of existing data will provide managers with new insights into the experimental design considerations of future studies (e.g., sample size and statistical power, detection array deployment, release strategies, development of interdisciplinary studies that include detailed water quality, habitat, and hydrodynamic measurements, etc.). The study will also help to identify data gaps from previous investigations. Results of hypothesis testing will help inform development of the functional relationships (drivers-linkages-outcomes) shown in the conceptual model as well as addressed in development of salmonid lifecycle models. Study results will help identify specific functional relationships that affect juvenile salmonid survival and form part of an improved technical foundation for future study designs and potential management actions (e.g., consideration of modification of river flow to reduce predation mortality, effects of exports and tidal conditions on route selection and subsequent risk of mortality, etc.). Finally, conducting this work in the Palantir platform will yield an entirely new, easily accessible knowledge base that brings together all of the acoustic- and radio-tag data with a very large set of related data.

Assessment Team

As part of the proposed project an interdisciplinary team of scientists has been assembled as part of the assessment team. The assessment team will provide the overall scientific direction, assist in data management and data analysis, provide input on statistical analyses and modeling, assist in the identification of specific recommendations regarding refinements to the experimental design of remote-sensing studies, as well as integrating results across various studies and data sources. The data assessment team will also provide expertise in identifying opportunities and constraints in the application of prior study results to developing specific recommendations and study findings, conducting statistical power analyses and examining statistical confidence that can be placed in results of various investigations, as well as integrating information from an interdisciplinary perspective. The individuals included as part of the assessment team, and a brief description of their background and contribution to the proposed project team, are briefly described below.

Chuck Hanson (Hanson Environmental, Inc.) – Dr. Hanson has participated in a number of Bay-Delta survival studies and remote-sensing investigations including development and implementation of Vernalis Adaptive Management Plan (VAMP), participation in the Clifton Court Forebay steelhead predation investigations, participation in the Georgiana Slough non-physical barrier acoustic tag monitoring programs, participation in the design of experimental investigations to determine baseline survival of juvenile salmonids migrating from both the Sacramento and San Joaquin river systems, and other remote-sensing studies. Dr. Hanson would serve as project manager for the proposed investigation.

Barbara Byrne (National Marine Fisheries Service) – Ms. Byrne serves on the staff of the National Marine Fisheries Service (NMFS) and will assist in the design of individual analyses as well as the interpretation of results of this investigation as they relate to the evaluation of various protective actions including reasonable and prudent alternatives included in the NMFS Operations Criteria and Plan (OCAP) Biological Opinion for the CVP and SWP. Ms. Byrne will also provide a linkage between the technical project team and NMFS and other resource agency managers involved in Bay-Delta restoration efforts, management actions, and regulatory permitting.

David Delaney (Cramer Fish Sciences) – Dr. Delaney has been actively involved in leading the data analysis and statistical modeling of results from the 2012 stipulation studies in which acoustically tagged juvenile steelhead were released into the lower San Joaquin River and subsequently their migration and survival tracked and monitored at various locations within the central and Western Delta as a function of SWP/CVP exports and OMR reverse flows. Dr. Delaney has also been involved in the coordination of data analyses with other Delta remote sensing projects including development of reach-specific survival estimates and migration route selection for juvenile steelhead released into the lower San Joaquin River as part of the USBR Six-year juvenile steelhead survival studies.

Steve Lindley (National Marine Fisheries Service) – Dr. Lindley serves as senior staff to the NMFS Southwest Fisheries Science Center and is lead scientist for developing the NMFS winter-run Chinook salmon lifecycle model. Dr. Lindley has also participated in the design and direction of various remote monitoring studies including studies designed to evaluate migration and survival of juvenile salmonids within the Sacramento River, predation and predation management at specific locations on both the Sacramento River as well as the lower San Joaquin River. Dr. Lindley will facilitate the identification of specific analyses and data sets that would be applicable to refining the salmonids lifecycle model as well as developing results of technical analyses that can be used to identify and evaluate the potential for various alternative management actions intended to improve the protection and survival of juvenile salmonids migrating from the Sacramento and San Joaquin rivers through the Bay-Delta estuary.

Rebecca Buchanan (University of Washington) – Dr. Buchanan is an expert on data analysis and modeling of results from remote-sensing studies conducted both within the Bay-Delta estuary as well as other river systems in the Pacific Northwest. Dr. Buchanan is currently leading efforts to analyze reach-specific survival rates and migration route selection from acoustic tagging studies conducted within both the Sacramento and San Joaquin rivers including the VAMP studies and USBR Six-year steelhead survival studies. Dr. Buchanan will contribute to the identification of specific analytical techniques, modeling framework and approaches for determining reach-specific and overall survival rates, route selection and migration rate evaluations, as well as the overall integration of information among various studies as part of this investigation.

Bryan Manly (West, Inc.) – Dr. Manly has been actively involved in conducting a variety of statistical analyses of data collected on survival, population dynamics, and the relationship between the response of various fish species and environmental conditions within the Bay Delta estuary. Dr. Manly will provide assistance in developing appropriate statistical testing techniques, validation of statistical assumptions, assistance in the interpretation of results of statistical analyses, and the identification of various data sets appropriate for integration and analysis as part of this investigation.

Dave Vogel (Natural Resource Scientists, Inc.) – Mr. Vogel has been involved in the design and implementation of both radio tagging and acoustic tagging studies conducted in the Sacramento River system as part of the evaluations of the Red Bluff Diversion Dam, fish migration in the Delta Cross Channel, Georgiana Slough, Mokelumne River, the north, central, and south Delta, in addition to juvenile survival studies conducted in the lower San

Joaquin River and south Delta as part of VAMP. He has served as a Principal Investigator for 22 fish telemetry studies in the Delta. Mr. Vogel will provide assistance in identifying various appropriate data sources and remote monitoring studies, development of appropriate hypothesis testing, analysis of juvenile salmonid and predator behavior, and will contribute to developing results, findings, and recommendations from these analyses as they pertain to both hypothesis testing and refining the technical and scientific foundation for subsequent experimental design considerations for future remote monitoring studies within the rivers and Delta.

Jon Bureau (U.S. Geological Survey) – Mr. Bureau has extensive knowledge in conducting and evaluating results of hydrodynamic studies, water velocity monitoring and modeling, water quality monitoring and modeling, as well as the integration of information on hydrodynamic conditions and other factors affecting juvenile salmonid migration through the Sacramento and San Joaquin rivers and Delta. Mr. Bureau has been actively involved in the design, implementation, and analysis of results of acoustic monitoring studies as part of the North Delta Delta Cross Channel gate investigations, the Georgiana Slough non-physical barrier performance evaluations, and other studies conducted to monitor fish movement in relationship to environmental conditions occurring within the tributary rivers and Delta. Mr. Bureau will contribute to the integration of results of physical monitoring and hydrodynamic modeling results and analyses, water quality monitoring, and information on channel characteristics, tidal conditions, and other environmental covariates as they relate to the analysis and interpretation of results on the behavioral response, migration route selection, migration rate and timing, and reach-specific survival studies developed through remote monitoring of salmonids within the Delta.

Sheila Greene (Westlands Water District) – Ms. Greene has extensive long-term experience in data management for both survival studies as well as other biological monitoring programs within the Bay-Delta estuary in addition to detailed experience in integrating information on SWP and CVP export operations, results of hydrodynamic monitoring and modeling, and water quality studies within the Bay Delta estuary. Ms. Greene will help facilitate identifying specific data sources for inclusion as part of the comprehensive data set, provide information and assistance in the integration of information among various studies and data sources, assist in the interpretation and evaluation of statistical and modeling results, and assist in the development of specific recommendations for refinements to the experimental design for future remote monitoring studies.

Mark Tomkins (Newfields, Inc.) – Dr. Tomkins has extensive experience in management and analysis of large-scale interdisciplinary data sets. Dr. Tomkins has initiated development of a multifaceted large-scale database platform (Palantir) including results of various physical monitoring data sources as well as fishery and other biological monitoring conducted within the Sacramento and San Joaquin River systems and Delta. Dr. Tomkins will help oversee and manage the compilation of information as part of the integrated database, facilitate management of the database platform, and help facilitate and manage data queries and access to various elements of the compiled database as well as oversee the documentation of the database and QA/QC of the database.

Matt Holland (Delta Stewardship Council/Delta Science Program) – Dr. Holland serves as staff to the Delta Stewardship Council/Delta Science Program and will provide a linkage among various scientific investigators and individual studies conducted within the Bay-Delta estuary. Dr. Holland will also assist in identifying information sources, the integration of data among various studies, and will assist in the interpretation of results of various analyses as they relate to both scientific findings of individual analyses as well as recommendations related to management actions within the Bay Delta estuary.

Josh Murauskas (Anchor) - Mr. Muraushas has extensive experience with the data analysis for survival studies using CWT-tags, PIT-tags, and acoustic and radio telemetry conducted in the Columbia River, Puget Sound and northern British Columbia. Mr. Muraushas has extensive experience in using large datasets to address complex ecological questions. Mr. Muraushas will assist in identifying statistical analyses, survival modeling, and the integration of environmental covariates as part of the data re-analysis.

Melissa Bruns (Hanson Environmental, Inc.) – Ms. Bruns will assist in the compilation and transfer of data sets from various investigators into the comprehensive data management platform, assist in database documentation and QA/QC, assist in performing data queries, and assist in analysis of various data sets. Ms. Bruns has extensive experience in statistical analyses and database management and has been involved in the analysis and integration of information from various data sources related to the Bay-Delta estuary.

Project Scope/Tasks

The project scope and an outline of project tasks involved in the compilation, analysis, and documentation of information from prior remote-sensing studies used in developing the proposed project are briefly outlined below.

- Identify and inventory Bay-Delta remote sensing studies
- Compile technical reports for each study;
- Coordinate with each study PI regarding study constraints, opportunities, data transfer, study design, etc.;
- Develop data analysis plan including:
    - Hypotheses to be tested
    - Relevant studies
    - Data parameters
    - Environmental covariates
    - Data gaps
    - Statistical/model approach to analysis
    - Schedule
    - Level of effort
    - Documentation
- Compile data from multiple studies;

- Data QA/QC, metadata, data labels, GPS release locations and tag detectors, tagging data, release data, associated data (e.g., tag life, tag detection, centennial tags, etc.)
- Identify data sets for each analysis;
- Conduct statistical/model analyses (ANOVA, GLM, reach-specific survival, descriptive, etc.);
- Document hypotheses tested, data sources, analyses, results, and discussion for each analysis;
- Review results of each analysis with original PI;
- Synthesize data/analyses among studies;
- Document database and analytical results;
- Prepare draft technical documentation report;
- Independent peer review; and
- Prepare final technical documentation report.

Products/Deliverables

Documentation Report - As part of the proposed project, results will be documented in a technical documentation report that identifies the specific data sets that were used in each of the analyses, the experimental design and analytical approach, results, discussion, and recommendations developed from each of the individual analyses, as well as a synthesis of information across studies for use as part of the foundation for (1) designing future remote-sensing studies, (2) identifying potential management actions that would improve and enhance the overall survival of juvenile salmonids and other fish species migrating and inhabiting the Sacramento and San Joaquin River systems and Bay-Delta estuary, and (3) identifying areas for further investigation through either additional data analysis, additional field studies, the integration of additional information on abiotic and biotic factors needed to analyze and evaluate specific hypotheses, mechanisms, or underlying relationships to help further advance the scientific underpinnings of existing and future remote-sensing investigations. In addition to the technical documentation report, results of key analyses will be published in peer reviewed scientific journals and presented at scientific conferences.

Documented Database - In addition to development of the technical documentation report, the proposed project will produce a documented, multifactorial database, containing the information compiled from various investigations as well as other available data sources that can be used as both a platform for further analytical investigations and hypothesis testing from prior studies as well as a framework for organizing and documenting results of future studies. The documented database will serve as a framework that can be used in the future for incorporating additional information from subsequent remote monitoring studies as well as supporting additional analyses in the future as part of individual studies or as part of a more comprehensive assessment and evaluation of potential management actions. It is expected that at completion of the study the documented database will be publically available to all scientific researchers and other interested parties for use in further scientific analyses as well as a framework for compiling results of ongoing and future studies.

<u>Reference Library</u> - The project will also develop a compilation of technical reports and scientific literature in the form of an electronic reference library that can then be used by current and future investigators in readily accessing results and information from prior studies. The electronic reference library will serve as a resource for providing additional documentation on results and interpretation of various findings, information on the underpinning experimental design and implementation of various studies included as part of this project. The library will also serve as a reference source for developing and evaluating the potential for future management actions, evaluating the performance of restoration, and for advancing and refining the approach for conducting and evaluating results of remote-sensing studies conducted on juvenile salmonids and other fish species within the Bay Delta estuary.

Schedule

The proposed project has been designed to be completed within a one-year period. It the general schedule for conducting the proposed project includes:

- Months 1-3: Identification and compilation of data sources, database QA/QC and documentation, initial data queries, compilation of technical reports and documentation;
- Months 4-9: Data analyses, statistical hypothesis testing, modeling, synthesis of results and findings, development of discussion and recommendations regarding elements of future experimental designs and data analysis procedures;
- Months 10-12: Completion of the draft technical documentation report, independent peer review, preparation of the final database documentation, completion of the reference library, completion of technical report revisions and final report distribution.

Level of Effort/Budget

The anticipated level of effort and budget for the proposed compilation and re-analysis of data from prior remote-sensing studies conducted within the Bay-Delta estuary is summarized in Table 1. Given the number of uncertainties inherent in the details associated with compilation, documentation, analysis, and interpretation of multiple interdisciplinary data sets as part of the proposed project, the anticipated budget has been developed based on an assumed level of effort associated with various individuals and tasks. As part of conducting the proposed investigation monthly status reports and updates on the level of effort and expenditures will be prepared and provided to the funding agencies. The level of effort allocated among tasks and individuals may be adjusted and refined based on results of individual analyses, the identification of additional or alternative priorities, or refinements to the overall approach and scope of the proposed investigation. Information on the level of effort and financial expenditures and allocation among the various parties participating in the proposed project will be consolidated into a single integrated monthly and quarterly status report for use as part of project management. The monthly reports will also include information on the accomplishments each month, priorities for subsequent activities, areas of variance from the proposed project implementation plan, and identification of variation in the level of expenditures relative to both the proposed and anticipated monthly level of effort and total budget allocation. Quarterly reports will include a summary of the accomplishments to date, a schedule of anticipated activities for the subsequent quarter, adjustments to refine the level of effort and budget during the prior quarter as well as those anticipated during the subsequent quarter, and adjustments necessary to maintain the overall project schedule for completing individual analyses and development of the final documentation report, compilation of the documented database and reference library as project deliverables.

Literature Cited

Bowen, M.D., and R. Bark. 2012. 2010 Effectiveness of a Non-Physical Fish Barrier at the HHOR site of the Old and San Joaquin Rivers (CA). Technical Memorandum 86-68290-10-07. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center.

Bowen, M.D., S. Hiebert, C. Hueth, and V. Maisonneuve. 2012. 2009 Effectiveness of a Non-Physical Fish Barrier at the HOR site of the Old and San Joaquin Rivers (CA). Technical Memorandum 86-68290-09-05. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center.

Buchanan, R.A., J.R. Skalski, P.L. Brandes, and A. Fuller. 2013. Route Use and Survival of Juvenile Chinook Salmon through the San Joaquin River Delta. *North American Journal of Fisheries Management 33(1):216-229.*

California Department of Water Resources. 2012. *2011 Georgiana Slough Non-Physical Barrier Performance Project Report.* Sacramento, CA.

Liedtke, T.L., J.W. Beeman, and L.P. Gee. 2012. *A Standard Operating Procedure for the Surgical Implantation of Transmitters in Juvenile Salmonids.* U.S. Geological Survey Open-File Report 2012-1267.

MacFarlane, B.R., A.P. Klimley , S. L. Lindley , A. J. Ammann , P. T. Sandstrom , E. D. Chapman, C. J. Michel , and T. E. Pearson. 2009. Juvenile salmonid movement patterns and survival in the Sacramento River and San Francisco Bay from acoustic tagging. Presentation to the Bay-Delta Science Conference, Sacramento CA

Michel, C.J. 2010. River and estuarine survival and migration of yearling Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*) smolts and the influence of environment. Master's thesis, University of California-Santa Cruz, Santa Cruz, California.

Perry, R.W. and J.R. Skalski. 2008. Migration and Survival of Juvenile Chinook Salmon through the Sacramento-San Joaquin River Delta During the Winter of 2004-2007. Report prepared for U.S. Fish and Wildlife Service, Stockton, California. 32 pp.

Perry, R.W. and J.R. Skalski. 2009. Survival and Route Probabilities of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta During the Winter of 2005-2008. Report prepared for U.S. Fish and Wildlife Service, Stockton, California. 54 pp.

Perry, R.W., J.R. Skalski, P.L. Brandes, P.T. Sandstrom, A.P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento – San Joaquin River Delta. *North American Journal of Fisheries Management* 30:142-156.

Perry, R.W. 2010. Survival and Migration Dynamics of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. Doctoral dissertation. University of Washington.

Perry, R.W., J.G. Romine, N.S. Adams, A.R. Blake, J.R. Burau, S. Johnston, and T.L. Liedtke. 2012. Using a Non-Physical Behavioral Barrier to Alter Migration Routing of juvenile Chinook Salmon in the Sacramento-San Joaquin River. *River Research and Applications*. DOI: 10.1002rra.2628.

Perry, R.W., P.L. Brandes, J.R. Burau, A.P. Klimley, B. MacFarlane, C. Michel, and J.R. Skalski. 2012. Sensitivity of survival to migration routes used by juvenile Chinook salmon to negotiate the Sacramento-San Joaquin River Delta. Series: Environmental Biology of Fishes, Online First, 9 February 2012.

Perry, R.W., P.L. Brandes, J.R. Burau, A.P. Klimley, B. MacFarlane, C. Michel, and J.R. Skalski. 2013. Sensitivity of Survival to Migration Routes Used by Juvenile Chinook Salmon to Negotiate the Sacramento – San Joaquin River Delta. *Environmental Biology of Fishes* 96:381-392.

San Joaquin River Group Authority (SJRGA). 2011. 2010 Annual Technical Report On Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP). 167 pp.

Vogel, D.A. 2002. Juvenile Chinook salmon radio-telemetry study in the southern Sacramento-San Joaquin Delta, December 2000 – January 2001. Contract report for the U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. June 2002. 27 p. plus figures and appendices.

Vogel, D.A. 2004. Juvenile Chinook Salmon Radio-Telemetry Studies in the Northern and Central Sacramento-San Joaquin Delta 2002-2003. Report to the National Fish and Wildlife Foundation, Southwest Region. 44 pp.

Vogel, D.A. 2010. Evaluation of Acoustic-Tagged Juvenile Chinook Salmon Movements in the Sacramento – San Joaquin Delta during the 2009 Vernalis Adaptive Management Program. Prepared for the Vernalis Adaptive Management Program, Natural Resource Scientists, Inc. Red Bluff, CA.

Vogel, D.A. 2011. Evaluation of Acoustic-Tagged Juvenile Chinook Salmon Movements and Predatory Fish Movements in the Sacramento – San Joaquin Delta during the 2010 Vernalis Adaptive Management Program. Prepared for the Vernalis Adaptive Management Program, Natural Resource Scientists, Inc., Red Bluff, CA.

Vogel, D.A. 2012. North/Central Delta salmon outmigration study, 2008 – 2009: Predator fish tagging and mobile telemetry survey results. Technical report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. December 2012. 43 p. including appendix.

Vogel, D.A. 2013. 2011 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and Vernalis Adaptive Management Plan. Davis, CA.

Table 1. Collaborative hypothesis testing based on analysis of existing remote sensing tag studies: Budget

Project Element	Level of Effort (% PY)	Budget
Project Management		
C. Hanson	50	220,000
Data Base Management		
M. Tomkins	25	110,000
M. Bruns	50	99,000
Staff TBD	50	99,000
Data Analysis		
D. Delaney	50	122,100
M. Bruns	50	99,000
Assessment/Advisory Team (1)		
B. Byrne		35,000
S. Lindley		25,000
R. Buchanan		35,000
B. Manley		25,000
D. Vogel		55,000
J. Bureau		35,000
S. Greene		25,000
M. Holland		25,000
J. Murauskas		35,000
Technical Editor		25,000
Documentation Graphics/Word Processing		30,000
Computer Processing		30,000
Peer Review		15,000
Travel/Miscellaneous Expenses (5%)		57,205
	Total	**$1,201,305**

(1)Team members or their agencies will be reimbursed for time spent participating in data analyses and interpretation of results.

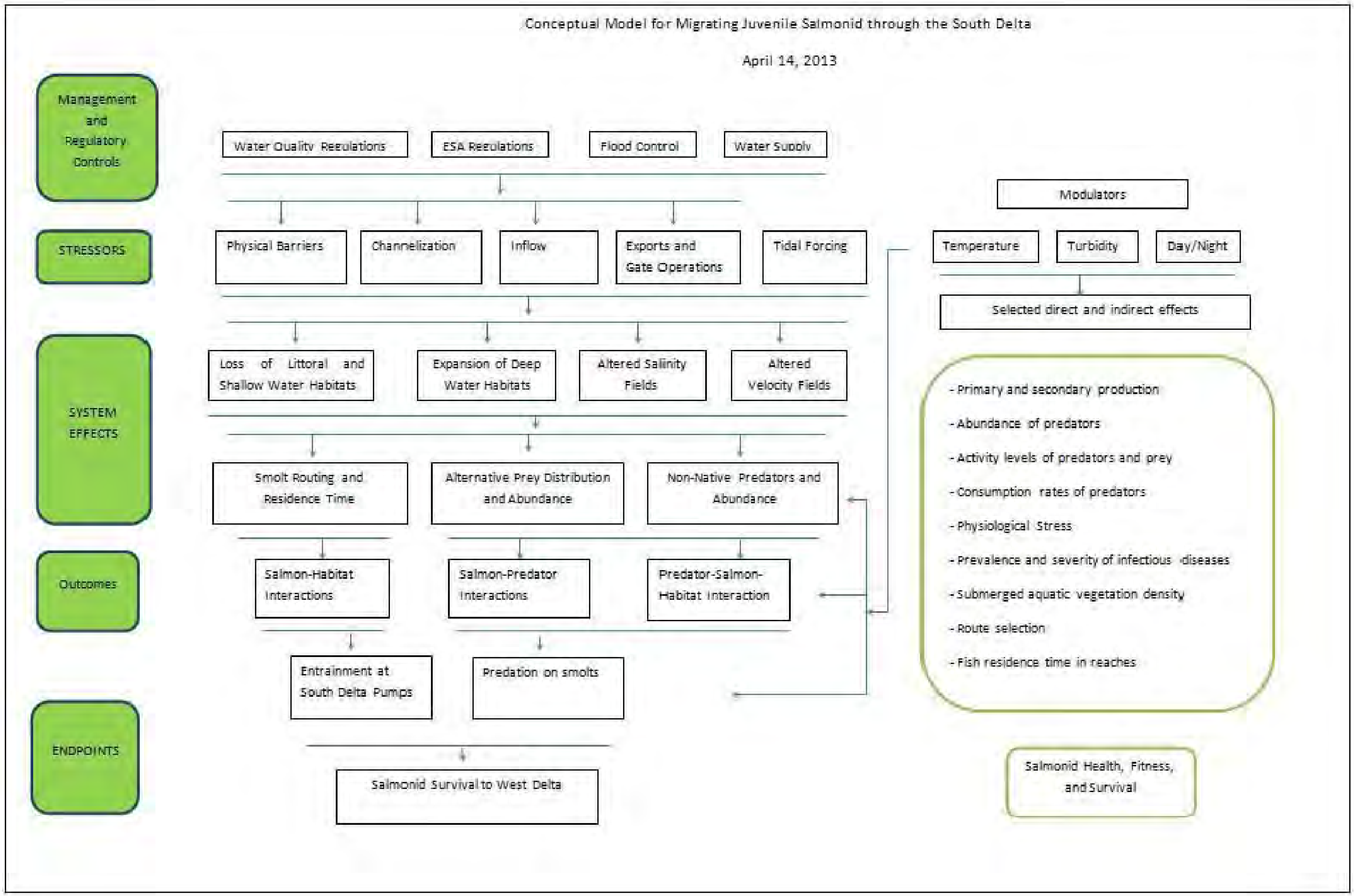


Figure 1. Conceptual model.

APPENDIX K
FIELD MOVEMENT STUDY

J. Stuart Draft Proposal

What is the movement behavior of juvenile Chinook salmon in the Old River channel under the influence of tidal patterns and export operations?

Hypotheses:

H_{1o}: Net daily and 21-day net movement of fish within the Old River channel relative to tidal excursion is not influenced by the magnitude of the export influence on OMR flows as measured by the 14-day average.

H_{1a}: For fish already present in the Old River channel, increased export effects, as reflected by a more negative 14-day average Old and Middle River flow value (OMR), affects net daily and net 21-day movement of fish already entrained into channels by tidal oscillations (*i.e.*, the increased influence of exports reduce or delay movement back to original starting position of the fish prior to tidal excursion; enhance net movement in southwards direction towards export facilities with each tidal oscillation).

H_{2o}: Tidal conditions (spring vs. neap) does not affect the magnitude of overall movements or the net movement of fish towards the export facilities under stable export conditions.

H_{2a}: Gross sub daily and net daily movements of fish within the Old River channel corridor towards the export facilities are influenced by whether a spring tide or neap tide condition exists under a stable export pumping condition (stable OMR flows). A spring tide condition will transport fish farther south (upstream direction) in comparison to a neap tidal condition under stable export conditions.

H_{3o}: Distance from the export facilities has no influence on the net daily movement of fish within the Old River corridor.

H_{3a}: Distance from export facilities influences net daily movement of fish in Old River corridor.

H_{4o}: Fish position within the river channel (across channel and along channel direction) is not influenced by the stage of the tidal oscillation (flood versus ebb tide). Fish distribution within the channel is not related to tidal stage.

H_{4a}: Fish position within the river channel (across channel and along channel direction) is influenced by the stage of the tidal oscillation (flood versus ebb tide). Fish are distributed within the channel in relation to the tidal stage.

Background and Purpose: Understanding the influence of tidal forcing on the movement of juvenile Chinook salmon within the channels of the South Delta in relation to the additional influence of export operations on overall water movement is critical to implementing management decisions to protect ESA listed salmonid species. This study incorporates components of the Lindley-Israel draft conceptual model, testing the linkages of the identified stressors of exports and tidal forcing upon the system effects of altered velocity fields and flow volumes, subsequent salmonid routing and movement behavior, and finally the eventual disposition of the migrating salmonids as represented by the endpoints of entrainment at the export facilities and survival through the salvage process to Chipps Island, mortality due to predation events in the Old River channel route, or routing of emigrating fish to the western Delta via movement through the Lower San Joaquin River corridor (see figure 1). The final endpoints represent the terminal survival potential for emigrating salmonids occurring within the channels of the South Delta dependent on the ultimate route the fish follows. Previous studies (Vogel 2001, 2004) have implicated tidal forcing, exports, and river inflows as factors influencing the movement of migrating salmonids within the channels of the South Delta. This study builds upon this work by implementing more sophisticated techniques and technology to track and identify fish movement and behavior in the channels under the hydrodynamic conditions present at the time of the fish movement through the channels. Information gathered from the proposed study could be incorporated into the 2012 IRP's suggested XT survival and STS models to inform equation parameters of smolts passing through a defined river reach.

Experimental Approach: This study will use acoustically tagged juvenile Chinook salmon (late-fall run Chinook salmon are proposed) released at three separate points in the Old River channel route at predetermined distances from the inlet to Clifton Court Forebay. If funding and interest are present, steelhead smolts can be concurrently released to assess their response to the experimental conditions or substituted completely for the late-fall Chinook salmon. Fish will be released under two different tidal conditions; spring and neap, over a four day period centered at the peak tidal condition to spread out the dispersion of fish into the migratory corridor. These tidal releases will be nested within a high export condition (most negative Old and Middle River [OMR] flow condition) and a low export condition (most positive OMR flow condition) that will span the entire 28 day tidal cycle. Efforts will be made to maintain a stable net 14-day tidally averaged OMR flow condition in the field for the duration of the spring/neap tidal cycle under each export condition. Movement behavior of tagged fish will be detected by an array of receivers strategically located within the Old River channel corridor and channels leading off of this corridor to other parts of the Delta. Ambient hydrodynamic conditions will be extracted from existing gauges in the delta and supplemented by field deployed acoustic Doppler current meters in reaches without gauges. Observed fish movements under the different hydrodynamic conditions will be compared between tidal phases and export conditions. In addition, terminal fish fate and within reach survival will be compared utilizing the acquired acoustic tag receiver data. It is anticipated that this study will be multi-year in nature to accomplish replication of the study conditions, and to reduce unanticipated bias due to over reliance on any one year's conditions and results.

An additional river reach within the Old River study area approximately 1 kilometer in length will be instrumented with receivers to give a two-dimensional tracking of acoustically tagged fish as they move through the reach under differing tidal conditions, export conditions, and ambient light (day-night) to provide latitudinal and longitudinal positions in the channel reach.

Methods (including statistical analysis plan): Three release sites along the axis of the Old River channel corridor (from the export facilities north to the San Joaquin River), approximately 7 km apart, will be selected. Proposed sites are the Highway 4 Bridge (7.4 km from Clifton Court Forebay to HW 4 Bridge), Railroad Cut (7.3 km HW 4 Bridge to RR Cut), and approximately Rock Slough (single channel reach approximately 1.5 km north of Rock Slough; 6.7 km north of RR Cut). Three sets of 120 acoustically tagged juvenile Chinook salmon will be tagged (late-fall are proposed due to timing of study, however smolting steelhead can be used concurrently or in place of late fall Chinook salmon) and released on either a spring tide or neap tide phase; 120 fish at each release site, a total of 360 fish per tidal phase. Fish will be released over a 3 day period centered on the peak spring or neap tide, with 40 fish released per day. Fish will be released on an incoming flood tide starting five hours before high tide to aid in dispersion from the release sites and movement into the proposed study area. Fish will be released at a rate of 10 fish per hour in groups of 5 (5 fish every 30 minutes), with the final releases of fish occurring 1 hour before slack high tide. The high tide which occurs during daylight hours will selected to promote the safety of the release crew. The first release groups of tagged fish are proposed for December to take advantage of the increased export flexibility at this time for obtaining higher exports. The new moon occurs on December 3, 2013, and January 1, 2014. The full moon occurs on December 17, 2013. The first quarter-moon occurs on December 10, 2013 and the third-quarter moon on December 25, 2013. Exports are expected to be higher in December, resulting in a very negative OMR flow. After January 1, the OMR flows are constrained to be no more negative than -5,000 cfs by regulatory actions. During the period between January 1, 2014 and March 31, 2014, a proposed period of at least 3 weeks with reduced exports (and hence more positive OMR flows) will be necessary to obtain the low export portion of the study design. A third export level would be desirable with intermediate OMR levels to provide “shape” to the response of study fish to hydrodynamic conditions, provided sufficient funds and interest are present. A proposed network of acoustic receivers to detect the acoustic tags implanted in the study fish will be deployed along the Old River corridor. Approximately 40 -45 receivers are anticipated, but may change due to modeling requirements or logistics of deployment. A total of twenty dual arrays are proposed at each of the exit points of the study area to provide a high probability of detection for any fish not participating in the study by leaving the defined study area. Dual receivers will be deployed within Railroad Cut, Woodward Canal/North Victoria Canal, Victoria Canal/ North Canal, Grantline/ Fabian Bell Canal, and adjacent to the SWP inlet to Clifton Court Forebay, the CVP trash racks, and Old River near Tracy to provide a high level of detection probability and a directional component to the tag detections as they leave the study area. Additional dual receivers will be located on Indian Slough and Rock Slough. Receiver locations are intended to cover potential “exit” points from the Old River corridor from which tagged fish may leave the experimental system. An additional set of dual receivers will be deployed at Chipps Island to give a survival estimate of fish reaching the western Delta through either the salvage facilities or by moving downstream and out of the study area. These points will also provide the necessary detection locations to populate a statistical survival model of the study area. An additional 13 single receivers will be deployed along the Old River corridor from approximately Rock Slough to the area between the inlets to the CVP and SWP. Locations will be on alternating apexes of the channel meanders along the length of the Old River corridor. An additional 1 km reach of river with a straight alignment just upstream (south) of the Highway 4 Bridge will be instrumented with 10-13 single receivers to provide sufficient coverage to determine 2-D positions of tagged fish within this reach (see Figure 2).

The experimental design can be divided into three modules that can be implemented individually yet benefit from the synergistic implementation of all three together. Each of the three modules; tidal forcing, export influence, and 2-D tracking for within channel distribution could be implemented individually and valuable information collected to inform management decisions.

There are six monitoring stations currently available on the California Data Exchange Center (CDEC) that provide river flow, water temperature, flow velocity, and river stage in the study area. If additional site specific data is required (i.e. flow velocity) then independent equipment such as an ADCP may be deployed to record data in conjunction with the permanent monitoring sites. Independent equipment deployment can also provide the flexibility to measure fine scale velocity profiles in a specific river reach. A survival model similar to what has already been achieved for the VAMP studies and the 6-year acoustic tag study will be developed for this study to provide survival estimates within the study area. This model may then be incorporated into larger survival models if similar tags and receivers are used elsewhere in the South Delta region. Data derived from the acoustic tag receivers and the hydrodynamic data from study area gauges will provide the necessary input to assess the movements of tagged fish within the study area in relation to tidal forcing and export influenced hydrodynamic conditions as well as the influence of distance from the export facilities on net fish movements. Comparisons of the two by two by three study design (tides x OMR flows x release site distance from export facilities) will allow testing of the hypotheses described above through analysis of variance and general linear modeling. Fish movement described by the 2-D array will allow testing of distribution patterns against factors such as tidal stage and day/night patterns.

Experimental Challenges: The ability to manipulate export levels to achieve uniform 14-day tidally averaged OMR flow hydrodynamic conditions will be difficult. Maintenance of uniform OMR flows (*i.e.*, uniform hydrodynamic conditions in the Old River corridor) during the study is predicated on not exceeding regulatory constraints regarding take of listed fish as well as water quality criteria. The necessary reduction in exports for the low OMR flow conditions will necessarily require a reduction in the expected volume of exported water. Flexibility in management decisions is required. Locations of acoustic receivers are determined by access to shore based land sites, in-water structures, and the ability to service them and download collected data. Locations also need to be secure to avoid loss or damage to equipment. Precise locations of receivers are also influenced by the complexity of the delta channels and their bathymetry. Some crucial receivers (exit points) must be close enough together to minimize loss of tags between receivers (*i.e.*, predation losses) but far enough apart to not overlap and provide distinct temporal separation (provides directional data). Receivers should also have a "clear view" of the surrounding water column so that acoustic signals are not distorted or shielded by obstructions (*i.e.*, tule islands) or sources of noise in the water (*i.e.*, agricultural pumps on water diversion). Use of hatchery late-fall Chinook salmon or steelhead may not represent wild fish behavior in a completely accurate manner. Study fish released into the study area will not have had time to acclimate to the river habitat as would an upstream release, but conversely would not need the very high release numbers to adequately populate the study area under consideration given the expected attrition rate observed in previous Delta studies, and thus would be considerably less expensive or labor intensive while providing the necessary number of detected fish in a given study reach to draw conclusions regarding the movement behavior and survival of tagged fish from the detection histories.

Application of Findings to Management: Findings from this study will facilitate the determination of export effects on the far-field survival of salmonids smolts in the South Delta waterways leading to the export facilities, a parameter that is currently deficient in the calculation of loss related to project operations. It will provide information as to how far away and to what magnitude the diversion of water influences fish movements in the channels leading to the export facilities. Finally, it will help determine the interaction between tidal forcing, export operations, local hydrodynamics, and the movement of salmonid juveniles in the waterways leading to the export facilities.

Technology Transfer: The findings of this study will first be presented in workshops and regional meetings as data is processed and analyzed. A final technical report will issued when final analysis of the data is completed which will be disseminated to interested state and federal agencies as well as interested parties. Portions of the study, as appropriate, will be submitted for publication in peer reviewed journals, based on the focus of the journal.

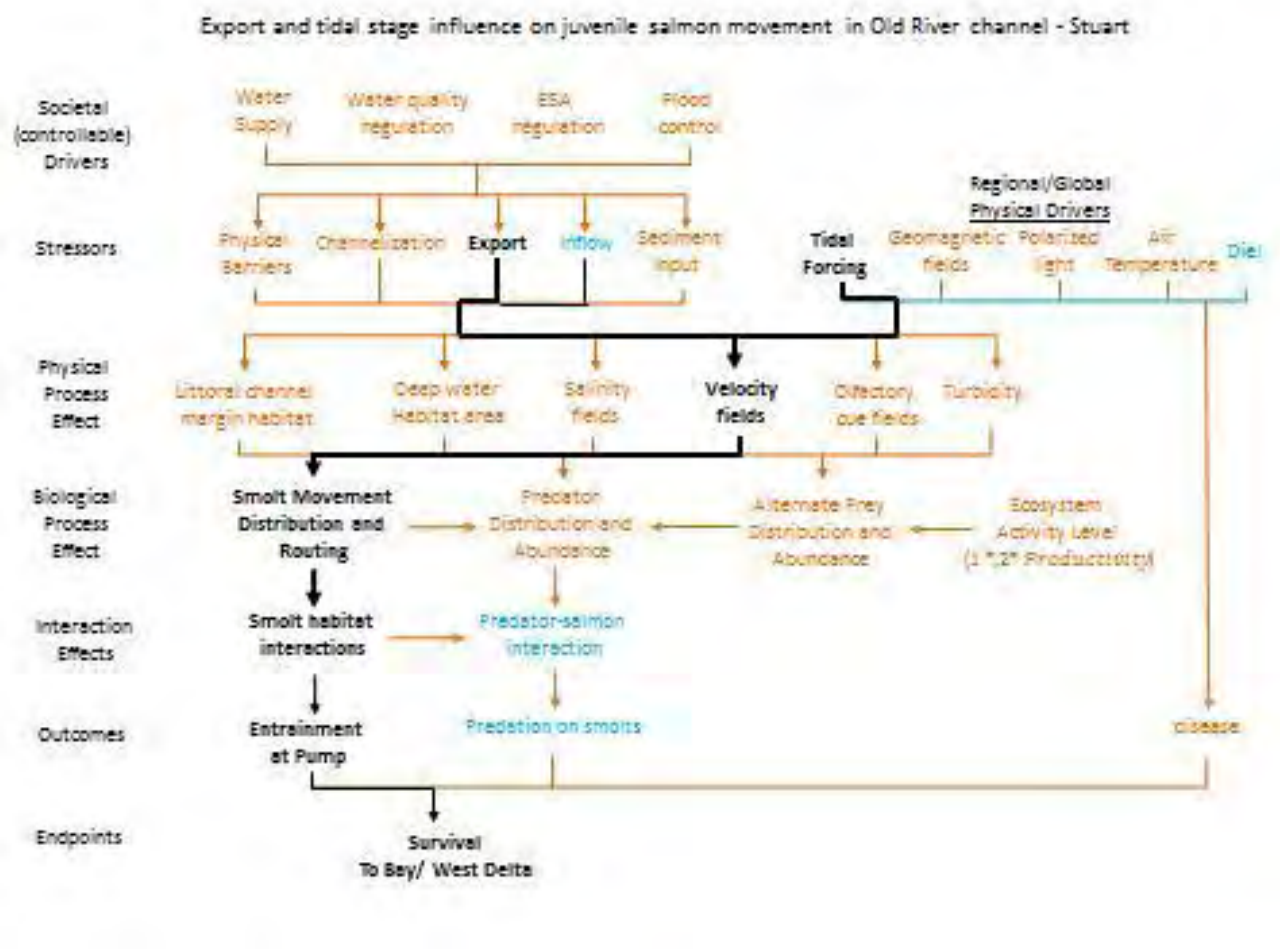


Figure 1: Lindley-Israel conceptual model with Stuart proposal linkages. Black line indicates direct study linkages through model. Blue text indicates parameters not directly measured or manipulated, but could be incorporated into study depending on the data assessment.

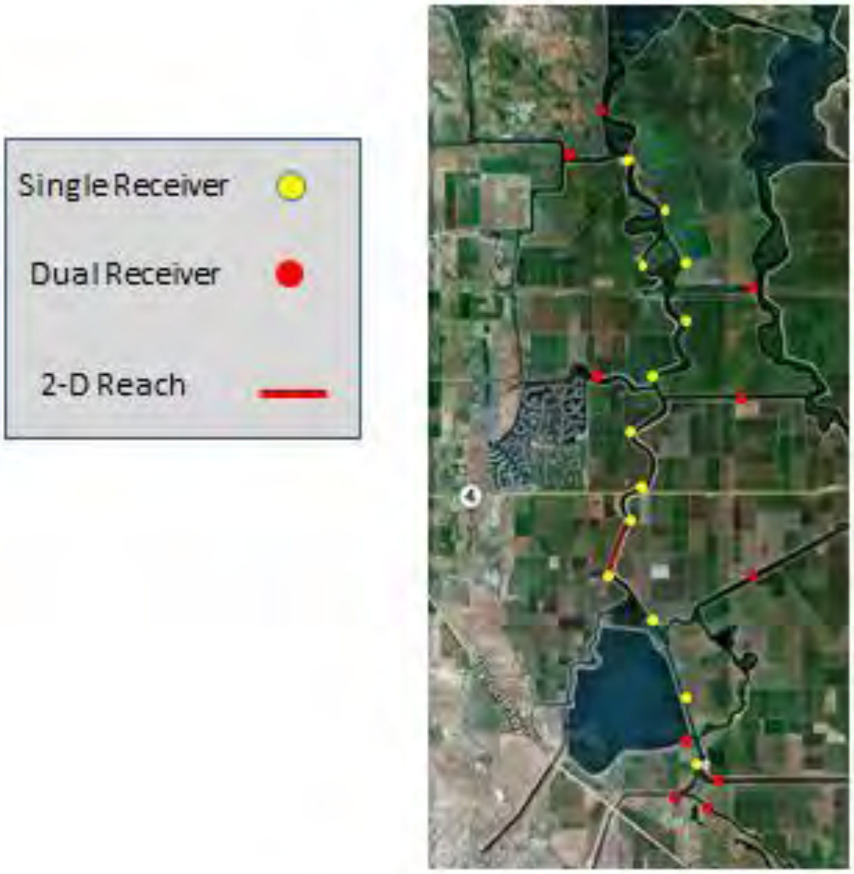
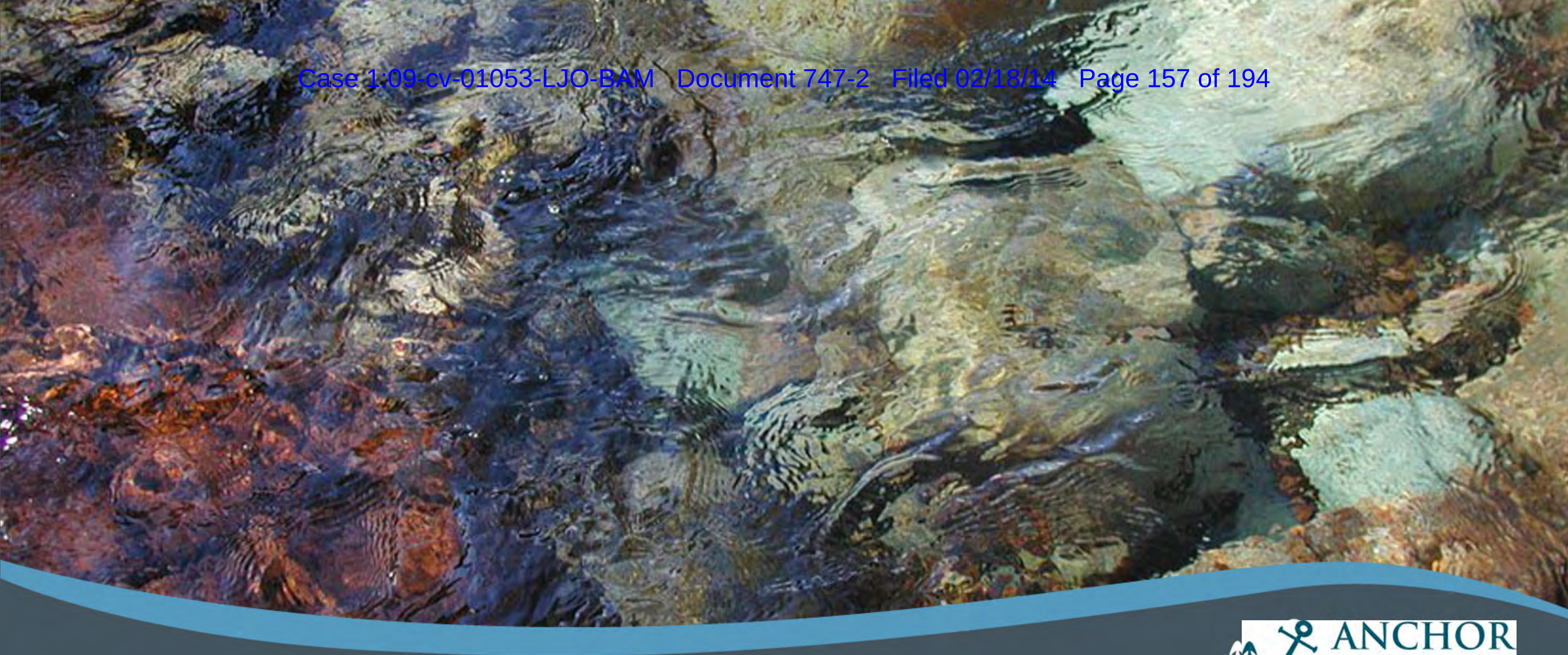


Figure 2: Receiver placement locations (proposed). The 2-D reach will have 10-13 receivers within the 1 km reach to provide the necessary coverage to calculate tag position in the channel.

APPENDIX L
CONDITIONS TESTED – 6-YEAR STEELHEAD SURVIVAL STUDY



Central Valley Steelhead Survival Study Considerations for 2014

Presented by
Josh Murauskas

September 25, 2013

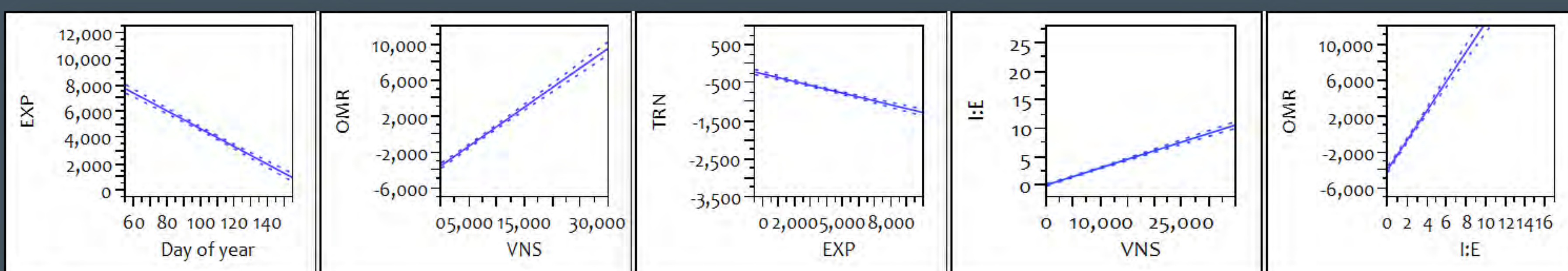
Study Objectives

"To determine proportional causes of mortality hypothesized to be related to operational *changes in hydrology*…"

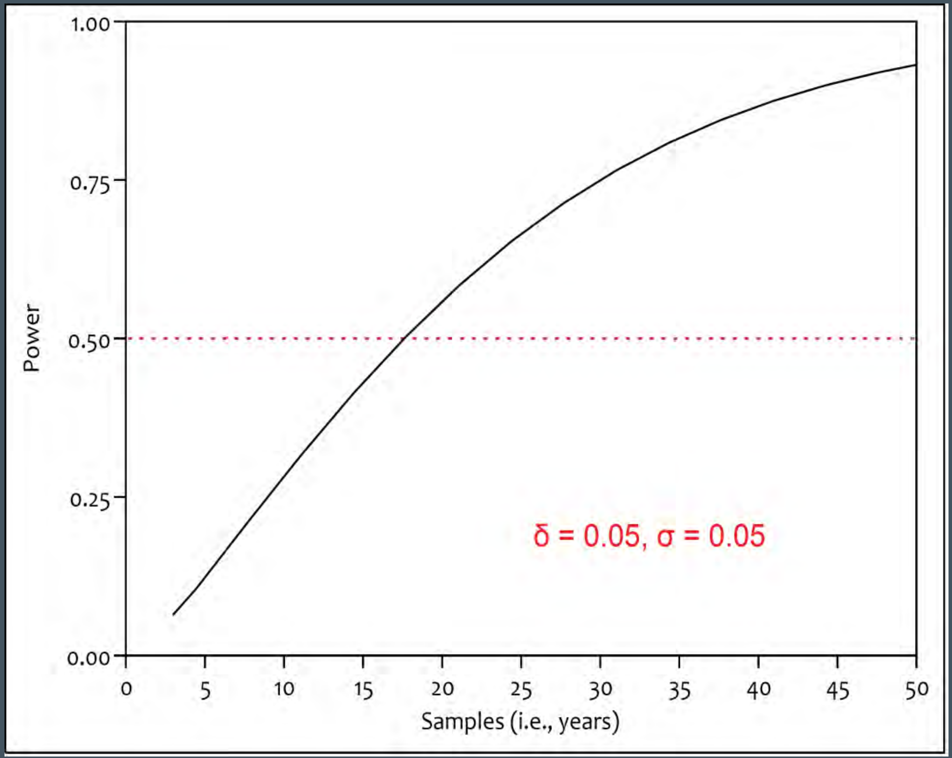
- Discussed approaches
  1. RPA path forward
  2. Operate to maximize coverage

Multivariate Considerations

- Day of year & exports: r = -0.613
- VNS & OMR: r = 0.805
- Exports & TRN: r = -0.502
- VNS & I:E: r = 0.700
- OMR & I:E: r = 0.668



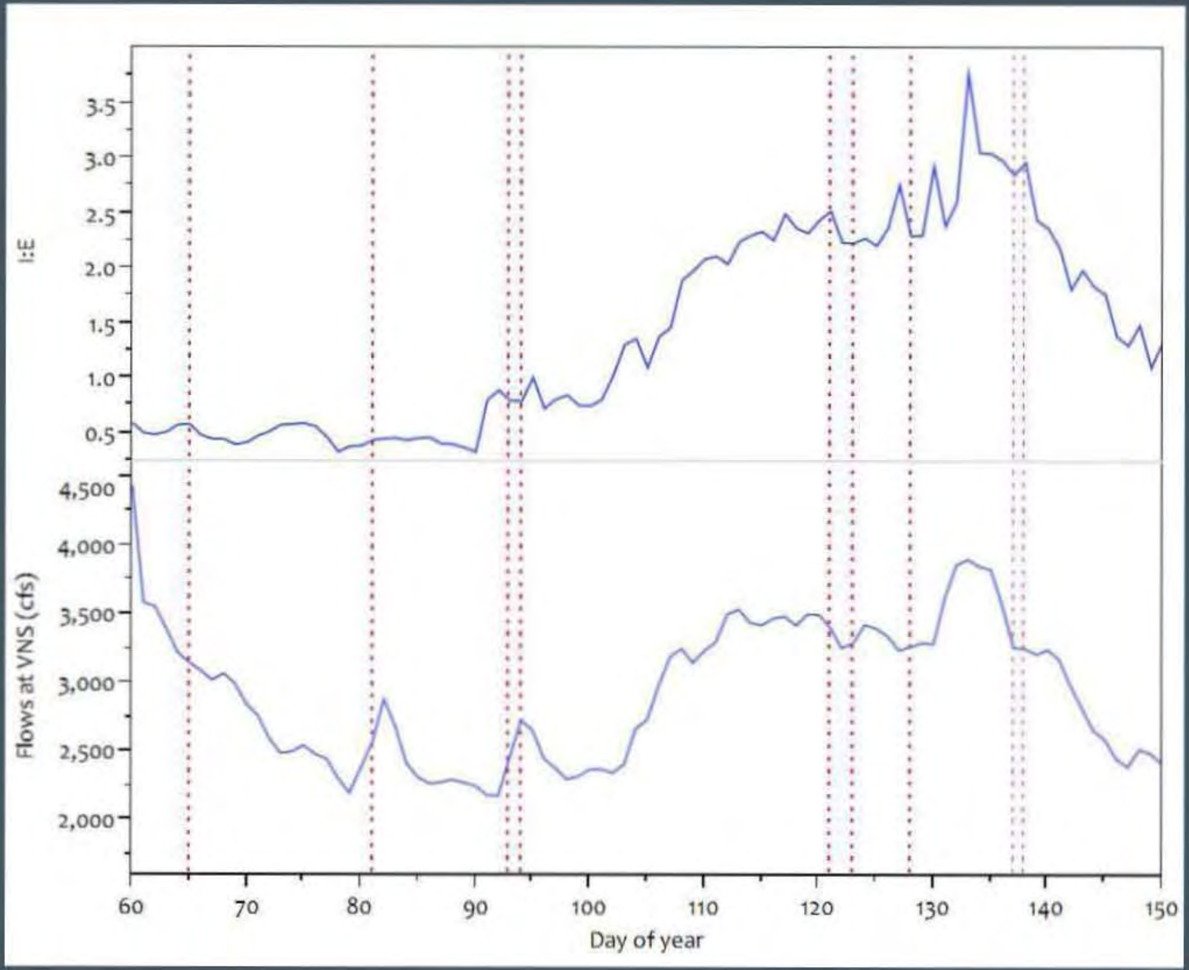
Sample Size Considerations



Considerations

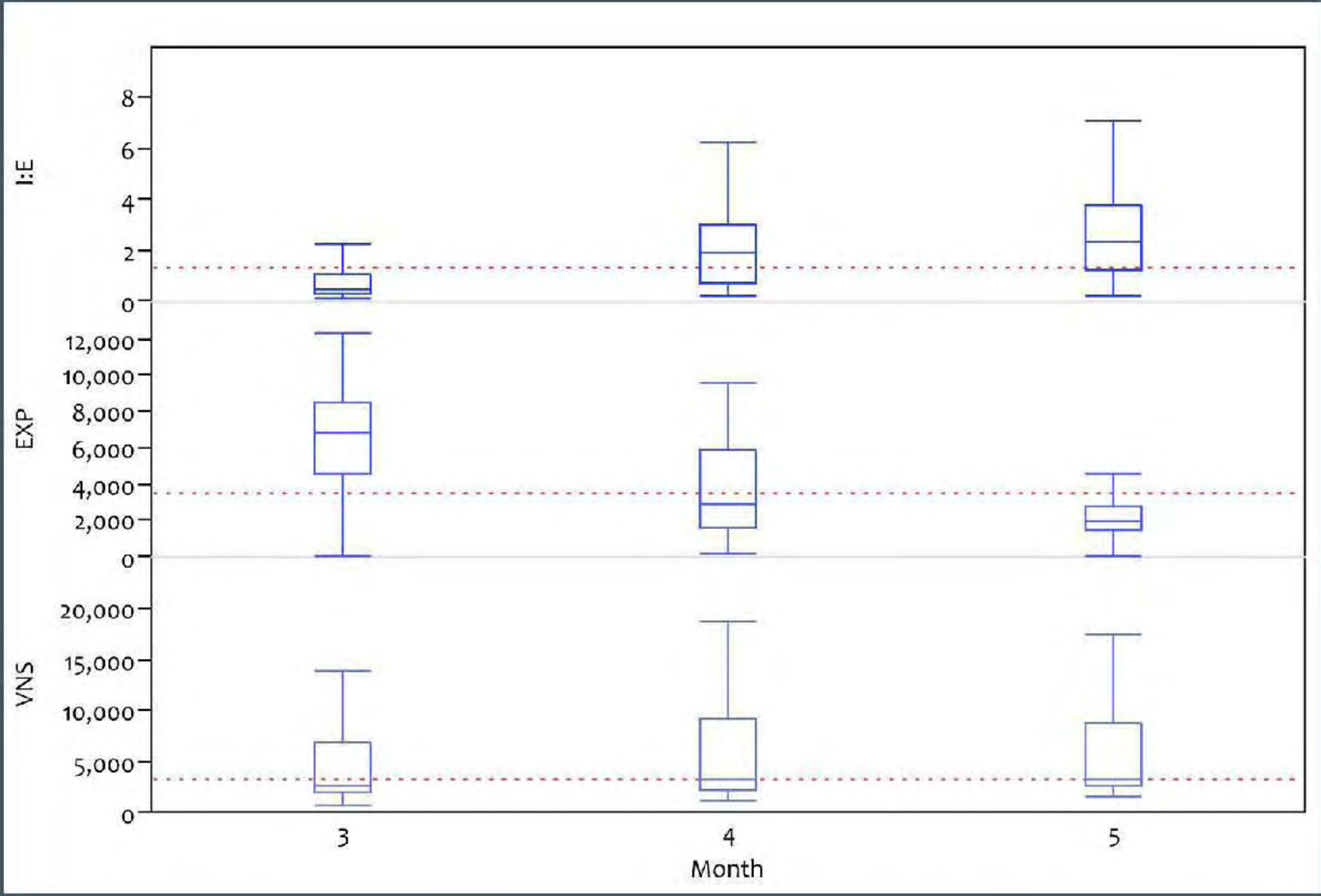
- α - Significance
- σ – Error
- δ – Effect size
- n – Sample size

- Effect size
  - Distance between means
  - Strength of a phenomenon



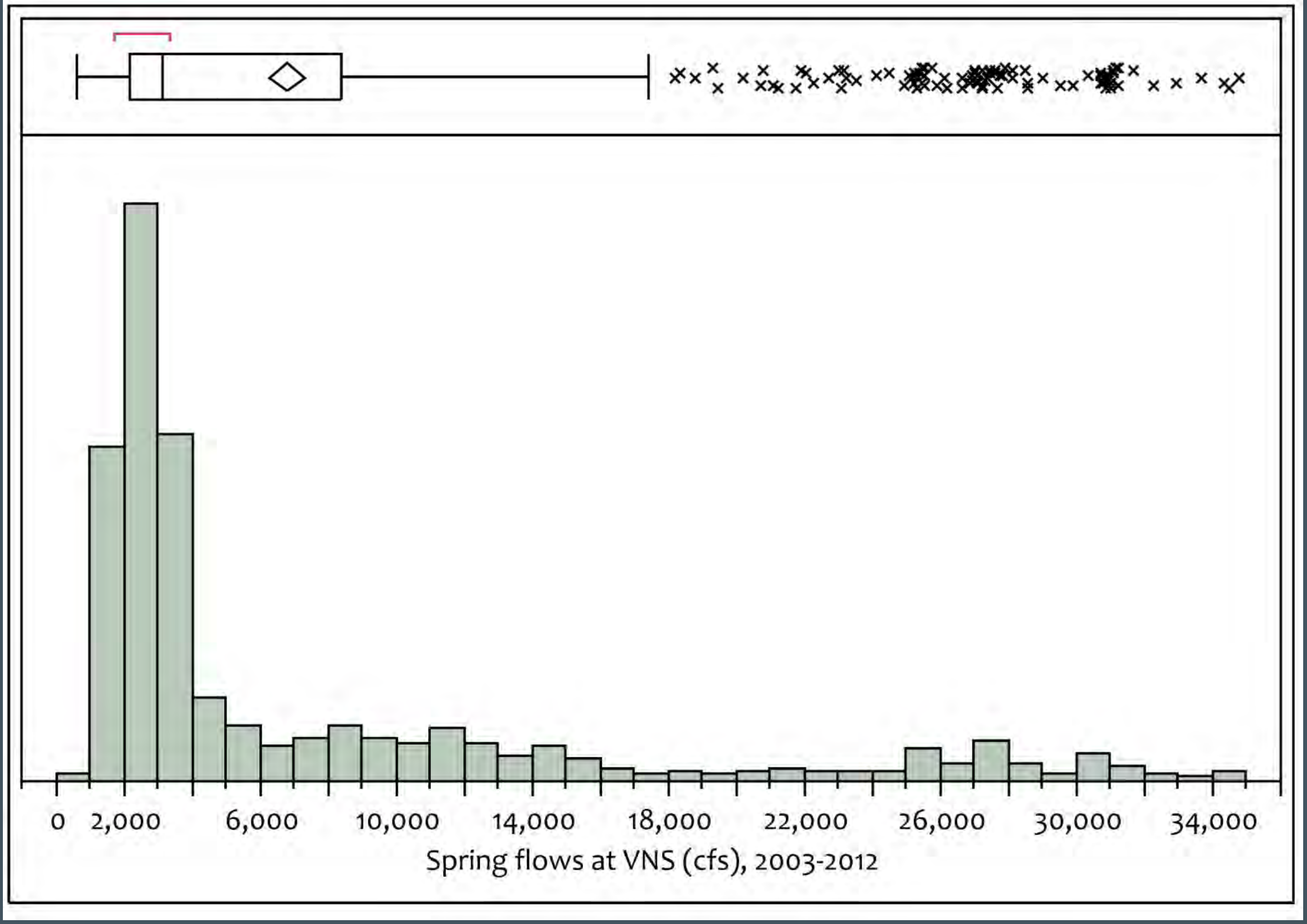
I:E
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Flows at VNS (cfs)
4,500
4,000
3,500
3,000
2,500
2,000
60
70
80
90
100
110
120
130
140
150
Day of year

Temporal Considerations



** Based on CDEC data from 2003-2012, spring months only*

Arithmetic Mean and Outliers



ANCHOR QEA

Distribution of Conditions, 2003-2012

Station	25th Q	Median	75th Q	Mean	Std Dev
VNS	2,158	3,145	8,412	6,740	7,773
EXP	1,562	3,419	6,427	4,308	2,934
OMR	-3,027	-1,697	762	-639	3,822
TRN	-872	-573	-348	-632	455
I:E	0.5	1.3	2.6	7.3	136.6

** Spring months only (March-May); all data from CDEC*

ANCHOR QEA

Maximize Coverage or Fill Gaps?

Combined exports

Flows at Vernalis	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1st Quartile	✓	✓	✓	✓
2nd Quartile	✓	✓	✓	✓
3rd Quartile	✓	✓	✓	✓
4th Quartile	✓	✓	✓	✓

ANCHOR QEA

Coverage of Conditions

Combined exports

Flows at Vernalis

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1st Quartile	✓	✓✓	✓✓	
2nd Quartile		✓		
3rd Quartile				
4th Quartile		✓	✓✓	

** Based on median values observed within 14 days following first release of study groups*

Past Conditions

Combined exports

Flows at Vernalis

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1st Quartile	2.17%	8.80%	8.70%	5.22%
2nd Quartile	7.83%	6.52%	3.48%	7.17%
3rd Quartile	12.83%	3.59%	2.28%	6.20%
4th Quartile	2.17%	6.09%	10.43%	6.20%

** Based on CDEC data from 2003-2012, spring months only*

ANCHOR QEA

Coverage of Conditions (VNS, I:E)

I:E ratio

Flows at Vernalis

	1st Quartile	**2nd Quartile**	**3rd Quartile**	**4th Quartile**
1st Quartile	✓	✓✓✓	✓	
2nd Quartile			✓	
3rd Quartile				
4th Quartile			✓✓✓	

** Based on median values observed within 14 days following first release of study groups*

ANCHOR QEA

Past Conditions

I:E ratio (columns) / *Flows at Vernalis* (rows)

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1st Quartile	14.44%	9.08%	1.42%	0.00%
2nd Quartile	8.64%	7.33%	7.88%	1.31%
3rd Quartile	3.50%	4.70%	9.85%	7.00%
4th Quartile	0.00%	1.97%	5.91%	16.96%

** Based on CDEC data from 2003-2012, spring months only*

ANCHOR QEA

Trends over time

Five-year block	Median daily spring inflow at Vernalis	Median daily spring combined exports	Median daily spring I:E
1994-1997	6,398	2,080	2.1
1998-2002	5,494	2,992	1.8
2003-2007	3,305	5,343	1.8
2008-2012	2,602	2,919	1.1

Maximize Effect?

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1st Quartile	VNS ≤ 2,158 EXP ≤ 1,562 I:E ≤ 0.5			VNS ≤ 2,158 EXP ≥ 6,427 I:E ≥ 2.6
2nd Quartile				
3rd Quartile				
4th Quartile	VNS ≥ 8,412 EXP ≤ 1,562 I:E ≤ 0.5			VNS ≥ 8,412 EXP ≥ 6,427 I:E ≥ 2.6

ANCHOR QEA

Discussion: Potential Strategies

RPA Path

Utilize opportunities to collect performance estimates across range of environmental conditions

Multivariate testing?

Hypothesis Testing

Rely on operational decisions to maximize differences in hydraulic conditions

Testing means?

ANCHOR QEA

APPENDIX M
POWER ANALYSIS

Power Analysis: Survival to Chipps Island

Prepared for: South Delta Salmon Research Collaboration Group

Prepared by: Rebecca Buchanan, University of Washington

July 10, 2013

Executive Summary

Sample sizes were calculated to provide 80% power to detect a treatment effect on survival to Chipps Island with an error rate of α=0.05 or α=0.10. For steelhead, the desired treatment effect was a 10% increase in survival; for Chinook salmon, it was a 100% increase in survival. Steelhead were assumed to have higher survival than Chinook salmon. However, the smaller treatment effect to be detected for steelhead resulted in higher sample sizes than for Chinook. Necessary sample sizes for steelhead using a single replicate ranged from approximately 800 to 17,000 (α=0.10), depending on whether survival is high or low, the location of the release site (Durham Ferry or head of Old River), where survival is measured from (Mossdale or the head of Middle River), and whether the route is restricted to salvage routes or includes all routes to Chipps Island. Using two replicates halved the necessary sample size per replicate. For Chinook, necessary sample sizes for a single replicate ranged from approximately 100 to 3,000. Larger treatment effects require fewer fish. Power curves (e.g., Figure E1) showing necessary sample sizes for alternative treatment effects and survival levels are included in Appendix B.

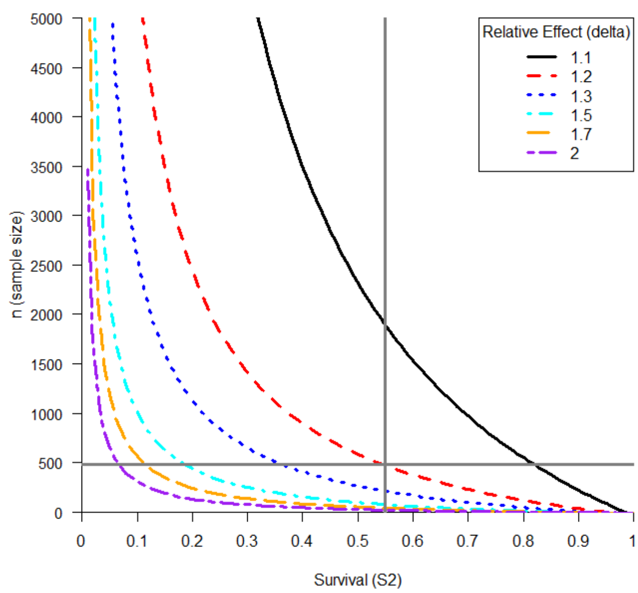


Figure E1. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.88. The cross-bars indicate the observed survival and sample size in 2011 (steelhead).

Introduction

A power analysis was performed to determine the appropriate sample size necessary to detect an effect of different water export operations on juvenile salmonid survival through the Delta. Survival is to be measured to Chipps Island both in total (all routes) and via the salvage facilities at the State Water Project and the Central Valley Project. For the purposes of the power analysis, two release locations were considered:

1. Durham Ferry (DF), with survival measured from Mossdale Bridge (assumes barrier at the Head of Old River [HOR] is not installed), and
2. Old River (OR) just downstream of its head, with survival measured from the Head of Middle River (HMR).

In each case, sample sizes were computed to provide 80% power to detect a given relative (i.e., multiplicative) effect on survival of different treatments using either 1 or 2 replicates. For steelhead, the size of the relative effect (δ) was 1.1 (i.e., 10% increase). For Chinook salmon, the relative effect size was δ=2.0 (i.e., 100% increase). The probability of a Type I error (error rate) was fixed at α=0.05 or α=0.10. One-tailed tests were used (i.e., one-sided alternative hypotheses).

Methods

For each scenario, a simplified version of the Delta survival release-recapture model was used, including only two reaches and two detection sites (Figure 1). The first reach was the region between the release site and the study area, i.e., the San Joaquin River between Durham Ferry and Mossdale Bridge for the DF releases, and the Old River between the HOR and the HMR for the OR releases. The first detection site was either Mossdale or the pooled receivers at the HMR, depending on the release site. The second reach consisted of the routes through the Delta from the first detection site to Chipps Island. For estimating total Delta survival, the routes included both inriver (non-salvage) routes and salvage and transport routes. For estimating survival to Chipps Island via salvage, only the salvage routes were included in the second reach. For Durham Ferry releases, all routes, including salvage routes, included routes using the San Joaquin River at the head of Old River, because fish that remain in the San Joaquin River at that junction may nevertheless arrive at the salvage facilities by entering the interior Delta downstream of Stockton.

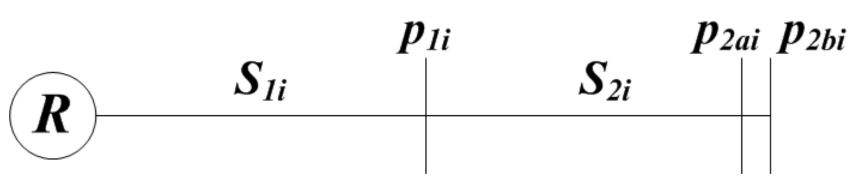


Figure 1. Model schematic. R = release of size *n*, S_{ji}=probability of survival through reach *j* (*j*=1,2) for treatment *i* (*i*=1,2). p_{1i}=conditional detection probability at site 1 for treatment *i*, p_{2ai} (p_{2bi}) = conditional detection probability at the first (second) station in dual array at site 2 for treatment i.

For each desired survival comparison, the power to detect the given treatment effect size (δ) was derived assuming that the ratio of survival estimates under the two treatments is log-normally distributed. It was assumed that different treatments affected oly survival in the second reach (S_{2i}). All other parameters were equated across treatment groups for the purpose of the power analysis: $S_{i1} = S_i$, $p_{1i} = p_1$, $p_{2ai} = p_{2a}$, and $p_{2bi} = p_{2b}$ for $i = 1, 2$. The variance of the survival ratio was derived based on the CJS model (Cormack 1964), and used to compute the power for the various sample sizes, or alternatively to compute the necessary sample size for a power level of 80% (Snedecor and Cochran 1989). Details are provided in Appendix A.

Parameter values (Table 1) used in the power analysis were based on recent VAMP studies for Chinook salmon (SJRGA 2011, 2013), and the 2011 6-year study for steelhead (preliminary results). Parameters were considered for a "high survival" year and a "low survival" year, based on the range of available estimates from the VAMP and 6-year studies. Detection probabilities were selected based on the assumption that higher survival is more likely in high flow years, when detection probabilities are likely to be lower.

Table 1. Parameter values used in power analysis.

	Mossdale to Chipps Island				Head of Middle River to Chipps Island				Detection at Chipps Island	
Species	S_1	S_2 (total)	S_2 (salvage)	p_1	S_1	S_2 (total)	S_2 (salvage)	p_1	p_{2a}	p_{2b}
Steelhead										
High Survival	0.55	0.55	0.25	0.75	0.95	0.60	0.40	0.85	0.85	0.85
Low Survival	0.35	0.35	0.15	0.90	0.75	0.45	0.30	0.95	0.90	0.90
Chinook										
High Survival	0.85	0.10	0.05	0.80	0.85	0.20	0.10	0.85	0.85	0.85
Low Survival	0.50	0.02	0.01	0.95	0.70	0.05	0.03	0.95	0.90	0.90

Results

Survival: Mossdale to Chipps Island

Total Survival from Mossdale

For steelhead, using the parameters in Table 1 and a single replicate, the size of the release group at Durham Ferry necessary to achieve 80% power to detect an increase in total survival from Mossdale to Chipps Island of 10% (δ=1.1) with a Type I error rate of α=0.05 is n = 2,594 for a high survival year, and n = 7,607 for a low survival year (Figure B1; Table 2). For a Type I error rate of α=0.10 (1 replicate), n = 1,891 for high survival, and n = 5,546 for low survival (Table 2, Figure B2). Using two replicates, the necessary sample sizes decrease to n = 1,297 for high survival and n = 3,803 for a low survival (α=0.05), and n = 946 for a high survival year and n = 2,773 for a low survival year (α=0.10) (Table 2, Figure B3, B4). In general, increasing the number of replicates and increasing the Type I error rate (α) require smaller sample sizes for a given effect size (δ) and power level. Detecting a larger effect size also requires fewer fish.

For Chinook salmon, using the parameters in Table 1 and a single replicate, the size of the release group at Durham Ferry necessary to achieve 80% power to detect a 100% increase (δ=2.0) in total survival from Mossdale to Chipps Island with a Type I error rate of α=0.05 is n = 254 for a high survival year, and n = 2,002 for a low survival year (Figure B5; Table 2). For a Type I error rate of α=0.10 with a single replicate, n = 185 for a high survival year, and n = 1,460 for a low survival year (Table 2, Figure B6). Using two replicates halves the necessary sample size per replicate, with n = 127 for a high survival year and n = 1,001 for a low survival year (α=0.05), and n = 93 for a high survival year and n = 730 for a low survival year (α=0.10) (Table 2).

Table 2. Sample sizes necessary at Durham Ferry to have a probability (power) of 80% to detect a relative effect of size δ with a Type I error rate of α on total survival from Mossdale to Chipps Island. Sample sizes are based on the parameters in Table 1.

Species	Relative Effect Size (δ)	Number of replicates (k)	Error Rate (α)	Survival	Sample Size (n)
Steelhead	1.1	1	0.05	High	2,594
				Low	7,607
			0.10	High	1,891
				Low	5,546
		2	0.05	High	1,297
				Low	3,803
			0.10	High	946
				Low	2,773
Chinook	2.0	1	0.05	High	254
				Low	2,002
			0.10	High	185
				Low	1,460
		2	0.05	High	127
				Low	1,001
			0.10	High	93
				Low	730

Survival via Salvage from Mossdale

For steelhead, using the parameters in Table 1 and a single replicate, the size of the release group at Durham Ferry necessary to achieve 80% power to detect a 10% increase (δ=1.1) in survival via salvage from Mossdale to Chipps Island of with a Type I error rate of α=0.05 is n = 9,666 for a year with high survival (low detection probabilities), and n = 23,511 for a year with low survival (high detection probabilities) (Table 3). For a Type I error rate of α=0.10, n = 7,048 for high survival, and n = 17,142 for low survival. Using two replicates, the necessary sample sizes decrease to n = 4,833 for a high survival year and n = 11,755 for a low survival year with α=0.05, and n = 3,524 for high survival and n = 8,571 for low survival with α=0.10 (Table 3). Larger effect sizes require fewer fish (Figure B7, Figure B8).

For Chinook salmon, using the parameters in Table 1 and a single replicate, the size of the release group at Durham Ferry necessary to achieve 80% power to detect a 100% increase (δ=2.0) in survival via salvage from Mossdale to Chipps Island with a Type I error rate of α=0.05 is n = 547 for a year with high survival, and n = 4,059 for a year with low survival (Table 3, Figure B9). For an error rate of α=0.10, n = 399 for a high survival year, and n = 2,960 for a low survival year (Table 3, Figure B10). Using two replicates, the necessary sample sizes decrease to n = 273 for high survival and n = 2,030 for low survival with α=0.05, and n = 199 for high survival and n = 1,480 for low survival with α=0.10 (Table 3).

Table 3. Sample sizes necessary at Durham Ferry to have a probability (power) of 80% to detect a relative effect of size δ with a Type I error rate of α on survival via salvage from Mossdale to Chipps Island. Sample sizes are based on the parameters in Table 1.

Species	Relative Effect Size (δ)	Number of replicates (k)	Error Rate (α)	Survival	Sample Size (n)
Steelhead	1.1	1	0.05	High	9,666
				Low	23,511
			0.10	High	7,048
				Low	17,142
		2	0.05	High	4,833
				Low	11,755
			0.10	High	3,524
				Low	8,571
Chinook	2.0	1	0.05	High	547
				Low	4,059
			0.10	High	399
				Low	2,960
		2	0.05	High	273
				Low	2,030
			0.10	High	199
				Low	1,480

Survival: Head of Middle River to Chipps Island

Total Survival from Head of Middle River

For steelhead, using the parameters in Table 1 and a single replicate, the size of the release group at the head of Old River necessary to achieve 80% power to detect a 10% increase (δ=1.1) in total survival from the head of Middle River to Chipps Island with an error rate of α=0.05 is n = 1,076 for a year with high survival, and n = 2,192 for a year with low survival (Table 4, Figure B11). For a Type I error rate of α=0.10, n = 785 for high survival, and n = 1,598 for low survival (Table 4, Figure B12). Using two replicates, the necessary sample sizes decrease to n = 538 for high survival and n = 1,096 for low survival with α=0.05, and n = 392 for high survival and n = 799 for low survival with α=0.10 (Table 4).

For Chinook salmon, using the parameters in Table 1 and a single replicate, the size of the release group at the head of Old River necessary to achieve 80% power to detect a 100% increase (δ=2.0) in total survival from head of Middle River to Chipps Island with a Type I error rate of α=0.05 is n = 102 for a year with high survival, and n = 549 for year with low survival (Table 4, Figure B13). For a Type I error rate of α=0.10, n = 74 for high survival, and n = 400 for low survival (Table 4, Figure B14). Using two replicates, the necessary sample sizes halve to n = 51 for high survival and n = 274 for low survival with α=0.05, and n = 37 for high survival and n = 200 for low survival with α=0.10 (Table 4).

Table 4. Sample sizes necessary at the head of Old River to have a probability (power) of 80% to detect a relative effect of size δ with a Type I error rate of α on total survival from the head of Middle River to Chipps Island. Sample sizes are based on the parameters in Table 1.

Species	Relative Effect Size (δ)	Number of replicates (k)	Error Rate (α)	Survival	Sample Size (n)
Steelhead	1.1	1	0.05	High	1,076
				Low	2,192
			0.10	High	785
				Low	1,598
		2	0.05	High	538
				Low	1,096
			0.10	High	392
				Low	799
Chinook	2.0	1	0.05	High	102
				Low	549
			0.10	High	74
				Low	400
		2	0.05	High	51
				Low	274
			0.10	High	37
				Low	200

Survival via Salvage from Head of Middle River

For steelhead, using the parameters in Table 1 and a single replicate, the size of the release group at the head of Old River necessary to achieve 80% power to detect a 10% increase (δ=1.1) in survival via salvage from the head of Middle River to Chipps Island with a Type I error rate of α=0.05 is n = 2,457 for a year with high survival, and n = 4,243 for a year with low survival (Table 5). For a Type I error rate of α=0.10, n = 1,792 for high survival and n = 3,093 for low survival (Table 5). Using two replicates, the necessary sample sizes halve to n = 1,229 for a year with high survival and n = 2,121 for a year with low survival with α=0.05, and n = 896 for high survival and n = 1,547 for low survival with α=0.10 (Table 5).

For Chinook salmon, using the parameters in Table 1 and a single replicate, the size of the release group at the head of Old River necessary to achieve 80% power to detect a 100% increase (δ=2.0) in survival via salvage from head of Middle River to Chipps Island with a Type I error rate of α=0.05 is n = 240 for a year with high survival, and n = 941 for a year with low survival (Table 5). For a Type I error rate of α=0.10, n = 175 for high survival, and n = 686 for low survival (Table 5). Using two replicates, the necessary sample sizes halve to n = 120 for a high survival year and n = 470 for a low survival year with α=0.05, and n = 87 for a high survival year and n = 343 for a low survival year with α=0.10 (Table 5).

Table 5. Sample sizes necessary at the head of Old River to have a probability (power) of 80% to detect a relative effect of size δ with a Type I error rate of α on survival via salvage from the head of Middle River to Chipps Island. Sample sizes are based on the parameters in Table 1.

Species	Relative Effect Size (δ)	Number of replicates (k)	Error Rate (α)	Survival	Sample Size (n)
Steelhead	1.1	1	0.05	High	2,457
				Low	4,243
			0.10	High	1,792
				Low	3,093
		2	0.05	High	1,229
				Low	2,121
			0.10	High	896
				Low	1,547
Chinook	2.0	1	0.05	High	240
				Low	941
			0.10	High	175
				Low	686
		2	0.05	High	120
				Low	470
			0.10	High	87
				Low	343

List of References

Cormack, R. M. 1964. Estimates of Survival from the Sighting of Marked Animals. *Biometrika* 51: 429-438.

Snedecor, G. W., and W. G. Cochran. 1989. Statistical Methods, 8th edition. Iowa State University Press, Ames, Iowa.

San Joaquin River Group Authority (SJRGA) 2011. 2010 Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP). Prepared for the California Water Resources Control Board in compliance with D-1641. Available at http://www.sjrg.org/.

San Joaquin River Group Authority (SJRGA) 2013. 2011 Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP). Prepared for the California Water Resources Control Board in compliance with D-1641. Available at http://www.sjrg.org/.

Appendix A: Statistical Methods

Consider a two-reach release-recapture model with a dual array at the end of the second reach (Figure A1), with two treatments, where a treatment is defined by the water export operations protocol. For treatment $\mathrm{i}\ (\mathrm{i}=1,2)$, survival parameters are S_{1i} and S_{2i}; detection parameters are p_{1i} at site 1, and p_{2ai} and p_{2bi} at the dual array at site 2. Let δ be the relative effect of treatment 2 on survival in reach 2, compared to treatment 1:

$$\delta = \frac{S_{22}}{S_{21}}.$$

If treatment 2 has a positive effect on survival in the second reach, then $\delta > 1$. No effect would yield $\delta = 1$. Thus, the appropriate hypotheses to test are

$$H_0 : \delta = 1 \text{ vs. } H_a : \delta > 1.$$

The sample size n necessary to achieve power of $1-\beta$ to detect a relative effect of size δ or larger with error rate α is

$$n = \frac{V_R\left(z_{1-\alpha} + z_{1-\beta}\right)^2}{\left(ln(\delta)\right)^2},$$

where

z_q is the qth quantile of the standard normal distribution (for $q = 1-\alpha$ or $q = 1-\beta$), and

$$V_R = \frac{1}{S_{21}^2}\left(V_1 + \frac{V_2}{\delta^2}\right).$$

The quantity $V_i \quad (i = 1,2)$ is the variance of the CJS estimator of S_{2i}, scaled by the sample size (Cochran 1964):

$$V_i = \frac{S_{2i}}{S_{1i}p_{2i}}\left[\frac{q_{2ai}q_{2bi}}{p_{2ai}p_{2bi}}\left(p_{2i} - p_{2ai}p_{2bi}\right) + \frac{1 - S_{2i}p_{2i}}{p_{1i}}\right],$$

where

$q_{2ai} = 1 - p_{2ai}$, $q_{2bi} = 1 - p_{2bi}$, and $p_{2i} = 1 - q_{2ai}q_{2bi}$.

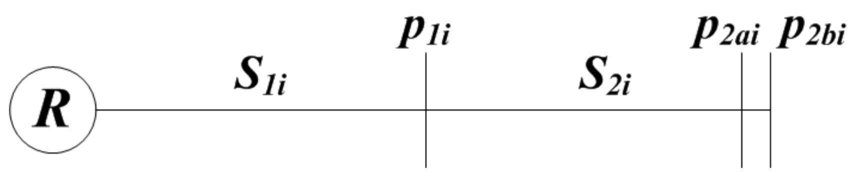


Figure A2. Model schematic. R = release of size *n*, S_{ji}=probability of survival through reach *j* (*j*=1,2) for treatment *i* (*i*=1,2). p_{1i}=conditional detection probability at site 1 for treatment *i*, p_{2ai} (p_{2bi}) = conditional detection probability at the first (second) station in dual array at site 2 for treatment i.

Appendix B: Power Plots

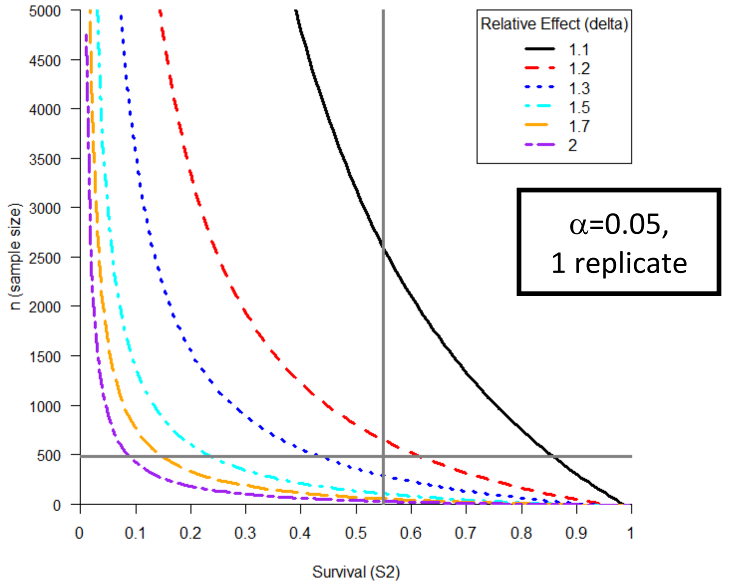


Figure B1. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.85. The cross-bars indicate the observed survival and sample size in 2011 (steelhead).

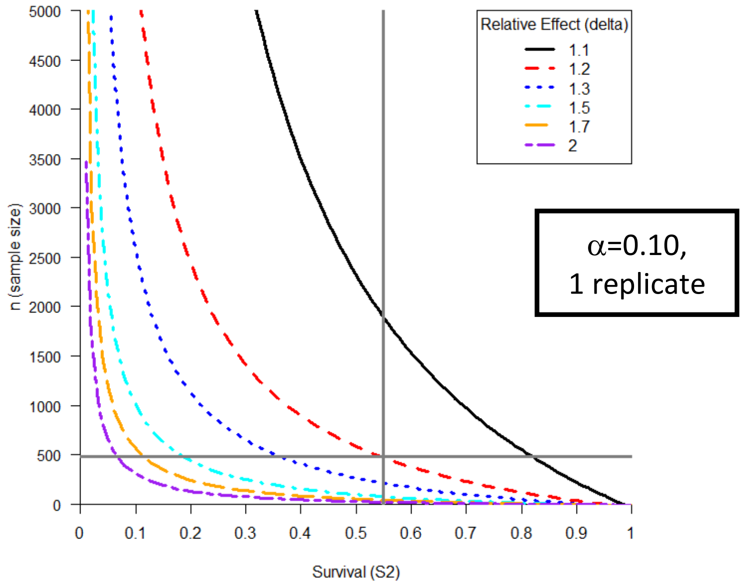


Figure B2. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.88. The cross-bars indicate the observed survival and sample size in 2011 (steelhead).

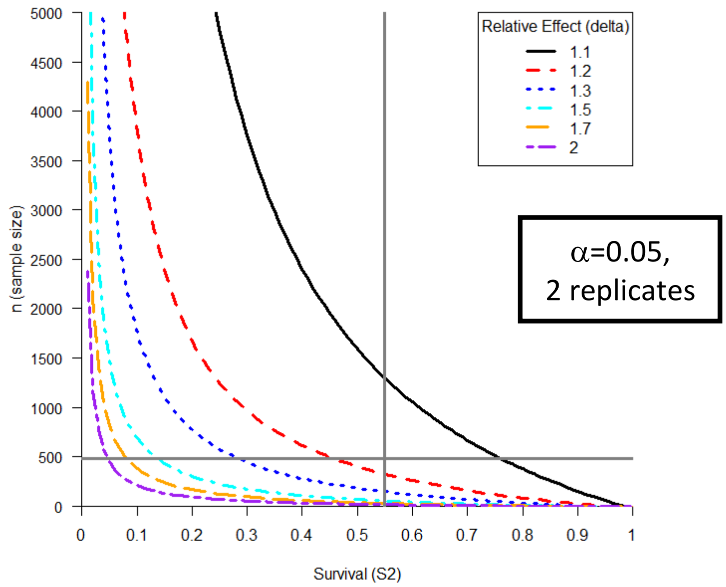


Figure B3. Sample sizes (*n*) necessary versus survival (S2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with two replicates (α=0.05). Survival and detection parameters are: S1=0.55, p1=0.75, p_{2a}=p_{2b}=0.88. The cross-bars indicate the observed survival and sample size in 2011 (steelhead).

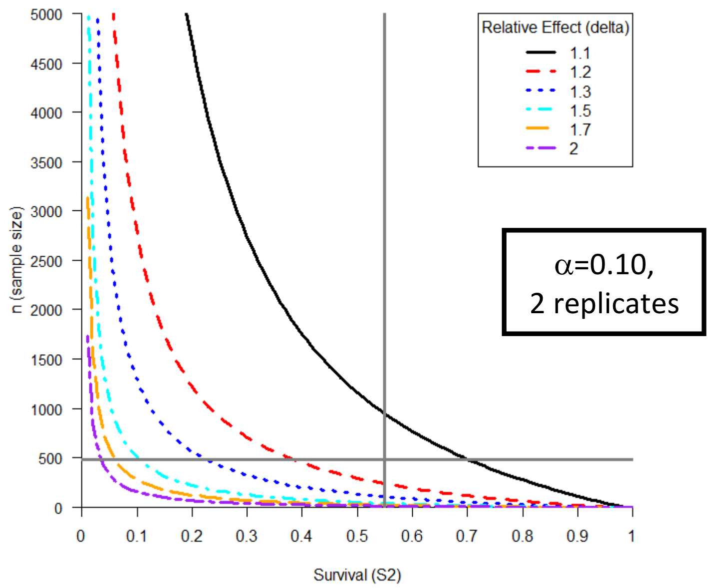


Figure B4. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with two replicates (α=0.10). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.88. The cross-bars indicate the observed survival and sample size in 2011 (steelhead).

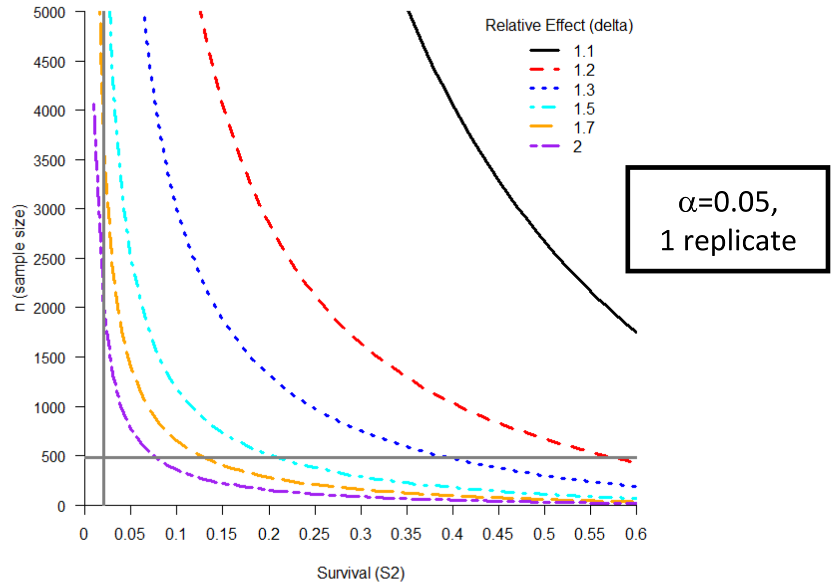


Figure B5. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.50, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the observed survival and sample size in 2011 (Chinook salmon).

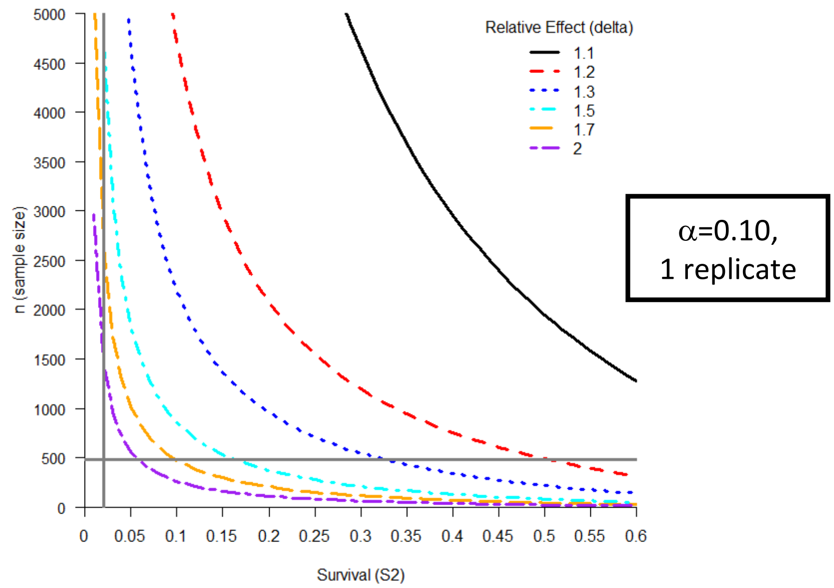


Figure B6. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.50, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the observed survival and sample size in 2011 (Chinook salmon).

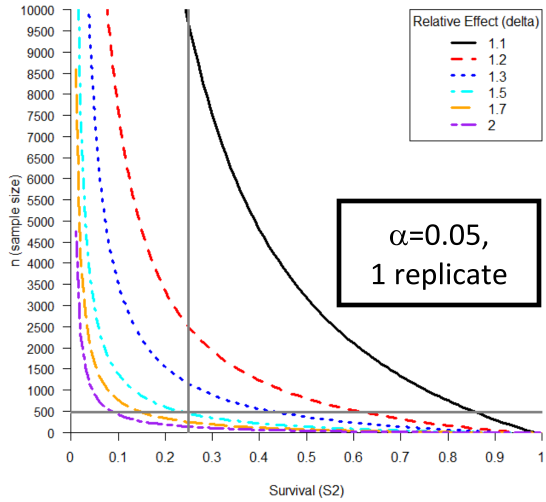


Figure B7. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.85. The cross-bars indicate the assumed survival via salvage for a high survival year, and the observed sample size in 2011 (steelhead).

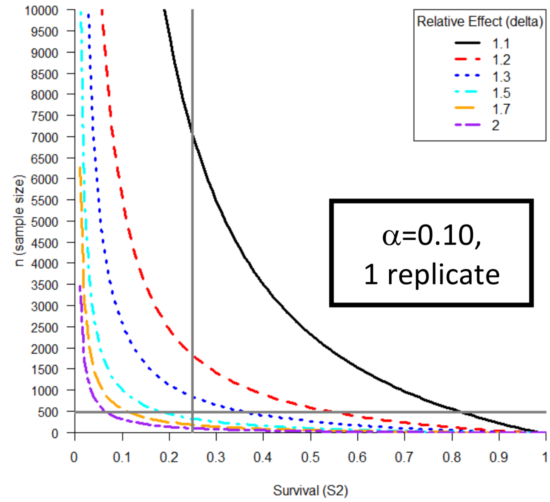


Figure B8. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.55, p_1=0.75, p_{2a}=p_{2b}=0.85. The cross-bars indicate the assumed survival via salvage for a high survival year, and the observed sample size in 2011 (steelhead).

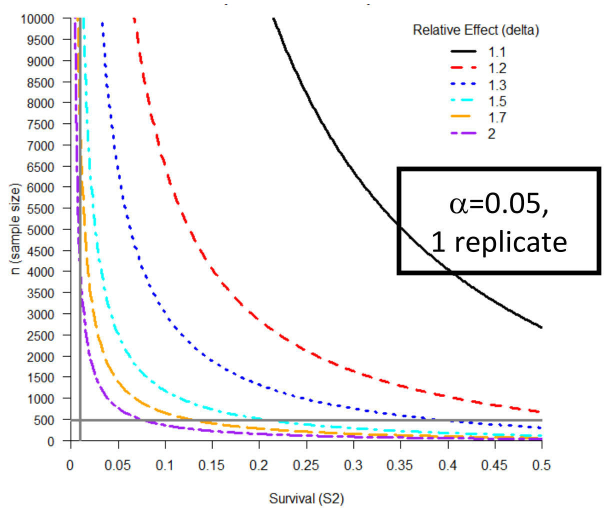


Figure B9. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.50, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the assumed survival via salvage for a low survival year, and the observed sample size in 2011 (Chinook).

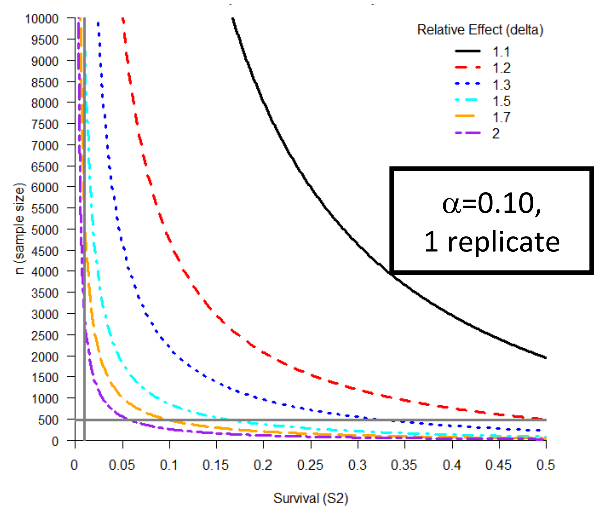


Figure B10. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.50, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the assumed survival via salvage for a low survival year, and the observed sample size in 2011 (Chinook).

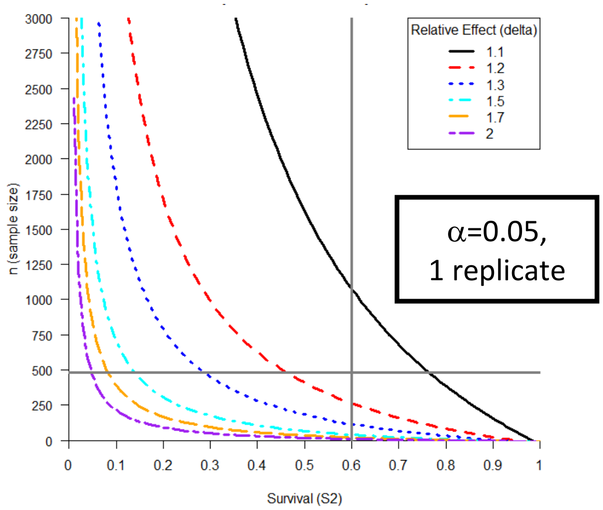


Figure B11. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.95, p_1=0.85, p_{2a}=p_{2b}=0.85. The cross-bars indicate the assumed survival via salvage for a high survival year, and the observed sample size in 2011 (steelhead).

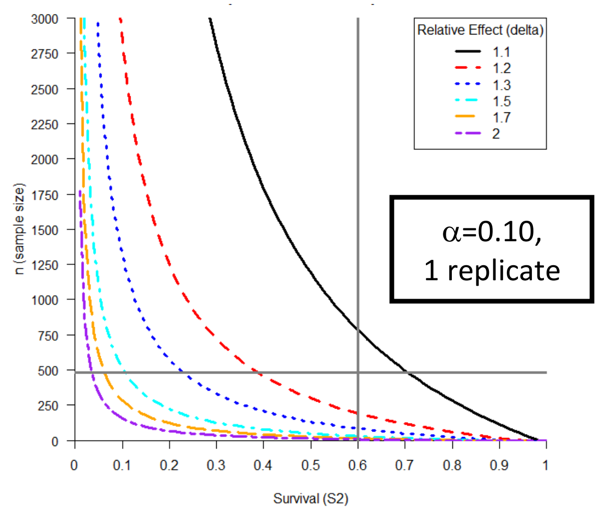


Figure B12. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.95, p_1=0.85, p_{2a}=p_{2b}=0.85. The cross-bars indicate the assumed survival via salvage for a high survival year, and the observed sample size in 2011 (steelhead).

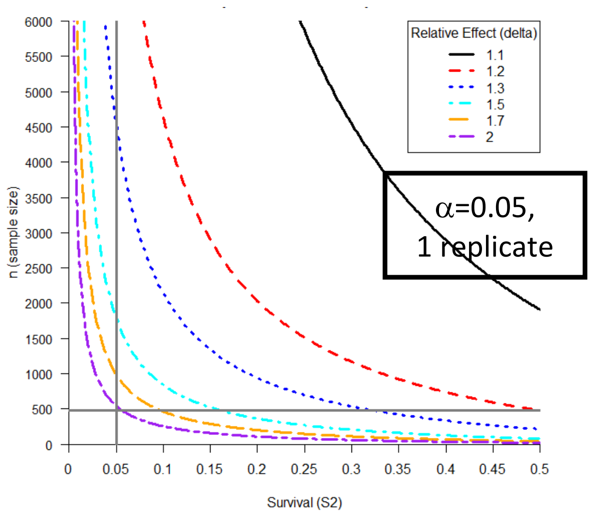


Figure B13. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.05). Survival and detection parameters are: S_1=0.70, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the assumed survival via salvage for a low survival year, and the observed sample size in 2011 (Chinook).

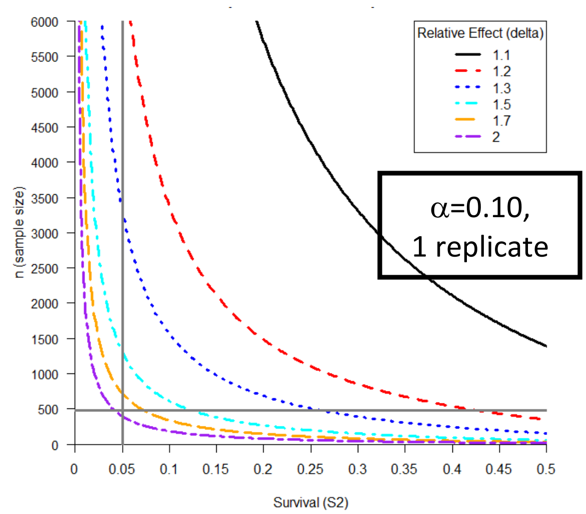


Figure B14. Sample sizes (*n*) necessary versus survival (S_2) to achieve 80% power to detect a relative effect of size delta (δ) in a one-tailed test with a single replicate (α=0.10). Survival and detection parameters are: S_1=0.70, p_1=0.95, p_{2a}=p_{2b}=0.90. The cross-bars indicate the assumed survival via salvage for a low survival year, and the observed sample size in 2011 (Chinook).

APPENDIX N
POTENTIAL FUTURE RESEARCH

INVENTORY OF EXISTING/ONGOING STUDIES

Discussion of Opportunities to Leverage Already-Planned Releases of Tagged Fish (or Taking Advantage of Planned Treatment Conditions)

The fairly recent proliferation of studies in the Central Valley that use acoustically-tagged fish provides opportunities for additional data collection. When multiple studies use compatible tag and receiver technology, opportunities are created to get additional information about the focal study fish (from receivers placed for other studies) and additional information from the focal receiver array (if fish released for other studies pass the focal study's receivers). If studies are designed to be conducted under particular treatment conditions (e.g., extreme high and low Vernalis flows or exports, predator removal treatments), executing multiple studies at the same time would leverage those difficult-to-achieve treatment conditions. Even if specific treatment conditions are not a factor, coordination of different studies (including monitoring efforts) can maximize learning if the suite of studies is designed to tease out different aspects of some driver-linkage-outcome pathway or provide estimates of important covariates. For example, fine-scale hydrodynamic mapping, estimates of submerged aquatic vegetation, and measures of relative predation (estimated using tethered fish) would be interesting and relevant covariates for estimates of steelhead survival through particular reaches of the south Delta, but would need to be collected during the transit time of the tagged steelhead.

SDSRC, perhaps in coordination with Interagency Ecological Program (IEP) Biotelemetry Project Work Team, plans to assemble a comprehensive inventory of existing and upcoming studies and discuss ways to leverage planned releases of tagged fish or planned treatment conditions. This inventory will help SDSRC as it considers potential study designs and would be a useful tool for the rest of the research community as well.

LONGER TERM RESEARCH HORIZON

Many research challenges lay ahead. There is a general lack of ecological community knowledge and the role of juvenile salmonids in food web dynamics for the Delta (Grossman et al. 2013). For survival research, many studies are hindered by what might be considered a lack of overlap in statistical power and desired effect size detection that can be achieved with the combination of tools and resources currently available for studies relative to the "signal to noise" ratio in the environment. Specifically, the ability to measure a survival effect (signal) from a particular manipulation, or under a certain environmental condition, and conclude that survival measurement varied significantly with that condition versus some other variable is limited, given both random variance associated with the tested condition, as well as the associated influence of other variables that may also affect survival (noise). The research horizon for resolving and potentially improving an understanding of this system and ability to advise management has three main pathways (which are not mutually exclusive) for improvement including:

- Technological improvements (to be discussed below)
- Descriptive food web studies that increase knowledge of stock densities of forage and predatory fish, seasonal timing/abundance, behavior, and relationships to biotic and abiotic habitat variables (such as plants, flow, and channel type)
- Conducting natural or manipulated survival studies across a greater range of conditions through either approval for increased manipulation of the variables described in the conceptual model (e.g., manipulating I:E ratio to greater extremes) or supporting studies across a sufficiently long timeframe (many years) for a wide range of conditions to be tested

Types of research projects are likely to include:

- Empirical data collection studies
- Reach survival studies that make use of telemetry (multiple technologies including acoustic, VHF, and passive integrated transponder [PIT] tags)
- Predation studies that attempt to observe and quantify predation of juvenile salmonids by piscine predators (via acoustic predation detection tags, baited tethers, or pop-up balloon tags)
- Community surveys used traditional net/electrofishing methods coupled with hydroacoustic survey tools
- Laboratory studies
- Captive predator studies for tag testing, gut passage times, bioenergetics, and prey selectivity behaviors
- Hydro acoustic measurements of community species in the lab for calibrating species identification of data collected in the field

- Captive salmonid studies on tolerance to Delta environmental variables such as temperature, dissolved oxygen, and orientation/navigation abilities in reverse flow conditions
- Modeling efforts
- Life cycle models
- Particle tracking models
- Predator-prey game theory models
- Bioenergetics models

All of these studies are limited to relatively near-term time horizons and geared towards discovering to what degree survival and recovery can be manipulated without significant habitat modification (restoration) and reduction in water exports. If it is concluded that recovery cannot be achieved under current (and likely declining) salmonid habitat conditions, then a higher level question of what conditions would have to be manipulated to achieve recovery, and whether it can be done given competing human and economic resource requirements, may be required.

NEW RESEARCH TOOLS

Many methods and directions were discussed by the SSWG. Tools and technology are advancing quickly in terms of hardware, software, signal processing, and modeling exercises. The development of many of these tools began on the Columbia River system where, historically, greater resources have been applied to resolving technological and mathematical limitations. However many of these tools were driven by the need to evaluate the impacts of hydropower on fish passage. While many of these tools have proved valuable for research applications in the Delta, they are not necessarily tailored to the issues associated with extreme water withdrawals relative to supply and food web communities dominated by non-native species. As such, it is likely that the research tools of the future will be a combination of the "tried and true" as well as invention driven by the specific needs of the Delta research community.

Acoustic Telemetry

Although in use for more than a decade in the Central Valley, basin-scale work began in 2007, with many technologies now being used for varying applications from high-resolution movement data in localized regions to basin-scale comparative reach survival studies. This technology is typically limited by short tag life and targeted towards measures of juvenile outmigration variables. However, new developments on the horizon include tags that detect consumption by a predator (although current limitations include delayed detection associated with both digestive time and time between last detection as a 'smolt' and first, if ever, detection by the tag after transfer to a predator.)

Passive Integrated Transponder Tags

This technology, also known as RFID (Radio Frequency Identification), relies on radio (light) wave energy, which has more limited propagation range in water in part due to a lack of internal battery, instead being powered by energy transmitted from an antennae, with which the tag typically needs to pass within less than 1 meter for a detection to be achieved. While a seeming weakness, the tag can continue to transmit its ID for the life of the fish any time it is comes in proximity of an antennae, as such enabling the secondary function of providing adult return and potentially SAR (smolt to adult return rate) statistics. At this point, no reports are forthcoming from vendors about a PIT tag that would provide a code change or some other recognition mechanism if the original host-smolt were consumed by a piscine predator. However two acoustic tag vendors (HTI and Vemco) have predation sensing tag technologies that are almost ready for production. While the technology is currently proprietary, it may be that the same technology could be applicable to PIT tags in the near future.

Predation Event Recorders

Balloon tags and tethering tools are tools that are geared toward documenting individual predation events whereby the predator is captured through the process of consuming a juvenile salmonid. There are now tags that can be attached to a smolt that will inflate a balloon when consumed by a predator, forcing it to the surface where it can be collected by a scientist. In addition, the use of baited tethers, effectively fishing with salmonid smolts as bait attached to a series of moored or drifting buoys, is an experimental protocol that is useful for assessing relative predation across different habitat types or between different manipulation scenarios.

Hydroacoustics

The SWFSC and others have made many recent advances in calibrating echo returns of active sonar data to the point of being able to resolve targets to the species level (Conti and Demer 2003; Demer et al. 2009; Renfree et al. 2009). Through a combination of laboratory testing and paired net sampling and hydroacoustic surveys, it is conceivable that hydroacoustics could be used to develop species-specific stock assessments and habitat preferences of the entire Delta fish community.

Models

A variety of models have yet to be developed. Some require solutions that will simply come from continued empirical studies in the watershed, such as general linear models built around relationships between survival and various biotic and abiotic variables such that response curves can be developed between survival and specific variables as well as interactive terms between variables. Particle tracking models are under development that take into consideration both the predicted movements of a passive particle in the water column and how the behaviors of a fish may cause it to deviate from expected passive drifting patterns. Game theory models of predator-prey interactions can be developed that would be used to predict both predator and prey behavioral responses and strategies under varying population densities and then tested against empirical data collected on both species densities in the field as well as associated survival patterns. Bioenergetic models can be built around food webs to assess the relative contributions of juvenile salmonids to Delta community structure and their resilience to such factors as asymmetric apparent competition (i.e., Does the presence of abundant alternative prey species allow predator populations to persist at a level that will drive salmonids to extinction with no feedback repercussions on the predator?).

Life cycle models that incorporate parameters from all of the above can be used to evaluate survival and what threshold variables are required at various life stages for recovery to occur. A refined conceptual model (through more empirical data collection) will allow for a greater understanding of how all the variables influence survival and if any variables are missing from the list of issues currently considered.

REFERENCES

Conti, S. G. and D. A. Demer, 2003. Wide-bandwidth acoustical characterization of anchovy and sardine reverberation measurements in an echoic tank. Journal of Marine Science in press.

Demer, D. A., G. R. Cutter, J. S. Renfree, and J. L. Butler, 2009. A statistical-spectral method for echo classification. ICES Journal of Marine Science: Journal du Conseil 66:1081-1090.

Grossman, G. D., T. E. Essington, B. Johnson, J. Miller, N. E. Monsen, and T. N. Pearsons, 2013. Effects of fish predation on salmonids in the Sacramento River-San Joaquin Delta and associated ecosystems. Page 71, http://deltacouncil.ca.gov/sites/default/files/documents/files/Fish_Predation_Final_Report_9_30_13.pdf.

Renfree, J. S., S. A. Hayes, and D. A. Demer, 2009. Sound-scattering spectra of steelhead (*Oncorhynchus mykiss*), coho (*O. kisutch*), and Chinook (*O. tshawytscha*) salmonids. Ices Journal of Marine Science 66:doi: 10.1093/icesjms/fsp1069.

EXHIBIT C

United States Department of the Interior

BUREAU OF RECLAMATION
Central Valley Operations Office
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

IN REPLY REFER TO:
CVO-100
ENV-7.00

JAN 3 1 2014

Ms. Maria Rea
Supervisor, Central Valley Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento, CA 95814

Subject: Contingency Plan for February Pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3.C of the 2009 Coordinated Long-term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Biological Opinion (2009 BiOp)

Dear Ms. Rea:

The Bureau of Reclamation and the Department of Water Resources (DWR) have prepared the enclosed Temporary Urgency Change (TUC) Petition which will serve as the drought contingency plan for the month of February consistent with the drought exception procedures outlined in the 2009 BiOp RPA Action I.2.3.C. Reclamation is seeking concurrence from the National Marine Fisheries Service (NMFS) that the TUC Petition is within the limits of the Incidental Take Statement (ITS) of the 2009 BiOp. Additionally, because actions under the TUC Petition are in compliance with the drought exception procedures described in the 2009 BiOp, these actions do not jeopardize species or adversely modify or destroy designated critical habitat addressed in the 2009 BiOp.

As you are aware, California is facing unprecedented critically dry conditions in the current water year, following two previous dry years. As a result of this continued aridity, CVP and SWP reservoir levels were already significantly below average in October at the beginning of the 2013/2014 water year. The low initial storage and historically dry conditions experienced since January 2013 throughout the State have resulted in significant reductions in water supplies and will likely lead to critical water shortages in 2014. The dry conditions and persistent lack of precipitation prompted Governor Brown to announce an Emergency Proclamation on drought conditions on January 17, 2014, finding that "conditions of extreme peril to the safety of persons and property exist in California due to water shortage and drought conditions."

In response to this water shortage crisis, Reclamation and DWR have submitted a TUC Petition Regarding Delta Water Quality requesting the State Water Resources Control Board (State Board) to consider modifying requirements of D-1641 for February to enable changes in operations that will provide minimum human health and safety supplies and conserve water for later protections of instream uses and water quality. As described in the TUC Petition, Reclamation and DWR specifically request modification of the D-1641 Delta outflow requirements and Delta Cross Channel (DCC) gate operations. The changes would provide that the February outflow requirements, commonly known as X2 criteria, would be satisfied by a minimum health and safety level of export. This change would reduce reservoir releases from those otherwise required to meet D-1641 in February to conserve storage for later fishery protection, minimum human health and safety needs and if necessary, salinity control. In addition, the request includes modifying February DCC gate operations to allow for opening of the gates as water quality and fishery conditions warrant and as restricted to specific monitoring of fish.

During any period by which the CVP and SWP are operating under a temporary change order, there will be close coordination on current and projected operations on a weekly basis through existing meetings (Delta Operations for Salmon and Sturgeon, Smelt Working Group, Delta Conditions Team, Water Operations Management Team, etc.). An additional weekly drought coordination meeting among Reclamation, DWR, U.S. Fish and Wildlife Service, NMFS, the California Department of Fish and Wildlife, and the State Board will also be needed to ensure effective coordination among the pertinent agencies. We anticipate this group will help guide development of a CVP/SWP operational strategy and corresponding contingency plan to address operations through the operating season if conditions fail to improve. The result of this effort would inform both future determinations with the 2009 BiOp and the 2008 U.S. Fish and Wildlife Service Coordinated Long-term Operation of the CVP and SWP Biological Opinion and additional TUC petitions to the State Board, if necessary.

RPA Action I.2.3.C is triggered based on the February forecast showing that end of September Shasta storage will be less than 1.9 million acre feet. While Reclamation has not yet completed the February forecast, the January 90 percent exceedance hydrology forecast shows Reclamation to be unable to meet 1.9 MAF at the end of September. Given that there has been no appreciable precipitation in January, we expect the February forecast to show reduced storage levels from the January forecast. Therefore, Reclamation and DWR are submitting this contingency plan for February. Reclamation and DWR are committed to updating this contingency plan by March 1, 2014, as required by RPA Action I.2.3.C. Also, RPA Action I.2.3.C requires a relaxation of the Wilkins Slough navigation criteria. Reclamation will target a navigation control point at Wilkins Slough not to exceed 4,000 cubic feet per second during February. Reclamation will coordinate actions specific to Wilkins Slough with NMFS.

Reclamation requests that NMFS consider the enclosed TUC Petition as the February contingency plan which includes proposed changes to the project description for the 2009 NMFS BiOp and change to RPA action IV.1.2. The TUC Petition is consistent with the drought contingency exceptions contemplated in the 2009 BiOp (RPA Action I.2.3.C). RPA Action IV.1.2 requires the DCC gates to be closed from February 1 through May 20 to protect winter-run, spring-run, and fall-run Chinook salmon, steelhead and green sturgeon from entrainment into the interior Delta and prohibits elevated risks to these salmonids. These actions combined help to preserve Shasta storage for later in the year consistent with the Drought Exception Procedure in RPA Action I.2.3.C.

Specific to DCC gate operations, NMFS has convened a team of biologists to develop an initial set of biological triggers for operation of the DCC during the month of February. Reclamation looks forward to working with NMFS and other State and Federal resource agencies.

The enclosed analysis supports Reclamation's conclusion that changes identified in the TUC Petition are consistent with the drought exception procedures of the 2009 BiOp. Any take resulting from these changes are within the limits of the existing take limits in the 2009 BiOp. Additionally, because actions under the TUC Petition are in compliance with the drought exception procedures described in the 2009 BiOp, these actions do not jeopardize species or adversely modify or destroy designated critical habitat addressed in the 2009 BiOp. Reclamation seeks NMFS' concurrence in this determination.

We look forward to working with you and your staff as we navigate through this extremely challenging water year and appreciate your willingness to work with us on this time sensitive matter.

Sincerely,

Paul Fujitani
Deputy Manager, Operations

Enclosures - 2

cc: Mr. Chuck Bonham
Director
California Department of Fish and Wildlife
1416 Ninth Street
Sacramento, CA 95814

Mr. Mark Cowin
Director
California Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Mr. Michael A. Chotkowski
Field Supervisor, Bay Delta Fish and Wildlife Office
U.S. Fish and Wildlife Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814

cc: Continued on next page.

Mr. Dean Messer
Chief, Environmental Services
California Department of Water Resources
P.O. Box 94836
West Sacramento, CA 94236-0001

Mr. John Leahigh
Operations Control Office
California Department of Water Resources
3310 El Camino Avenue, Suite 300
Sacramento, CA 95821

Mr. Ren Lohoefener
Regional Director
Pacific Southwest Region
U. S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, CA 95825

Mr. David Murillo
Regional Director
Mid-Pacific Region
Bureau of Reclamation
2800 Cottage Way
Sacramento, CA 95825
(w/encl to each)

BUREAU OF RECLAMATION
2800 Cottage Way, E-1604
Sacramento, California 95825

DEPARTMENT OF WATER RESOURCES
1416 Ninth Street, Room 1115-1
Sacramento, California 95814

IN REPLY REFER TO:
CVO-100
WTR-4.10

JAN 29 2014

Mr. Thomas Howard
Executive Director
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Subject: Temporary Urgency Change Petition Regarding Delta Water Quality

Dear Mr. Howard:

The Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) submit the attached Temporary Urgency Change Petition to request the State Water Resources Control Board (Water Board) consider modifying requirements of Reclamation's and DWR's water right permits to enable changes in operations that will provide minimum human health and safety supplies and conserve water for later protections of instream uses and water quality.

Reclamation and DWR, operators of the Central Valley Project (CVP) and State Water Project (SWP), respectively, have grave concerns over current hydrologic conditions in the Sacramento-San Joaquin Delta/San Francisco Bay watershed. These dry conditions and persistent lack of precipitation create an urgent need to act as announced by the Governor in his January 17, 2014, Emergency Proclamation on drought conditions. The continuation of extremely dry conditions in the Bay-Delta watershed poses a threat to the effective management of water resources because forecasts by Reclamation and DWR indicate there is not an adequate water supply to meet water right permit obligations under Water Rights Decision 1641 (D-1641) to support instream and Delta beneficial uses. Thus, this Temporary Urgency Change Petition is submitted consistent with Directives 8 and 9 of the Governor's Emergency Proclamation.

As described in the Temporary Urgency Change Petition, Reclamation and DWR request the Water Board change certain terms of the Projects' water rights permits from what is currently provided in D-1641 for the next 180 days, with a specific request for the month of February 2014, and for future changes to be determined through monitoring and management provisions as described in the Petition. Reclamation and DWR specifically request modification of February Delta outflow requirements and Delta Cross Channel (DCC) gate operations. The changes would modify the February outflow requirement, commonly known as X2 criteria, to allow management of reservoir releases on a pattern that will conserve storage for later fishery protection and minimum human health and safety needs. In addition, the request includes modifying the February closure requirement of the DCC gates as water quality and fishery conditions warrant and as restricted by specific monitoring of fish. Under this proposal the Projects would maintain reservoir releases that would sustain minimum health and safety export levels, currently estimated to be 1500 cubic feet per second. Before Reclamation implements any action which may be approved by the Water Board, Reclamation will utilize the drought exception procedures described in the 2009 NMFS CVP/SWP Long Term Operation Biological Opinion, as applicable, and complete the regulatory process with the Fish and Wildlife Service related to delta smelt provided for in the 2008 CVP/SWP Long Term Operation Biological Opinion.

Reclamation and DWR believe that the severe dry conditions support the Water Board taking immediate action where the changes in operations will not injure other lawful users of water, will not unreasonably effect fish, wildlife or other instream beneficial uses, and are in the public interest. If sufficient precipitation were to occur to systemically recover upstream storage, then the Projects could resume operating to the D-1641 objectives, as appropriate.

However, if critically dry conditions in the Bay-Delta watershed persist, Reclamation and DWR, through a team of managers from their agencies, will continue to meet with the Water Board staff to consider additional modifications of D-1641 water quality objectives and to coordinate management of water supplies during the course of the declared drought emergency.

We urge the Water Board to approve the Petition and look forward to cooperatively working with the Board and its staff during this challenging period to manage Bay-Delta water resources for the benefit of the people and natural resources of the state of California.

Sincerely,

Mark W. Cowin
Director
Department of Water Resources

Date: 1/29/2014

David Murillo
Regional Director
Bureau of Reclamation

Date: 1/29/2014

cc: See next page.

cc: Ms. Maria Rea
National Oceanic &
Atmospheric Administration
National Weather Service
650 Capitol Mall
Sacramento, California 95814

Mr. Ren Lohoefener
U.S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, California 95825

Mr. Dan Castleberry
U.S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, California 95825

Mr. Carl Wilcox
Department of Fish and Wildlife
4001 North Wilson Way
Stockton, California 95205

Mr. Chuck Bonham
Department of Fish and Wildlife
4001 North Wilson Way
Stockton, California 95205

Mr. Les Grober
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Mr. Craig Wilson
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Mr. Carl Torgersen
Department of Water Resources
1416 Ninth Street, Room 1115-9
Sacramento, California 95814

Ms. Laura King Moon
Department of Water Resources
1416 Ninth Street, Room 1115-1
Sacramento, California 95814

Mr. Paul Helliker
Department of Water Resources
1416 Ninth Street, Room 1115-9
Sacramento, California 95814

Mr. David Roose
Department of Water Resources
1416 Ninth Street, Room 605-1
Sacramento, California 95814

Mr. James Mizell
Department of Water Resources
1416 Ninth Street, Room 1104
Sacramento, California 95814

Ms. Cathy Crothers
Department of Water Resources
1416 Ninth Street, Room 1104
Sacramento, California 95814

Mr. Ronald Milligan
Central Valley Operations
Bureau of Reclamation
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

Please indicate County where your project is located here: various

MAIL FORM AND ATTACHMENTS TO:
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Tel: (916) 341-5300 Fax: (916) 341-5400
http://www.waterboards.ca.gov/waterrights

PETITION FOR CHANGE

Separate petitions are required for each water right. Mark all areas that apply to your proposed change(s). Incomplete forms may not be accepted. Location and area information must be provided on maps in accordance with established requirements. (Cal. Code Regs., tit. 23, § 715 et seq.) Provide attachments if necessary.

- ☐ **Point of Diversion** Wat. Code, § 1701
- ☐ **Point of Rediversion** Cal. Code Regs., tit. 23, § 791(e)
- ☐ **Place of Use** Wat. Code, § 1701
- ☐ **Purpose of Use** Wat. Code, § 1701
- ☐ **Distribution of Storage** Cal. Code Regs., tit. 23, § 791(e)
- ☒ **Temporary Urgency** Wat. Code, § 1435
- ☐ **Instream Flow Dedication** Wat. Code, § 1707
- ☐ **Waste Water** Wat. Code, § 1211
- ☐ **Split** Cal. Code Regs., tit. 23, § 836
- ☐ **Terms or Conditions** Cal. Code Regs., tit. 23, § 791(e)
- ☐ **Other**

Application: various   Permit: various   License: various   Statement:

I (we) hereby petition for change(s) noted above and described as follows:

Point of Diversion or Rediversion – Provide source name and identify points using both Public Land Survey System descriptions to ¼-¼ level and California Coordinate System (NAD 83).

Present: Not requested

Proposed: No change

Place of Use – Identify area using Public Land Survey System descriptions to ¼-¼ level; for irrigation, list number of acres irrigated.

Present: Not requested

Proposed: No change

Purpose of Use

Present: Not requested

Proposed: No change

Split

Provide the names, addresses, and phone numbers for all proposed water right holders.

Not requested

In addition, provide a separate sheet with a table describing how the water right will be split between the water right holders: for each party list amount by direct diversion and/or storage, season of diversion, maximum annual amount, maximum diversion to offstream storage, point(s) of diversion, place(s) of use, and purpose(s) of use. Maps showing the point(s) of diversion and place of use for each party should be provided.

Distribution of Storage

Present: Not requested

Proposed: No change

Temporary Urgency
This temporary urgency change will be effective from February 1, 2014 to July 30, 2014.

Include an attachment that describes the urgent need that is the basis of the temporary urgency change and whether the change will result in injury to any lawful user of water or have unreasonable effects on fish, wildlife or instream uses.

Instream Flow Dedication – Provide source name and identify points using both Public Land Survey System descriptions to ¼-¼ level and California Coordinate System (NAD 83).

Upstream Location: Not requested

Downstream Location: Not requested

List the quantities dedicated to instream flow in either: ☐ cubic feet per second or ☐ gallons per day:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Will the dedicated flow be diverted for consumptive use at a downstream location? ○ Yes ○ No
If yes, provide the source name, location coordinates, and the quantities of flow that will be diverted from the stream.

Waste Water
If applicable, provide the reduction in amount of treated waste water discharged in cubic feet per second.

Will this change involve water provided by a water service contract which prohibits your exclusive right to this treated waste water? ○ Yes ◉ No

Will any legal user of the treated waste water discharged be affected? ○ Yes ○ No

General Information – For all Petitions, provide the following information, if applicable to your proposed change(s).

Will any current Point of Diversion, Point of Storage, or Place of Use be abandoned? ○ Yes ◉ No

I (we) have access to the proposed point of diversion or control the proposed place of use by virtue of:
☒ ownership ☐ lease ☐ verbal agreement ☐ written agreement

If by lease or agreement, state name and address of person(s) from whom access has been obtained.

Give name and address of any person(s) taking water from the stream between the present point of diversion or rediversion and the proposed point of diversion or rediversion, as well as any other person(s) known to you who may be affected by the proposed change.

This petition does not involve a change in point of diversion. No person(s) will be injured by the proposed change. See supplement for additional information.

All Right Holders Must Sign This Form: I (we) declare under penalty of perjury that this change does not involve an increase in the amount of the appropriation or the season of diversion, and that the above is true and correct to the best of my (our) knowledge and belief. Dated 1/29/14 at Sacramento, CA.

[signature] Chief, SWP Water Ops
Right Holder or Authorized Agent Signature

[signature] Acting Operations Mgr
Right Holder or Authorized Agent Signature

NOTE: All petitions must be accompanied by:
(1) the form Environmental Information for Petitions, including required attachments, available at: http://www.waterboards.ca.gov/waterrights/publications_forms/forms/docs/pet_info.pdf
(2) Division of Water Rights fee, per the Water Rights Fee Schedule, available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/fees/
(3) Department of Fish and Wildlife fee of $850 (Pub. Resources Code, § 10005)

State of California
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Tel: (916) 341-5300 Fax: (916) 341-5400
http://www.waterboards.ca.gov/waterrights

ENVIRONMENTAL INFORMATION FOR PETITIONS

This form is required for all petitions.

Before the State Water Resources Control Board (State Water Board) can approve a petition, the State Water Board must consider the information contained in an environmental document prepared in compliance with the California Environmental Quality Act (CEQA). This form is not a CEQA document. If a CEQA document has not yet been prepared, a determination must be made of who is responsible for its preparation. As the petitioner, you are responsible for all costs associated with the environmental evaluation and preparation of the required CEQA documents. Please answer the following questions to the best of your ability and submit any studies that have been conducted regarding the environmental evaluation of your project. If you need more space to completely answer the questions, please number and attach additional sheets.

DESCRIPTION OF PROPOSED CHANGES OR WORK REMAINING TO BE COMPLETED

For a petition for change, provide a description of the proposed changes to your project including, but not limited to, type of construction activity, structures existing or to be built, area to be graded or excavated, increase in water diversion and use (up to the amount authorized by the permit), changes in land use, and project operational changes, including changes in how the water will be used. For a petition for extension of time, provide a description of what work has been completed and what remains to be done. Include in your description any of the above elements that will occur during the requested extension period.

As described in Attachment 1, historically dry conditions in the current water year following two previous dry years, the projections for continued dry conditions, and the regulatory demands upon the water supply remaining in storage of the State Water Project (SWP) and the Central Valley Project (CVP) (jointly the Projects) cause the Department of Water Resources (DWR) and the United States Bureau of Reclamation (Reclamation) to request a change to certain terms of their water rights permits as provided in D-1641 for the next 180 days, with a specific request for February 2014, consistent with Governor Brown's January 17, 2014 Emergency Proclamation (Proclamation). Reclamation and DWR request modification of D-1641: (1) modifying the Habitat Protection Outflow at Collinsville – commonly known as X2 criteria, during February 2014 and providing alternative method of compliance by operating to sustainable health and safety combined export rates of 1500 cfs at the CVP and SWP delta pumps; (2) modifying the February closure requirement of the Delta Cross Channel (DCC) gates, as water quality and fishery conditions warrant, in conjunction with balancing Delta salinity requirements. Reclamation proposes to open the DCC gates as soon as possible to reduce salinity in the central Delta. To balance salinity and fishery concerns, Reclamation proposes that the gates be closed when the observed Sacramento River flows at Wilkins Slough are greater than or equal to 7,500 cfs or Knights Landing or Sacramento River Catch Indices are greater than or equal to 3 older juvenile per day. Gates would remain closed until these flow and fish monitoring indices are no longer exceeded for at least 7 days. A monitoring and management process would be established to provide the necessary tools to address changing conditions.

CEQA requirements for the purposes of this Petition are waived pursuant to Directives 8 and 9 of the Proclamation. These directives read: "The Water Board will consider modifying requirements for reservoir releases or diversion limitations, where existing requirements were established to implement a water quality control plan," and "for purposes of carrying out directives 5 and 8, Water Code section 13247 and Division 13 (commencing with section 21000) of the Public Resources Code and regulations adopted pursuant to that Division are suspended on the basis that strict compliance with them will prevent, hinder, or delay the mitigation of the effects of the emergency."

Recent operations forecasts completed by the CVP and SWP operations offices, which incorporate the Projects' low storage and record low runoff forecasts have identified an unacceptable level of risk of the Projects' major reservoirs dropping to dead pool or near dead pool levels at which reservoir release capacities will be substantially diminished. As a result, without modification to D-1641 significant risks to temperature control, minimum in-stream flow requirements, and complete loss of salinity control in the Sacramento-San Joaquin Delta could result later this season. As a consequence the Projects are contemplating not releasing any additional water from upstream reservoirs until significant improvement of upstream storage is realized. DWR and Reclamation have an urgent need for modification of the objectives set forth in D-1641 in order to protect the public interest.

Insert the attachment number here, if applicable: 1

Coordination with Regional Water Quality Control Board

For change petitions only, you must request consultation with the Regional Water Quality Control Board regarding the potential effects of your proposed change on water quality and other instream beneficial uses. (Cal. Code Regs., tit. 23, § 794.) In order to determine the appropriate office for consultation, see: http://www.waterboards.ca.gov/waterboards_map.shtml. Provide the date you submitted your request for consultation here, then provide the following information.

Date of Request: N/A

Will your project, during construction or operation, (1) generate waste or wastewater containing such things as sewage, industrial chemicals, metals, or agricultural chemicals, or (2) cause erosion, turbidity or sedimentation? ○ Yes ◉ No

Will a waste discharge permit be required for the project? ○ Yes ◉ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable:

Local Permits

For temporary transfers only, you must contact the board of supervisors for the county(ies) both for where you currently store or use water and where you propose to transfer the water. (Wat. Code § 1726.) Provide the date you submitted your request for consultation here.

Date of Contact: N/A

For change petitions only, you should contact your local planning or public works department and provide the information below.

Person Contacted: N/A Date of Contact:

Department: Phone Number:

County Zoning Designation:

Are any county permits required for your project? If yes, indicate type below. ○ Yes ◉ No

☐ Grading Permit ☐ Use Permit ☐ Watercourse ☐ Obstruction Permit

☐ Change of Zoning ☐ General Plan Change ☐ Other (explain below)

If applicable, have you obtained any of the permits listed above? If yes, provide copies. ○ Yes ○ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable:

Federal and State Permits

Check any additional agencies that may require permits or other approvals for your project:

☐ Regional Water Quality Control Board ☐ Department of Fish and Game

☐ Dept of Water Resources, Division of Safety of Dams ☐ California Coastal Commission

☐ State Reclamation Board ☐ U.S. Army Corps of Engineers ☐ U.S. Forest Service

☐ Bureau of Land Management ☐ Federal Energy Regulatory Commission

☐ Natural Resources Conservation Service

Have you obtained any of the permits listed above? If yes, provide copies. ○ Yes ○ No

For each agency from which a permit is required, provide the following information:

Agency	Permit Type	Person(s) Contacted	Contact Date	Phone Number
N/A				

If necessary, provide additional information below:

Insert the attachment number here, if applicable: ☐

Construction or Grading Activity

Does the project involve any construction or grading-related activity that has significantly altered or would significantly alter the bed, bank or riparian habitat of any stream or lake? ○ Yes ◉ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable: ☐

Archeology

Has an archeological report been prepared for this project? If yes, provide a copy. ○ Yes ◉ No

Will another public agency be preparing an archeological report? ○ Yes ◉ No

Do you know of any archeological or historic sites in the area? If yes, explain below. ○ Yes ◉ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable: ☐

Photographs

For all petitions other than time extensions, attach complete sets of color photographs, clearly dated and labeled, showing the vegetation that exists at the following three locations:

☐ Along the stream channel immediately downstream from each point of diversion

☐ Along the stream channel immediately upstream from each point of diversion

☐ At the place where water subject to this water right will be used

Maps

For all petitions other than time extensions, attach maps labeled in accordance with the regulations showing all applicable features, both present and proposed, including but not limited to: point of diversion, point of rediversion, distribution of storage reservoirs, point of discharge of treated wastewater, place of use, and location of instream flow dedication reach. (Cal. Code Regs., tit. 23, §§ 715 et seq., 794.)

Pursuant to California Code of Regulations, title 23, section 794, petitions for change submitted without maps may not be accepted.

All Water Right Holders Must Sign This Form:
I (we) hereby certify that the statements I (we) have furnished above and in the attachments are complete to the best of my (our) ability and that the facts, statements, and information presented are true and correct to the best of my (our) knowledge. Dated 1/29/14 at Sacramento, California.

[signature] Chief, SWP Water Ops
Water Right Holder or Authorized Agent Signature

[signature] Acting Operations Mgr
Water Right Holder or Authorized Agent Signature

NOTE:
- **Petitions for Change may not be accepted unless you include proof that a copy of the petition was served on the Department of Fish and Game. (Cal. Code Regs., tit. 23, § 794.)**
- **Petitions for Temporary Transfer may not be accepted unless you include proof that a copy of the petition was served on the Department of Fish and Game and the board of supervisors for the county(ies) where you currently store or use water and the county(ies) where you propose to transfer the water. (Wat. Code § 1726.)**

ATTACHMENT 1

SUPPLEMENT TO 2014 TEMPORARY URGENCY CHANGE TO CERTAIN DWR AND RECLAMATION PERMIT TERMS AS PROVIDED IN D-1641

California Department of Water Resources
Application Numbers 5630, 14443, 14445A, 17512, 17514A, Permits 16478, 16479, 16481, 16482, 16483

U.S. Bureau of Reclamation Permits for the Central Valley Project
Application Numbers: 23, 234, 1465, 5626, 5628, 5638, 9363, 9364, 9366, 9367, 9368, 13370, 13371, 14858A, 14858B, 15374, 15375, 15376, 15764, 16767, 16768, 17374, 17376, 19304, 22316

License Number 1986 and Permit Numbers: 11885, 11886, 12721, 11967, 11887, 12722, 12723, 12725, 12726, 12727, 11315, 11316, 16597, 20245, 11968, 11969, 11970, 12860, 11971, 11972, 11973, 12364, 16600, 15735

I. Requested Change

Due to the record setting dry conditions faced by California in the current water year, and following two previous dry years and the projections for continued dry conditions, the Department of Water Resources (DWR) and the United States Bureau of Reclamation (Reclamation) (collectively Projects) are requesting the State Water Resources Control Board (SWRCB) change terms of the Projects' water rights permits from what is currently provided in Water Rights Decision 1641 (D-1641) for the next 180 days, with specific requests for the month of February, 2014, and future requests as determined through a multi-party coordination process. (described below in section II(1)(d)) Consistent with Directives 8 and 9 of Governor Brown's January 17, 2014 Emergency Proclamation (Proclamation; Attached to this petition), Reclamation and DWR request modification of D-1641 outflow and Delta cross-channel standards described in D-1641 Table 3. The changes would modify the February outflow requirement, commonly known as X2 criteria, to allow management of reservoir releases on a pattern that will conserve storage for later fishery protection and minimum health and safety needs. In addition, the request includes modifying the February closure requirement of the DCC gates as water quality and fishery conditions warrant and as restricted by specific monitoring of fish. Under this proposal the Projects would maintain reservoir releases that would sustain minimum health and safety export levels, currently estimated to be 1500 cfs. DWR and Reclamation also request implementation of an ongoing management team to meet weekly through the effective window of this urgency change that will coordinate management of water supplies by proposing additional standards modifications necessary to protect health and safety, water quality, and protection of listed species cold water pool. Before Reclamation implements any action which may be approved by the Water Board, Reclamation will utilize the drought exception procedures described in the 2009 NMFS CVP/SWP Long Term

Operation Biological Opinion, as applicable, and complete the regulatory process with the Fish and Wildlife Service related to delta smelt provided for in the 2008 CVP/SWP Long Term Operation Biological Opinion. These requested modifications are summarized below and described in detail in later sections of this Supplement.[1]

1) Modification of February Outflow

Reclamation and DWR propose maintaining exports at minimum health and safety levels of 1,500 cfs as an emergency drought measure to protect cold water pools for salmon and Steelhead. This will also maintain water supply and improve water quality consistent with Directive 8 of the Proclamation. This modification is necessary because of the extraordinarily dry conditions currently existing, the forecasts of limited future precipitation, extremely low reservoir storage, and the competing needs for water later in the year. The Projects are currently operating to D-1641 water quality requirements but forecasts indicate that relief in some of these operations is needed in order to have water available later in the year for health and safety, Delta salinity control and listed species cold water pool protection. Our best estimate of a sustainable minimum health and safety level is currently a maximum combined export rate of 1,500 cfs. DWR and Reclamation intend to review current conditions and health and safety needs, which might support periods of lower levels that would be protective of health and safety.

2) Modification of DCC Gate Operations

D-1641 requires the closure of the DCC gates from February 1 through May 20. However, under the Governor's Emergency Proclamation, the Projects are seeking the use of the DCC gates as a means of controlling salinity conditions in the Delta. Normally, runoff and the Delta inflow/outflow needed to meet the X2 requirement would assist in meeting salinity requirements in the Delta with the DCC gates closed. Under these extremely low flow conditions, however, DCC gate operations may be needed to protect interior Delta salinity conditions sufficient to meet minimum human health and safety water quality requirements.

II. Basis to Authorize Modification of Water Rights

The California Water Code, Section 1435, authorizes the State Water Board to grant a temporary change order for any permittee or licensee who has an urgent need to change a permit or license, where the State Water Board finds: 1) the permittee has an urgent need for the proposed change, 2) the proposed change may be made without injury to any other lawful user of water, 3) the proposed change can be made without unreasonably affecting fish, wildlife, or other instream beneficial uses, 4) the proposed change is in the public interest. The law also requires consultation with representatives of the Department of Fish and Wildlife.

---

[1] In addition, given the dry conditions, there may need to be additional requests for modification to D-1641 standards described in Tables 1, 2 and 3 as provided through the process described in section II.1.d of this supplement.

DWR and Reclamation provide the information below to support the findings necessary under California Water Code section 1435. The current hydrology and storage are critically low and without the modifications requested there exists an unacceptable risk that DWR and Reclamation will be unable to provide future protection of beneficial uses that rely upon storage from the Projects. Therefore, the modifications requested are urgent and critical and can be implemented in a manner satisfying requirements of section 1435, as described below. .

1) DWR and Reclamation Have an Urgent Need for the Change

California is entering its third straight year of below-average rainfall and very low snowmelt runoff. As a result of this continued aridity, reservoir levels throughout the state were already significantly below average in October at the beginning of the 2013/2014 water year. The low initial storage and historically dry conditions experienced in the last 12 months, since January 2013, have resulted in significant reductions in water supplies and will likely lead to critical water shortages in 2014.

In order to meet the requirements of D-1641, the SWP and CVP have released water from storage to meet in-basin demands since April 2013 These demands upon the stored water of the SWP and CVP have been exacerbated by the unprecedentedly high use of river water on the Sacramento River and Feather River systems, commonly referred to as depletions. There is anecdotal evidence that water users within the Delta are diverting much greater quantities than is typically assumed for this period. These depletions further reduce the amount of storage remaining for future protection of beneficial uses.

If the requested February modification in Delta outflow requirement is granted, Reclamation and DWR forecast that a Delta Outflow of at between 3,000 and 4,500 cfs will provide additional preservation of cold water pool for listed species later in the year. Such an outflow rate can also provide the water quality necessary to maintain minimum exports of 1,500 cfs for minimum human health and safety deliveries, and is contingent upon modification of Delta salinity standards. The 4,500 cfs Delta outflow is the estimated minimum nominal rate assumed to maintain salinity levels above 250 mg/l chloride at all export locations specified under Table 1 of D-1641. This outflow forecast, however, cannot be used to guarantee an outflow level because of the significant depletions occurring and is based on an assumption of 1,500 cfs minimum health and safety exports.

In December 2013, DWR announced its initial 2014 allocations of Table A water supplies for the State Water Contractors at 5 percent. Because of the relentless dry pattern, the Department of Water Resources anticipates that no 2014 supply would be allocated this year, which if not increased over the course of the year would represent the largest reduction in SWP allocations for its Municipal and Industrial contractors on record. Furthermore, DWR anticipates that the February 1 Bulletin 120 hydrologic criterion will be met to trigger for 50% shortages to its Feather River settlement contractors. Concurrently, Reclamation will announce its initial allocation for CVP contractors in February. Under the current conditions there would be significant deficiencies to the water supply available to all CVP users throughout the system.

Forecasts for Water Year 2014 indicate it is likely to be one of the most severe drought years in California's history. The current precipitation trend for both the Northern Sierra 8-station and Southern Sierra 5-station indices is drier than the two driest water years on record (1924 and 1977) (see http://cdec.water.ca.gov/cgi-progs/products/PLOT_ESI.pdf and http://cdec4gov.water.ca.gov/cgi-progs/products/PLOT_FSI.pdf). Extremely low reservoir storage levels are forecasted for this year in Northern California, in some cases surpassing prior record low levels.

At this time, total storage at the SWP's Lake Oroville is roughly 1.2 million acre-feet (MAF), and the total combined storage at the CVP's Shasta and Folsom reservoirs is also very low at about 1.8 MAF. Storage in all three reservoirs is below what they were at this time in 1977 when the state was in a severe drought (see http://cdec.water.ca.gov/cgi-progs/products/rescond.pdf).

Of even more concern is the lack of snowpack in the watersheds feeding into the Projects' major Sacramento Valley reservoirs. The current water year's lack of precipitation has resulted in a northern California snowpack which is a mere 4% of the typical seasonal peak (see http://cdec.water.ca.gov/cgi-progs/products/PLOT_SWC.pdf).

The continuation of extremely dry conditions in the Bay-Delta watershed poses great challenges to the effective management of water resources, and Reclamation and DWR do not believe that there is an adequate water supply to meet all obligations under D-1641. Current projections indicate that without the requested change to Reclamation and DWR's water rights permits, there exists a substantial risk that by late spring 2014 and into 2015 the Projects' major reservoirs will be drafted to dead pool or near dead pool levels at which point reservoir release capacities will be substantially diminished. As a result, significant risks to health and safety, temperature control, minimum in-stream flow requirements, and an inability to repel salinity in the Sacramento-San Joaquin Delta could result later this season, (see attachment A). Under the current circumstances the Projects believe the most prudent course of action is to conserve storage in upstream reservoirs until significant improvement of that storage is realized. Such a decision may mean that some objectives set forth in D-1641 would require modification, as discussed below in section II.1.d.

a. Authorization to Take Extraordinary Measures

As a result of these extraordinary conditions, the Governor signed the Proclamation on January 17, 2014. This Proclamation includes the following two directives:

> Directive 8 - "the Water Board to consider modifying requirements for reservoir releases or diversion limitations, where existing requirements were established to implement a water quality control plan. These changes would enable water to be conserved upstream later in the year to protect cold water pools for salmon and steelhead, maintain water supply, and improve water quality."
>
> Directive 9 – "The Department of Water Resources and the Water Board will take actions necessary to make water immediately available, and, for the purposes of carrying out directives 5 and 8, Water Code section 13247 and Division 13 (commencing with section 21000) of the Public Resources Code and regulations adopted pursuant to that Division are suspended on the basis that strict compliance with them will prevent, hinder, or delay the mitigation of the effects of the emergency."

DWR has initiated a number of actions to minimize drought impacts and meet minimum health and safety needs including aggressive conservation efforts and taking a lead role in the Governor's Interagency Drought Task Force. Under the Proclamation, the SWRCB is authorized to modify D-1641.

b. Modification of Outflow at Collinsville (X2)

The Projects are allowed to meet the habitat protection outflow requirement, commonly known as X2, in one of three ways:

- Daily Electrical Conductivity (EC) of 2.64 millimhos per cm (mmhos/cm) or less at Collinsville; or
- 14-day average EC of 2.64 mmhos/cm or less at Collinsville; or
- 3-day average of the Net Delta Outflow Index of 7,100 cfs.

Reclamation and DWR propose modifying D-1641 to recognize that reducing exports to minimum health and safety levels of 1,500 cfs is an emergency drought measure to protect cold water pools for salmon and Steelhead, maintain water supply, and improve water quality, consistent with Directive 8 of the Proclamation, which recognizes the extraordinarily dry conditions and operational projections resulting from satisfying all the competing requirements on water under D-1641 as currently written. The most crucial of these are storage to be released to the Delta for health and safety, salinity control, and for listed species cold water protection later in the year. The best estimate from DWR and Reclamation of a sustainable health and safety level is a maximum combined export rate of 1,500 cfs.

The sustainable level of 1,500 cfs is primarily related to operational considerations for municipal and industrial diverters who rely solely for their export supply from the delta or the canal between the Project export pumps and San Luis Reservoir. This sustainable level of exports for health and safety is recognized in the USFWS Delta Smelt Biological Opinion for CVP and SWP Operations on page 296, and the NMFS Salmonid Biological Opinion for CVP and SWP Operations on pages 643 and 644. However, Reclamation and DWR are re-evaluating this level based on current conditions that might support a lower export level.

Without a modification of the X2 requirement, Reclamation and DWR would be forced to increase releases from upstream reservoirs in February to meet Delta outflow levels up to 7,100 cfs. The estimated impact to reservoir storage could be approximately 144 TAF, which is the difference between the currently projected Delta Outflow of at between 3,000 and 4,500 cfs will provide additional preservation of cold water pool for listed species later in the year. Such an outflow rate can also provide the water quality necessary to maintain minimum exports of 1,500 cfs for minimum human health and safety deliveries, and is contingent upon modification of Delta salinity standards. The 4,500 cfs is the estimated minimum nominal rate assumed to maintain salinity levels above 250 mg/l chloride at all export locations specified under Table 1 of D-1641. This outflow forecast, however, cannot be used to guarantee an outflow level because of the significant depletions occurring and is based on an assumption of 1,500 cfs minimum health and safety exports.

In addition, if X2 requirements remain in effect as currently mandated in D-1641, the outflow requirements will decrease the likelihood that adequate cold-water reserves will be available to meet regulatory requirements protecting salmon and other cold-water fish species in the summer and fall of 2014 and could even result in a "loss of control" over salinity encroachment in the Delta by late spring 2014 and into 2015 in a worst case scenario. "Loss of control" is a term associated with a condition when due to storages at or near dead pool the major Project reservoirs will have insufficient release capability to expel encroachment of ocean water into the Delta, which will make the Delta waters incompatible with in-Delta beneficial uses. This condition will persist until Northern California receives a rainy season with sufficient runoff to flush the Delta of ocean water to once again allow for these in-Delta beneficial uses. Additionally, failure to sufficiently control Delta salinity will jeapordize the ability to provide for human health and safety.

Reclamation and DWR, however, propose continued discussions, as described in subsection (d) below, in order to consider potential modification of other standards in conjunction with the outflow requirement that will best balance protection of all beneficial uses.

c. Health and Safety Modifications of Delta Cross Channel Operation to Maintain Acceptable Interior Delta Salinity Conditions

D-1641 requires the closure of the DCC gates from February 1 through May 20. However, under the Governor's Emergency Proclamation, the Projects are seeking the use of the DCC gates as a means of controlling salinity conditions in the Delta. Normally, runoff and the Delta inflow/outflow needed to meet the X2 requirement would assist in meeting salinity requirements in the Delta with the DCC gates closed. Under these extremely low flow conditions, however, DCC gate operations may be needed to protect interior Delta salinity conditions sufficient to meet minimum human health and safety water quality requirements.

Immediate relaxation of interior Delta salinity control standards would create unacceptable risk to minimum human health and safety requirements. The imprecise nature of salinity control within the Delta in combination with a steep salinity gradient, which does not allow for an adequate margin of error, and the persistence of human health and safety concerns once triggered, supports maintaining existing interior delta salinity control standards as operational targets.

Towards that end, Reclamation and DWR request permission to open the gates for human health and safety purposes based on consultation with the fishery agencies as described in (d) below. Several different operational concepts to balance human health and fishery concerns are currently under discussion between Reclamation, DWR and the fishery agencies, including a possible diurnal open/close schedule. We propose to continue evaluation and discussion of these concepts and associated fish presence monitoring needs through the process described in (d) below.

d. Proposed Reporting and Management

As stated in the Proclamation, the dry conditions and water supply levels are of a magnitude that they present peril to the safety of persons and property. In order to facilitate declarations 8, 14 and 16 of the Governor's proclamation, DWR and Reclamation propose that the operations and regulatory changes requested in this petition include regular monitoring, to ensure that the objectives of this proposal and the requirements of Water Code Section 1435 are met under any changed conditions. Thus, DWR and Reclamation propose convening a team of managers from their agencies authorized to act in order to coordinate management of water supplies during the course of the declared drought emergency to meet weekly with appropriate managers at the SWRCB, California Department of Fish and Wildlife (DFW), National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (FWS) also authorized to act in order to coordinate management of water supplies and protection of natural resources during the course of the declared drought emergency. DWR and Reclamation expect to work with DFW, NMFS, and FWS to ensure that this process meets the requirements of CESA and ESA, including complying with the drought contingency provision (RPA Action I.2.3.c.) in the 2009 NMFS Biological Opinion. This process will be structured to allow the regulatory agencies to provide feedback and concur on potential project operations and related effects on an ongoing basis as the drought emergency is addressed. As a result of this coordination, DWR and Reclamation may submit to the SWRCB additional information on any further adjustments needed to regulatory requirements in order to balance the protection of health and safety, water quality and cold water pool for listed species.

The discussions and any future requests for possible modifications of water quality objectives found in D-1641 Table 1 "Municipal and Industrial Beneficial Uses," Table 2 "Agricultural Beneficial Uses," and Table 3 "Fish and Wildlife Beneficial Uses." This team will report periodically to the SWRCB on the necessity of changes to south Delta agricultural salinity standards outside the control of DWR, western, interior and export area agricultural salinity standards, Suisun Marsh salinity standards dependent upon outflows, San Joaquin River flows that endanger heath and safety or the protection of listed species cold water pool, and western Delta municipal and industrial salinity standards that can be modified without harming health and safety.

2) There Will be no Impact to Other Legal Users of Water

The Projects have been augmenting natural flow by releasing previously stored water to meet in-stream requirements and to maintain minimum outflows in the Delta to control salinity intrusion. Under the proposed changes to outflow requirements, the Projects will continue to augment natural flow with storage releases. The Projects do not propose to cease all reservoir releases, but rather to significantly reduce the releases to levels necessary to maintain salinity standards but below those that would be required to meet the existing minimum flow requirement of 7,100 cfs in February.

The Projects have not been appropriating natural flow and Term 91 went into effect in March 2013. Term 91 conditions remain in effect. It is anticipated that Term 91 conditions will continue until the hydrology within the Delta watershed improves significantly. The Projects have been making significant releases of Project storage to meet the water quality objectives contained in D-1641. As a result, Project storage levels continue to decline. No other legal users of water are entitled to divert Project storage releases. In the absence of those releases, the water quality in the tributaries with Project facilities as well as the Delta would likely see declines beyond existing conditions.

Although Term 91 continues to be in place to prevent water rights holders who are subject to Term 91 from diverting Project releases intended to protect fish and wildlife, it is clear that other appropriative and riparian users are diverting greater quantities of water than typical for this time of year and those quantities are not supported by natural flow. The amount of river accretion measured between the Project reservoirs and the

Freeport gage on the Sacramento River is at historical lows for this time of year. This infers that non-Project diversions are at record highs in the Sacramento Valley. In addition, there is anecdotal evidence that water users within the Delta are diverting much greater quantities than is typically assumed for this period. This anecdotal evidence is supported by continued observations of degrading salinity conditions in the western and central Delta despite the Projects meeting the nominal 4,500 cfs outflow requirement throughout the month of January, which would typically be sufficient to maintain salinity conditions. More specifically, the actual in-Delta consumptive use, (a subtractive component of the net Delta outflow index) which cannot be measured directly, is likely much greater than the assumed value in the index. In other words, due to the extreme lack of precipitation, additional and unexpected diversions are occurring to compensate for the weather. These facts support a determination that the proposed changes to the Delta outflow standard will not injure any other legal user of water. Rather, reductions in stream flow will stem from the release of less stored water that is not legally available for appropriation absent the changes.

If natural flows increase and senior in-basin water rights are satisfied, the appropriation of natural flows in upstream Project reservoirs will be necessary to protect beneficial uses later in the year. These beneficial uses include necessary water later in the summer for temperature control for fish and releases for Delta salinity control when unstored flow is insufficient to meet these critical system needs.

3) The Change Will Not Result in Unreasonable Impacts to Fish and Wildlife or Other Instream Uses

Extreme drought conditions are well known to stress the aquatic resources of the San Francisco estuary and its watershed. Dry conditions during winter are expected to adversely affect spawning and rearing conditions for Longfin Smelt, migration and spawning conditions for Delta Smelt, and migration conditions for Winter-run Chinook salmon, Spring-run Chinook salmon, Steelhead Trout, and Southern DPS Green Sturgeon. While maintaining flows would provide some short-term support for these species, continued dry conditions may lead to even worse impacts later in the year. For example, reduced flows may decrease survival of the salmonids during winter, but a failure to maintain adequate reservoir storage could lead to a loss in ability to maintain cold water later in the year for Winter-run Chinook Salmon egg survival, and to provide suitable upstream conditions for Spring-run Chinook Salmon and Steelhead Trout rearing. Similarly, it is critical to maintain the ability to provide a water storage pool to support Delta Smelt and Longfin Smelt rearing and maturation later in the year. Hence, this proposal seeks to balance the short-term and long-term habitat needs of some of the covered anadromous and pelagic species during the entirety of water year 2014.

Specifically, the proposed reduced reservoir release operations are intended to minimize adverse impacts to cold water pool for fisheries benefits, and allow for some level of salinity and temperature control later in season. The proposed DCC gate operations are intended to provide benefits to both water quality and Delta outmigrating anadromous fish protection during February, when there may be substantial immigration of listed salmonids into the Delta. This immigration event has yet to be observed in the 2014 water year.

A supporting factor for the proposed operations is that the current distribution of key fish species of concern is such that they are at relatively low risk of entrainment at the South Delta water diversions. (For Salmonid and Green Sturgeon see attachment B: Salmonid and Green Sturgeon Monitoring and Exposure Evaluation.) The evidence includes the following:

Winter-Run Chinook Salmon: The current data suggest that young Winter-run have not yet initiated their migration into the Delta. This is expected as published statistical analyses have shown that Winter-run migration is largely triggered when flows reach 14,000 cfs, a level well above this year's drought conditions. Note that this analysis is based on a multi-agency study published by authors from NMFS, USFWS, DFW, and DWR (del Rosario, et al. 2013- published in San Francisco Estuary and Watershed Science). At this point, most Winter-run sized fish appear to be distributed well-upstream of the Delta. Monitoring data through 1/25/14 show moderate catch of Winter-run sized Chinook in the upper Sacramento River (Red Bluff), catch at the Knights Landing and the Sacramento Trawl monitoring stations considered entry points to the Delta has been rare over the migration season. Given the current upstream distribution, as well as analysis of historic data indicating 14,000 cfs as a trigger for substantial downstream migration, the proposal to open the DCC gates then close them if Wilkins Slough flows reach 7,500 cfs or if older juvenile salmonids are observed in elevated levels at Knights Landing or in the Sacramento River trawls is a reasonable measure for protection once Winter-run sized Chinook enter the Lower Sacramento River and Delta in February.

Spring-run Chinook Salmon: A small, but greater than average spawning run of Spring-run Chinook returned to the upper Sacramento River. In 2013, this greater-than-average return of spawners was observed across many tributaries supporting Spring-run Chinook Salmon. Rain events during mid-November increased daily average flows in upper Sacramento River tributaries conducive to triggering outmigration of yearling Spring-run Chinook into the main-stem, although the rapid return to stable tributary flows and low temperature suggest these fish may have abandoned outmigration. Hundreds of smaller-sized Spring-run Chinook Salmon juveniles continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than previous years. Fifty-one juvenile spring run Chinook were observed in middle (GCID) Sacramento fish monitoring stations through January 14 2014. Two juvenile Spring-run Chinook Salmon were observed in late October and early November at the Tisdale Weir and Knights Landing fish monitoring stations. Since then, no Spring-run Chinook have been observed in lower Sacramento and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. Given the current upstream distribution, as well as analysis of historic data indicating 14,000 cfs as a trigger for substantial downstream migration of older juvenile salmonids, the proposal to open the DCC gates then close them if Wilkins Slough flows reach 7,500 cfs or older juvenile salmonids are observed in elevated levels at Knights Landing or in the Sacramento River trawls is a reasonable measure for protection once spring-run Chinook salmon enter the Lower Sacramento River and Delta in February.

Longfin Smelt: There has been no salvage of Longfin Smelt this water year. Although adult Longfin Smelt were not collected in the San Joaquin River or South Delta this December, low numbers of larval Longfin Smelt have been collected in the region by last week's Smelt Larva Survey. Importantly, the majority of larval Longfin Smelt appear to be distributed in the Cache Slough Complex, lower Sacramento River, and Suisun Bay. As the proposed operations will not result in increased outflow, and exports will be maintained at low levels, it is unlikely that they will trigger a change in the Longfin Smelt distribution that will increase the population's risk of entrainment. Juvenile Longfin Smelt salvage at the CVP/SWP pumping facilities is generally higher when their distribution puts them at risk of entrainment (i.e., significant portion of the population in the South and Central Delta) and exports, as indexed by Old and Middle River flows, are high (Grimaldo et al., 2009, published in the *North American Journal of Fisheries Management)*. Thus, current larval distributions and minimal pumping operations as proposed in this petition are highly unlikely to result in increased entrainment.

In addition, it is worth noting here that new, ongoing research conducted by DWR, SWC, DFW, and UC Davis is investigating the possibility of Longfin Smelt spawning and rearing in the Napa River and tributaries to the South Bay that are not currently surveyed during routine monitoring. Longfin Smelt are not at risk of entrainment in these areas. While research on these areas is only just beginning, anecdotal evidence suggests that these areas may be productive for Longfin Smelt and there are already observations of Longfin Smelt in South Bay tributaries in 2014.

Notably, larval Longfin Smelt have been detected at the station 716 near the Barker Slough pumping plant, pumping restrictions under the DFW Incidental Take Permit for Barker Slough operations have been triggered. Hence, DFW has provided formal advice to the Water Operations Management Team (WOMT) group to limit pumping to 50 cfs until Longfin Smelt are not detected at station 716.

Delta Smelt: As for Longfin Smelt, no Delta Smelt have been salvaged this water year at the South Delta fish facilities. This is expected as adult Delta Smelt appear to be distributed well away from entrainment risk this winter. For example, the first Spring Kodiak Trawl survey (1/13/14-1/14/14) collected 148 Delta Smelt, with over half the catch in the Suisun Bay region, with the rest in Cache Slough Complex and the lower Sacramento River and confluence region. The Spring Kodiak Trawl is conducted on a monthly basis, with the second survey planned for the week of February 10. Adult Delta Smelt are highly unlikely to shift their distribution towards the South Delta until a "first flush" event occurs (e.g. high turbidities brought on by a major precipitation event) and triggers upstream movement. As the proposed operations will involve conditions of reduced exports and outflow, it is highly unlikely that they will result a change in Delta Smelt distributions that would increase entrainment risk to the population. Published analyses of a 13-year dataset of salvage records at the CVP/SWP fish collection facilities indicate that increased salvage of Delta Smelt at the CVP/SWP occurs when turbidities increase in the South Delta and Old and Middle River flows are highly negative (Grimaldo et al., 2009, published in the *North American Journal of Fisheries Management)*. Given the present low turbidity conditions throughout the Delta, and the proposed reduction in export levels to minimum health and safety standards, there is no reason to expect the proposed operations to create conditions that would trigger movement toward the CVP/SWP pumps.

The Smelt Larval Survey has not collected any Delta Smelt this year during the two January surveys. Unless there is a shift in current weather patterns that brings about increased turbidities and outflow, adult and juvenile Delta Smelt are unlikely to be an entrainment issue this year.

Steelhead: Information on steelhead is extremely limited. Observed 2013 patterns of outmigrating *O. mykiss* juveniles during the summer at RBDD were similar to previously observed patterns, although a greater abundance appears to have passed than in the past 5 years. Smolts are seldom observed in Sacramento River and Delta fish monitoring due to sampling biases related to the large fish size and their swimming ability. False negatives are more likely with Steelhead smolts than Winter-run sized Chinook salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. Between 1998 and 2011, observations of natural-origin Steelhead juveniles (n=2137) in these efforts in the Delta occured less than 10% of the time in January, >30% of the time during February, and >20% of the time during March. A single Steelhead was observed in lower Sacramento and Delta seine and trawl surveys in water year 2014 (one 300mm observed 12/11/13 in the Chipps Island Trawl). One Steelhead has also been observed at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. While outmigrating Steelhead have not been observed in the Mossdale trawl this winter, it is feasible the fish observed in salvage was from the San Joaquin or Sacramento River. Given the general pattern of the majority of juvenile Steelhead presence in the Delta during March, as well as their larger size making them less susceptible to predation, and longer residency within the Delta, the proposal to open the DCC gates but close them if Wilkins Slough flows reach 7,500 cfs or older juvenile salmonids are observed in elevated levels at Knights Landing or in the Sacramento River trawls is a reasonable measure for protection prior to the majority of smolts migrating through the Lower Sacramento and San Joaquin rivers and into the Delta before March. The lack of observational data on Steelhead create significant uncertainties surrounding the risk to these populations due to entrainment into the South Delta due to opening the Delta Cross Channel

Green Sturgeon: Information on Green Sturgeon is extremely limited. Spawning in the upper Sacramento River during 2013 was documented. Juveniles were observed at RBDD and more juveniles (n=443) were enumerated than the long-term average of 426 fishes. Green Sturgeon observations are extremely rare in the Delta and none have been observed in lower Sacramento and Delta fish monitoring surveys, or at the fish collection facilities at the South Delta CVP/SWP export pumps in recent years. In 2011, over a thousand juvenile Green Sturgeon were enumerated at RBDD and none were observed in Delta or Bay fish monitoring. While this paucity of Green Sturgeon in the Bay/Delta monitoring data may suggest no impact due to Delta Cross Channel operations or export operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year of age due to habitat, predation, or multiple stressors. Green Sturgeon also may not have produced sufficient juveniles to recruit into an emigrating juvenile lifestage that can be detected during monitoring activies. This lack of observational fish data on Green Sturgeon creates significant uncertainties surrounding the species' entrainment risk due to opening the Delta Cross Channel.

Under the proposed modified operations, the Interagency Ecological Program (IEP) will continue to monitor risks to key species of concern. Planned monitoring activities will allow for adequate monitoring for all species of concern, without incurring additional take. Key oversight groups (e.g. Smelt Working Group; Delta Operations for Salmon and Sturgeon; WOMT) will continue to evaluate the data on a weekly basis, or more frequently if necessary. In addition, USFWS has held and continues to host discussions regarding the potential for enhanced field monitoring and modeling activities. Moreover, DWR is currently working on a contract to expedite the implementation of the SmeltCAM, a promising new monitoring tool with multiple applications (e.g. take reduction, habitat assessments).

<u>Consultation with California Department of Fish and Wildlife</u>

DWR and Reclamation have met numerous times during the past few months with representatives of the DFW, as well as with NMFS and FWS, to discuss the hydrologic situation and potential measures to address it. On December 18, 2013, this group met to discuss water system operations, including additional openings of Delta Cross

Channel gates during the winter and spring of 2014. On January 15, 2014, DWR and Reclamation presented the water system operations proposal and the requested Delta outflow Delta Cross Channel gate operations modifications contained in this petition to DFW, NMFS and FWS (as well as to representatives of the SWRCB), and discussed it with this group again on January 24, 2014. During each of these meetings, DWR and Reclamation provided answers to questions posed by DFW. Furthermore, consultation between DWR, Reclamation, and DFW has occurred by virtue of the Governor's creation of a Drought Task Force. Both direct talks concerning this petition and discussions on the drought more generally have presented opportunities to consult as required under the State Water Code.

4) The Change is in the Public Interest

The change is in the public interest by preserving water supplies to meet health and safety needs, by increasing the duration and likelihood of maintaining at least minimal salinity control later in year, and by increasing the duration and likelihood of of success in maintaining cold water pool sufficient for sensitive species through the remainder of the year.

The public interest is best served by maintaining sustainable minimum exports and water quality necessary for the protection of human heath and safety. DWR and Reclamation will inquire with the local agencies receiving water from the Projects to better understand the minimum health and safety needs of those agencies as the water year progresses.

In addition, by modifying the Delta outflow as proposed in this petition the probability that the Projects will be able to prevent the "loss of control" over Delta salinity this summer will increase. If Delta outflow continues to drop as a result of insufficient storage to control seawater intrusion, this condition will persist until the Northern California receives a rainy season with sufficient runoff to flush the Delta of ocean water to once again allow for in-delta beneficial uses. In this event, the enormous amount of water necessary to flush the delta could constitute an unreasonable use of water.

III. Due Diligence has been Exercised

DWR exercised due diligence to avoid this situation in reducing allocations to its water supply contractors in 2013 when the current severe dry pattern began to emerge, and by making an initial allocation for 2014 that was the lowest on record. As discussed earlier this allocation may be reduced further and possibly no 2014 water would be allocated to SWP water supply contractors and Feather River settlement contractors may see a 50 percent shortage in allocation.

In addition, prior to this petition DWR and Reclamation have reduced exports and maintained the minimum outflow necessary for salinity control. All avenues to conserve water in storage were exercised while continuing to meet regulatory requirements.

The drafting of this petition began immediately upon the issuance of the Governor's Proclamation of a State of Emergency , and information supportive of this petition was developed through the marshalling of staff resources to examine and determine narrow and focused changes to address the problem. As noted above, DWR and Reclamation have met with SWRCB staff and with representatives of DFW, NMFS and FWS, to discuss the elements of this petition, and to seek their input on how best to manage multiple needs for water supply.

A PROCLAMATION OF A STATE OF EMERGENCY

WHEREAS the State of California is experiencing record dry conditions, with 2014 projected to become the driest year on record; and

WHEREAS the state's water supplies have dipped to alarming levels, indicated by: snowpack in California's mountains is approximately 20 percent of the normal average for this date; California's largest water reservoirs have very low water levels for this time of year; California's major river systems, including the Sacramento and San Joaquin rivers, have significantly reduced surface water flows; and groundwater levels throughout the state have dropped significantly; and

WHEREAS dry conditions and lack of precipitation present urgent problems: drinking water supplies are at risk in many California communities; fewer crops can be cultivated and farmers' long-term investments are put at risk; low-income communities heavily dependent on agricultural employment will suffer heightened unemployment and economic hardship; animals and plants that rely on California's rivers, including many species in danger of extinction, will be threatened; and the risk of wildfires across the state is greatly increased; and

WHEREAS extremely dry conditions have persisted since 2012 and may continue beyond this year and more regularly into the future, based on scientific projections regarding the impact of climate change on California's snowpack; and

WHEREAS the magnitude of the severe drought conditions presents threats beyond the control of the services, personnel, equipment and facilities of any single local government and require the combined forces of a mutual aid region or regions to combat; and

WHEREAS under the provisions of section 8558(b) of the California Government Code, I find that conditions of extreme peril to the safety of persons and property exist in California due to water shortage and drought conditions with which local authority is unable to cope.

NOW, THEREFORE, I, EDMUND G. BROWN JR., Governor of the State of California, in accordance with the authority vested in me by the state Constitution and statutes, including the California Emergency Services Act, and in particular, section 8625 of the California Government Code **HEREBY PROCLAIM A STATE OF EMERGENCY** to exist in the State of California due to current drought conditions.

IT IS HEREBY ORDERED THAT:

1.State agencies, led by the Department of Water Resources, will execute a statewide water conservation campaign to make all Californians aware of the drought and encourage personal actions to reduce water usage. This campaign will be built on the existing Save Our Water campaign (www.saveourh20.org) and will coordinate with local water agencies. This campaign will call on Californians to reduce their water usage by 20 percent.

2.Local urban water suppliers and municipalities are called upon to implement their local water shortage contingency plans immediately in order to avoid or forestall outright restrictions that could become necessary later in the drought season. Local water agencies should also update their legally required urban and agricultural water management plans, which help plan for extended drought conditions. The Department of Water Resources will make the status of these updates publicly available.

3.State agencies, led by the Department of General Services, will immediately implement water use reduction plans for all state facilities. These plans will include immediate water conservation actions, and a moratorium will be placed on new, non-essential landscaping projects at state facilities and on state highways and roads.

4.The Department of Water Resources and the State Water Resources Control Board (Water Board) will expedite the processing of water transfers, as called for in Executive Order B-21-13. Voluntary water transfers from one water right holder to another enables water to flow where it is needed most.

5.The Water Board will immediately consider petitions requesting consolidation of the places of use of the State Water Project and Federal Central Valley Project, which would streamline water transfers and exchanges between water users within the areas of these two major water projects.

6.The Department of Water Resources and the Water Board will accelerate funding for water supply enhancement projects that can break ground this year and will explore if any existing unspent funds can be repurposed to enable near-term water conservation projects.

7.The Water Board will put water right holders throughout the state on notice that they may be directed to cease or reduce water diversions based on water shortages.

8.The Water Board will consider modifying requirements for reservoir releases or diversion limitations, where existing requirements were established to implement a water quality control plan. These changes would enable water to be conserved upstream later in the year to protect cold water pools for salmon and steelhead, maintain water supply, and improve water quality.

9.The Department of Water Resources and the Water Board will take actions necessary to make water immediately available, and, for purposes of carrying out directives 5 and 8, Water Code section 13247 and Division 13 (commencing with section 21000) of the Public Resources Code and regulations adopted pursuant to that Division are suspended on the basis that strict compliance with them will prevent, hinder, or delay the mitigation of the effects of the emergency. Department of Water Resources and the Water Board shall maintain on their websites a list of the activities or approvals for which these provisions are suspended.

10. The state's Drinking Water Program will work with local agencies to identify communities that may run out of drinking water, and will provide technical and financial assistance to help these communities address drinking water shortages. It will also identify emergency interconnections that exist among the state's public water systems that can help these threatened communities.

11.The Department of Water Resources will evaluate changing groundwater levels, land subsidence, and agricultural land fallowing as the drought persists and will provide a public update by April 30 that identifies groundwater basins with water shortages and details gaps in groundwater monitoring.

12.The Department of Water Resources will work with counties to help ensure that well drillers submit required groundwater well logs for newly constructed and deepened wells in a timely manner and the Office of Emergency Services will work with local authorities to enable early notice of areas experiencing problems with residential groundwater sources.

13.The California Department of Food and Agriculture will launch a one-stop website (www.cdfa.ca.gov/drought) that provides timely updates on the drought and connects farmers to state and federal programs that they can access during the drought.

14.The Department of Fish and Wildlife will evaluate and manage the changing impacts of drought on threatened and endangered species and species of special concern, and develop contingency plans for state Wildlife Areas and Ecological Reserves to manage reduced water resources in the public interest.

15. The Department of Fish and Wildlife will work with the Fish and Game Commission, using the best available science, to determine whether restricting fishing in certain areas will become necessary and prudent as drought conditions persist.

16. The Department of Water Resources will take necessary actions to protect water quality and water supply in the Delta, including installation of temporary barriers or temporary water supply connections as needed, and will coordinate with the Department of Fish and Wildlife to minimize impacts to affected aquatic species.

17. The Department of Water Resources will refine its seasonal climate forecasting and drought prediction by advancing new methodologies piloted in 2013.

18. The California Department of Forestry and Fire Protection will hire additional seasonal firefighters to suppress wildfires and take other needed actions to protect public safety during this time of elevated fire risk.

19. The state's Drought Task Force will immediately develop a plan that can be executed as needed to provide emergency food supplies, financial assistance, and unemployment services in communities that suffer high levels of unemployment from the drought.

20. The Drought Task Force will monitor drought impacts on a daily basis and will advise me of subsequent actions that should be taken if drought conditions worsen.

I FURTHER DIRECT that as soon as hereafter possible, this Proclamation be filed in the Office of the Secretary of State and that widespread publicity and notice be given of this Proclamation.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 17th day of January, 2014.

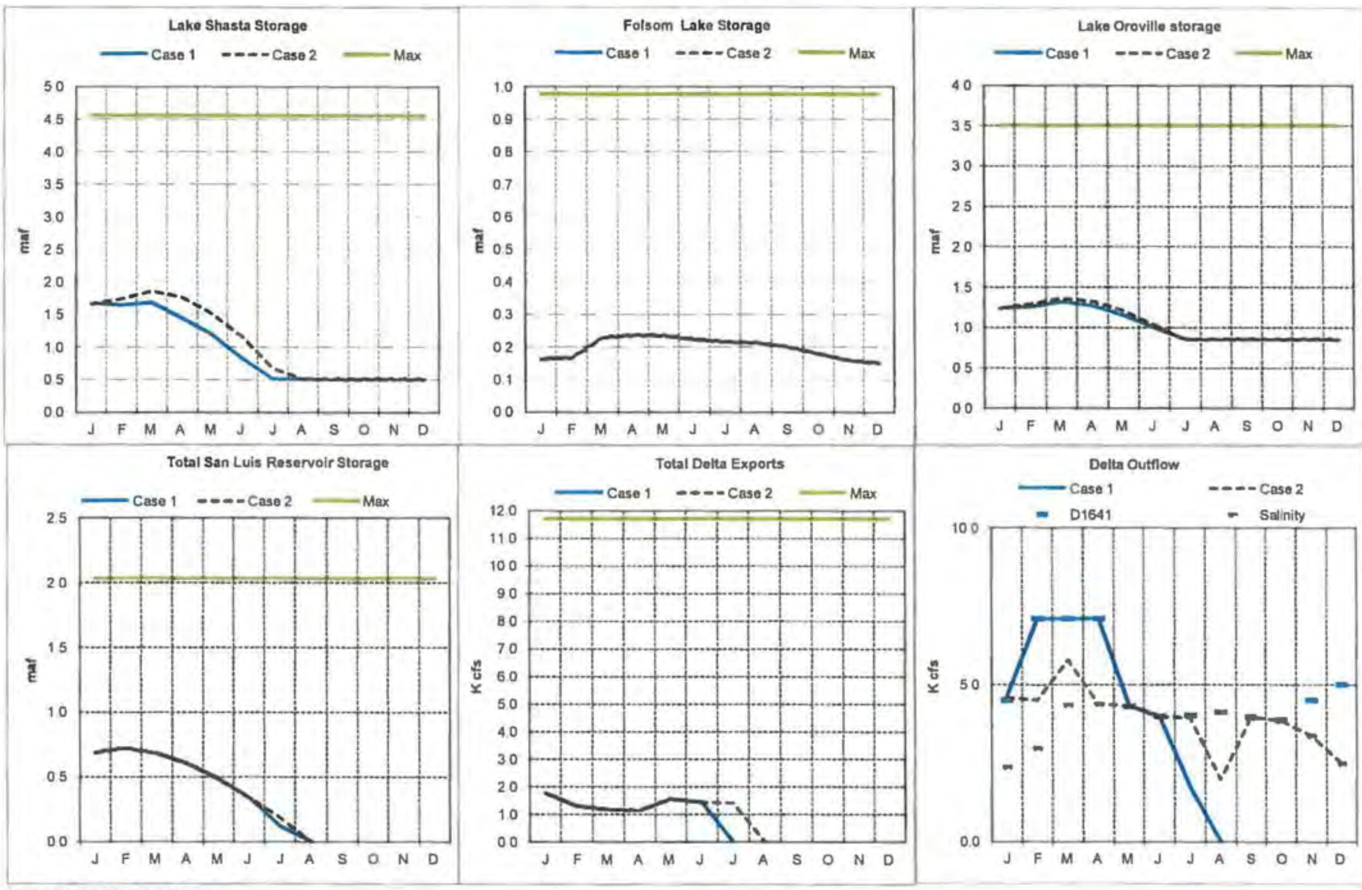
EDMUND G. BROWN JR.,
Governor of California

ATTEST:

DEBRA BOWEN,
Secretary of State

Attachment A

January 1st WSI Forecast



Flows are monthly averages

Attachment B

Salmonid and Green Sturgeon Monitoring and Exposure Evaluation

Summary

Juvenile winter run and spring run Chinook salmon, steelhead, and green sturgeon are experiencing unprecedented river conditions in WY2014. Persistent lack of precipitation, minimum flows to conserve storage, and minimum exports to slow degradation of Delta water quality are challenging biologists to understand the distribution of these species through the Sacramento River and Delta. Maintaining life history diversity of salmonids is important to increasing viability of winter run and spring run Chinook salmon, and multiple juvenile life history strategies occur in the Central Valley resulting in bimodal patterns of outmigration for these species. These bimodal patterns of outmigration have not been materialized in WY2014 fish monitoring data.

Some physical triggers documented to be drivers of salmonid outmigration have not yet been met on the Sacramento River. While uncertainty exists in the current WY 2014 fish monitoring dataset, trapping conditions when recoveries of outmigrating fish are observed at rotary screw traps appear more sensitive to capturing these fish in comparison to WY 2012. In WY 2014, the capture of older juvenile sized Chinook salmon at rotary screw traps in reduced flow and turbidity conditions suggests the rotary screw traps detect fish at very low densities (indicated by 1 or 2 individuals being captured) and thus the presence of fish in higher densities (indicated by recovery of pulse > 3 fish) would be detectable when this elevated density of fish pass the trapping locations. Older juvenile winter run and spring run Chinook salmon continue to be seen is higher-than-usual levels in upper Sacramento River fish monitoring thus far in WY2014.

While entrainment risks increase when listed salmonids and green sturgeon are emigrating past an open Delta Cross Channel (DCC), biological and physical observations in winter 2014 and review of historical species presence suggest a low, but increasing, risk of population-level impacts from opening the DCC between February 1 and February 28 . Winter run and spring run Chinook salmon populations appear to remain throughout the upper and middle Sacramento River area and no pulse has been observed entering the lower Sacramento River. Historic analysis of fish monitoring suggests in Critical and Dry years 93% of winter run Chinook salmon enter the Lower Sacramento River by the end of February. Potential risks from opening the Delta Cross Channel may be further minimized by maintaining minimum combined pumping, utilizing biological and physical triggers for protective DCC gate closures, increasing fish monitoring to assess where listed salmonids are actually distributed, and utilizing these data to inform DCC gate operations.

Current Old and Middle River (OMR) flows are more positive than the most protective conditions (-2,500 cfs) that can be put into effect by the NMFS BiOp when there is an elevated risk (due to fish salvage), suggesting a decreased risk to South Delta entrainment and salvage

than when NMFS BiOp RPA actions are taken due to maximum risk (as measured via fish salvage) with moderate certainty in biological data and high certainty in the physical data.

Approach

To describe potential impacts to listed salmonids and green sturgeon, the following approach is taken.

1. Describe current status and weekly monitoring of broodyears of winter run Chinook, spring run Chinook, steelhead and green sturgeon potentially impacted by the requested DCC opening and biological and physical operational criterion between February 1 and February 28, 2014.
2. Review Delta Cross Channel Gates winter closure biological rationale and biological, behavioral, and physical mechanisms underlying action.
3. Review pertinent biological and physical concern levels regarding listed salmonids, additional recent papers regarding salmon and steelhead movement patterns, current Delta hydrodynamics, recovery of tagged salmonid groups.
4. Assess the certainty we have in these monitoring data, protection triggers, and papers germane to quantifying risks to listed salmonids and green sturgeon through discussion and documenting alternate interpretations.
5. Analyze risks to affected species with this petitions relative to risks with the unmodified D-1641 action.

1. Current status

Winter run Chinook salmon

A modest spawning run of winter run Chinook salmon (n=6,075) returned to the upper Sacramento River in 2013, which was larger than the spawning run that produced these fish in the Sacramento River during the summer of 2010. Redd surveys detected <0.5% of the winter run Chinook salmon redds built in 2013 to be downstream of the 2013 temperature compliance point at Airport Bridge. Typically a pulse of fry outmigrates from the upper Sacramento River in early October and rear in the middle Sacramento River. In fact, a pulse of Winter run Chinook fry appeared to have moved downstream of Red Bluff Diversion Dam (RBDD) during early October, although monitoring of this pattern is uncertain due to the federal furloughs that kept biologists from monitoring this site (Figure 1 and 2). If flows remain high in the fall, a substantial proportion of winter run Chinook can be transported downstream of Red Bluff Diversion Dam. However, thousands of larger-sized winter run Chinook continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than previous years (Figure 2). Of the estimated 4.3 million juvenile winter run Chinook expected to migrate past RBDD (based on the 2013 spawner escapement and JPE survival values), approximately 1.6 million fish have migrated past RBDD by January 14, 2014 (USFWS, Red Bluff, biweekly data).

While the absence of the majority of winter run Chinook moving past RBDD this late in the winter in RBDD screw trap monitoring records has not previously been observed, such a protracted and significant daily passage of winter run Chinook salmon past this location in January has also not been observed (Bill Poytress, USFWS, pers. comm.). Based on these current estimates of passage and juvenile abundance, there is a fair likelihood that a substantial proportion of the winter run Chinook population remains above RBDD. On recent weekly DOSS calls, the topic of the position of winter run Chinook salmon has been discussed. There has been agreement that the center of winter run Chinook distribution lies between Red Bluff and Colusa with fish going from above Red Bluff all the downstream into the Delta.

Winter run Chinook juveniles have been passing the monitoring station at the Glen-Colusa Irrigation District intake in the middle Sacramento River since October (Figure 3). As of January 27 2014, 13 winter run Chinook salmon smolts, but no fry or parr, have been observed in GCID fish monitoring in January. The declining recovery trend of outmigrating winter run Chinook past GCID's screw traps in January may suggest that winter run Chinook, which past RBDD earlier in the fall and winter as fry and parr, have abandoned outmigration to rear between RBDD and GCID. Typically, fry and parr that cannot sustain territories in river flows maintain outmigration past Knights Landing and into the Lower Sacramento River with late fall/early winter Sacramento Valley rainstorms when flows are typically greater than 7500 cfs. Infrequent, rare juvenile winter run Chinook were observed in October and December at the Tisdale Weir fish monitoring station on the Middle Sacramento River and in October at the Knights Landing fish monitoring station on the Lower Sacramento River (Table 1). Rosario et al (2013) described multiple pulses of distinctly different sized winter run Chinook salmon typically moving through the Lower Sacramento River at Knights Landing between November and January. However, there seems to have been almost a complete lack of smaller winter run Chinook fry outmigration during WY2014 through the Lower Sacramento River and Delta (Table 1), although Rosario et al (2013) did not report on any uniquely dry water years similar to WY2014. Unlike the typical pattern of substantial proportions of winter run salmonid rearing in the Delta rearing, a substantial proportion of winter run Chinook parr are undergoing smoltification while in the middle and upper Sacramento River waiting for physiological or environmental cues.

Based on 2013 escapement, the juvenile production estimate for winter run Chinook salmon juveniles entering the Delta ranges from approximately 1.32 million fish (using the JPE method from WY2013) to approximately 400,000 fish (using limited winter run Chinook specific riverine survival estimates of 0.16). No juvenile winter run Chinook salmon have been observed in lower Sacramento and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. On recent weekly DOSS calls, the topic of the proportion of the population of winter run Chinook salmon that has entered the lower Sacramento River or Delta has been discussed. There are a diversity of opinions, and estimates of <5%, based on the information in this assessment, to as much as

>30%, based on expert opinion, of the winter run Chinook salmon are downstream of Knights Landing and in the Delta.

Spring run Chinook salmon

A small, but greater than average spawning run of spring run Chinook returned to the upper Sacramento River. In 2013, this greater-than-average return of spawners was observed across many tributaries supporting spring run Chinook salmon. Rain events during mid-November increased daily average flows in upper Sacramento River tributaries conducive to triggering outmigration of yearling spring run Chinook into the mainstem, although the rapid return to stable tributary flows and low temperature suggest these fish may have abandoned outmigration (Matt Johnson, CDFW, pers comm.). Hundreds of smaller-sized spring run Chinook salmon juveniles continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than previous years (Figure 4). Since October, 90 juvenile, but no smolting, spring run Chinook salmon were observed in middle (GCID) Sacramento fish monitoring stations (Figure 4, these are included in the "older juvenile" data presented) through January 27 2014. Only two juvenile spring run Chinook salmon during late October and early November have been observed at the Tisdale Weir and Knights Landing fish monitoring stations in WY 2014 (Table 1). Spring run Chinook salmon have been observed outmigrating past rotary screw traps on Butte Creek and the Feather River, and will not be observed downstream due to the confluences of these watersheds to be downstream of mainstem rotary screw traps. Thus, there is additional uncertainty in being able to quickly observe pulses of these spring run Chinook entering the Delta. Since late Fall, no spring run Chinook have been observed in lower Sacramento and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps.

Steelhead

Information on steelhead is extremely limited. Observed 2013 patterns of outmigrating *O. mykiss* parr (young of year) during the summer at RBDD were similar to previously observed patterns, although a greater abundance appears to have passed than in the past previous 5 years (Figure 5). Smolts are seldom observed in Sacramento River and Delta fish monitoring due to sampling biases related to the large fish size and their swimming ability. False negatives are more likely with steelhead smolts than smaller older juvenile Chinook salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. Between 1998 and 2011, observations of natural steelhead juveniles (n=2137) in these efforts in the Delta occurs less than 10% of the time in January, >30% of the time during February, >30% of the time during February, and >20% of the time during March. A single steelhead was observed in lower Sacramento and Delta seine and trawl surveys (one 300mm steelhead observed 12/11/13 in the Chipps Island Trawl). Multiple steelhead smolts were observed in American River fish monitoring and will not be observed anywhere before entering the Delta due to the American River confluence being downstream of the mainstem rotary screw traps. Thus, there is additional uncertainty in being able to quickly observe pulses of American River steelhead entering the Delta. One steelhead was observed at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps on January 1/23/14. No outmigrating steelhead have been observed in the Mossdale trawl this winter.

Green sturgeon

Information on green sturgeon is extremely limited. Spawning in the upper Sacramento River during 2013 was documented. Juveniles were observed at RBDD and more juveniles (n=443) were enumerated than the long-term average of 426 fishes (Figure 6). Green sturgeon observations are extremely rare in the Delta and none have been observed in lower Sacramento and Delta fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps in recent years. In 2011, over a thousand juvenile green sturgeons were enumerated at RBDD and none were observed in river, Delta, or Bay fish monitoring. While this absence in the monitoring may suggest no impact due to Delta Cross Channel operations or export operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year old due to habitat, predation, or multiple stressors; which is a phenomenon that has been observed in other North American sturgeon species.

2. Review Delta Cross Channel Gates winter closure biological rationale and biological, behavioral, and physical mechanisms underlying action.

Emigrating salmonids are vulnerable to diversion into the DCC when the gates are open. Calendar-based closure of the DCC Gates between February and May 20 protect winter run, spring run, and fall run Chinook salmon and steelhead from entrainment into the Interior Delta and prohibits elevated risks to these salmonids. Analysis of historic recovery data from Knights Landing suggest in Critical and Dry years, on average 72% and 92% of winter run Chinook salmon enter the Lower Sacramento River by the end of January or February, respectively. Calendar-based closures of the DCC are based on historical patterns of outmigrating fish; with some exceptions allowed prior to January 31.

A series of studies conducted by Reclamation and USGS (Horn and Blake 2004) used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the river during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night (~70%) to entrainment into the DCC than during the day (~30%; Jon Burau, pers. comm.). Additional studies have shown that the mortality rate of the fish diverted into the DCC and subsequently into the Mokelumne river system is quite high (Perry and Skalski 2008; Vogel 2004, 2008). Closure of the DCC gates during periods of salmon emigration eliminates the potential for entrainment into the DCC and the Mokelumne River system with its high mortality rates. In addition, closure of the gates appears to redirect the migratory paths of emigrating fish into channels with relatively less mortality (*e.g.,* Sutter and Steamboat Sloughs), due to a redistribution of river flows among the channels. The overall effect is an increase in the apparent survival rate of these salmon populations as they move through the Delta.

3. Pertinent biological and physical concern levels for salmonids

While it has been hypothesized that winter run Chinook fry and parr simply migrate downstream daily regardless of environmental cues, the interactions between a fish's physiology and behavior make this process more complex. Smolting is observable as interwoven endocrine system and behavioral shifts that appear to be affected by ecological drivers (i.e. prey density, , photoperiod, temperature, flow, turbidity). Fry, not washed out by sufficient flows or lack of habitat (a density-dependent process) , use positive rheotaxis (swim into flow) to establish feeding stations close to their natal redds. These bottom-oriented parr effectively defend territories until a physiological shift makes the fish more receptive to environmental cues. At the same time, the behavior of these fish change towards schooling and active movement downstream. Biologists have adapted using observations of these environmental cues and movement patterns to precautionarily operate the DCC gates and export facilities for the last decade since the Environmental Water Account used the Chinook Salmon Decision Tool. The Chinook Salmon Decision Tree was last revised in 2007 (USBR 2008), although it was modified (and codified operationally) in the Biological Opinion (BiOp, NMFS 2009).

First Alert: The First Alert of the Chinook Salmon Decision Tree was codified in the NMFS BiOp RPA Action IV.1.1 and modified to replace the yearling Chinook catch component with a flow component for implementation in October and November 2013. Both components of this Alert were exceeded on November 20. 2013 indicating conditions conducive to yearling spring run Chinook salmon migration from the tributaries to the mainstem Sacramento River. These components were mean daily flows greater than 110 cfs in Deer or Mill creeks and mean daily flow increasing more than 50% in Deer and Mill creeks. These conditions quickly returned to levels less than the Alert's criteria within five days (Figure 7 and 8).

Second Alert: The Second Alert of the Chinook Salmon Decision Tree was codified in the NMFS BiOp RPA Action IV.1.1. The Sacramento River water temperature at Wilkins Slough criterion of 56.3F was exceeded on November 9, 2013 and although somewhat variable has remained below this criterion since November 15, 2013 (Figure 9). The second component, a Wilkins Slough flow are greater than 7,500 cfs, has not been exceeded in water year 2014(Figure 10).

Related to the Second Alert's second component regarding flow triggers for downstream migration pulses, recent synthesis of mainstem fish monitoring have shown that there is an abrupt and substantial winter run Chinook migration into the Lower Sacramento River at Knights Landing when flow at Wilkins Slough exceed 14,125cfs. When this magnitude of a pulse is observed, the first day of the pulse nearly coincided with a catch spike increase of 5% of the season's cumulative catch (del Rosario et al. 2013). Flows of this magnitude have not been observed in WY 2014. Rather, flows remained relatively stable to decreasing below Wilkins Slough throughout December to January 14, but have decreases substantially with Upper and Middle Sacramento in-river depletions (Figure 10). There is a likelihood that in water year 2014, where there has not been a large pulse flow that triggers considerable downstream migration, spring and winter run Chinook may reside in territories until reaching physiological conditions optimal for outmigration and environmental conditions optimal for reduced outmigration passage risks.

Action Triggers: Action Triggers in the Chinook salmon Decision Tree were modified and codified in NMFS BiOp RPA Action IV.1.2. These Action Triggers use fish monitoring catch indices from Knights Landing and Sacramento River to detect substantial winter run Chinook migration into the lower Sacramento River. Catch index exceedance values were based on analyses of historic screw trap, beach seine, and trawl data (Chappell 2004).

Although WY 2001 was somewhat different regarding Sacramento River flow, it is as close as a comparison we have for the conditions we've observed in WY 2014. In WY 2001, fall and early flows were low, very stable, and only achieved the Salmon Decision Tree Wilkins Slough flow exceedance Second Alert twice before February. Also, the Knights Landing Catch Index was exceeded with both of these flow alerts being exceeded. However, a substantial older juvenile Chinook catch pulses did not occur until February. In 2000-2001, the intermittent catch of older juveniles during the Fall and early winter accounted for 8-10% of the year's total recoveries of older juveniles at those monitoring stations. This 8-10% moving past Knights Landing provided distinctly different Knights Landing rotary screw trap, Sacramento River trawl, and beach seining recovery patterns and numbers than the monitoring results of the current WY 2014 effort (Table 2, Figure 11 and 12). In comparison, the juvenile production estimate of winter run Chinook entering the Delta for WY2001 was estimate to be approximately 370,000 fish, which is less than the estimates of approximately 1.3 million to 410,000 fishes entering the delta using 2013 adult spawner escapement and a range of river survival estimates from 0.53 to 0.16, respectively. However, there were approximately twice as many older juvenile Chinook salmon (n= 37) recovered at Knights Landing and two exceedances of the Knights Landing Catch Index compared to Knights Landing and Tisdale rotary screw traps combine (n= 17) in WY 14 (Table 2). Also, unlike WY 2014 when older juvenile Chinook salmon have yet to be recovered in beach seine or trawl monitoring (up to January 26, 2014), in WY 2001 there were 46 older juveniles captured during this dry period in beach seines and an additional 7 fish in the Sacramento Trawl monitoring observed in Delta monitoring during this period, prior to substantial flows on the Sacramento River in WY2001 (Table 2). This comparison of dry hydrology fish monitoring suggests that WY2014 monitoring results suggest that less fish have entered currently than in comparable years when 8-10% were approximated to have entered the Delta undetected.

Multiple exceedance levels exist to modify DCC operations in a manner that reduces risks due to the elevated presence of spring run and winter run Chinook salmon upstream of the Delta. Neither the Knights Landing Catch Index not Sacramento River Catch Index have exceeded any action trigger threshold in WY 2014, so no DCC gate closure was required by the NMFS BiOp until December 1, the first calendar based date for DCC closure. The DCC gates were occasionally closed in October and November to assist in meeting the Rio Vista flow criterion in D-1641.

The NMFS BiOp RPA Action IV.1.2 modified the Chinook Salmon Decision Tree to precautionarily close the DCC later in the winter when Knights Landing Catch and Sacramento River Catch indices may be under-representative of the number of fish passing these locations due to poor trap efficiencies and detection rate or low production. The flow and turbidity conditions when juvenile winter and spring run Chinook salmon have been observed at in these rotary screw traps in WY 2014 appear to be similar and even lower in most cases than when these levels (1 or 2 individuals) of capture have occurred previously at these sites in recent years (Table 2). In WY 2014, these data indicate under lower turbidity and flows, these rotary screw traps are capable of detecting low densities of migrating fish (1 or 2 individuals). Additionally, mainstem rotary screw traps have been operating during the night for the greater portion of WY2014, when the perceived bias due to fish visual cures and behavior caused by clear water is less likely. These lines of evidence suggest that Sacramento River mainstem rotary screw traps have captured winter run and spring run Chinook of small and large sizes in 2013 and these monitoring efforts are sensitive to detecting the distribution of individual, and thus pulses, of these species.

A bias is inherent in every type of fish monitoring technique used to evaluate fish presence and distribution along the Sacramento River and through the Delta. It is hypothesized that passage becomes less detectable due to decreased ability to avoid the traps under high water velocities and increased turbidity. While false negatives in the fish monitoring system are possible, in WY2014 the recovery of fish in a broad range of densities between Red Bluff Diversion Dam and Chipps Island suggests false negatives are very unlikely. Monitoring results from rotary screw traps in WY2014 in comparison to these same locations in WY 12 show current efforts are capable of detecting similar very low densities of individuals migrating under low flow and turbidity conditions (Table 2). In WY 2014, the capture of older juvenile sized Chinook salmon at rotary screw traps in reduced flow and turbidity conditions suggests the rotary screw traps detect fish at very low densities (indicated by 1 or 2 individuals being captured) and thus the presence of fish in higher densities (indicated by recovery of larger pulses of fish) would be detectable when this elevated density of fish pass the trapping locations.

The Chinook Salmon Decision Tree Action Triggers proposed in the 2008 Biological Assessment (USBR 2008) included operational water quality criteria to assess when there is an elevated risk of exceeding D-1641 water quality standards when the DCC is closed and export levels are maintained. Increased susceptibility to salinity intrusion in the South Delta is indicated when the following EC levels are exceeded: Jersey Point >1.8 EC, Bethel Island >1.0, and Holland Tract >0.8. Currently, export levels are at combined minimum pumping levels and all three operational water quality concern criteria have been exceeded at least once during January (Figure 13-15). Water quality modeling demonstrating the incremental benefit to water quality at these locations is included in Appendix A and B.

Current Delta Cross Channel Operations, and Delta Hydrodynamics and Survival:

Action IV.2.3 in the 2009 NMFS BiOp uses fish loss density, daily loss, and surrogate Coleman National Fish Hatchery (CNFH) releases of winter run and late fall Chinook salmon as triggers to reduce the vulnerability of emigrating ESA-listed salmon, steelhead, and green sturgeon to entrainment into South Delta channels and at the pumps between January 1 and June 15. A calendar-based requirement for the 14-day OMR average flow to be no more negative than -5,000cfs started January 1, although it has not yet controlled export operations. Depending on what level of fish trigger is exceeded, combined exports are managed to a level so that the 5-day net average OMR flow in not more negative than -3,500 or -2,500cfs OMR until fish densities return below levels of concern.

Earlier in January 2014, operational considerations for D-1641 outflow standards controlled exports to 1,500 cfs combined exports at the state and federal export facilities, and in the past weeks operational consideration for D-1641 Municipal and Industrial water quality standards in the South Delta surpassed outflow considerations, and these considerations have controlled exports to combined exports of 1500cfs pumping. . Although some flow gauges remain inoperable along Old and Middle River, average daily flows in Old and Middle River have averaged approximately -1800cfs in December 2013, and are averaging approximately -1400 in January 2014 (Figure 16). Currently, combined export levels are less than 1,500 cfs, and are required due to the lack of Delta inflow and consideration for South Delta water quality. These export levels, and those described in the perition, maintain Old and Middle River conditions less negative than the most protective Action Response in NMFS BiOp Action IV.2.3 and provide south Delta hydrodynamic conditions more conducive to salmonids successfully exiting the Delta at Chipps Island (relative to a condition with more negative OMR conditions).

The anticipated Delta inflow levels (4500 cfs) described in this petition necessary to maintain currently degraded water quality conditions are much lower than are afforded under minimum standards to meet the D-1641 X2 standard in February. As stated in the petition, 7,100 cfs would be necessary as the D-1641 Habitat Protection Flow this month if not for extraordinary meterological and hydrologic conditions. This reduction in Delta inflow from 7100 cfs to 4500 cfs may influence survival of fish entering the Delta. A decrease in inflows increases fish's residence time in the Delta, as well as reverse advection of these fish in the north Delta, and these are likely to increase mortality. The potential for tidal "sloshing" of salmonids past Georgiana Slough and the DCC will increase with reduced inflow, and this will increase exposure of individuals to these routes into the Interior Delta, which may increase mortality of these fishes. The quantity of increased mortality is uncertainty, since no available models link residence time or Interior Delta entrance passages to a quantifiable level of mortality. The difference between 7100 and 4500 cfs is small compared to the daily tidal flux, and tidal hydrodynamics become a greater drivers of the hydraulics around the DCC gates at lower inflows. Mortality may also increase with lower inflows than mandated in D-1641, due to disorientation of salmonids making them more susceptible to predation, caused by entrainment into the DCC.

Recovery of tagged salmonid groups: The majority of tagged salmon releases have not yet been made in WY2014, but two groups provide some information useful to assessing Chinook salmon risks. A November release of 100,000 fall Chinook in the Mokelumne River and a December release of 267,000 late fall Chinook in Battle Creek may provide information in the river and Delta monitoring of listed species. As of January 13 2014, no fish from the November release of 100,000 fall Chinook in the Mokelumne River have been recovered in the Delta or salvage fish monitoring. As of January 13 2014, the December release of 267,000 late fall Chinook in Battle Creek has resulted in detection of 40 fish at the GCID rotary screw trap and five of these fish exiting the Delta at Chipps Island in the past week, but not in salvage fish monitoring effort. Although these fish were recovered in the middle River and Delta, they were not observed in other monitoring efforts at Tisdale, Knights Landing, Sacramento trawl, or in the Delta Juvenile Fish Monitoring Program beach seines. The absence of the larger Battle Creek tagged late fall Chinook from these efforts may be indicative of their large size. These groups of tagged Chinook are likely in different physiological condition, are almost twice the size, and thus do not make good surrogates for winter run Chinook salmon. Using information from these fish to assess outmigration of winter or spring run Chinook salmon is highly uncertain. Further, these data suggest uncertainty exists in our monitoring system regarding recovery of groups of fish as large as 267,000fish. While the actual number of winter run Chinook passing these monitoring stations is unknown, more winter run Chinook were seen at most these locations than the tagged CWT group. This information creates uncertainty in interpreting fish monitoring results regarding quantities of a fish population migrating past monitoring stations and indicates a substantial quantity of winter run Chinook could migrate downstream undetected.

4. **Quantifying risks to listed salmonids and green sturgeon and assessing the certainty we have in the evidence for these risks.**

Fish monitoring observations made through January 27, 2014 suggest that pulses of listed salmon have passed middle Sacramento River monitoring sites at Glen-Colusa Irrigation District, and continue to rear and slowly migrate downstream, but these pulses have not passed Knights Landing into the Lower Sacramento River. The second component of the second alert of NMFS BiOp RPA IV.1.1 and the Chinook Salmon Decision Tree exceeding 7,500 cfs at Wilkins Slough (adjacent to Knights Landing) has not been exceeded. While clear water and low flows may influence the efficiency of monitoring stations, the detection of older juveniles in WY2014 appears to be occurring at conditions perceived to be worse for detecting fishes. While it is improbable that fish are captured randomly in rotary screw traps at low densities and then not recovered during higher density migration quantities, considerably more juveniles may have to pass downstream in order for 1 or 2 to be detected at monitoring stations. On occasion, these stations have operated for up to 24 hour periods during WY2014, when clear water would not influence efficiencies at night. While the absence of detecting fish in the Knights Landing and Tisdale rotary screw traps should not lead to the assumption that listed fish have not passed this location, recent assessments of these data suggest that catch spikes of as little as 5% cumulative catch are observable and are nearly coincident with rapid increases in flow greater than 14,125 cfs. Historic analyses (Chappell 2004) developed a catch index value of greater than or equal to 3 fish/TAF at Knights Landing rotary screw trap or Sacramento fish monitoring, indicative of recovery of older juveniles moving past the site at higher densities and elevating the risk of entrainment into an open Delta Cross Channel.

Observations made through January 14, 2014 suggest that abiotic triggers for pulsed migration of a substantial, detectable percentage (>5%) of winter run Chinook salmon have not occurred in WY2014. Detection of low densities of older juveniles in rotary screw traps appears to have increased over normal environmental conditions, suggesting there has been a decreased risk to missing fish moving by at higher densities due to poor turbidity and flow conditions at trapping sites. Substantial catches of larger-size juvenile winter run Chinook continue daily at RBDD rotary screw traps, the majority of an estimated JPE has not been observed to have not past RBDD rotary screw trap, and the catch index at Knights Landing has not exceeded 1 fish/day. These lines of evidence support the winter run Chinook population remaining above the lower Sacramento River, which keeps risks from opening the DCC under current fish distribution conditions very low. The fish monitoring surveys used for the Knights Landing and Sacramento Catch indices appear to be detecting low density of fish, and thus using established biological and physical triggers for closing the DCC gates maintains protection for these older juvenile Chinook salmon (i.e winter run and spring run Chinook). Thus, the risks to winter run and spring run Chinook salmon, steelhead, and green sturgeon populations with this petition are not greater than with the unmodified action at the population scale, however, there is a risk of entraining individuals through an open DCC gate. While the monitoring system continues to perform adequately, Chinook Salmon Decision Tree biological trigger of Knights Landing Catch Index exceeding 3fish/day and Wilkins Slough flows greater than 7500cfs provides for protective closure of the DCC during the petition's February period.

Based on observational fish and physical data, currently there is not an elevated risk of entrainment into the Interior Delta to winter run Chinook, spring run Chinook salmon, and green stugeon populations from opening the Delta Cross Channel. The risk to these populations will increase when flow and associated physical cues change, as well as, the later into the winter a significant proportion of winter and spring run Chinook remain rearing above the Lower Sacramento River. Green sturgeon likely did not produce sufficient juveniles to recruit into an emigrating juvenile lifestage. The lack of observational fish data on steelhead and green sturgeon create significant uncertainties surrounding the risk to these populations due to entrainment into the South Delta due to opening the Delta Cross Channel. Entrainment into the Interior Delta likely exposes individuals from these populations to lower survival than through the western Delta or mainstem Sacramento River, but a previous study on steelhead (Singer et al 2013) did not demonstrate this to be always true. In that study, survival was estimated to be higher through the eastern Delta route (i.e. Georgiana, Mokelumne, and San Joaquin River routes) than the western Delta route (Sutter and Steamboat Sloughs) in one of two years studied, although survival was highest along the Sacramento mainstem route in both years.

The Delta trawl fish monitoring efforts are detecting low densities of outmigrating tagged Chinook salmon. Thus, the presence of tagged fish in the Delta monitoring and the rare observation of smaller outmigrating salmonids, suggest pulses of outmigrants and even individuals are detectable under current Delta monitoring efforts. It is unlikely that we would be able to detect fish sized larger (tagged) and smaller (fall run) but not winter run Chinook and yearling spring run Chinook in the Delta, further suggesting the majority of these populations remain upstream of these sampling sites in the Delta. While the weather conditions remain the same and D-1641 compliance standard become more stringent into the winter and spring, there is a high certainty that combined 1,500cfs export levels are likely to be all the exports combined. Thus, while the necessity to reduce the vulnerability of emigrating winter run Chinook, yearling spring run Chinook, and CV steelhead in the lower Sacramento River to entrainment into channel of the South Delta is very low due to the lack of their presence in these areas, current Delta hydrodynamic conditions are better than those used by the agencies to protect emigrating salmonids from entrainment into the south Delta from the Sacramento River and Interior Delta (i.e. Forks of the Mokelumne). The Delta conditions observed in December 2013 and January 2014 may have led to our observation on no recovery of tagged Chinook in the salvage, yet recovery of these fish at Chipps Island. Based on observation and physical data, currently these is a lower risk to winter run Chinook, spring run Chinook, steelhead and green sturgeon to hydrodynamic conditions in the Interior and South Delta caused by CVP/SWP export operations than if the D-1641 Operational Standard was being implemented to its greatest extent.

5. **Analyze risks to affected species with this petition relative to risks with the unmodified D-1641 operational standard.**

The relative risks of the petition vs. an unmodified operation may be considered in two ways. First, one can consider the relative risk for any individual salmonid that passes the Delta Cross Channel. For that individual, the risk of diversion into the DCC, and into a migratory pathway that has been shown to be associated with lower outmigration success, is increased for the petition (open DCC with physical and biological triggers for fish protection) compared to the unmodified action (closed DCC). The likelihood of entrainment of an individual into a closed DCC is zero. The likelihood of entrainment of an individual into an open DCC (the measure of increased risk) depends on the local flow regime and the position of the individual in that flow regime. It should be noted that individuals that pass the DCC, whether open or closed, may still enter a lower survival migratory pathway via Georgiana Slough.

Second, one can consider the relative risk for the different populations of green sturgeon and listed salmonids (winter-run and spring-run Chinook, steelhead). Quantification of this population-level risk requires an estimate of the exposure of the population (in terms of number of individuals or fraction of the population), multiplied by the individual risk assessment described in the paragraph above. An assessment of the distributions of the listed sturgeon and salmonid populations is provided in section 1 through 4; the degree of increased risk increases with the fraction of the population assumed to be exposed to an open DCC.

References

Chappell, E. 2004. Are the current EWA Chinook Decision Tree numeric criteria appropriate? Presentation to the EWA Technical Review Panel Supporting Documents. Available at: http://www.science.calwater.ca.gov/events/reviews/review_ewa_archive_04.html

Del Rosario, R.B, Y.J. Redler, K. Newman, P.L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 11(1): 24p.

Horn, M.J. and A. Blake. 2004. Acoustic tracking of juvenile Chinook salmon movement in the vicinity of the Delta Cross Channel. 2001 Study results. U.S. Department of the Interior. Technical Memorandum No. 8220-04-04.

National Marine Fisheries Service. 2009. Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. Central Valley Office, Sacramento CA.

Perry, R.W. and J.R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River delta during the winter of 2006-2007. Report prepared for the U.S. Fish and Wildlife Service. September 2008. 32 pages.

Singer, G.P, A.R Hearn, E.D Chapman, M.L. Peterson, P.E. LaCivita, W.N. Brostoff, A. Bremmer, and A.P. Klimley. 2013. Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). Environmental Biology of Fishes 96: 363-379.

U.S Bureau of Reclamation. 2008. Appendix B: Chinook Salmon Decision Tree *in* Biological Assessment on the Continued Log-term Operations of the Central Valley Project and the State Water Project. Mid-Pacific Region, Sacramento CA.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the northern and central Sacramento-San Joaquin Delta, 2002-2003. Report to the National Fish and Wildlife Foundation, Southwest Region. January. 44 pp.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the Northern Sacramento-San Joaquin Delta 2006-2007. Report prepared for the California Department of Water Resources, Bay/Delta Office. Natural Resource Scientists, Inc. March. 43 pages.

Table 1. Fish observation data from Tisdale and Knights Landing rotary screw traps in WY 2014. Data updated through January 27, 2014.

Location	Gear	Start Date	Stop Date	Num. of Hours During Sampling Period	Flow cfs (@ WLK)	Cone RPM (8.3)	Cone RPM (8.4)	Total Cone Rev (8.3)	Total Cone Rev. (8.4)	Total Hrs Fished	Water T (F)	Secchi (ft)	Turbidity (FTU)	Unmarked Chinook CATCH	Min FL	Max FL	# Fall	# Spring	# Winter	# Late fall	# Ad-clip CS	# Ad-clip SH	# Unclip SH	Fall+Spring CPUE (catch per hour)	Winter+Late fall CPUE (catch per hour)	Unclip SH CPUE (catch per hour)
TIS	2 x 8' Cone	9/30/2013	10/1/2013	25.00	6,405	2.5	2.6	2,926	4,108	46.14	62	NA	4.5	1	34	34	0	0	1	0	0	0	0	0.000	0.022	0
TIS	2 x 8' Cone	10/2/2013	10/3/2013	23.50	5,987	2.6	2.6	3,323	3,816	46.06	61	NA	4.6	1	36	36	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2488	2696	44.9	61	5.6	1.5	2	38	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2486	2696	44.9	61	5.6	1.5	2	38	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/8/2013	10/10/2013	44.00	5840	1.7	1.7	5099	5521	104.1	60	5.9	1.1	1	38	38	0	0	1	0	0	0	0	0.000	0.010	0
TIS	2 x 8' Cone	10/9/2013	10/10/2013	21.75	5,458	1.7	2.2	2,198	3,080	44.78	57	NA	5.5	1	37	37	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/10/2013	10/11/2013	23.75	5269	1.9	1.8	2566	2642	49.7	60	6.0	2.6	1	41	41	0	0	1	0	0	0	0	0.000	0.020	0
TIS	2 x 8' Cone	10/22/2013	10/23/2013	23.50	3,845	0.0	1.9	0	1,014	9.09	59	NA	11.4	1	36	36	0	0	1	0	0	0	0	0.000	0.110	0
TIS	2 x 8' Cone	10/23/2013	10/24/2013	22.00	4,008	1.1	2.1	1,764	3,032	51.09	58	NA	6.7	1	39	39	0	0	1	0	0	0	0	0.000	0.020	0
KL	2 x 8' Cone	11/8/2013	11/8/2013	7.25	5310	1.3	1.6	590	759	15.7	57	3.9	3.9	1	38	38	0	1	0	0	0	0	0	0.064	0.000	0
TIS	2 x 8' Cone	11/10/2013	11/11/2013	16.25	5,057	1.3	2.1	829	1,214	20.13	54	NA	5.9	1	35	35	0	1	0	0	0	0	0	0.050	0.000	0
TIS	2 x 8' Cone	12/16/2013	12/18/2013	8.75	4,586	1.0	1.8	497	945	17.03	45	NA	8.0	1	79	79	0	0	1	0	0	0	0	0.000	0.059	0
TIS	2 x 8' Cone	12/21/2013	12/21/2013	8.25	4,833	1.3	1.7	493	878	14.93	45	NA	7.1	1	75	75	0	0	1	0	0	0	0	0.000	0.067	0
TIS	2 x 8' Cone	12/23/2013	12/24/2013	15.00	4,850	1.2	1.7	818	1,623	28.05	46	NA	8.9	1	94	94	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	12/30/2013	12/31/2013	15.25	4,689	1.2	2.0	886	1,597	25.61	45	NA	5.6	1	34	34	1	0	0	0	0	0	0	0.039	0.000	0
TIS	2 x 8' Cone	1/3/2014	1/4/2014	15.00	4,536	0.8	1.8	720	1,540	29.42	48	NA	8.6	1	37	37	1	0	0	0	0	0	0	0.034	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/4/2014	8.25	4,458	1.3	1.8	625	936	16.68	46	NA	6.3	1	39	39	1	0	0	0	0	0	0	0.060	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/5/2014	15.25	4,458	1.3	1.9	1,080	1,819	27.79	46	NA	7.8	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/5/2014	1/6/2014	15.50	4,416	0.9	1.6	914	1,457	33.16	48	NA	7.2	3	35	37	3	0	0	0	0	0	0	0.090	0.000	0
TIS	2 x 8' Cone	1/6/2014	1/6/2014	8.50	4,425	0.9	1.6	513	834	17.40	46	NA		1	38	38	1	0	0	0	0	0	0	0.057	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/8/2014	8.50	3,917	0.3	1.2	287	760	24.96	46	NA	6.1	1	33	33	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/9/2014	14.75	3,917	0.7	1.4	311	1,108	21.05	43	NA	7.7	2	40	40	2	0	0	0	0	0	0	0.095	0.000	0
KL	2 x 8' Cone	1/10/2014	1/11/2014	13.75	3757	1.1	1.1	972	857	27.7	48	6.2	2.9	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/12/2014	1/13/2014	15.00	3,730	0.8	1.6	885	1,632	34.46	47	NA	8.0	3	38	41	3	0	0	0	0	0	0	0.087	0.000	0
KL	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	1.3	1.3	1094	1053	27.5	49	6.0	2.4	1	37	37	1	0	0	0	0	0	0	0.036	0.000	0
KL	2 x 8' Cone	1/16/2014	1/17/2014	14.25	3520	1.2	1.0	1013	894	29.0	49	5.5	3.0	2	37	40	2	0	0	0	0	0	0	0.069	0.000	0
KL	2 x 8' Cone	1/24/2014	1/25/2014	14.00	3440	1.1	1.1	987	838	28.0	50	5.7	3.8	1	100	100	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	0.8	1.5	407	1,288	24.88	49	NA	10.9	1	38	38	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/14/2014	1/15/2014	15.00	3873	0.6	1.5	432	1,218	25.53	48	NA	7.4	2	38	39	2	0	0	0	0	0	0	0.078	0.000	0
TIS	2 x 8' Cone	1/20/2014	1/21/2014	20.00	3478	2.8	2.2	2,728	2,823	37.63	46	NA	6.98	2	38	39	2	0	0	0	0	0	0	0.053	0.000	0
TIS	2 x 8' Cone	1/21/2014	1/22/2014	14.75	3492	2.5	2.4	2,230	1,953	28.78	47	NA	8.4	1	40	40	1	0	0	0	0	1	0	0.035	0.000	0
TIS	2 x 8' Cone	1/23/2014	1/24/2014	15.25	3483	2.8	2.1	2,348	2,002	30.88	48	NA	8.65	1	40	40	1	0	0	0	0	0	0	0.032	0.000	0
TIS	2 x 8' Cone	1/24/2014	1/25/2014	14.75	3450	2.5	2.0	2,187	1,818	29.58	48	NA	8.23	1	35	35	1	0	0	0	0	1		0.034	0.000	0
TIS	2 x 8' Cone	1/26/2014	1/27/2014	14.50	3396	2.2	1.8	1,935	1,786	31.20	45	NA	8.27	1	142	142	0	0	0	1	0	0	0	0.000	0.032	0

Table 2. Environmental data from Tisdale and Knight Landing rotary screw trap for WY 2014 when winter run and spring run Chinook salmon were enumerated between October 1 and January 27, but only through January 14 during other observational periods. NA = Not accessed or available.

Location and number of fish recovered	Number of fish observed	Turbidity			Daily flows at Wilkins slough		
		Average	Min	Max	Average	Min	Max
Combined Tisdale and Knights Landing WY 2014							
1 fish	13	6.1	1.1	11.4	4465	3395	6405
2 fish	4	4.7	1.5	7.7	4431	3476	5902
Tisdale 2011-2012							
1 fish	7	8.41	5.8	12.4	7069	4870	11900
2 fish	6	9.27	8	10.6	6040	5050	7690
Knights Landing 2011-2012							
1 fish	4	9.39	7.8	10.6	6967	8440	5893
2 fish	6	6.73	6.1	7.3	9299	9454	9144
Knights Landing 2000-2001							
1 fish	8	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
>3 fish	27	NA	NA	NA	NA	NA	NA
Beach Seine 2001-2001							
1 fish	6	NA	NA	NA	NA	NA	NA
> 4 fish	42	NA	NA	NA	NA	NA	NA
Sacramento Trawl 2000-2001							
1 fish	2	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
3 fish	3	NA	NA	NA	NA	NA	NA

Figure 1. Red Bluff Diversion Dam passage of juvenile older Chinook salmon and associated environmental data. Figure supplied by DWR to DOSS on January 27, 2014.

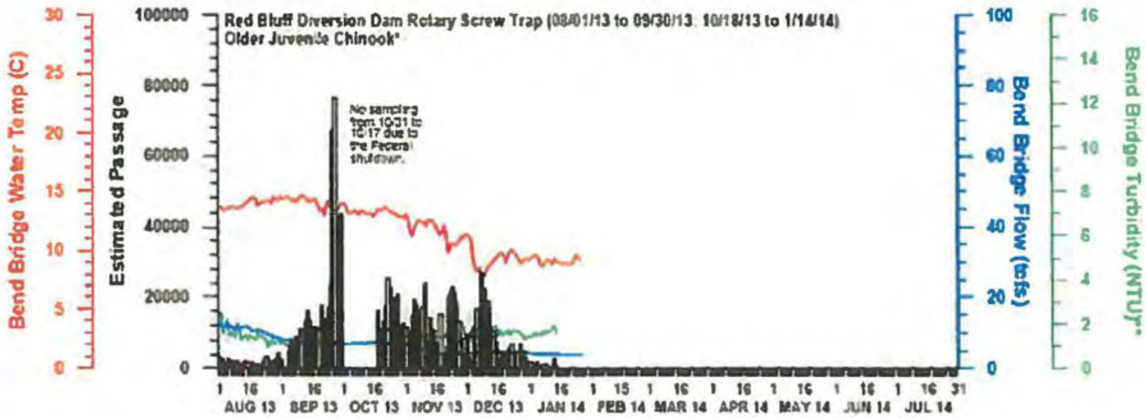


Figure 2. Weekly estimated passage of juvenile winter run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Winter run passage value interpolated using a monthly mean for the period of October 1 through October 17, 2013 due to government shutdown. Figure supplied by USFWS (2014).

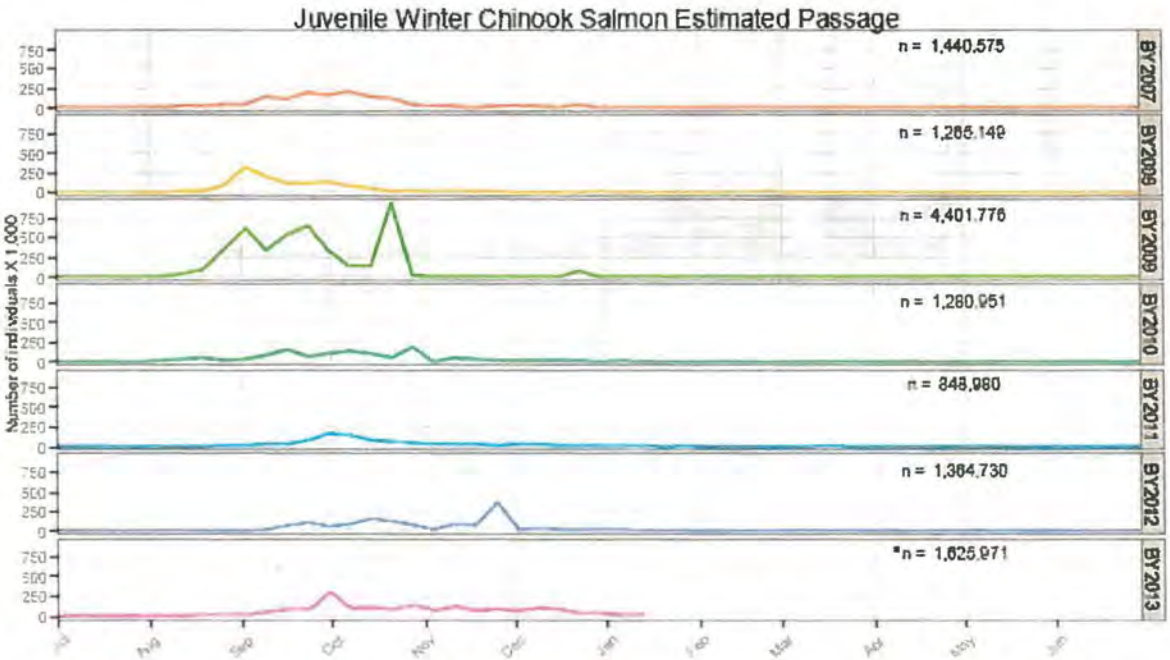


Figure 1. Weekly estimated passage of juvenile winter Chinook Salmon at Red Bluff Diversion Dam (RK391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 2007 to present.

*Winter run passage value interpolated using a monthly mean for the period October 1, 2013 - October 17, 2013 due to government shutdown.

Figure 3. Glen-Colusa Irrigation District Rotary Screw Trap older juvenile Chinook salmon catch data and associated environmental data. Figure supplied by DWR to DOSS on January 27, 2014.

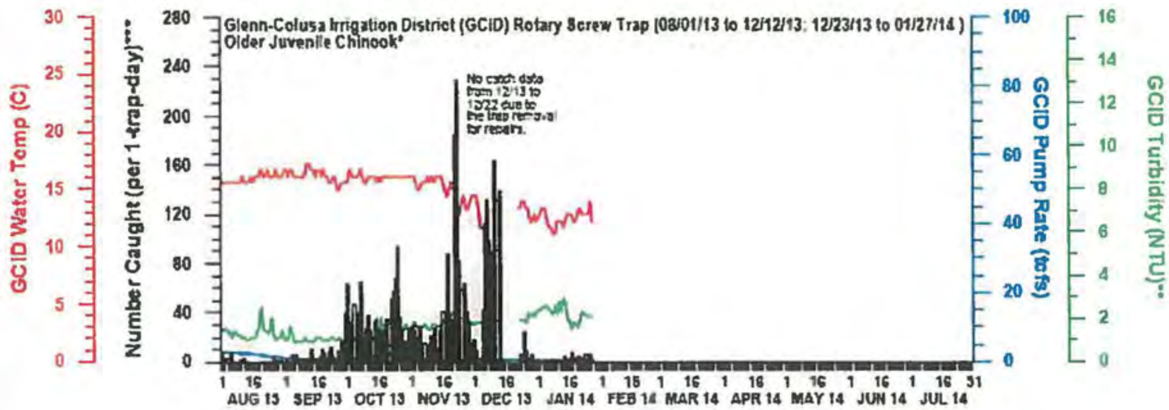


Figure 4. Weekly estimated passage of juvenile spring run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (2014).

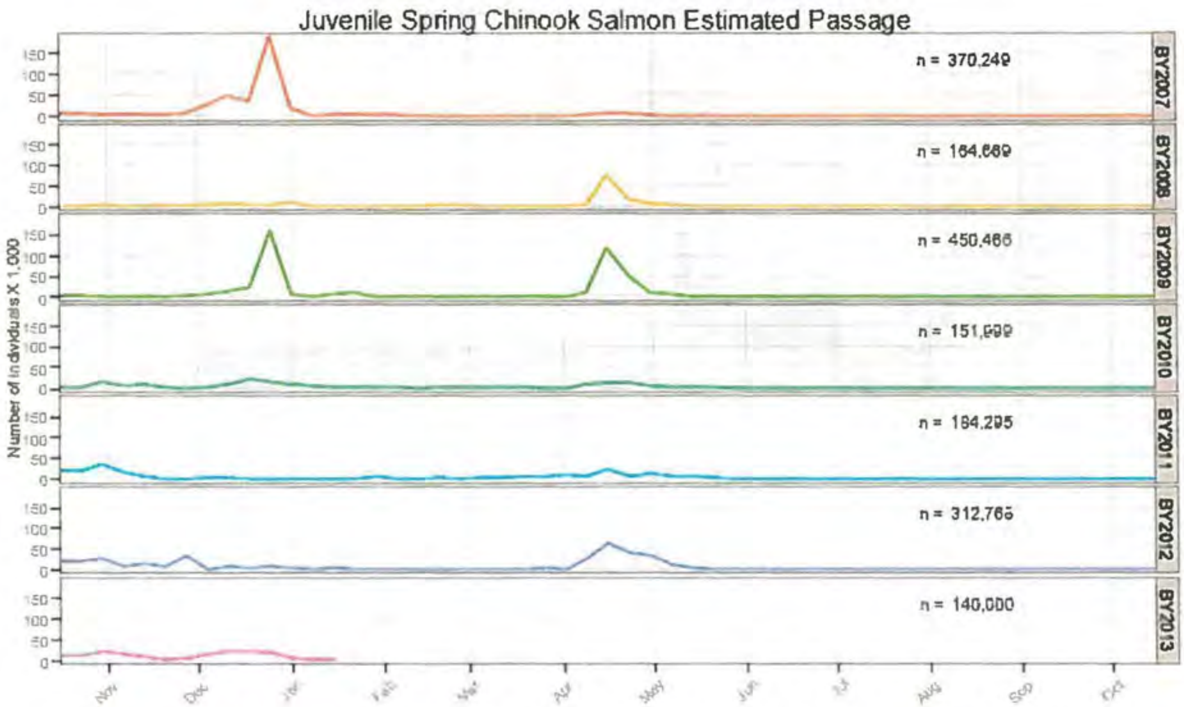


Figure 2. Weekly estimated passage of juvenile Spring Chinook Salmon at Red Bluff Diversion Dam (RK391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period October 16, 2007 to present

Figure 5. Weekly estimated passage of O. mykiss at Red Bluff Diversion Dam (RK 391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (2014).

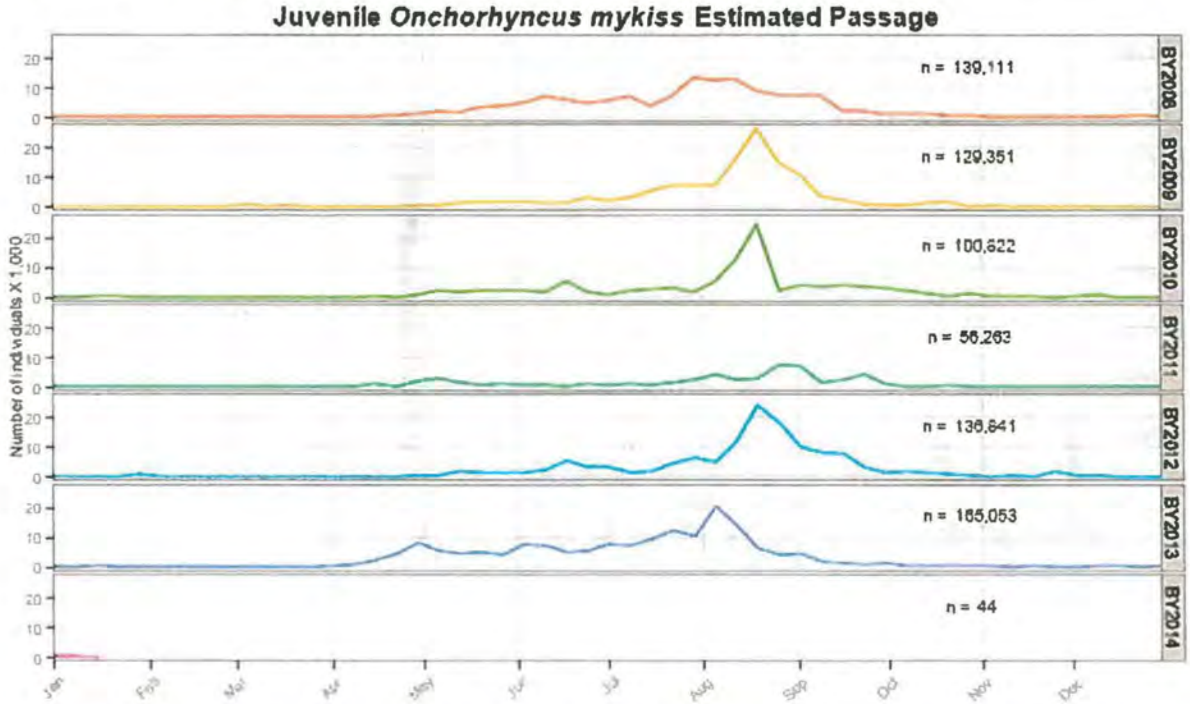


Figure 3. Weekly estimated passage of juvenile Rainbow/Steelhead trout at Red Bluff Diversion Dam (RK391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period January 1, 2008 to present.

Figure 6. Juvenile Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps. The dataset annual average is 426 fish. In 2011, an egg was observed directly above the rotary traps, thus the large number of fish in 2011 is a unique annual sampling of a spawning event (Josh Gruber, USFWS, pers comm.) If this data is removed the annual average of fish counted in 183 fishes.

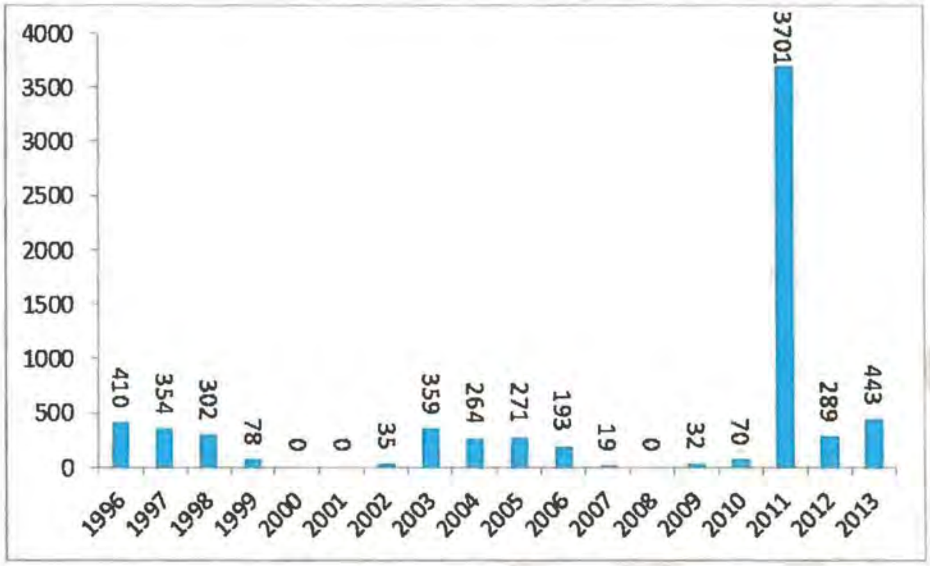


Figure 7. Deer Creek daily flow data for WY 2014. Downloaded from CDEC on January 28, 2014.

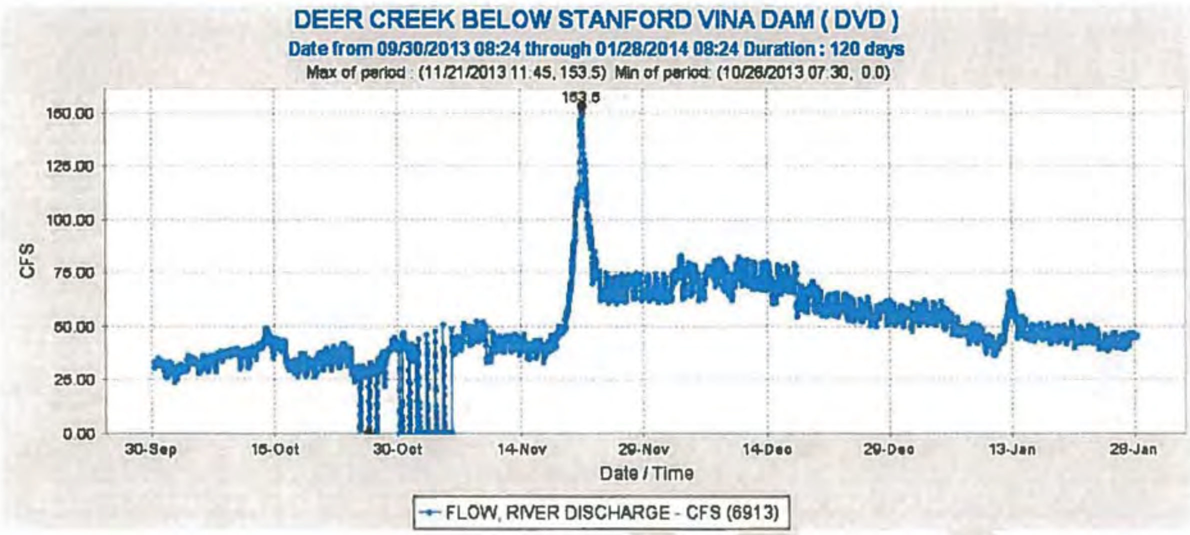


Figure 8. Mill Creek Daily flow data for WY 2014. Downloaded from CDEC on January 28, 2014

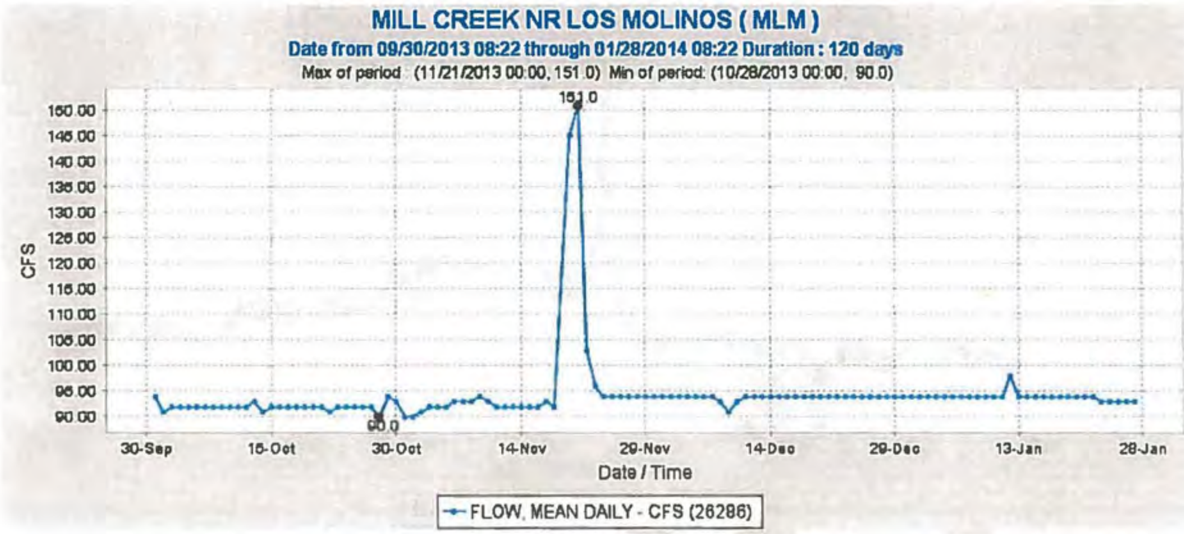


Figure 9. Wilkins Slough temperature date for WY 2014. Downloaded from CDEC on January 28, 2014.

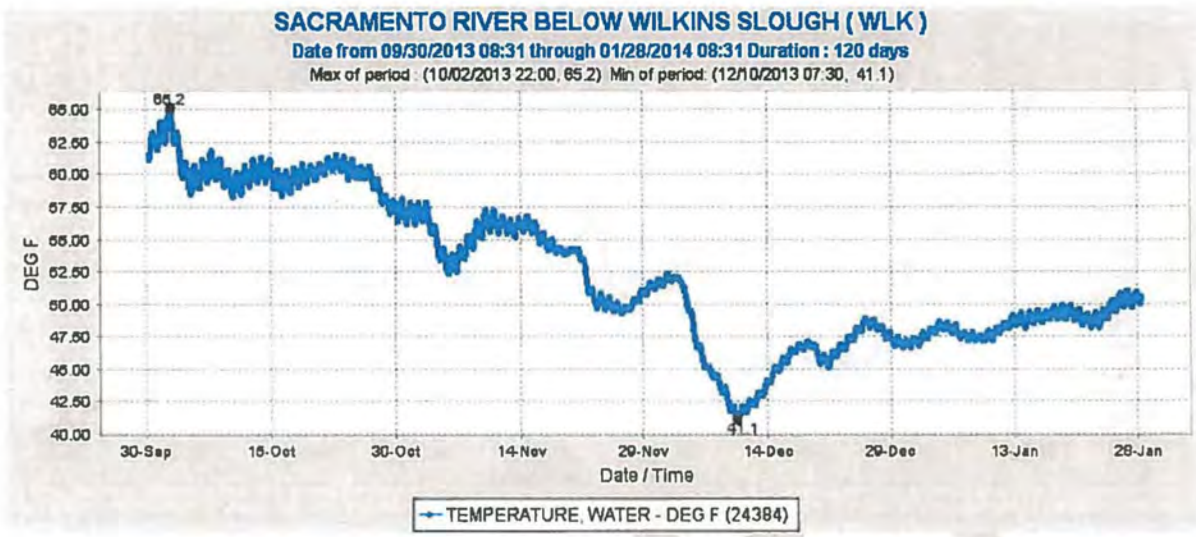


Figure 10. Wilkins Slough flow data for WY 2014. Downloaded from CDEC on January 28, 2014.

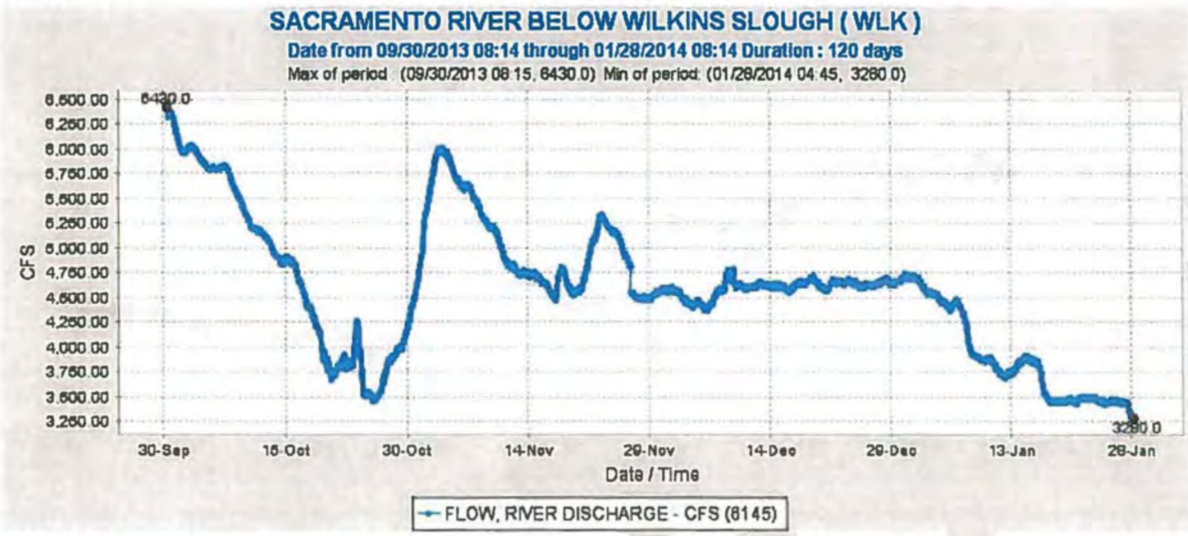
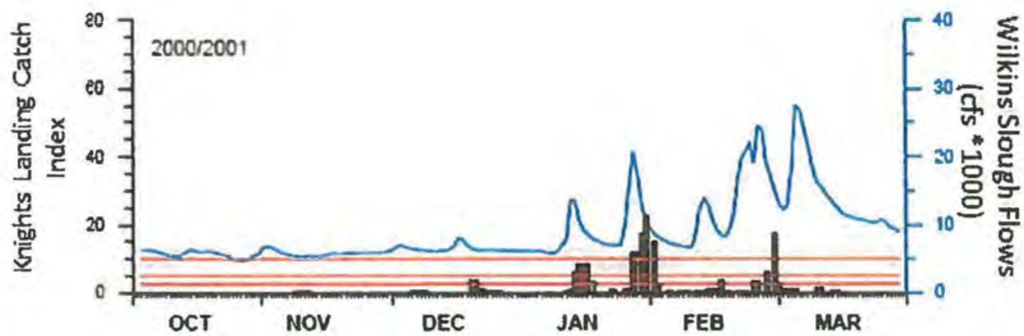


Figure 11. Knights Landing and Sacramento River indices and hydrology from October through March 2001. Figure taken and adapted from Chappell 2004. Red lines represent indice trigger exceedance values.



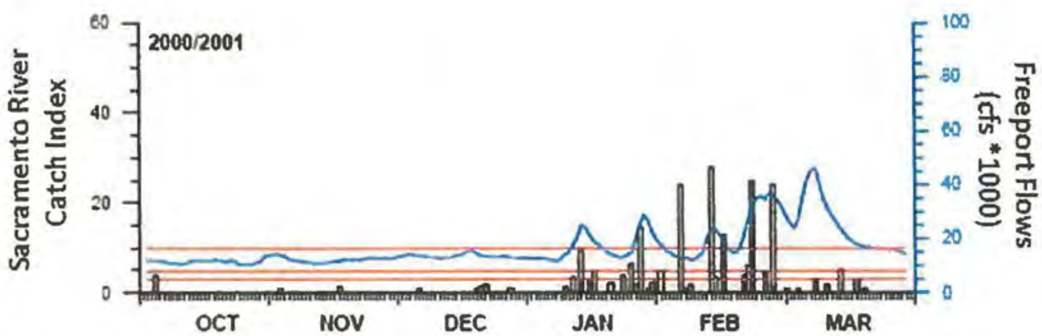


Figure 12. Knights Landing and Sacramento River indices and hydrology from August 2013 until January 13, 2014. Figures taken from DWR's Data Assessment Team weekly monitoring packet provided to DOSS on January 28,2014.

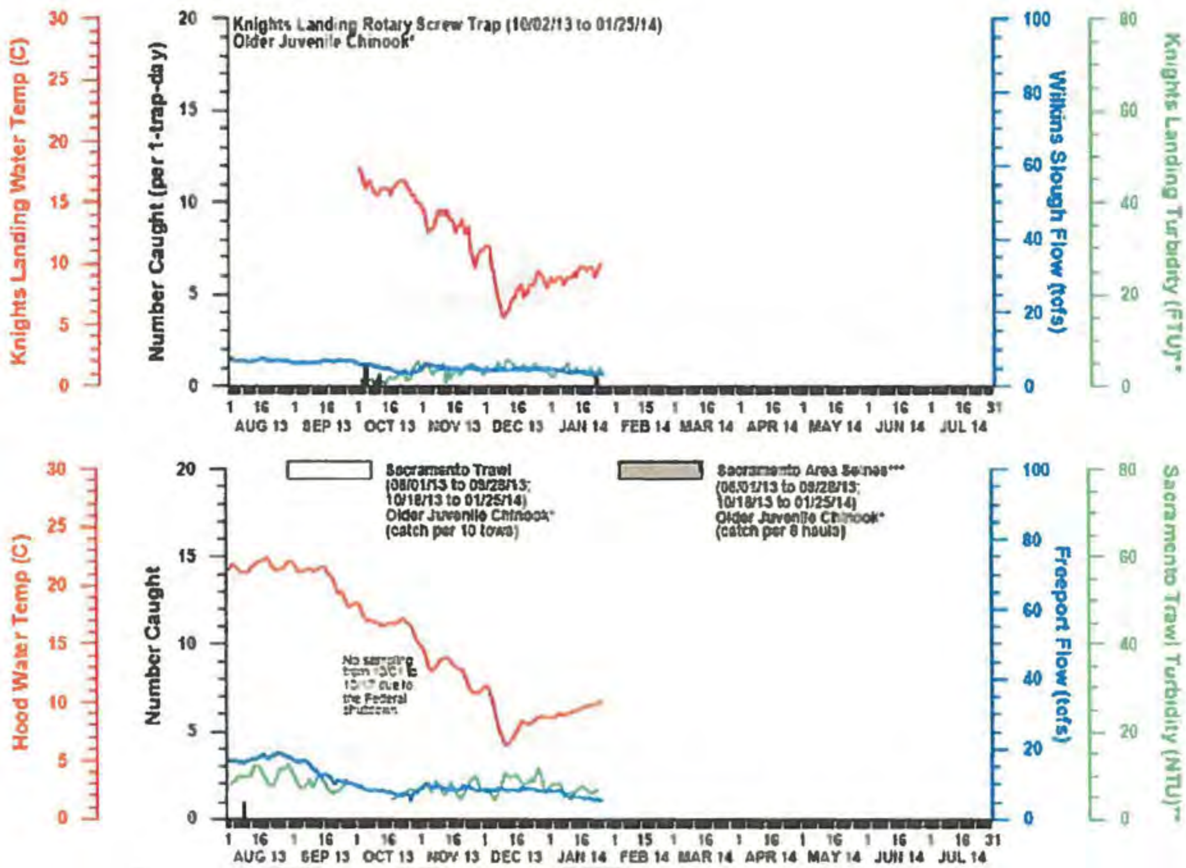


Figure 13. Jersey Point EC for WY 2014. Downloaded from CDEC on January 28, 2014. Operational water quality concern criteria is when EC is greater than 1.8, which has occurred numerous times in WY 2014.

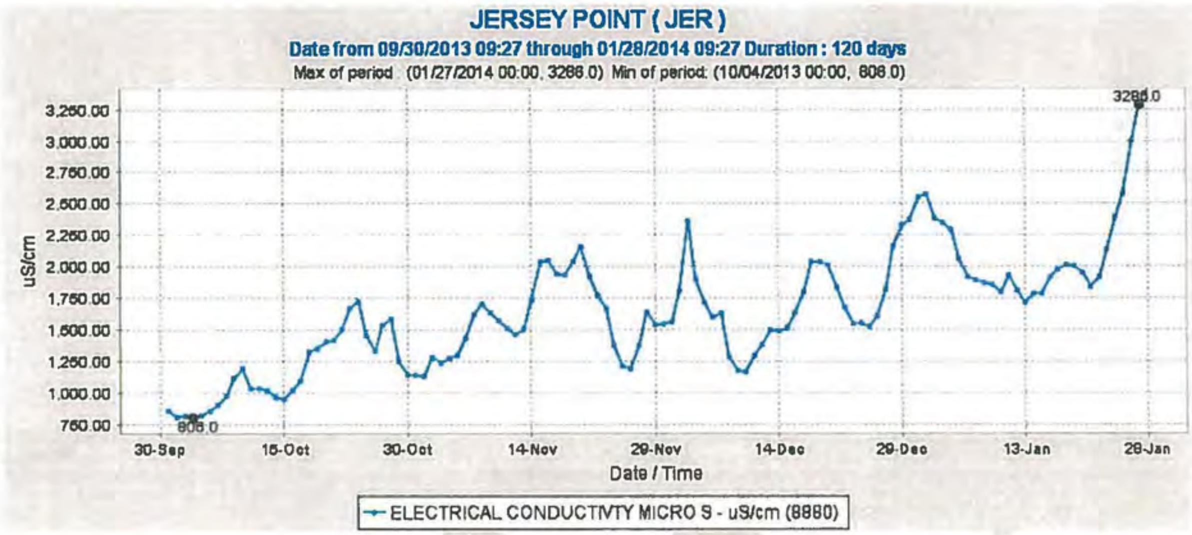


Figure 14. Bethel Island EC for WY 2014. Downloaded from CDEC on January 28, 2014. Operational water quality concern criteria is when EC is greater than 1.0, which has been exceeded for all of January thus far in WY 2014.

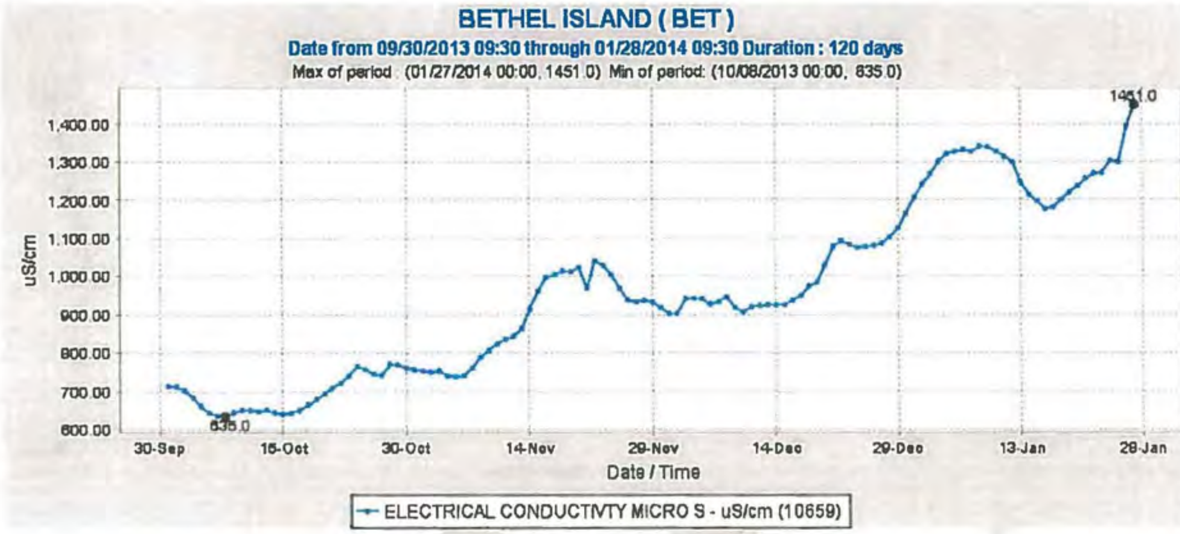


Figure 15. Holland Tract EC for WY 2014. Downloaded from CDEC on January 28, 2014. Operational water quality concern criteria is when EC is greater than 0.8, which has been exceeded for all of January in WY 2014.

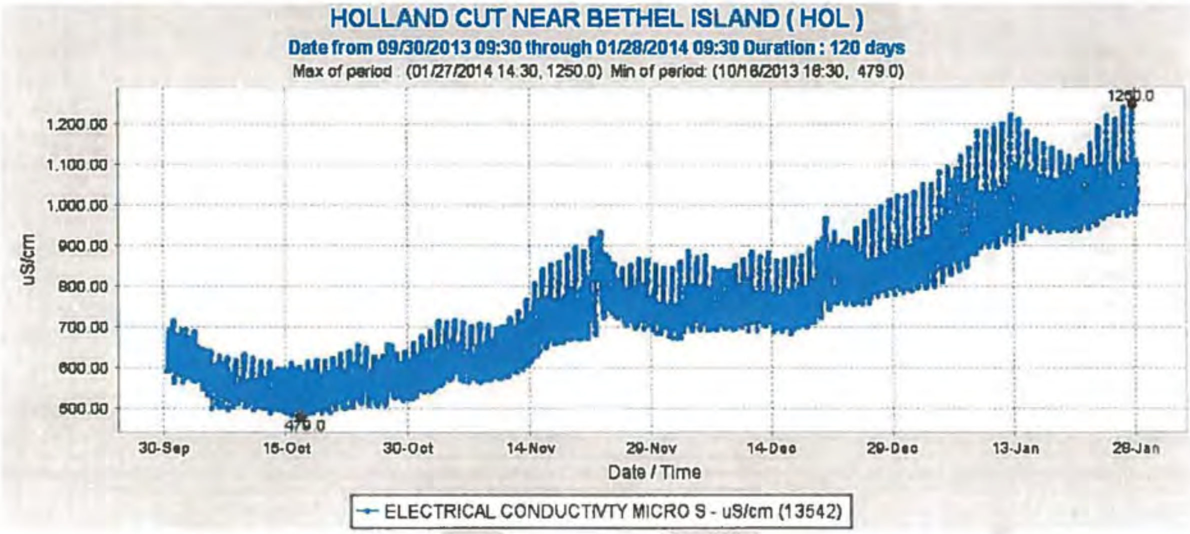
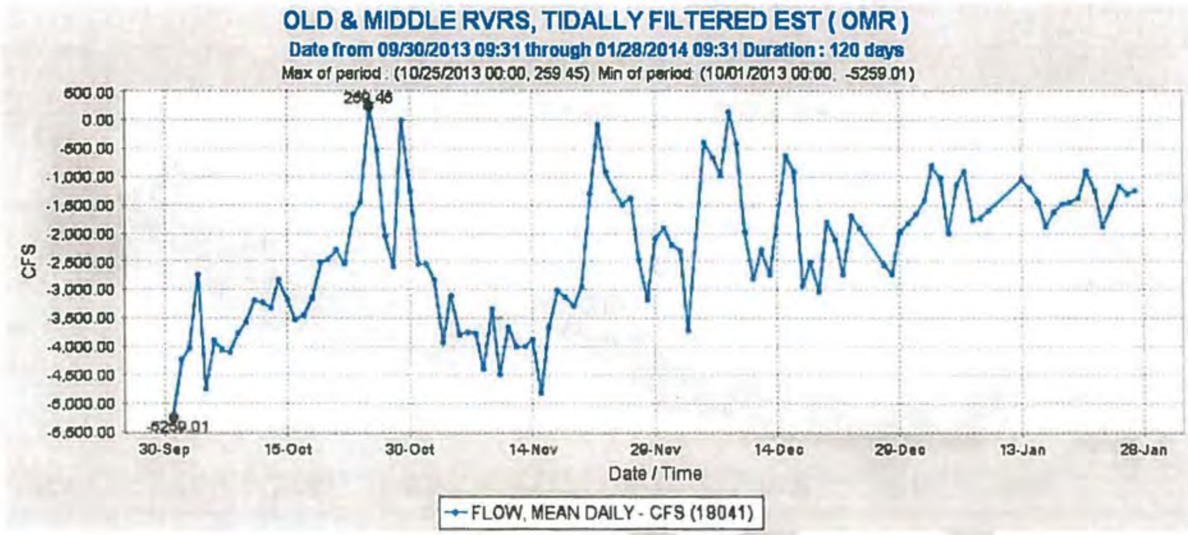
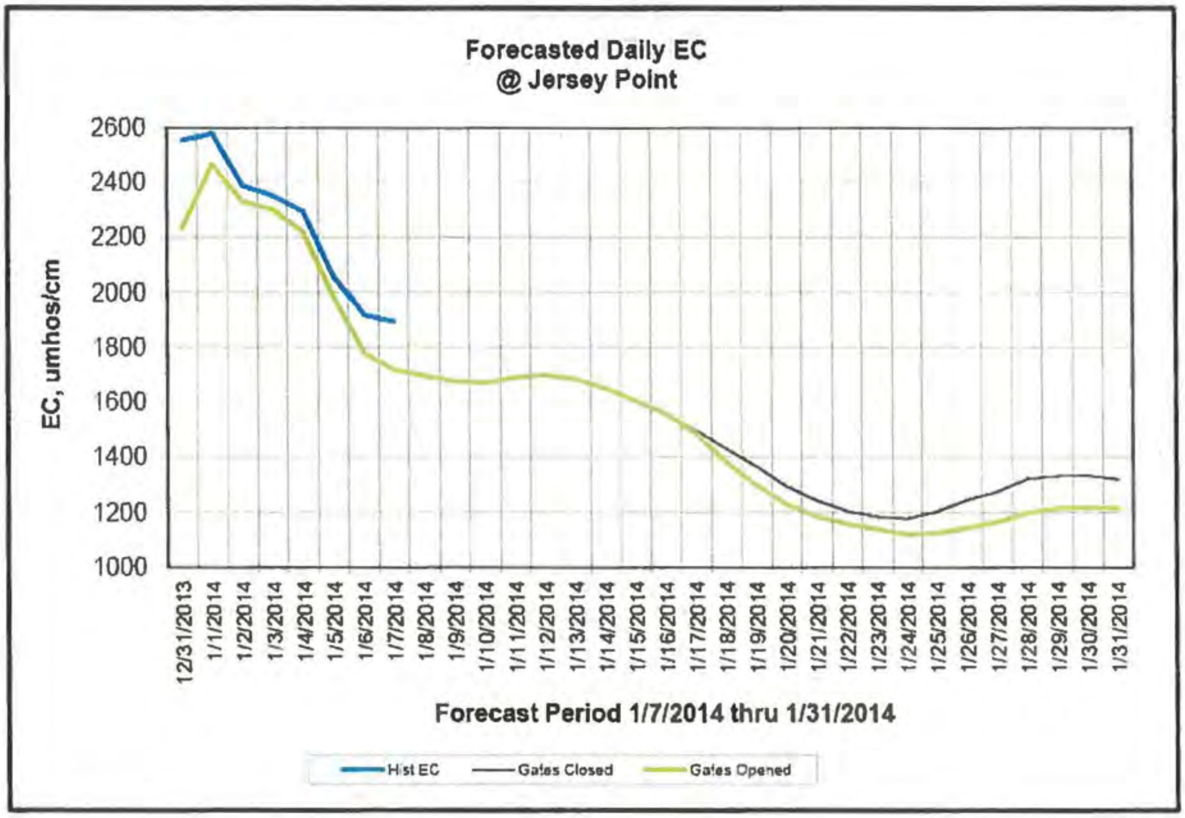
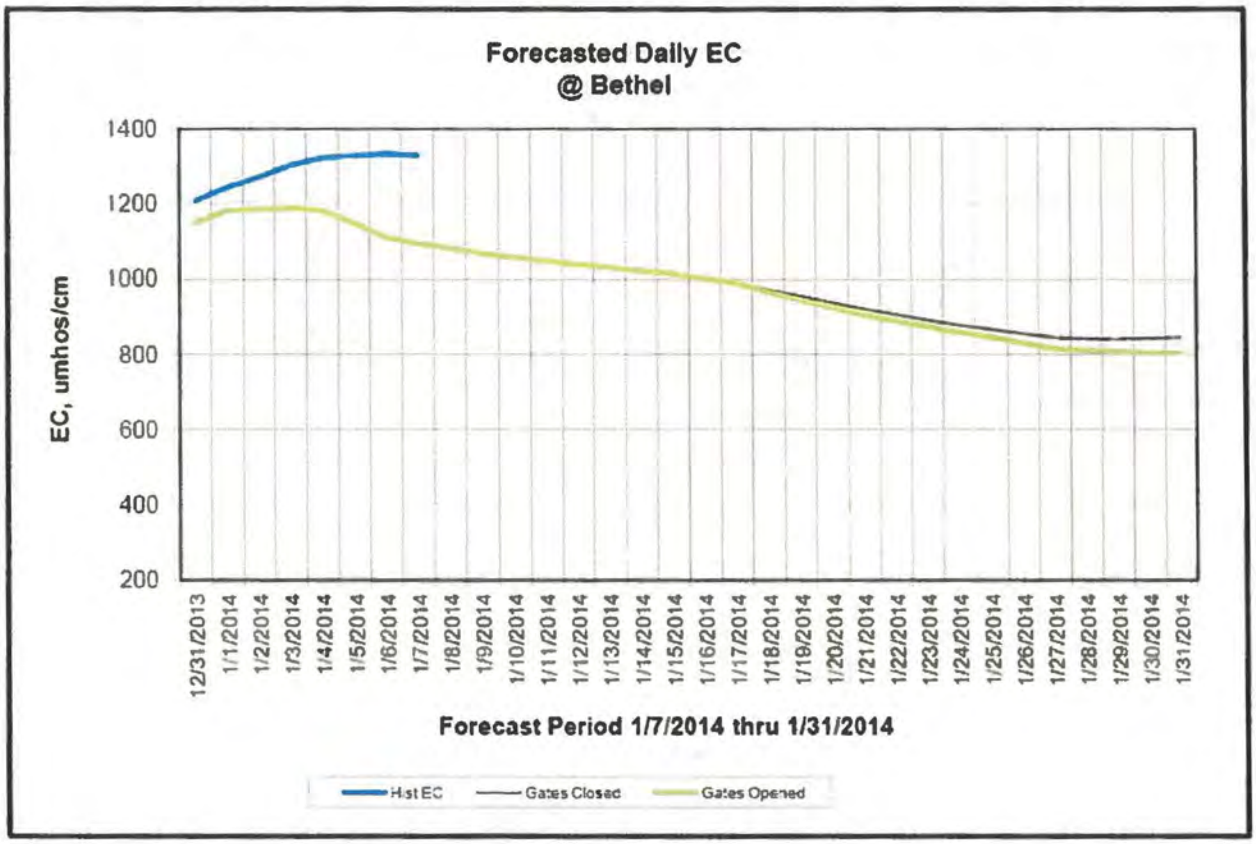


Figure 16. Old and Middle River tidally-filtered daily flows for WY 2014. Downloaded from CDEC on January 14, 2014.

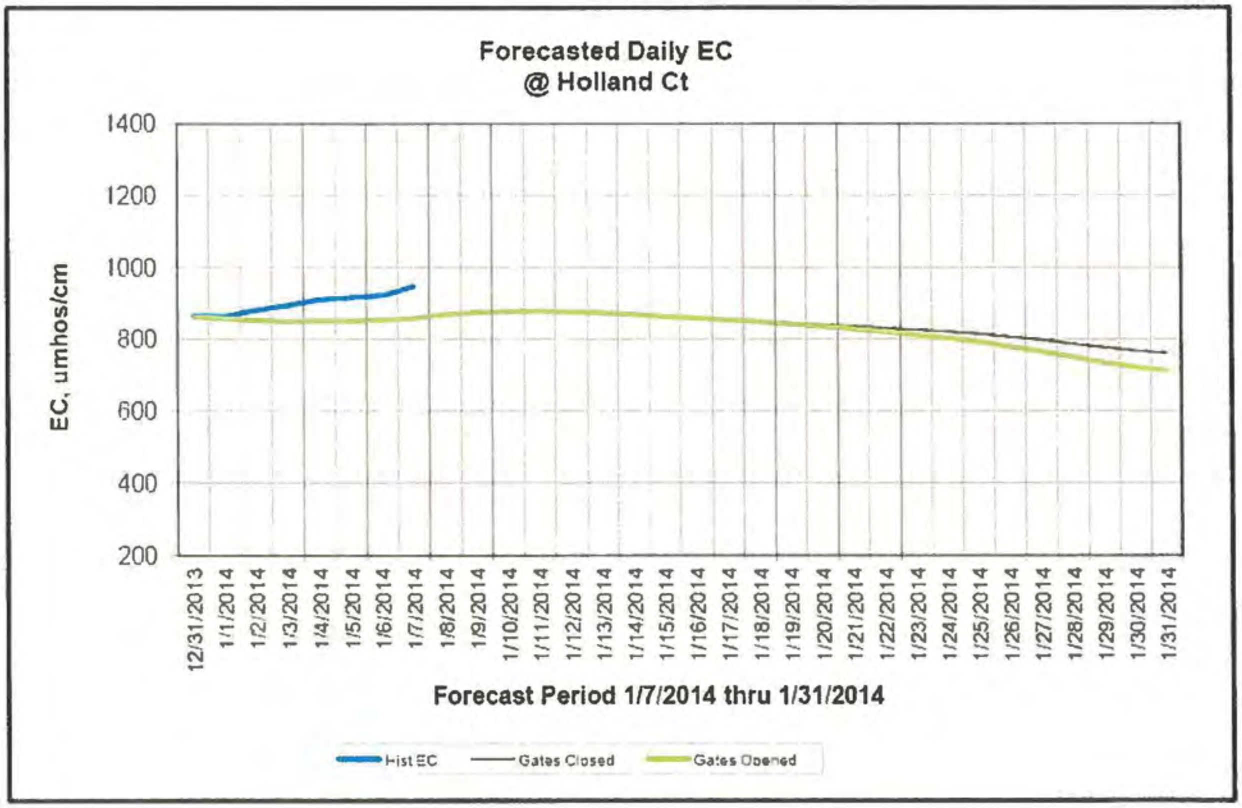


Appendix A. Department of Water Resource's Water Quality Modeling of Operational Water Quality Criteria Locations.





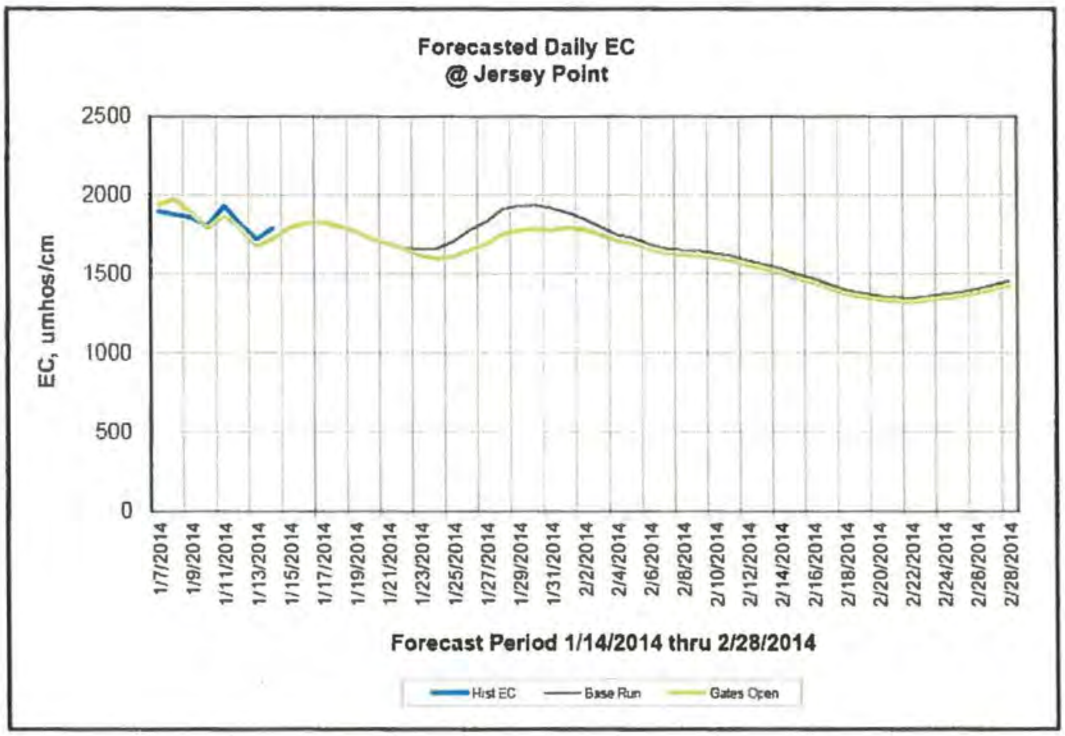
Forecasted Daily EC
@ Bethel
EC, umhos/cm
1400
1200
1000
800
600
400
200
12/31/2013
1/1/2014
1/2/2014
1/3/2014
1/4/2014
1/5/2014
1/6/2014
1/7/2014
1/8/2014
1/9/2014
1/10/2014
1/11/2014
1/12/2014
1/13/2014
1/14/2014
1/15/2014
1/16/2014
1/17/2014
1/18/2014
1/19/2014
1/20/2014
1/21/2014
1/22/2014
1/23/2014
1/24/2014
1/25/2014
1/26/2014
1/27/2014
1/28/2014
1/29/2014
1/30/2014
1/31/2014
Forecast Period 1/7/2014 thru 1/31/2014
Hist EC
Gates Closed
Gates Opened

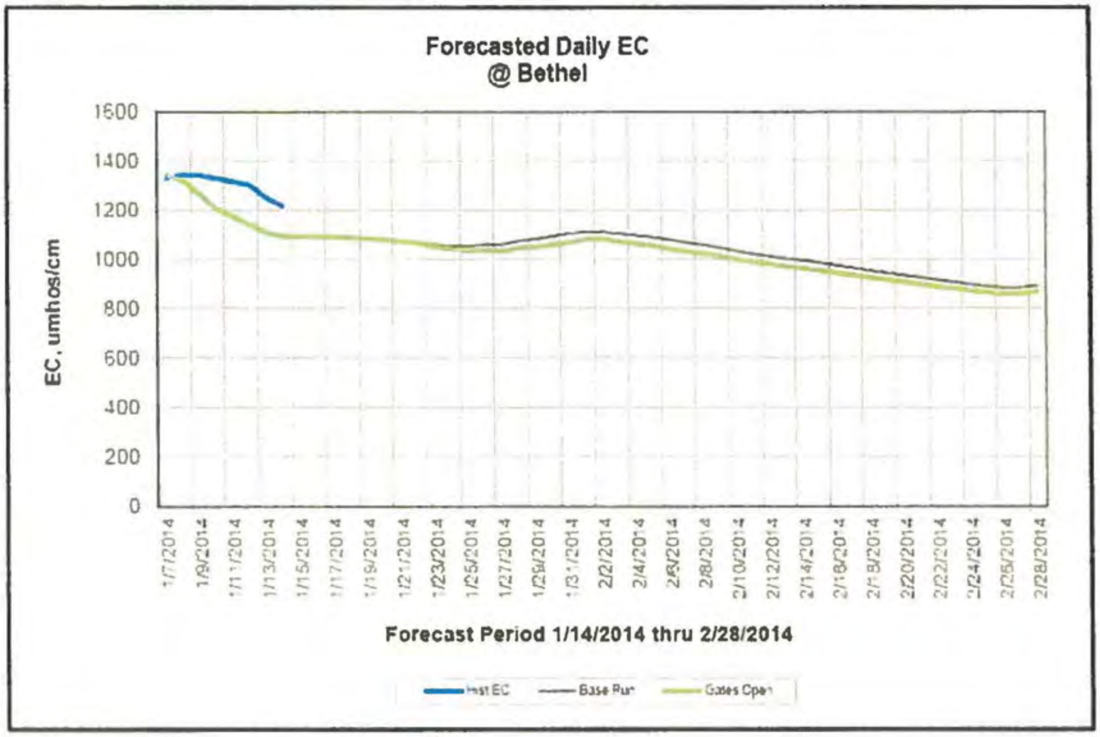


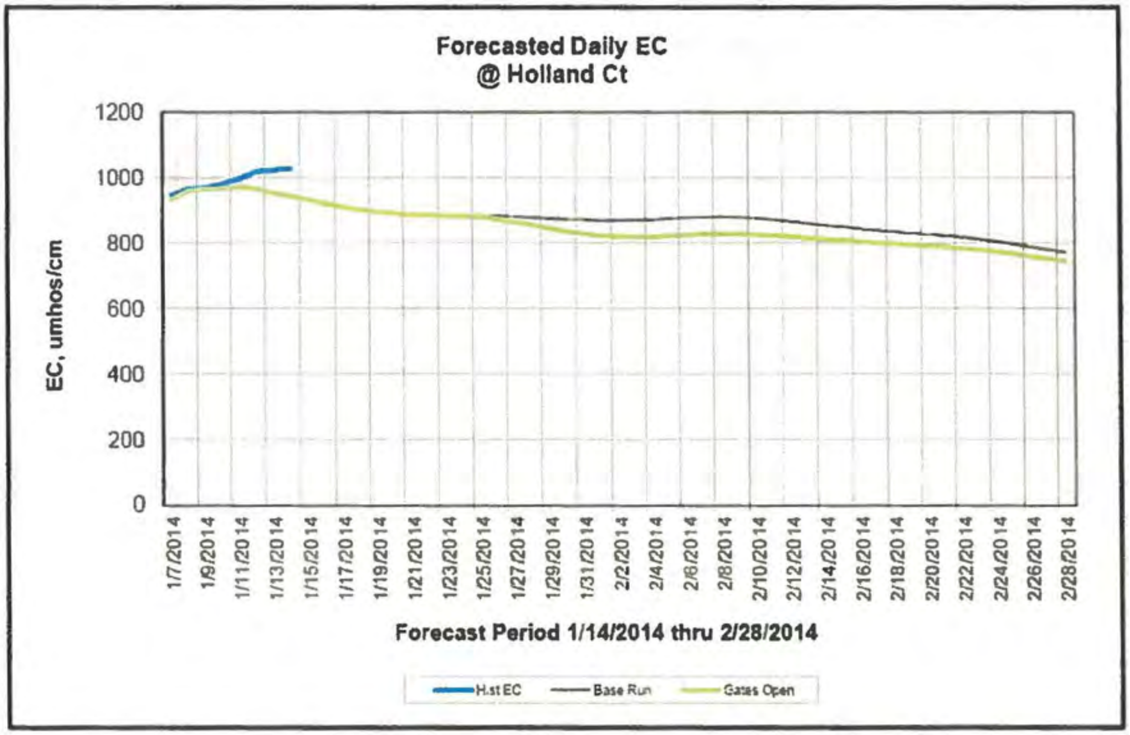
Forecasted Daily EC
@ Holland Ct
EC, umhos/cm
1400
1200
1000
800
600
400
200
12/31/2013
1/1/2014
1/2/2014
1/3/2014
1/4/2014
1/5/2014
1/6/2014
1/7/2014
1/8/2014
1/9/2014
1/10/2014
1/11/2014
1/12/2014
1/13/2014
1/14/2014
1/15/2014
1/16/2014
1/17/2014
1/18/2014
1/19/2014
1/20/2014
1/21/2014
1/22/2014
1/23/2014
1/24/2014
1/25/2014
1/26/2014
1/27/2014
1/28/2014
1/29/2014
1/30/2014
1/31/2014
Forecast Period 1/7/2014 thru 1/31/2014
Hist EC
Gates Closed
Gates Opened

Appendix B Department of Water Resource's Water Quality Modeling of Operational Water Quality Criteria Locations.

Base case: combined exports of 1,500 cfs with current reservoir releases
Gates Open: same exports as the base case with the cross channel gates closed from January 22nd to January 31st.




Forecasted Daily EC
@ Bethel
EC, umhos/cm
1600
1400
1200
1000
800
600
400
200
0
1/7/2014
1/9/2014
1/11/2014
1/13/2014
1/15/2014
1/17/2014
1/19/2014
1/21/2014
1/23/2014
1/25/2014
1/27/2014
1/29/2014
1/31/2014
2/2/2014
2/4/2014
2/6/2014
2/8/2014
2/10/2014
2/12/2014
2/14/2014
2/16/2014
2/18/2014
2/20/2014
2/22/2014
2/24/2014
2/26/2014
2/28/2014
Forecast Period 1/14/2014 thru 2/28/2014
Hist EC
Base Run
Gates Open


Forecasted Daily EC
@ Holland Ct
EC, umhos/cm
1200
1000
800
600
400
200
0
1/7/2014
1/9/2014
1/11/2014
1/13/2014
1/15/2014
1/17/2014
1/19/2014
1/21/2014
1/23/2014
1/25/2014
1/27/2014
1/29/2014
1/31/2014
2/2/2014
2/4/2014
2/6/2014
2/8/2014
2/10/2014
2/12/2014
2/14/2014
2/16/2014
2/18/2014
2/20/2014
2/22/2014
2/24/2014
2/26/2014
2/28/2014
Forecast Period 1/14/2014 thru 2/28/2014
H.st EC
Base Run
Gates Open

Status of Species

Winter-run Chinook salmon

A modest spawning run of Winter-run Chinook salmon (n=6,075) returned to the upper Sacramento River in 2013, which was larger than the spawning run that produced these fish in the Sacramento River during the summer of 2010. Redd surveys detected <0.5% of the Winter-run Chinook salmon redds built in 2013 to be downstream of the 2013 temperature compliance point at Airport Bridge. Typically a pulse of fry outmigrates from the upper Sacramento River in early October and rear in the middle Sacramento River. In fact, a pulse of Winter-run Chinook fry appeared to have moved downstream of Red Bluff Diversion Dam (RBDD) during early October, although monitoring of this pattern is uncertain due to the federal furloughs that kept biologists from monitoring this site (Figure 1 and 2). If flows remain high in the fall, a substantial proportion of Winter-run Chinook can be transported downstream of Red Bluff Diversion Dam. However, thousands of larger-sized Winter-run Chinook continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than previous years (Figure 2). However it should be noted that emigrating winter-run juveniles detected in the daily monitoring efforts have declined to numbers that are less than those seen in the early portion of the emigration season (low thousands compared to 5,000 to approximately 20,000 fish daily during September 2013). Of the estimated 4.3 million juvenile Winter-run Chinook expected to migrate past RBDD (based on the 2013 spawner escapement and JPE survival values), approximately 1.6 million fish have migrated past RBDD by January 14, 2014 [United States Fish and Wildlife Service (USFWS), Red Bluff, biweekly data]. While the absence of the majority of Winter-run Chinook moving past RBDD this late in the winter in RBDD screw trap monitoring records has not previously been observed, such a protracted and significant daily passage of Winter-run Chinook salmon past this location in January has also not been observed (Bill Poytress, USFWS, pers. comm.). Of 179 stranding sites along the Sacramento River from Tehama (Los Molinos) to Keswick Dam (about RM70), 21 completely isolated sites have been identified to have winter-run salmon trapped in them [Doug Killam, California Department of Fish and Wildlife (CDFW), pers. comm.].

Based on these current estimates of passage and juvenile abundance, there is a fair likelihood that a substantial proportion of the Winter-run Chinook population remains above RBDD. On recent weekly DOSS calls, the topic of the position of Winter-run Chinook salmon has been discussed. There has been agreement that a broad distribution of Winter-run Chinook lies between Red Bluff and Knights Landing with fish going from above Red Bluff downstream into the Delta.

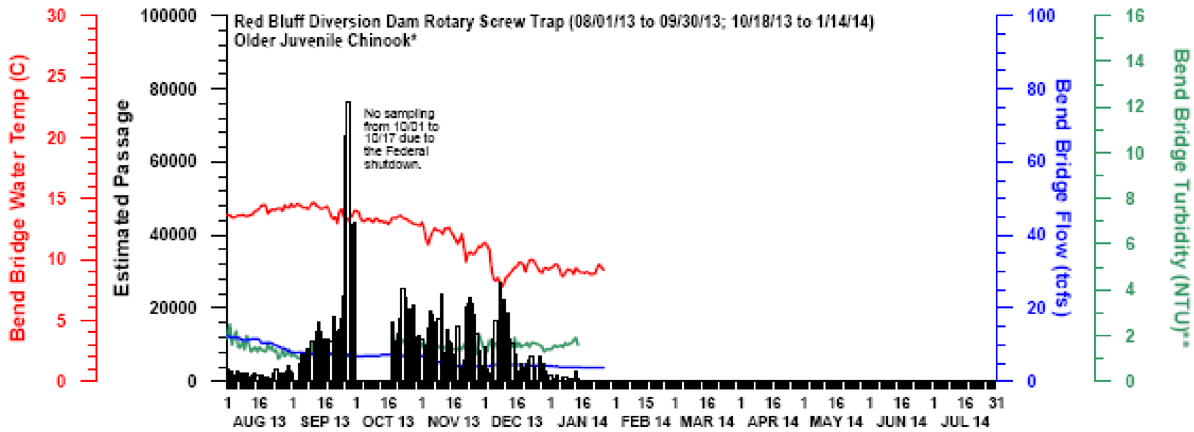


Figure 1. Red Bluff Diversion Dam Passage of Juvenile Older Chinook Salmon and Associated Environmental Data. [1]

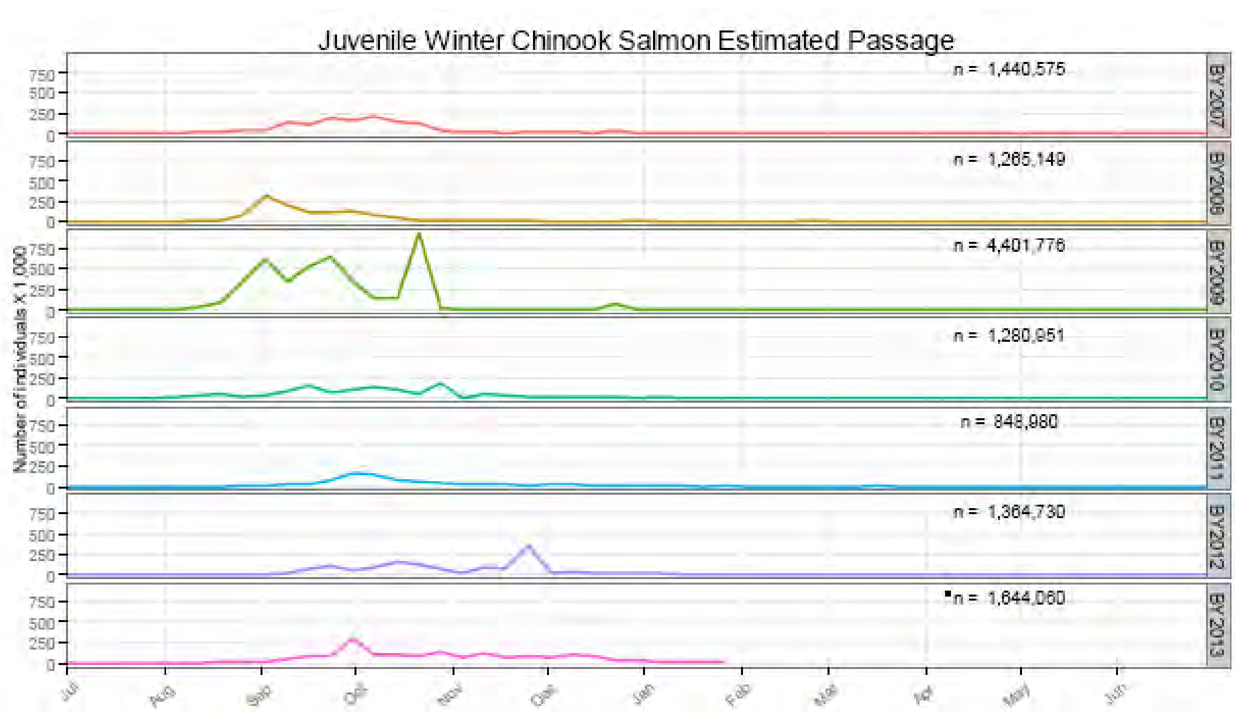


Figure 2. Weekly Estimated Passage of Juvenile Winter-run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY). [2]

[1] Figure supplied by DWR to DOSS on January 27, 2014.

[2] Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Winter-run passage value interpolated using a monthly mean for the period of October 1 through October 17, 2013, due to government shutdown. Figure supplied by USFWS on January 29, 2014.

Winter-run Chinook juveniles have been passing the location of the monitoring station at the Glen-Colusa Irrigation District intake canal in the middle section of the Sacramento River since October 2013 (Figure 4). As of January 27 2014, 13 Winter-run Chinook salmon smolts and 18 Winter-run juvenile, have been observed in GCID fish monitoring in January 2014. The declining recovery trend of outmigrating Winter-run Chinook past GCID's screw traps in January may suggest that Winter-run Chinook, which past RBDD earlier in the fall and winter as fry and parr, have abandoned outmigration to rear between RBDD and GCID or conversely, a majority of the fish observed past RBDD have also past GCID. The pulses in the GCID data reflect the pulses seen in the RBDD data for the corresponding time points in the emigration season. Typically, fry and parr that cannot sustain territories in river flows maintain outmigration past Knights Landing and into the Lower Sacramento River with late fall/early winter Sacramento Valley rainstorms increase flows to greater than 7,500 cfs. Juvenile Winter-run Chinook were infrequently observed in October and December 2013 at the Tisdale Weir fish monitoring station on the Middle Sacramento River and in October at the Knights Landing fish monitoring station on the Lower Sacramento River (Table 1). Rosario et al (2013) described multiple pulses of distinctly different sized Winter-run Chinook salmon typically moving through the Lower Sacramento River at Knights Landing between November and January. There seems to have been almost a complete lack of smaller Winter-run Chinook fry outmigration during Water Year (WY) 2014 through the Lower Sacramento River and Delta (Table 1). Also, in WY 2014, there have not been pulses of multiple size classes collected in the rotary screw traps at the same time, and fish the length of fish has recovered over time as the emigration season progresses. Rosario et al (2013) did not report on any uniquely dry water years similar to WY2014, thus direct comparisons between WY 2014 and their findings raise uncertainties. Unlike the typical pattern of substantial proportions of Winter-run salmonid population rearing in the Delta, in WY 2014 a substantial proportion of Winter-run Chinook parr are apparently undergoing smoltification while still in the middle and upper Sacramento River waiting for physiological or environmental cues to emigrate into the Delta.

Based on 2013 adult Winter-run Chinook salmon escapement, the juvenile production estimate for Winter-run Chinook salmon juveniles entering the Delta ranges from approximately 1.32 million fish (using the JPE method from WY2013) to approximately 400,000 fish (using limited Winter-run Chinook specific riverine survival estimates of 0.16). No juvenile Winter-run Chinook salmon have been observed in lower Sacramento River and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. On recent weekly DOSS calls, the topic of the proportion of the population of Winter-run Chinook salmon that has entered the lower Sacramento River or Delta has been discussed. There are a diversity of opinions, and estimates of <5%, based on the information in this assessment, to as much as >30%, based on expert opinion, of the Winter-run Chinook salmon are downstream of Knights Landing and in the Delta.

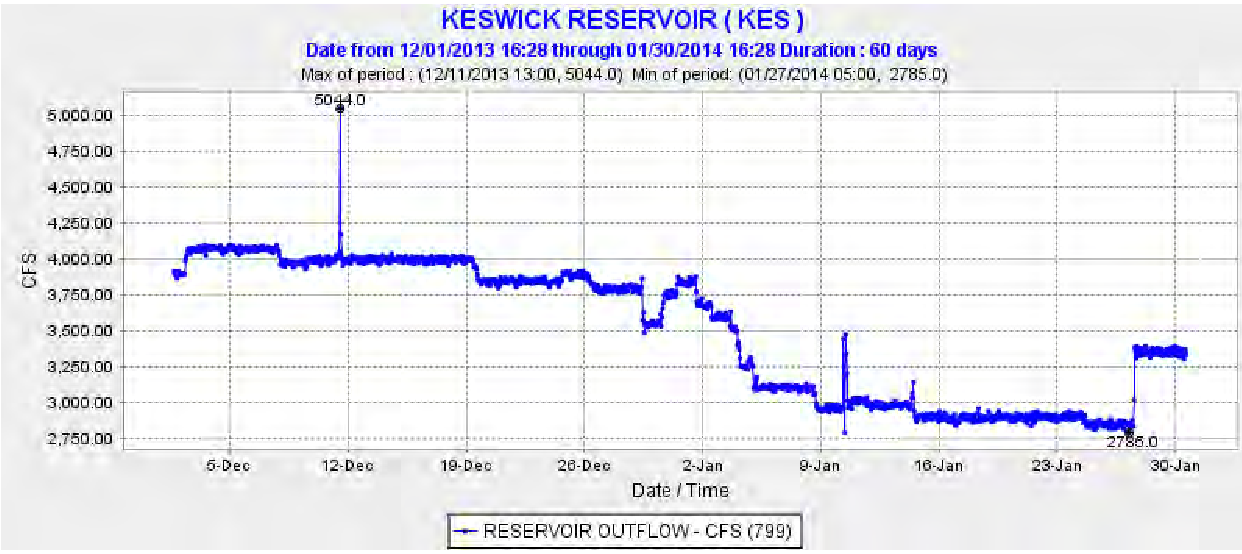


Figure 3. Keswick Reservoir Outflow for WY 2014.[3]

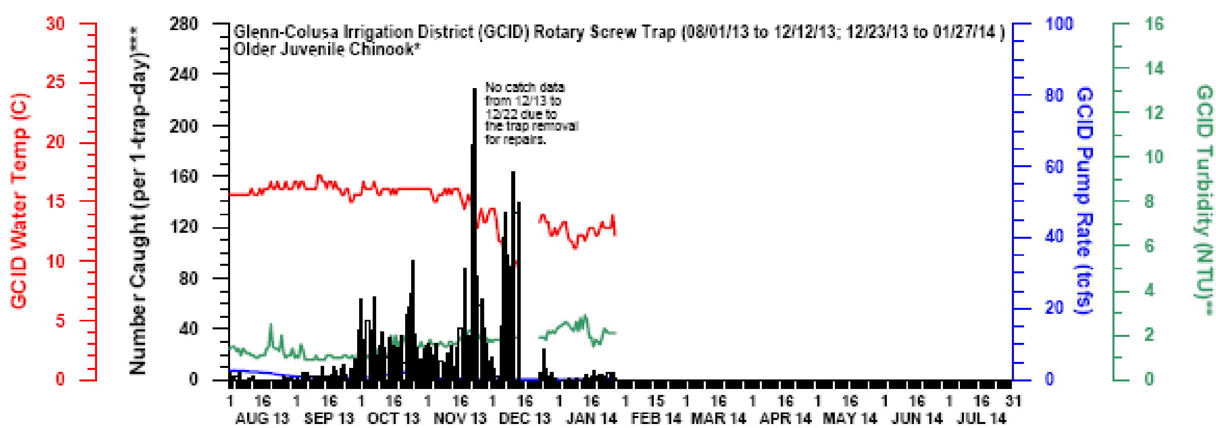


Figure 4. Glen-Colusa Irrigation District Rotary Screw Trap older juvenile Chinook salmon catch data and associated environmental data.[4]

Adult winter-run Chinook salmon are currently entering the Sacramento River and migrating to the upper reaches of the river in preparation for spawning during the summer of 2014. These adult Winter-run Chinook will hold in the upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam until they are ready to spawn during the summer. These

[3] Downloaded from CDEC on January 30, 2014.
[4] Figure supplied by DWR to DOSS on January 27, 2014.

fish require coldwater holding habitat for several months prior to spawning as their gonads mature, and then require cold water to ensure the proper development of their fertilized eggs, which are highly sensitive to thermal conditions during this embryo development period. Adults returning to the river in 2014 are predominantly members of the cohort from brood year 2011. Based on cohort replacement rate (CRR) estimates, the 2011 brood year was the third lowest CRR since 1992. It is likely that the escapement of Winter-run Chinook in 2014 will be approximately half the number of adults that spawned in 2013, based on the smaller number of adults that returned in 2011 compared to 2010. Fewer returning adults will typically result in lower juvenile production for that year, thus the juvenile production for 2014 is expected to be lower than 2013.

Table 1. Fish Observation Data from Tisdale and Knights Landing Rotary Screw Traps in WY 2014.[5]

Location	Gear	Start Date	Stop Date	Num. of Hours During Sampling Period	Flow cfs (@ WLK)	Cone RPM (8.3)	Cone RPM (8.4)	Total Cone Rev. (8.3)	Total Cone Rev. (8.4)	Total Hrs. Fished	Water T (F)	Secchi (ft)	Turbidity (FTU)	Unmarked Chinook CATCH	Min FL	Max FL	# Fall	# Spring	# Winter	# Late fall	# Ad-clip CS	# Ad-clip SH	# Unclip SH	Fall+Spring CPUE (catch per hour)	Winter+Late fall CPUE (catch per hour)	Unclip SH CPUE (catch per hour)
TIS	2 x 8' Cone	9/30/2013	10/1/2013	25.00	6,405	2.5	2.6	2,926	4,106	46.14	62	NA	4.5	1	34	34	0	0	1	0	0	0	0	0.000	0.022	0
TIS	2 x 8' Cone	10/2/2013	10/3/2013	23.50	5,987	2.6	2.6	3,323	3,816	46.06	61	NA	4.6	1	38	38	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2488	2696	44.9	61	5.6	1.5	2	36	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2488	2696	44.9	61	5.6	1.5	2	36	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/8/2013	10/10/2013	44.00	5640	1.7	1.7	5099	5521	104.1	60	5.9	1.1	1	38	38	0	0	1	0	0	0	0	0.000	0.010	0
TIS	2 x 8' Cone	10/9/2013	10/10/2013	21.75	5,458	1.7	2.2	2,198	3,080	44.76	57	NA	5.5	1	37	37	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/10/2013	10/11/2013	23.75	5269	1.9	1.8	2596	2842	49.7	60	6.0	2.8	1	41	41	0	0	1	0	0	0	0	0.000	0.020	0
TIS	2 x 8' Cone	10/22/2013	10/23/2013	23.50	3,845	0.0	1.9	0	1,014	9.09	59	NA	11.4	1	36	36	0	0	1	0	0	0	0	0.000	0.110	0
TIS	2 x 8' Cone	10/23/2013	10/24/2013	22.00	4,008	1.1	2.1	1,784	3,032	51.09	58	NA	6.7	1	39	39	0	0	1	0	0	0	0	0.000	0.020	0
KL	2 x 8' Cone	11/8/2013	11/8/2013	7.25	5310	1.3	1.6	590	759	15.7	57	3.9	3.9	1	38	38	0	1	0	0	0	0	0	0.064	0.000	0
TIS	2 x 8' Cone	11/10/2013	11/11/2013	16.25	5,057	1.3	2.1	829	1,214	20.13	54	NA	5.9	1	35	35	0	1	0	0	0	0	0	0.050	0.000	0
TIS	2 x 8' Cone	12/16/2013	12/16/2013	8.75	4,586	1.0	1.8	497	945	17.03	45	NA	8.0	1	79	79	0	0	1	0	0	0	0	0.000	0.059	0
TIS	2 x 8' Cone	12/21/2013	12/21/2013	8.25	4,633	1.3	1.7	493	878	14.93	45	NA	7.1	1	75	75	0	0	1	0	0	0	0	0.000	0.067	0
TIS	2 x 8' Cone	12/23/2013	12/24/2013	15.00	4,650	1.2	1.7	818	1,623	28.05	46	NA	8.9	1	94	94	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	12/30/2013	12/31/2013	15.25	4,689	1.2	2.0	886	1,597	25.61	45	NA	5.6	1	34	34	1	0	0	0	0	0	0	0.039	0.000	0
TIS	2 x 8' Cone	1/3/2014	1/4/2014	15.00	4,536	0.8	1.8	720	1,540	29.42	46	NA	8.6	1	37	37	1	0	0	0	0	0	0	0.034	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/4/2014	8.25	4,458	1.3	1.8	625	936	16.68	46	NA	6.3	1	39	39	1	0	0	0	0	0	0	0.060	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/5/2014	15.25	4,458	1.3	1.9	1,060	1,619	27.79	46	NA	7.8	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/5/2014	1/6/2014	15.50	4,416	0.9	1.6	914	1,457	33.18	48	NA	7.2	3	35	37	3	0	0	0	0	0	0	0.090	0.000	0
TIS	2 x 8' Cone	1/6/2014	1/6/2014	8.50	4,425	0.9	1.8	513	834	17.40	46	NA		1	38	38	1	0	0	0	0	0	0	0.057	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/8/2014	8.50	3,917	0.3	1.2	287	760	24.96	46	NA	6.1	1	33	33	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/9/2014	14.75	3,917	0.7	1.4	311	1,106	21.05	43	NA	7.7	2	40	40	2	0	0	0	0	0	0	0.095	0.000	0
KL	2 x 8' Cone	1/10/2014	1/11/2014	13.75	3757	1.1	1.1	972	857	27.7	48	6.2	2.9	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/12/2014	1/13/2014	15.00	3,730	0.8	1.6	885	1,632	34.46	47	NA	6.0	3	36	41	3	0	0	0	0	0	0	0.087	0.000	0
KL	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	1.3	1.3	1094	1053	27.5	49	6.0	2.4	1	37	37	1	0	0	0	0	0	0	0.036	0.000	0
KL	2 x 8' Cone	1/16/2014	1/17/2014	14.25	3520	1.2	1.0	1013	894	29.0	49	5.5	3.0	2	37	40	2	0	0	0	0	0	0	0.069	0.000	0
KL	2 x 8' Cone	1/24/2014	1/25/2014	14.00	3440	1.1	1.1	967	838	28.0	50	5.7	3.8	1	100	100	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	0.8	1.5	497	1,288	24.86	49	NA	10.9	1	38	38	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/14/2014	1/15/2014	15.00	3873	0.6	1.5	432	1,218	25.53	48	NA	7.4	2	38	39	2	0	0	0	0	0	0	0.078	0.000	0
TIS	2 x 8' Cone	1/20/2014	1/21/2014	20.00	3476	2.8	2.2	2,728	2,823	37.63	48	NA	6.98	2	38	39	2	0	0	0	0	0	0	0.053	0.000	0
TIS	2 x 8' Cone	1/21/2014	1/22/2014	14.75	3492	2.5	2.4	2,230	1,953	28.78	47	NA	6.4	1	40	40	1	0	0	0	0	1	0	0.035	0.000	0
TIS	2 x 8' Cone	1/23/2014	1/24/2014	15.25	3483	2.6	2.1	2,348	2,002	30.86	48	NA	6.65	1	40	40	1	0	0	0	0	0	0	0.032	0.000	0
TIS	2 x 8' Cone	1/24/2014	1/25/2014	14.75	3450	2.5	2.0	2,167	1,818	29.58	48	NA	8.23	1	35	35	1	0	0	0	0	1		0.034	0.000	0
TIS	2 x 8' Cone	1/26/2014	1/27/2014	14.50	3395	2.2	1.8	1,935	1,786	31.20	48	NA	6.27	1	142	142	0	0	0	1	0	0	0	0.000	0.032	0

[5] Data updated through January 27, 2014.

Spring-run Chinook salmon

A small, but greater than average spawning run of spring-run Chinook returned to the upper Sacramento River. In 2013, this greater-than-average return of spawners was observed across many tributaries supporting spring-run Chinook salmon. The adult escapement estimate for Central Valley spring-run in 2013 is 20,057 fish returning to the Feather River Hatchery and 18,499 fish returning to the tributaries. This is the largest return in the past 25 years. Rain events during mid-November increased daily average flows in upper Sacramento River tributaries conducive to triggering outmigration of yearling spring-run Chinook into the mainstem, although the rapid return to stable tributary flows and low temperature suggest these fish may have limited the extent to which larger numbers of yearling spring-run Chinook exited these watersheds. Hundreds of smaller-sized spring-run Chinook salmon juveniles continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than in previous years (Figure 5), which may be expected from a larger than average adult escapement this year. These smaller sized spring-run Chinook may have been subjected to greater stranding risks during reservoir release reductions earlier this winter. Since October 2013, 90 juvenile, but no smolting, spring-run Chinook salmon were observed in middle [Glenn Colusa Irrigation District (GCID)]. Sacramento River fish monitoring stations (Figure 4, these are included in the "older juvenile" data presented) through January 27 2014. Only three juvenile spring-run Chinook salmon have been observed during late October and early November 2013, at the Tisdale Weir and Knights Landing fish monitoring stations in WY 2014 (Table 2). Spring-run Chinook salmon have been observed outmigrating past rotary screw traps on Butte Creek (~42,000 fry) and the Feather River. These spring-run Chinook salmon will not be observed emigrating through the Lower Sacramento River, since the confluences of these watersheds are downstream of mainstem rotary screw traps, and thus these fish could move undetected into the Delta. Thus, there is additional uncertainty in being able to quickly observe pulses of these spring-run Chinook entering the Delta. Since late fall, no spring-run Chinook have been observed in lower Sacramento and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps.

Adult spring-run Chinook will migrate into the upper Sacramento between May and July 2014. These adults oversummer in the upper Sacramento River before spawning and require coldwater holding habitat for the maturation of their gonads before spawning in September and October. Lack of cold water habitat will decrease the viability of their gametes as the mature and exposes adult fish to increased mortality through other avenues, such as disease and thermal stress. Additionally, the brood year 2014 eggs will require continued cold water thermal conditions as they develop in the gravel during the September through November 2014 incubation period.

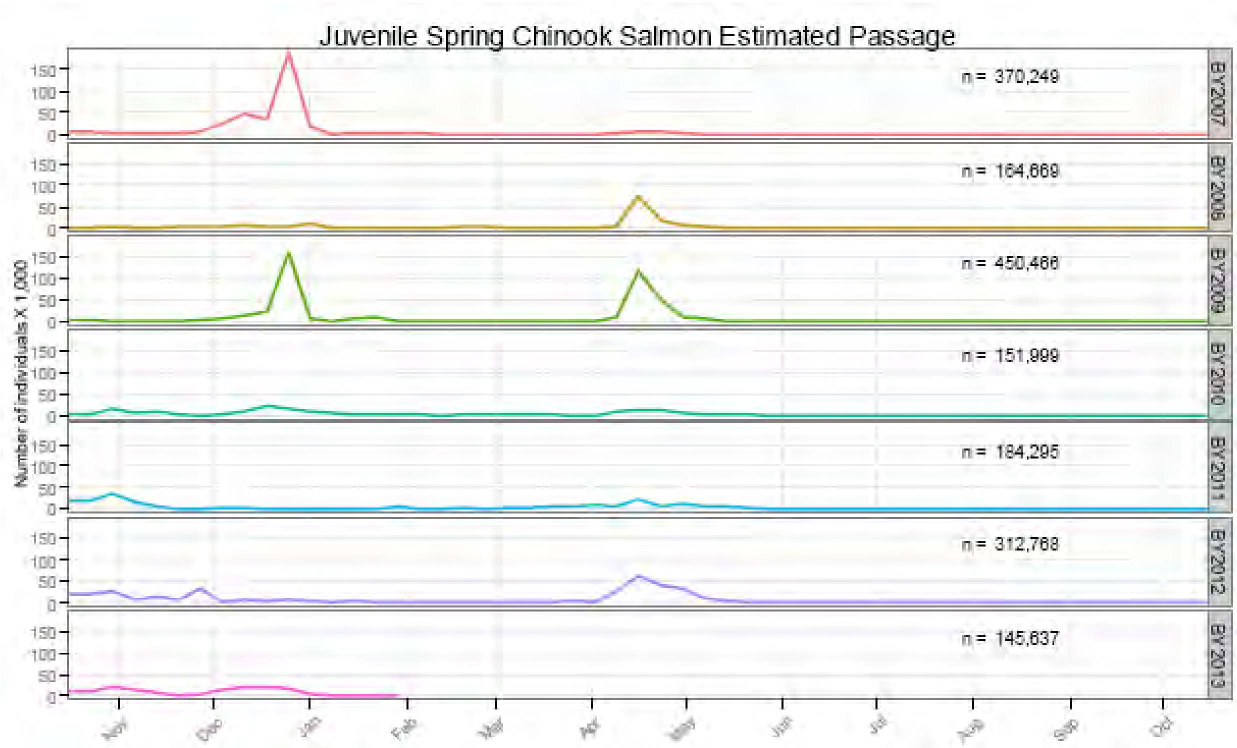


Figure 5. Weekly Estimated Passage of Juvenile Spring-Run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY).[6]

[6] Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (January 29, 2014).

Table 2. Environmental Data from Tisdale and Knights Landing Rotary Screw Trap for WY 2014 When Winter-run and Spring-run Chinook Salmon were Enumerated Between October 1 and January 27, But Only Through January 14 During Other Observational Periods.
NA = Not accessed or available.

Location and number of fish recovered	Number of fish observed	Turbidity			Daily flows at Wilkins slough		
		Average	Min	Max	Average	Min	Max
Combined Tisdale and Knights Landing WY 2014							
1 fish	13	6.1	1.1	11.4	4465	3395	6405
2 fish	4	4.7	1.5	7.7	4431	3476	5902
Tisdale 2011-2012							
1 fish	7	8.41	5.8	12.4	7069	4870	11900
2 fish	6	9.27	8	10.6	6040	5050	7690
Knights Landing 2011-2012							
1 fish	4	9.39	7.8	10.6	6967	8440	5893
2 fish	6	6.73	6.1	7.3	9299	9454	9144
Knights Landing 2000-2001							
1 fish	8	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
>3 fish	27	NA	NA	NA	NA	NA	NA
Beach Seine 2001-2001							
1 fish	6	NA	NA	NA	NA	NA	NA
> 4 fish	42	NA	NA	NA	NA	NA	NA
Sacramento Trawl 2000-2001							
1 fish	2	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
3 fish	3	NA	NA	NA	NA	NA	NA

Steelhead

Information on steelhead is extremely limited. Observed 2013 patterns of outmigrating *O. mykiss* parr (young of year) during the summer at RBDD were similar to previously observed patterns, although a greater abundance appears to have passed than in the past previous five years (Figure 6). Steelhead smolts are seldom observed in Sacramento River and Delta fish monitoring due to sampling biases related to their larger fish size and their enhanced swimming ability. False negatives are more likely with steelhead smolts than smaller older juvenile Chinook salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. Since October 2013, GCID fish monitoring has detected 10 wild steelhead, eight of which were in October. Between 1998 and 2011, temporal observations of natural steelhead juveniles (n=2137) collected in these monitoring efforts in the Delta occurs less than 10% of the time in January, >30% of the time during February, >30% of the time during February, and >20% of the time during March. So far in WY2014, A single steelhead was observed in lower Sacramento and Delta seine and trawl surveys (one 300mm steelhead observed 12/11/13 in the Chipps Island Trawl). Multiple steelhead smolts were observed in American River fish monitoring and will not be observed anywhere before entering the Delta due to the American River confluence being downstream of the mainstem rotary screw traps. Thus, there is additional uncertainty in being able to quickly observe pulses of American River steelhead entering the Delta. One steelhead was counted at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps on January 1/23/14. No outmigrating steelhead have been observed in the Mossdale trawl this winter.

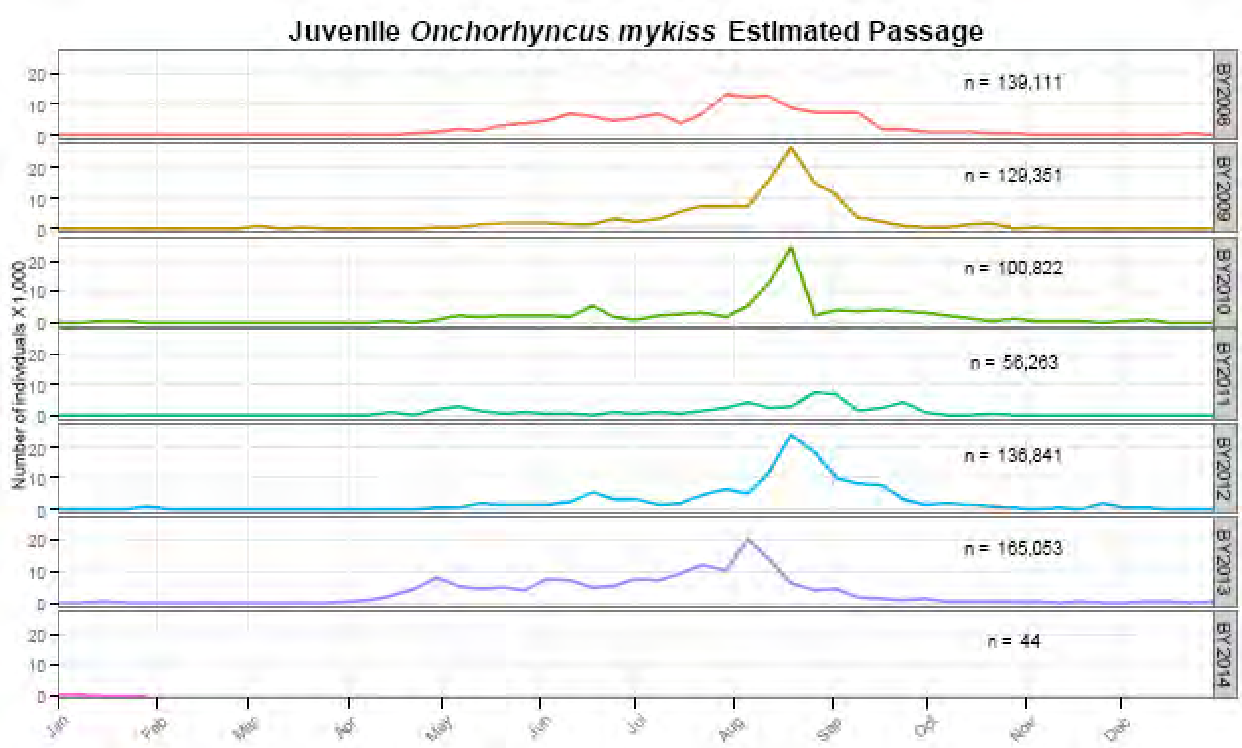


Figure 6. Weekly Estimated Passage of *O. mykiss* at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY).[7]

Green sturgeon

Information on green sturgeon is extremely limited and the recovery is limited due to their low vulnerability to monitoring techniques. Adult green sturgeon will immigrate into the upper Sacramento River through the Delta between March and June. Spawning in the upper Sacramento River was documented during 2013. Juveniles were observed at RBDD and more juveniles (n=443) were enumerated than the long-term average of 426 fishes (Figure 7). At GCID, 2 green sturgeon were observed during June 2013. Green sturgeon observations are extremely rare in the Delta and none have been observed in lower Sacramento and Delta fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps in recent years. In 2011, over a thousand juvenile green sturgeons were enumerated at RBDD and none were observed in river, Delta, or Bay fish monitoring. While this absence in the monitoring may suggest no impact due to Delta Cross Channel operations or outflow operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year old due to habitat, predation, or multiple stressors;

---

[7] Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (January 29, 2014).

which is a phenomenon that has been observed in other North American sturgeon species. Greater monitoring needs to be conducted in order to reduce this uncertainty.

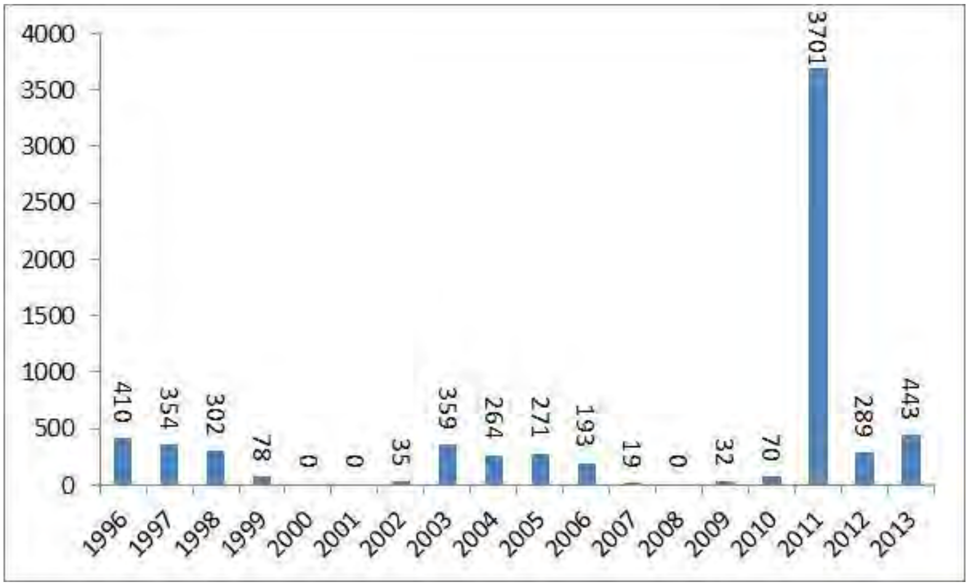


Figure 7. Juvenile Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps.[8]

Analytical Framework

Methods and Metrics

To evaluate impacts to listed species due to Delta hydrodynamics caused by the petition's reduced outflow range, DSM2 output from between 1991 and 2011 for Freeport flows were examined for those that fell into relevant ranges (Figure 8) i.e. 4,000-5,000cfs and 7,000-8,000cfs). There were no Freeport flows for less than 4,000cfs, restricting our analysis from this portion of the petition's range. It is likely the patterns observed in the results are further amplified upstream as outflow is reduced. Hydrodynamics metrics such as daily proportion positive velocity and daily mean velocity were used to assess changes in the Delta caused by outflow reduction.

To evaluate impacts to listed species dues to tributary outflow changes, DCC gate opening, and Delta hydrodynamics caused by the petition's reduced outflow range, relevant peer-reviewed literature on these topics impact to fish biology, behavior, and survival were

[8] The dataset annual average is 426 fish. In 2011, an egg was observed directly above the rotary traps, thus the large number of fish in 2011 is a unique annual sampling of a spawning event (Josh Gruber, USFWS, pers comm.) If this data is removed the annual average of fish counted in 183 fishes.

reported. Results from these sources were used to evaluate modified operation of the DCC gates on reach-specific and through Delta survival. The NMFS BiOp (2009) was reviewed regarding biological rationale for outflow reduction under exceedance forecasts and DCC gate operations. Review of the development of relevant biological and physical triggers regarding historic DCC gate operations was compared to the current status of the species.

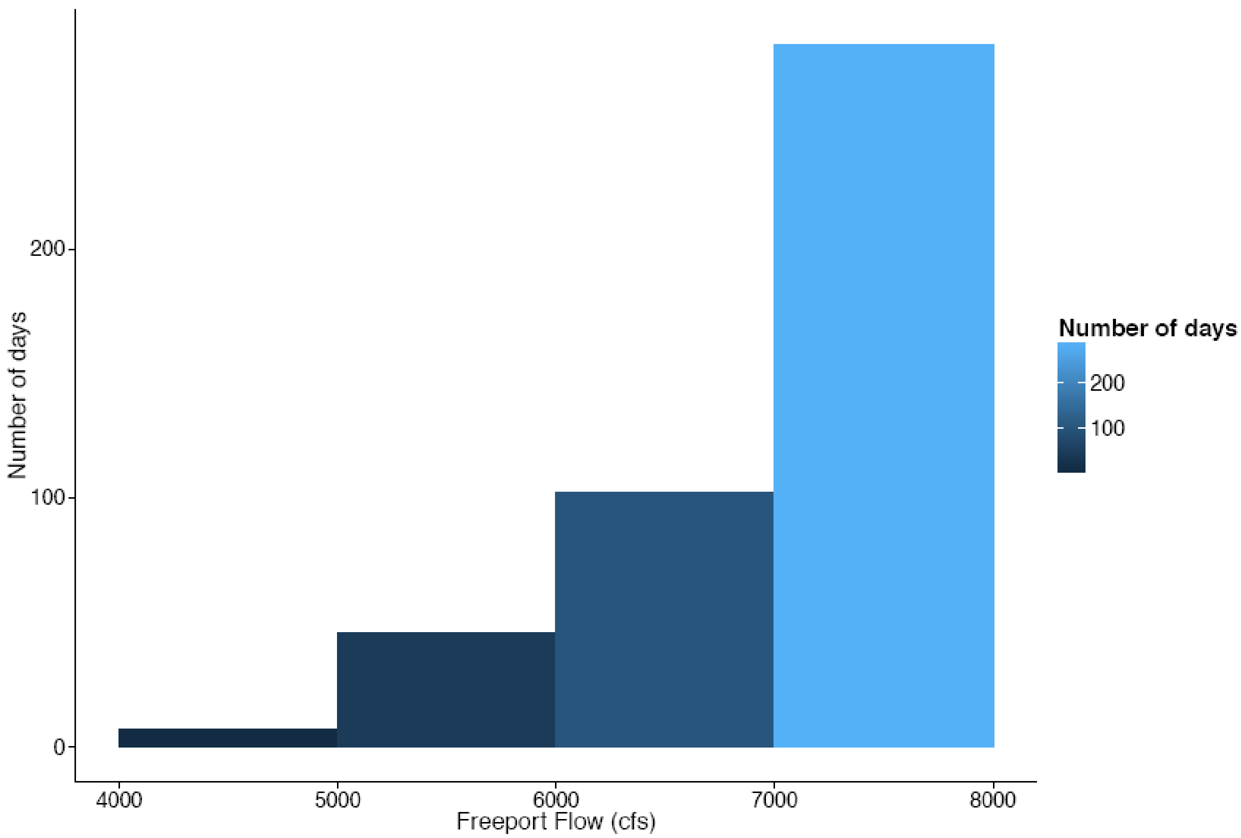


Figure 8. Histogram of the Number of Days When Freeport Flow Falls Into the Ranges Used in the Maps (for Water Years 1991-2011).[9]

[9] Figure provided by CFS, January 30, 2014.

Effects Analysis

Tributary Effects

Current storage conditions in CVP/SWP reservoirs are extremely low. CVP/SWP operators and fishery agencies are attempting to conserve cold water in these reservoirs for listed species' summertime temperature and habitat requirements. The 50% exceedance forecast issued in January 2014 (Table 3) demonstrates End-of-September (EOS) storage at all of the CVP/SWP reservoirs are projected to be at very low volumes throughout spring and summer operations for WY 2014. The 90% exceedance forecast issued for January 2014 projects EOS storage in Shasta Reservoir to be below 500TAF, which indicates a significant likelihood that reservoir releases will be unable to control water temperature downstream of Keswick Reservoir. This could lead to extremely high egg mortality or even complete brood year 2014 failure for Winter-run and spring-run Chinook (Table 4). While February exceedance forecasts are not yet available, they are predicted to be worse than the January forecasts described above due to January's continued dry metrological and hydrological conditions. Starting in February, D-1641 outflow standards require a minimum 3-day running average of daily Delta outflow of 7,100 cfs, which will require additional releases from CVP/SWP reservoirs that are inconsistent with the current implementation of NMFS BiOp Action 1.2.2.C and jeopardize implementation of NMFS BiOp Action 1.2.3.C beyond February. During the last week of January 2014, CVP operators have increased releases from Keswick Dam from the minimum 3,250 cfs to 3,750 cfs to reduced further degradation of D-1641 agricultural and municipal Delta water quality standards. These releases are not compliant with the precautionary management of the cold water pool identified in BiOp RPA 1.2.2.C, which require maintaining a release of 3,250 cfs from Shasta Reservoir to conserve storage. Thus, without a modification to the D-1641 Habitat Protection outflow standard of 7,100 cfs, Reclamation and DWR would be forced to increase releases from upstream reservoirs in February to meet Delta outflow and reduce precautionary reservoir storage conservation management necessary for minimizing extended drought impacts on brood year 2014 Winter-run Chinook salmon and spring-run Chinook salmon. The additional storage conservation measures taken during February by the petition's requested outflow range would likely preserve additional cold water pool for brood year 2014 Winter-run and spring-run Chinook salmon needs later in the year and improve the CVP storage system's ability to recover during the remainder of the winter and spring of WY2014.

Table 3. 50% Exceedance Forecast

50% Forecast

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity		1127	1172	1172	1256	1221	1168	1075	976	866	782	725	725	737
	Elev		2274	2274	[illegible]	[illegible]	[illegible]	2264	2252	2239	2224	2221	2221	2225
Whiskeytown		238	238	238	238	238	238	238	238	238	238	208	206	206
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shasta		1873	1884	2163	2608	[illegible]	2616	[illegible]	1988	1618	1426	1464	1441	1521
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Folsom		357	371	480	660	656	666	336	336	310	[illegible]	284	310	336
	Elev		[illegible]	407	427	[illegible]	[illegible]	401	[illegible]	[illegible]	[illegible]	[illegible]	399	[illegible]
New Melones		1019	1057	1061	1061	1068	987	914	784	767	706	468	393	329
	Elev		[illegible]	851	851	811	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Luis		339	532	568	580	572	366	240	160	224	182	455	370	440
	Elev		[illegible]	[illegible]	457	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111	[illegible]	[illegible]
Total			4012	[illegible]	[illegible]	[illegible]	[illegible]	5001	4291	[illegible]	[illegible]	3514	[illegible]	[illegible]

State End of the Month Reservoir Storage (TAF)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oroville		1258	1422	1667	1856	2004	1516	1126	1684	1438	1404	1322	1282	1364
	Elev		722	745	[illegible]	[illegible]	[illegible]	[illegible]	734	723	[illegible]	[illegible]	704	[illegible]
San Luis		774	825	825	840	666	612	326	156	127	98	7	36	156
Total San Luis (TAF)		613	[illegible]	611	1024	[illegible]	[illegible]	[illegible]	406	[illegible]	[illegible]	[illegible]	562	1030

Monthly River Releases (TAF/cfs)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity	TAF	11	11	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cfs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	300	300
Clear Creek	TAF	17	11	12	12	12	12	5	5	9	12	7	7
	cfs	300	200	200	200	200	200	85	85	150	200	200	200
Sacramento	TAF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	629	[illegible]	357	[illegible]	[illegible]	[illegible]
	cfs	[illegible]	[illegible]	[illegible]	[illegible]	4000	5000	10231	[illegible]	6000	4516	3700	3250
American	TAF	41	17	50	122	177	248	91	92	90	77	7	77
	cfs	683	882	866	2055	2887	4182	1478	1600	1604	1250	1280	250
Stanislaus	TAF	14	25	35	45	35	37	22	23	14	33	13	12
	cfs	223	457	623	757	616	660	364	368	240	536	212	200
Feather	TAF	55	53	[illegible]	74	[illegible]	134	132	117	74	100	104	77
	cfs	893	855	1250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1250	[illegible]	[illegible]

Trinity Diversions (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carr PP	11	37	65	112	36	56	65	26	29	7	7	7
Spring Crk. PP	25	50	50	50	30	50	60	60	30	25	10	10

Delta Summary (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tracy	17	127	45	45	[illegible]	45	65	50	202	202	[illegible]	202
USBR Banks	[illegible]	7	7	[illegible]	18	7	11	[illegible]	11	[illegible]	1	0
Contra Costa	11	14	17.7	9.2	12.7	5.7	[illegible]	12.7	14	[illegible]	[illegible]	[illegible]
Total USBR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
State Export	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Export	124	225	[illegible]	[illegible]	[illegible]	100	[illegible]	249	[illegible]	[illegible]	[illegible]	600
COA Balance	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Old/Middle R. std.												
Old/Middle R. calc.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Computed DOI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Excess Outflow	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Export/Inflow	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Export/Inflow std.	65%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25%	55%

Hydrology

	[illegible]	[illegible]	[illegible]	[illegible]
Water Year Inflow (TAF)	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] [illegible]

Table 4. 90% Exceedance Forecast.

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity		1157	1165	1151	1150	1135	1098	842	687	562	408	255	243	304
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Whiskeytown		207	207	206	206	210	211	210	210	210	206	206	206	206
	Elev		1155	1155	1155	1209	1209	1209	1209	1209	1199	1199	1199	1199
Shasta		1523	1707	1767	1821	1839	1661	1198	690	[illegible]	85	#N/A	#N/A	#N/A
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	#N/A	#N/A	#N/A	#N/A
Folsom		187	170	187	244	267	277	242	189	151	151	155	246	290
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New Melones		1045	1035	1025	1003	837	855	738	697	580	766	453	765	480
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Luis		326	357	384	398	375	338	228	155	94	152	240	371	415
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	#N/A	#N/A	#N/A

State End of the Month Reservoir Storage (TAF)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oroville		1205	1254	1333	1413	1363	1247	1022	845	723	692	704	645	650
	Elev		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Luis		274	342	415	411	368	273	209	171	[illegible]	90	189	316	340
Total San Luis (TAF)		602	708	799	813	743	611	421	329	[illegible]	250	[illegible]	687	[illegible]

Monthly River Releases (TAF/cfs)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity	TAF	18	17	18	35	32	47	28	28	27	23	18	18
	cfs	300	300	300	588	1,465	787	457	450	450	373	300	300
Clear Creek	TAF	12	11	12	12	7	5	7	7	9	12	12	12
	cfs	200	200	200	200	200	150	120	93	150	200	200	200
Sacramento	TAF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cfs	3250	3250	4250	6000	7,000	10000	10900	7895	5500	4000	3072	3750
American	TAF	31	28	33	48	41	41	73	31	30	31	30	31
	cfs	500	500	534	807	661	691	1185	500	500	500	500	500
Stanislaus	TAF	13	12	18	27	25	22	25	22	17	25	12	12
	cfs	200	215	295	450	410	365	396	352	280	389	200	200
Feather	TAF	61	53	50	119	50	20	144	77	74	77	74	77
	cfs	1000	950	850	2000	800	1450	2350	1250	1250	1250	1250	1250

Trinity Diversions (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carr PP	1	5	1	21	24	222	126	124	126	40	15	11
Spring Crk. PP	1	5	8	18	21	140	120	120	120	29	10	11

Delta Summary (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tracy	[illegible]	[illegible]	1	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
USBR Banks	[illegible]	0	[illegible]	3	[illegible]	0	0	[illegible]	10	3	10	[illegible]
Contra Costa	[illegible]	[illegible]	7	6.4	6.4	6.4	4.9	5.6	[illegible]	7	[illegible]	[illegible]
Total USBR	[illegible]	63	13	[illegible]	[illegible]	[illegible]	[illegible]	68	[illegible]	[illegible]	[illegible]	79
State Export	[illegible]	[illegible]	[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Export	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COA Balance	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Old/Middle River Std.												
Old/Middle R. calc.	[illegible]	-2,183	[illegible]	-573	[illegible]	[illegible]	-1,250	-1,712	[illegible]	[illegible]	[illegible]	[illegible]
Computed DOI	5562	7036	7103	7246	4032	4001	4002	3026	3043	3372	3033	7483
Excess Outflow	4052	0	[illegible]	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Export/Inflow	[illegible]	[illegible]	[illegible]	11%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Export/Inflow [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Hydrology

	Contingency	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	155	2,[illegible]	623	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

While Keswick releases have increased in the past week to minimize further risks to exceeding D-1641 Delta water quality standards, these increases are not at the magnitude necessary to meet the February 7,100 cfs habitat protection outflow standard. Additional increases in reservoir releases will be necessary in February to meet the D-1641 outflow and water quality standards. Any fluctuations in releases from reservoirs to meet the D-1641 unmodified outflow standard may cause reservoir release operations that may increase stranding risk to brood year 2013 juvenile Winter-run and spring-run Chinook salmon and steelhead due to unstable in-river water levels below the reservoirs. However, by increasing the stability in releases from Keswick reservoir at the lower levels, it is hypothesized that Chinook and steelhead smolt downstream emigration time will increase, resulting in reduced outmigration survival (Singer et al 2013) and reduced smoltification window (McCormick et al 1998). The quantity of storage that can be gained by operating to the petition's outflow range may be at least 144 TAF in February, which will be critical to Keswick and Nimbus operations necessary for the biological needs of winter-run Chinook, spring-run Chinook, steelhead, and green sturgeon downstream of these reservoirs during summer and fall of WY 2014.

Additionally, the reduction in reservoir storage without the petition's action will decrease the volume of water available for brood year 2014 Winter-run and spring-run Chinook later on in the year and has the potential to affect critical habitat for these species by diminishing spawning habitat area in the rivers below the reservoirs, negatively impacting food resources, and altering other principal constituent elements defined in the critical habitat designations for these species. Reductions in flow are anticipated to reduce the wetted area of the river channel below the reservoirs, which reduces the areas within the channel that can provide suitable areas for spawning, increasing the likelihood of redd superimposition, reduces habitat for the production of the invertebrate forage base needed for rearing juveniles, and altering physical and chemical attributes in the river such as dissolved oxygen and increased thermal loading due to lower flows and shallower water depth that can heat up more quickly due to ambient air temperature and solar irradiation. Thus, the petition's action regarding a reduced outflow range in February is a proactive approach by Reclamation and DWR to immediately implement appropriate contingency measures that may benefit brood year 2014 cold water listed species, as required in NMFS BiOp RPA I.2.3.C.

Storage at Folsom reservoirs are currently so low that Reclamation and DWR cannot call on them for releases to comply with the current D-1641 water quality standards and in-basin water user's needs. Reclamation is required to meet temperature criteria suitable for oversummer rearing of juvenile steelhead in the lower American River through NMFS BiOp RPA II.2. While the modeling required for this work is typically based initially on April's CVP/SWP forecast, current modeling suggests conditions to meet temperature criteria throughout the spring and summer are not achievable. Folsom reservoir storage is not an option for greater releases to meet D-1641's unmodified February outflow requirements, and thus the petition's reduction in outflow provides the only opportunities to benefit WY2014 storage in both Folsom and Shasta reservoirs.

Adult Green sturgeon are absent from the Sacramento and Feather rivers in February during the petition's action. Adult spawners are expected to start migrating upriver in March prior to spawning in the upper river. Impacts to juvenile and subadult life stages of green sturgeon are anticipated to minimal. It is expected that brood year 2013 juvenile green sturgeon are still upstream of the Delta, overwintering prior to entering the Delta. Age 1 to 3 green sturgeon are expected to be rearing in the delta, and are typically exposed to a broad spectrum of flows over the course of the year during this rearing phase and freely move throughout the Delta to find suitable conditions for their needs.

Delta Habitat Effects Regarding Salmonids and Green Sturgeon

Outflow Action

Although the NMFS BiOp (2009) does not contain outflow standards, the reduction in outflow as identified in the petition may impact juvenile salmonids migrating through the North Delta between Sacramento and Rio Vista, where Sacramento River flows meet the tidally dominated western Delta. The outflow range described in this petition, necessary to maintain currently degraded water quality conditions, are lower than those afforded under minimum standards to meet the D-1641 X2 standard in February. This reduction in Delta inflow from 7100 cfs to a range of between 3000and 4500 cfs may reduce survival of juvenile salmonids migrating through the North Delta through increased predation mediated by hydrodynamic mechanisms. Once immigrating fish reach the tidally dominated western Delta (i.e. Rio Vista towards Chipps Island) or San Joaquin River under the petition's outflow range (3000 to 4500 cfs), they are likely to encounter daily proportion of positive velocities and mean velocity that are similar to outflow conditions observed when the 7100 cfs standard is being achieved (Figure 9- 10).

In the North Delta, a decrease in outflow will impact the Delta hydrodynamics in two ways, which influence salmonid migration speed and patterns. These hydrodynamic processes influence survival due to changing juvenile salmonids exposure to predators through the North Delta and other relevant reaches (i.e. Georgiana Slough, Delta Cross Channel). First, reduced outflow may increase tidal excursion (reduced daily proportion of positive velocities) into the North Delta region, which may increase the duration of reverse flows into Georgiana Slough and/or an open Delta Cross Channel. These increased tidal excursions are likely to increase entrainment into Georgiana Slough and, if open, the Delta Cross Channel. Survival in the mainstem or one of the multiple distributary channels is lower due to the longer duration of the downstream emigration phase resulting from reduced flows as compared to periods of greater. Also, the increased tidal excursion may increase entrainment into Sutter and Steamboat sloughs by creating greater probability of flow convergence at these junctions. However, due to the lower flows, the time needed to migrate downstream through these two migratory corridors is also expected to increase, resulting in diminished survival compared to higher flows.

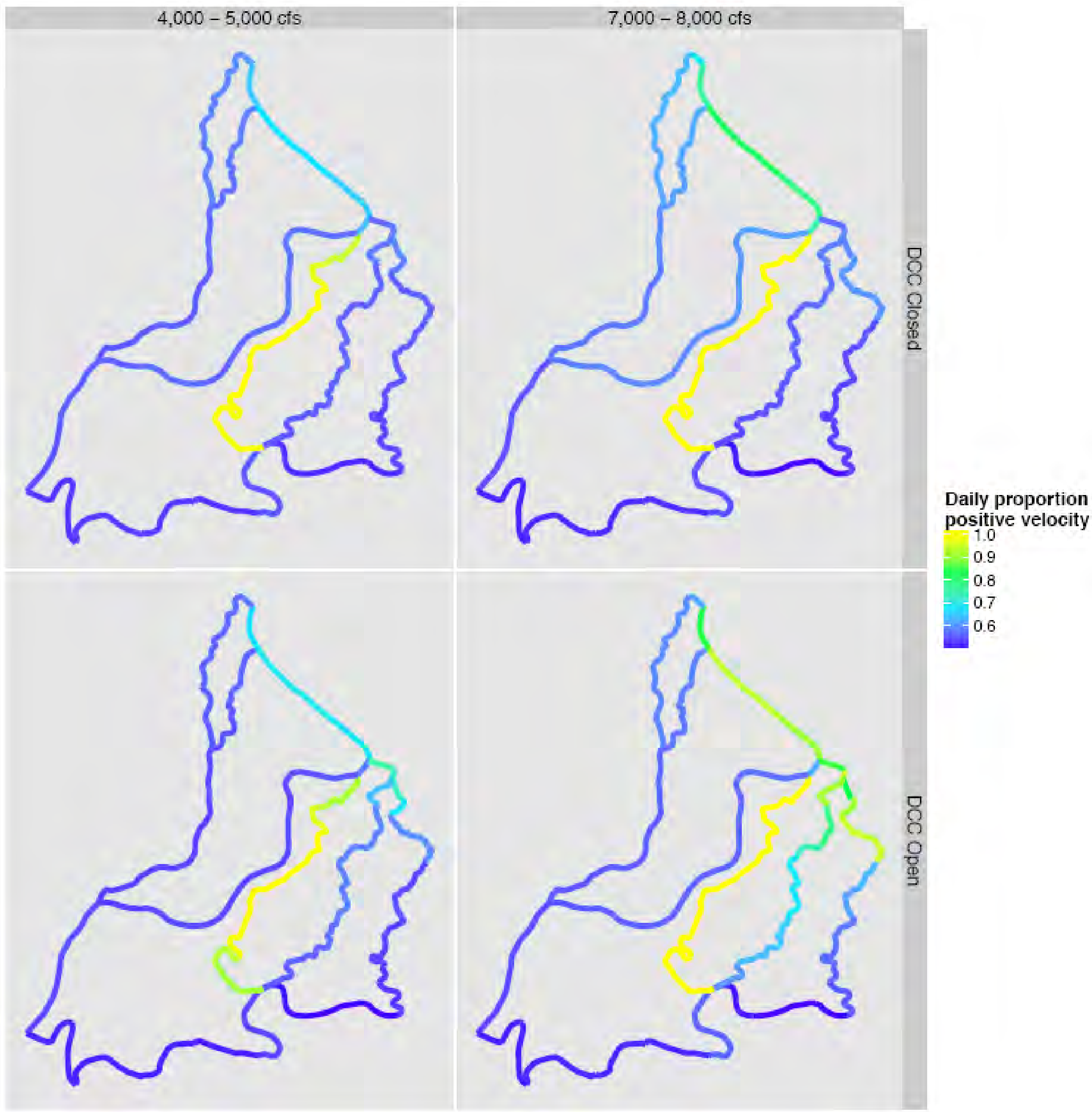


Figure 9. Maps of the Delta Region Near the DCC with the Channels Color-Coded for Daily Proportion Positive Velocity.[10]

[10] Figure provided by CFS, January 30, 2014.

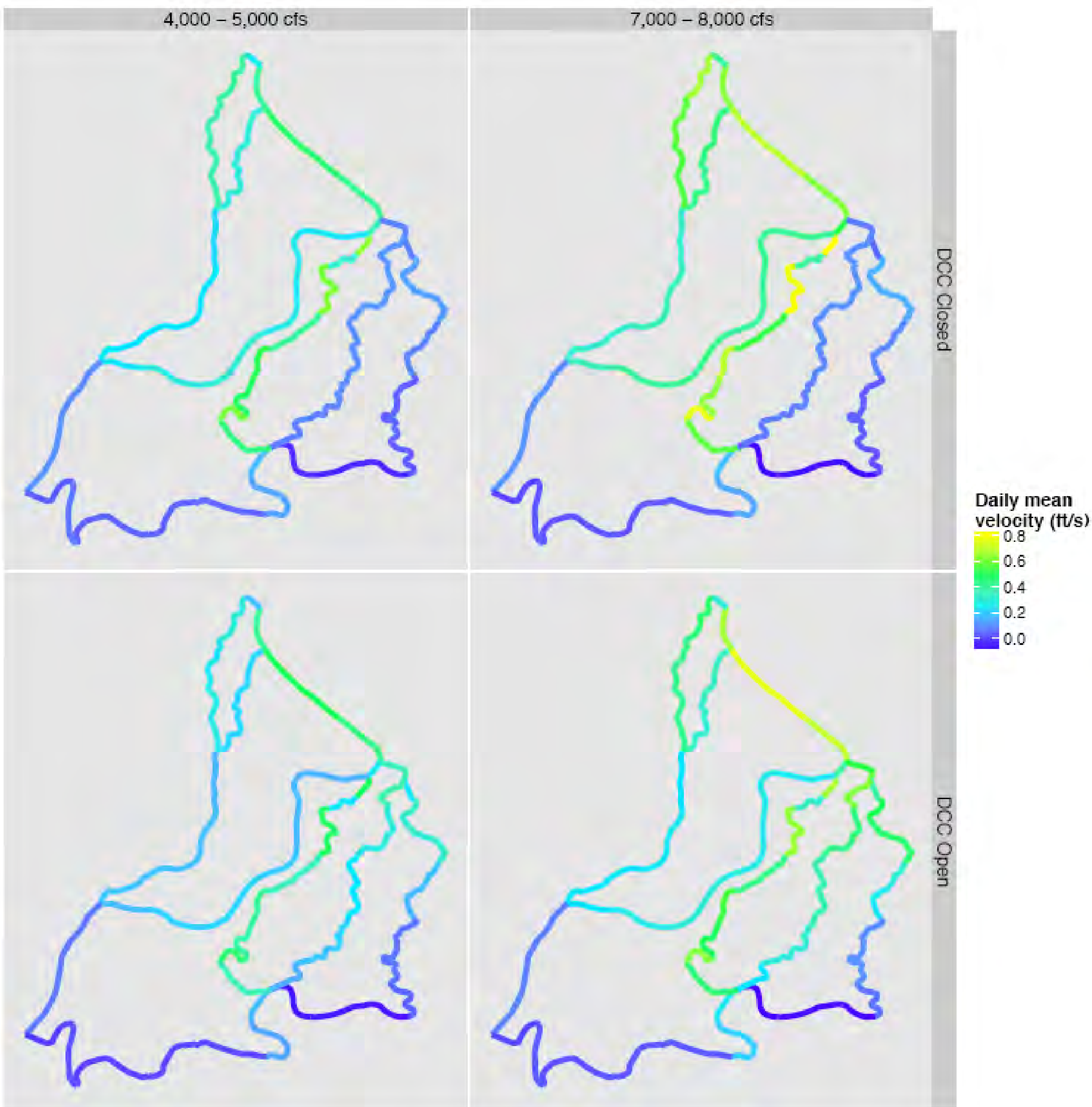


Figure 10. Maps of the Delta Region Near the DCC with the Channels Color-Coded for Daily Mean Velocity.[11]

[11] Figure provided by CFS, January 30, 2014.

Second, reduced outflow causes the daily mean channel velocity along the Sacramento River, and Sutter and Steamboat sloughs be less positive (Figure 10). When the DCC gates are open, the daily mean channel velocity becomes even less positive in these reaches (Figure 10) . Reducing outflow also causes a decrease in the daily proportion of positive velocities through the Sacramento River downstream of Sutter and Steamboat sloughs confluence with the Sacramento River (Figure 9). Also, Georgiana Slough flows become less positive as tidal excursion causes reversal in this channel when outflow is reduced. When the DCC gates are open, the daily proportion of positive velocities further decreases in the Sacramento River upstream of the DCC gates and more noticeably between the DCC gate and Georgiana slough. When the DCC is open, there is a reduction in the daily proportion of positive flows through Georgiana Slough.

Decreased daily proportion of positive velocities and daily mean channel velocities, due to the petition's reduced outflow range, will increase migrating salmonids' residence time in the North Delta, which likely exposes them to greater predation and increases mortality. There are no models to quantify the increase in mortality due to reduced flows in this reach, however comparisons may be made. The Delta Cross Channel's capacity is 3500cfs, which is in range of the petition's change to the outflow standard. Two telemetry studies reported on changes in reach-specific survival when the DCC was open and closed, which provide a comparison for survival through the North Delta reach and downstream when this quantity of daily flow is removed from the channel. The average difference in survival values for salmonid through the North Delta from Sutter and Steamboat Slough to Rio Vista when the DCC was open (n=7, survival ranged from 0.012-0.306) versus closed (n=3, survival ranged from 0.099-0.233) was 3.4% (Table 3, Romine et al 2013). Perry et al. (2010) had a single measurement of survival in this reach when the DCC gates were open vs. closed and the difference was 12.1%. Reach-specific survival showed large variation within and between studies, and factors other than travel time and flow are suggested to have contributed to variation in survival estimates including environmental conditions and temporal shifts in predators (Perry et al 2010) and tag failure (Romine et al. 2013). Regarding steelhead, a previous study (Singer et al 2013) did not demonstrate interior routes to have the lowest survival. In that study, steelhead smolt survival was estimated to be higher through the eastern Delta route (i.e. Georgiana, Mokelumne, and San Joaquin River routes) than the western Delta route (Sutter and Steamboat Sloughs) in one of two years studied, although survival was highest along the Sacramento mainstem route in both years.

BY14 adult Winter-run Chinook salmon may be affected by the petition's reduction in outflow, due to a reduction in a detectable flow signal for upriver migration. While green sturgeon may be present in February in the Delta, they do not migrate though the North Delta until March. Juveniles and sub-adults rearing and utilizing the Delta are not expected to be affected by the change in inflows to the Delta. Over the course of their rearing in the Delta (1 to 3 years for juveniles), the fish are exposed to a wide variety of flows depending on where they happen to be at a particular moment. In most of the Delta where green sturgeon are expected to be rearing, flows are tidally dominated.

Minimum Pumping Level Action

Action IV.2.3 in the 2009 NMFS BiOp uses fish loss density, daily loss, and surrogate Coleman National Fish Hatchery (CNFH) releases of Winter-run and late fall Chinook salmon as triggers to reduce the vulnerability of emigrating ESA-listed salmon, steelhead, and green sturgeon to entrainment into South Delta channels and at the pumps between January 1 and June 15. A calendar-based requirement for the 14-day OMR average flow to be no more negative than -5,000cfs started January 1, although it has not yet controlled export operations. Depending on what level of fish trigger is exceeded, combined exports are managed to a level so that the 5-day net average OMR flow in not more negative than -3,500 or -2,500cfs OMR until fish densities return below levels of concern.

Earlier in January 2014, operational considerations for D-1641 outflow standards controlled exports to 1,500 cfs combined exports at the state and federal export facilities, and in the past weeks operational consideration for D-1641 Municipal and Industrial water quality standards in the South Delta surpassed outflow considerations, and these considerations have controlled exports to combined exports of 1500cfs pumping. . Although some flow gauges remain inoperable along Old and Middle River, average daily flows in Old and Middle River have averaged approximately -1800cfs in December 2013, and are averaging approximately -1400 in January 2014 (Figure 11). Currently, combined export levels are less than 1,500 cfs, and are required due to the lack of Delta inflow and consideration for South Delta water quality. Current export levels, and those described in the petition for February, maintain Old and Middle River conditions less negative than the most protective Action Response in NMFS BiOp Action IV.2.3 and provide south Delta hydrodynamic conditions more conducive to salmonids successfully exiting the Delta at Chipps Island (relative to a condition with more negative OMR conditions).

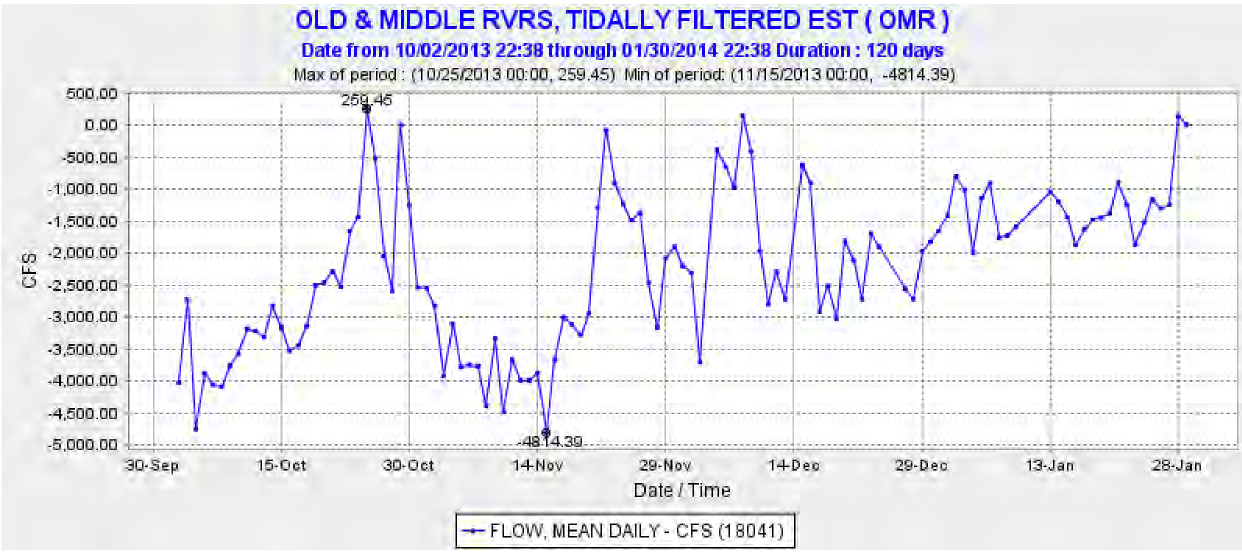


Figure 11. Old and Middle River tidally-filtered daily flows for WY 2014.[12]

DCC Gate Open Action

The NMFS BiOp (2009) and D-1641include a calendar-based closure of the DCC Gates between February 1 and May 20 to protect Winter-run, spring-run, and fall run Chinook salmon and steelhead from entrainment into the Interior Delta. Analysis of historic recovery data from Knights Landing show in Critical and Dry years, on average 72% and 92% of Winter-run Chinook salmon enter the Lower Sacramento River by the end of January or February, respectively. Analysis of historic recovery data from Knights Landing show in Critical and Dry years, on average 14% and 29% of spring-run Chinook salmon enter the Lower Sacramento River by the end of January or February, respectively. Calendar-based closures of the DCC are based on historical patterns of outmigrating fish; with some exceptions allowed prior to January 31. Studies have shown that the mortality rate of the fish entrained into the DCC and subsequently into the Mokelumne river system is higher than for fish that remain in the mainstem corridor(Perry and Skalski 2008; Vogel 2004, 2008). Closure of the DCC gates during periods of salmon emigration eliminates the potential for entrainment into the DCC and the Mokelumne River system with its high mortality rates. In addition, closure of the gates appears to redirect the migratory paths of emigrating fish into channels with relatively less mortality (*e.g.,* Sutter and Steamboat Sloughs), due to a redistribution of river flows among the channels. The overall effect is an increase in the apparent survival rate of these salmon populations as they move through the Delta.

[12] Downloaded from CDEC on January 30, 2014.

As described in the petition's Attachment B, fish monitoring observations made through January 27, 2014 suggest that pulses of listed salmonids have passed middle Sacramento River monitoring sites at Glen-Colusa Irrigation District, and continue to rear and slowly migrate downstream, but these pulses have not passed Knights Landing into the Lower Sacramento River. The second component of the second alert of NMFS BiOp RPA IV.1.1 and the Chinook Salmon Decision Tree exceeding 7,500 cfs at Wilkins Slough (adjacent to Knights Landing) has not been exceeded. While the absence of detecting fish in the Knights Landing and Tisdale rotary screw traps should not lead to the assumption that listed fish have not passed this location, recent synthesis of these data suggest that catch spikes of as little as 5% cumulative catch are observable and are nearly coincident with rapid increases in flow greater than 14,125 cfs (Rosario et al. 2013). Substantial catches of larger-size juvenile Winter-run Chinook continue daily at RBDD rotary screw traps, the majority of an estimated JPE has not been observed to have not past RBDD rotary screw trap, and the catch index at Knights Landing has not exceeded 1 fish/day. These lines of evidence support the Winter-run Chinook population remaining above the lower Sacramento River, which keeps risks from opening the DCC under current fish distribution conditions very low.

When emigrating salmonids are in proximity of the DCC gates they are vulnerable to entrainment through the DCC when the gates are open. A series of studies conducted by Reclamation and USGS (Horn and Blake 2004) used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the river during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night (~70%) to entrainment into the DCC than during the day (~30%; Jon Burau, pers. comm.).

The petition's action to open the DCC gates will increase mortality through the North Delta and Interior Delta. Perry et al (2010) includes two releases of acoustically tagged late fall Chinook salmon to evaluate the impact of DCC gate opening of reach specific and total Delta survival. Mainstem survival downstream of the DCC gate was lower when they were open (0.443) than when the closed (0.564). During 2008-2009, ten releases of juvenile late fall run Chinook salmon were made by USGS (Romine et al. 2013, Table 5) and through Delta survival was greater when the DCC gates were closed (0.170) than when they were open (0.123). These values are negatively biased due to tag failure (Romine et al. 2013). Perry et al. (2010) observed through Delta survival to be greater with the DCC closed (0.543) than open (0.351), principally due to increased survival through the Sutter and Steamboat Sloughs route from 0.263 to 0.561. The petition's opening of the DCC may increase straying of returning Winter-run Chinook adult salmon on the mainstem by diverting Sacramento River flows through the forks of the Mokelumne River and Central Delta.

Table 5. Average Values for Releases Described in Romine et al (2013).
Seven releases occurred with DCC open and three releases occurred with it closed.

DCC Position	S_A	S_B	S_C	S_D	Ψ_A	Ψ_B	Ψ_C	Ψ_D	S_{TOTAL}
Open	0.143	0.1	0.098	0.159	0.486	0.267	0.064	0.182	0.123
Closed	0.177	0.205	-	0.102	0.521	0.276	-	0.202	0.17

The petitions' action to open the DCC gates without physical or biological triggers will increase mortality of juvenile outmigrating and rearing winter run and spring run Chinook salmon. Juvenile steelhead smolts through Delta survival is likely to be modified due to reduced survival through the interior Delta when the DCC gates are open. Juvenile green sturgeon through Delta survival is likely to be modified due to the DCC gates being opened, but to a lesser extent. Due to the petition's change in DCC gate operation, green sturgeon are not affected. While green sturgeon may be present, they do not migrate through the North Delta until March. No studies have been conducted with acoustically tagged green sturgeon to examine survival effect on green sturgeon, but it is hypothesized that green sturgeon survival may be impacted to a lesser extent than salmonids.

DCC Gate Modified Operation Action

During the fall and early winter when listed salmonids are typically not present in the Lower Sacramento River and Delta, action triggers in the Chinook salmon Decision Tree use fish monitoring catch indices from Knights Landing and Sacramento River to detect substantial Winter-run Chinook migration into the lower Sacramento River. Catch index exceedance values were based on analyses of historic screw trap, beach seine, and trawl data (Chappell 2004). Historic analyses (Chappell 2004) modified the "critical trigger" and duration of Delta Cross Channel (DCC) closure in the Chinook Salmon Decision Tree. Multiple exceedance levels were identified to modify DCC operations in a manner that reduces risks due to the elevated presence of spring-run and Winter-run Chinook salmon upstream of the Delta. Neither the Knights Landing Catch Index not Sacramento River Catch Index have exceeded any action trigger threshold in WY 2014, so no DCC gate closure were required by the NMFS BiOp until December 1, the first calendar based date for DCC closure. The DCC gates were occasionally closed in October and November 2013 to assist in meeting the Rio Vista flow criterion in D-1641.

Analysis, based on Romine et al (2013), suggest a decrease in survival from operating the DCC gates with different rates of exposure to entrainment into the DCC and Georgiana Slough, due to reductions in reach-specific and total Delta survival (Table 6). Analysis, based on Perry (2010), suggests a relative decrease in survival of 10-16% assuming a 20-40%

exposure to an open DCC in the reach downstream of the DCC gates. Using the average daily Sacramento flow as measured at Freeport for the period of January 11 to January 27 of 2014 (which is the approximate period of time that Sacramento River has been at base flows to date), the estimated percent diversions (or entrainment risk) through the DCC gates, and Perry's flow-survival equation, the estimated relative reduction in the probability of survival in the mainstem Sacramento River downstream of an open DCC would be approximately 10-16% for a 25-40% flow diversion, respectively. This decrease in survival is cumulative in effect to existing exposure to Georgiana Slough and also does not account for additional impacts that are expected to occur from reductions in flow through Steamboat and Sutter sloughs.

Table 6. Reach-Specific and Total Delta Survival Estimates for Different Exposure Rates of Fish to Entrainment Into the DCC. Values Placed on Average Estimates in Table 1.

	Proportion of fish exposed through entrainment to DCC/GS					
	Closed	0.1	0.25	0.5	0.75	Open
S_A	0.177	0.1736	0.1685	0.16	0.1515	0.143
S_B	0.205	0.1945	0.1788	0.1525	0.1263	0.1
S_C	NA	0.0098	0.0245	0.0475	0.0735	0.098
S_D	0.102	0.1077	0.1163	0.1305	0.148	0.159
S_{TOTAL}	0.17	0.1712	0.1598	0.1504	0.1409	0.123

Cumulative Effects of Action

The Petition's action to: 1) Reduce the Delta outflow standard for February from 7100 to a lower outflow range and operate in a combined export rate of 1,500cfs , and 2) Modify operations of the DCC gates as water quality and fisheries conditions warrant, affect juvenile and adult life stages of Winter-run and spring-run Chinook, juvenile steelhead, and juvenile green sturgeon.

The petition's outflow action may reduce survival of juvenile listed salmonids, steelhead and green sturgeon, and may modify their designated critical habitat. The modification of juvenile Winter-run and spring-run Chinook salmon and steelhead survival due to changes in outflow would occur primarily through migratory corridors in the North Delta. The petition's action to reduce Delta outflow keeps the CVP/SWP operation proactively compliant with implementation of NMFS RPA I.2.2C and I.2.3C. The petition's outflow action avoids reservoir release operations which increase endangerment to brood year 2014 Winter-run and spring-run Chinook salmon due to potential loss of manager's ability to control temperature that could cause catastrophic mortality to incubating eggs and holding adults during summer 2014. The petition's combined export rate of 1,500 cfs may reduce entrainment and salvage of listed species at the CVP/SWP fish collection facilities adjacent to the South Delta export facilities.

The petition's DCC gate operation may increase mortality of juvenile outmigrating and rearing Winter-run and spring-run Chinook and juvenile steelhead dependent on implementation of closure requirements warranted by water quality and fisheries conditions. The petition's DCC gate operations may also cause straying of adult listed salmonids. While specific prescriptions have yet to be developed to achieve each of the classes of listed salmonids, behavioral, operational, and hydrodynamic information is available to identify balanced actions to protect listed species and water quality.

References

Chappell, E. 2004. Are the current EWA Chinook Decision Tree numeric criteria appropriate? Presentation to the EWA Technical Review Panel Supporting Documents. Available at: http://www.science.calwater.ca.gov/events/reviews/review_ewa_archive_04.html

Del Rosario, R.B, Y.J. Redler, K. Newman, P.L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 11(1): 24p.

Horn, M.J. and A. Blake. 2004. Acoustic tracking of juvenile Chinook salmon movement in the vicinity of the Delta Cross Channel. 2001 Study results. U.S. Department of the Interior. Technical Memorandum No. 8220-04-04.

McCormick, S.D., L.P. Hansen, T.P. Quinn, and R.L. Saunders. 1998. Movement, migration and smolting of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Science 55(Suppl. 1): 77-92.

National Marine Fisheries Service. 2009. Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. Central Valley Office, Sacramento CA.

Perry, R.W. and J.R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River delta during the winter of 2006-2007. Report prepared for the U.S. Fish and Wildlife Service. September 2008. 32 p.

Perry, R.W., J. Skalski, P. Brandes, P. Sandstrom, A.P. Klimley, A. Amman, and R.B. MacFarlane. 2010. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta. North American Journal of Fisheries Management 30: 142-156.

Perry, R.W. 2010. Survival and migration dynamics of juvenile Chinook salmon (*Oncorhynchus tshawytscha)* in the Sacramento-San Joaquin river Delta. Dissertation. School of Aquatic and Fisheries Science, University of Washington, Seattle, WA p. 237.

Romine, J.G., R.W. Perry, S.J. Brewer, N.S. Adams, T.L. Liedtke, A.R. Blake, and J.R. Burau. 2013. The Regional Salmon Outmigration Study- survival and migration routing of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta during the winter of 2008-2009. U.S. Geological Survey, Open File Report 2013-1142, 36 p.

Singer, G.P, A.R Hearn, E.D Chapman, M.L. Peterson, P.E. LaCivita, W.N. Brostoff, A. Bremmer, and A.P. Klimley. 2013. Interannual variation of reach specific migratory success for

Sacramento River hatchery yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). Environmental Biology of Fishes 96: 363-379.

U.S Bureau of Reclamation. 2008. Appendix B: Chinook Salmon Decision Tree *in* Biological Assessment on the Continued Log-term Operations of the Central Valley Project and the State Water Project. Mid-Pacific Region, Sacramento CA.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the northern and central Sacramento-San Joaquin Delta, 2002-2003. Report to the National Fish and Wildlife Foundation, Southwest Region. January. 44 p.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the Northern Sacramento-San Joaquin Delta 2006-2007. Report prepared for the California Department of Water Resources, Bay/Delta Office. Natural Resource Scientists, Inc. March. 43 p.

EXHIBIT D

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, CA 95814-4700

January 31, 2014

Mr. David Murillo
Regional Director
Bureau of Reclamation
2800 Cottage
Sacramento, California 95825

Mr. Mark Cowin
Director
California Department of Water Resources
1416 Ninth Street
Sacramento, California 95814

Dear Mr. Murillo and Mr. Cowin:

Re: Contingency Plan for February Pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3.C of the 2009 Coordinated Long-term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Biological Opinion (2009 BiOp)

This letter is in response to your January 31, 2014, letter, submitting the Temporary Urgent Change Petition (the TUC Petition) as a contingency plan and outlining your and California Department of Water Resources' (DWR) requested approval from the State Water Resources Control Board (SWRCB) for temporary modification to the Water Rights Decision 1641 (D-1641) permit terms related to the Delta outflow and Delta Cross Channel (DCC) standards described in D-1641, Table 3, for the month of February 2014. The U.S. Bureau of Reclamation (Reclamation) requested NOAA's National Marine Fisheries Service's (NMFS) concurrence that these actions are consistent with the current Endangered Species Act section 7 biological opinion on the long-term operation of the Central Valley Project (CVP) and State Water Project (SWP, CVP/SWP Opinion) that NMFS issued on June 9, 2009.

We understand that California is experiencing unprecedented drought conditions, entering its third straight year of below-average rainfall and very low snowmelt runoff. Calendar year 2013 was the driest year in recorded history for many parts of California, resulting in the low initial storage at the beginning of water year 2014. Water year 2014 is the driest to date. On January 17, 2014, the Governor of California announced an Emergency Proclamation, finding that "conditions of extreme peril to the safety of persons and property exist in California due to water shortage and drought conditions." NMFS stands ready to provide the assistance needed to manage through drought conditions in California. We realize that it is not possible to meet all needs during this very unusual water year; and we are working with the project operators of the CVP and SWP to protect health and safety while providing needed protections for fish.

NMFS built flexible drought provisions into the current CVP/SWP Opinion. We anticipated drought conditions, when we wrote the CVP/SWP Opinion and its reasonable and prudent alternative (RPA). The RPA Action I.2.3.C (pages 26-27 of the 2009 RPA with 2011 amendments) of the CVP/SWP Opinion provides drought exception procedures and requires that the U.S. Bureau of Reclamation (Reclamation) develop and submit to NMFS a drought contingency plan. The rationale for this action explicitly recognizes that in drought conditions, there is potential for conflict between the need to maintain storage at Shasta Reservoir and other legal and ecological requirements in the Delta, including outflow and salinity standards. This RPA provision is triggered if the February forecast, based on 90 percent hydrology, shows that the Clear Creek temperature compliance point or 1.9 million acre feet end of September storage at Shasta Reservoir is not achievable.

Although the February forecast will not be available for several weeks, the 90 percent hydrology for the January forecast (enclosure 1) indicates that the end of September storage in Shasta Reservoir will be approximately 453 thousand acre feet. The weather and lack of precipitation throughout January indicates that the February forecast will be similar, if not worse, than the January forecast. We agree with your determination that it is not possible for Reclamation to meet the Shasta Reservoir storage requirement and maintain Delta outflow and water quality standards requirements pursuant to D-1641, and that Action I.2.3.C is triggered.

Action I.2.3.C requires that a contingency plan be developed, and NMFS understands that Reclamation is submitting the TUC Petition to serve as the drought contingency plan for the month of February. NMFS finds that all required aspects of the contingency plan have been met, as follows:

- Reclamation commits to target a navigation control point at Wilkins Slough not to exceed 4,000 cfs during the month of February. Since January 8, 2014, flows at Wilkins Slough have been below 4,000 cfs (http://cdec.water.ca.gov/cgi-progs/queryDaily?WLK).
- On January 29, 2014, Reclamation and DWR filed a Temporary Urgency Change Petition (TUC Petition) with the State Water Resources Control Board, indicating that there is not an adequate water supply to meet water right permit obligations under D-1641 to support instream and Delta beneficial uses.
- Exports have been curtailed to the combined minimum health and safety rate of 1,500 cfs. Recently, combined exports were reduced to 550 cfs.

In the TUC Petition, Reclamation and DWR requested that the D-1641 Delta outflow standard be changed from a 3-day average of net delta outflow of 7,100 cfs at Collinsville to allow for the necessary 1,500 cfs minimum health and safety deliveries while also allowing additional preservation of cold water pool. Reclamation and DWR indicated that this operation may result in a Delta outflow in the 3,000 cfs to 4,500 cfs range. Reclamation and DWR also requested permission to open the DCC gates for human health and safety purposes based on the consultation process with the fishery agencies provided in the TUC Petition, Attachment 1, sections II.1.c and II.1.d.

The current hydrology and habitat conditions that juvenile Sacramento River winter-run Chinook salmon (winter-run) are experiencing are anomalous, and therefore, winter-run are not following emigration patterns typically seen for this time of year. There are differences in opinion regarding the current location of the bulk of juvenile winter-run, ranging from the majority rearing in the upper Sacramento River, to slow and steady rearing and migration down the Sacramento River as they await environmental cues (pulse flows and higher turbidity) for longer and quicker migrations. Professional opinions range from approximately 5-30% of the cohort are currently in the north Delta.

An interagency team of fisheries biologists from NMFS, Reclamation, DWR, and California Department of Fish and Wildlife (DFW) developed a set of operational criteria that provides for initial DCC gate opening on February 1, 2014, and a set of monitoring triggers that result in DCC gate closures or diurnal gate openings for various durations (enclosure 2). During the development of the operational criteria, hydrological migrational cues, the team discussed the differences in migrational behavior during the day and night, and the influence of flood and ebb tides on the hydrology of the Sacramento River at the confluence of the DCC. Additional monitoring activities have been deployed to augment the current monitoring in order to facilitate the real-time monitoring needs of the modified DCC gate operations (enclosure 3).

During any period in which Reclamation and DWR are operating the CVP/SWP under a temporary change order, there will be close coordination on current and projected operations on a weekly basis through existing meetings [Delta Operations for Salmonids and Sturgeon (DOSS) group, Delta Conditions Team, Water Operations Management Team (WOMT), *etc*.]. NMFS will continue to make weekly determinations under our RPA actions (to include consideration of operations pursuant to a temporary change order) regarding whether changes in operations are necessary to protect listed fish species. These determinations will continue to be presented at the weekly WOMT call. The DOSS, along with consideration of data provided by the Delta Conditions Team, will also continue to provide weekly advice to the NMFS. As discussed below, an additional weekly drought coordination meeting will also be needed to ensure effective coordination. This meeting will help guide development of a CVP/SWP operational strategy and corresponding contingency plan to address operations through the operating season if conditions fail to improve. The result of this effort will inform any future determinations pursuant to the CVP/SWP Opinion as well as any additional TUC Petitions to the SWRCB that may be submitted.

In the TUC Petition, Reclamation and DWR have proposed to convene a team of managers from Reclamation, DWR, SWRCB, DFW, NMFS, and the U.S. Fish and Wildlife Service in order to coordinate management of water supplies and protection of natural resources during the course of the declared drought emergency. NMFS recommends that weekly drought coordination meetings address the following topics:

- Reclamation's and DWR's consideration of any new TUC Petitions during the current water year, utilizing the drought exception procedures described in the 2009 NMFS BiOp.
- To extend the current request beyond February 28, 2014, or for any future changes or modifications to the project description, Reclamation will provide the fish agencies with

detailed descriptions of the changes and a complete effects analysis and determinations of effects to listed species, unless following emergency consultation provisions. NMFS will provide our findings or concurrence in writing prior to Reclamation taking the action.

- Reclamation's development of a contingency plan, to include the development of a comprehensive, system-wide approach to address future ESA compliance for coordinated water project operations during the drought beyond February 28, 2014.

In conclusion, NMFS concurs that the TUC Petition, as modified by the more specific DCC Gate closure criteria provided in enclosure 2, is consistent with Action 1.2.3.C and meets the specified criteria for a drought contingency plan. We are making this finding based on both the real-time physical and biological data and monitoring information attached to your letter, our supplemental rationale for DCC gate operational triggers in enclosure 2, and the underlying analysis of the CVP/SWP Opinion which concluded that implementation of the RPA is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, the Southern Distinct Population Segment of North American green sturgeon, and the Southern Resident killer whales, and will not result in the destruction or adverse modification of their designated critical habitats. Furthermore, the best available scientific and commercial data indicate that implementation of this plan will not exceed levels of take anticipated for implementation of the RPA specified in the CVP/SWP Opinion.

We anticipate that the DCC gate operational triggers will continue to be refined throughout the month of February as more real-time data is made available through the extensive monitoring program. That information will be continuously analyzed for changes in risk to species and risk to water quality. In addition, the drought contingency plan will be reviewed and updated based on data gathered through the monitoring efforts to ensure implementation of the plan continues to meet all ESA requirements.

We look forward to continued close coordination with you and your staff throughout this extremely challenging water year.

If you have any questions regarding this letter, please contact me at will.stelle@noaa.gov, (206)526-6150, or contact Maria Rea at (916)930-3600, maria.rea@noaa.gov.

Sincerely,

William W. Stelle, Jr.
Regional Administrator

Enclosures:
1. January forecast at 90 percent hydrology
2. Matrix of DCC gates operational criteria
3. Additional Monitoring Relative to Delta Cross Channel Operations

cc: Copy to file 151422SWR2006SA00268

Pablo Arroyave
Deputy Regional Director
Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

Sue Fry
Bureau of Reclamation
801 I Street
Suite 140
Sacramento, California 95814

Paul Fujitani
Deputy Manager, Operations
Bureau of Reclamation
3310 El Camino Avenue
Room 300
Sacramento, California 95821

John Leahigh
Bureau of Reclamation
3310 El Camino Avenue
Sacramento, California 95821

Chuck Bonham
Director
California Department of Fish & Wildlife
1416 Ninth Street
Sacramento, California 95814

Carl Wilcox
California Department of Fish & Wildlife
1416 Ninth Street
Sacramento, California 95814

Laura King-Moon
California Department of Water Resources
P.O. Box 942836
Room 115-2
Sacramento, California 94236

Dean Messer
Chief, Environmental Services
California Department of Water Resources
P.O. Box 942836
Sacramento, California 94236

Ren Lohoefener
Regional Director
US Fish & Wildlife Service
2800 Cottage Way, W-2606
Sacramento, California 95825

Dan Castleberry
Field Supervisor
US Fish & Wildlife Service
2800 Cottage Way
Sacramento, California 95825

Michael Chotkowski
Field Supervisor
US Fish & Wildlife Service
650 Capitol Mall
Suite 8-300
Sacramento, California 95814

Felicia Marcus
State Water Resource Control Board
P.O. Box 100
Sacramento, California 95812

Tom Howard
State Water Resource Control Board
P.O. Box 100
Sacramento, California 95812

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity		**1187**	**1165**	**1151**	**1150**	**1136**	**1008**	**842**	**687**	**532**	**408**	**355**	**343**	**354**
	Elev.		2273	2271	2271	2270	2256	2236	2215	2190	2167	2155	2152	2155
Whiskeytown		**205**	**206**	**206**	**206**	**238**	**238**	**238**	**238**	**238**	**206**	**206**	**205**	**206**
	Elev.		1199	1199	1199	1209	1209	1209	1209	1209	1199	1199	1198	1199
Shasta		**1673**	**1706**	**1782**	**1821**	**1639**	**1464**	**1099**	**698**	**473**	**453**	**#N/A**	**#N/A**	**#N/A**
	Elev.		939	944	947	935	923	894	854	824	#N/A	#N/A	#N/A	#N/A
Folsom		**187**	**176**	**182**	**244**	**262**	**272**	**242**	**198**	**198**	**190**	**196**	**206**	**237**
	Elev.		361	362	377	380	382	376	366	366	365	366	368	375
New Melones		**1049**	**1036**	**1025**	**1000**	**937**	**851**	**758**	**651**	**544**	**466**	**453**	**465**	**480**
	Elev.		947	946	942	934	921	906	887	867	850	847	850	853
San Luis		**329**	**357**	**384**	**388**	**375**	**331**	**251**	**155**	**94**	**152**	**243**	**371**	**415**
	Elev.		422	432	434	426	410	393	373	354	361	383	420	428
Total			4645	4730	4808	4587	4163	3430	2626	2079	1875	#N/A	#N/A	#N/A

State End of the Month Reservoir Storage (TAF)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oroville		**1286**	**1294**	**1353**	**1413**	**1365**	**1247**	**1065**	**845**	**725**	**692**	**704**	**645**	**656**
	Elev.		705	713	720	714	699	674	639	617	611	613	601	604
San Luis		**274**	**347**	**415**	**431**	**368**	**273**	**219**	**171**	**113**	**98**	**149**	**316**	**346**
Total San Luis (TAF)		**603**	**704**	**799**	**819**	**743**	**603**	**469**	**326**	**207**	**250**	**391**	**687**	**761**

Monthly River Releases (TAF/cfs)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity	TAF	18	17	18	36	92	47	28	28	27	23	18	18
	cfs	**300**	**300**	**300**	**600**	**1,498**	**783**	**450**	**450**	**450**	**373**	**300**	**300**
Clear Creek	TAF	12	11	12	12	12	9	7	5	9	12	12	12
	cfs	**200**	**200**	**200**	**200**	**200**	**150**	**120**	**85**	**150**	**200**	**200**	**200**
Sacramento	TAF	200	180	267	405	436	631	645	467	268	295	230	231
	cfs	**3250**	**3250**	**4350**	**6800**	**7100**	**10600**	**10500**	**7595**	**4501**	**4800**	**3873**	**3750**
American	TAF	41	28	33	48	49	51	73	31	30	31	30	31
	cfs	**660**	**500**	**534**	**801**	**800**	**860**	**1185**	**500**	**500**	**500**	**500**	**500**
Stanislaus	TAF	13	12	16	29	25	33	24	22	14	36	12	12
	cfs	**210**	**215**	**268**	**480**	**410**	**561**	**396**	**352**	**240**	**580**	**200**	**200**
Feather	TAF	61	53	58	119	55	86	144	77	74	77	74	77
	cfs	**1000**	**950**	**950**	**2000**	**900**	**1450**	**2350**	**1250**	**1250**	**1250**	**1250**	**1250**

Trinity Diversions (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carr PP	9	5	1	39	76	127	128	127	98	40	15	11
Spring Crk. PP	**4**	**5**	**8**	**10**	**70**	**120**	**120**	**120**	**120**	**30**	**10**	**11**

Delta Summary (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tracy	50	75	45	45	46	45	45	63	153	161	157	62
USBR Banks	0	0	0	0	0	0	0	0	0	0	0	0
Contra Costa	9.2	7	7	6.4	6.4	6.4	4.9	5.6	6.4	7	8.4	9.2
Total USBR	59	82	52	51	53	51	50	69	159	168	165	71
State Export	75	72	67	21	22	45	45	26	39	125	203	90
Total Export	134	154	119	72	74	96	95	95	198	293	368	161
COA Balance	0	0	0	9	-16	-1	-2	-2	-2	-2	-2	-2
Old/Middle River Std.												
Old/Middle R. calc.	-1,715	-2,062	-1,330	-873	-894	-1,351	-1,359	-1,412	-2,793	-3,479	-4,799	-2,058
Computed DOI	8589	7096	7109	7245	4002	4001	4002	3026	3043	3872	3933	7483
Excess Outflow	4083	0	0	0	0	0	0	33	34	374	437	3985
% Export/Inflow	20%	27%	18%	11%	14%	15%	16%	21%	41%	54%	61%	27%
% Export/Inflow std.	65%	45%	35%	35%	35%	35%	65%	65%	65%	65%	65%	65%

Hydrology

		Clair Engle	Shasta	Folsom	New Melones
Water Year Inflow (TAF)		195	2,281	623	184
Year to Date + Forecasted	% of mean	16%	41%	23%	17%

Enclosure 2

Delta Cross Channel Gates Operational Triggers with Supporting Information

Delta Cross Channel Gates Operational Triggers

		Fish monitoring and physical information	**Action to be taken**
Outmigrating Fish protection	Alert	Tisdale Rotary Screw trap catch index (CI) is ≥ 3 winter-run per day standardized to catch per unit effort	**No action taken**: Alert to potential emigration event. Fish are expected to be entering the lower Sacramento River from upstream.
	Alert	Wilkins Slough flows increase over base flows by 45% within a 5-day time period. Current flows are approximately 3,692 cfs; 45% increase is equal to 5353 cfs	**No action taken:** Fish are expected to be entering the lower Sacramento River from upstream due to an increase in flows.
	Low trigger	Knights Landing Catch Index (KLCI) or Sacramento River trawl Catch Index (SCI) is ≥ 3 fish per day, standardized to catch per unit effort. This signifies that a moderate increase in downstream migrating fish is currently occurring. These fish will be in the Delta within days.	**Action:** Within 24 hours of meeting the trigger criteria, the DCC gates will be closed for 4 consecutive days. Gates will reopen if the KCI or SCI remain below the trigger threshold for the entire 4-day period. If during the 4-day closure, the trigger is again exceeded, then a new 4-day closure will be initiated.
	High trigger	KLCI or SCI is ≥ 5 fish per day, standardized to catch per unit effort. This signifies that a large increase in downstream migrating fish is currently occurring. These fish will be in the Delta within days. A KLCI or SCI ≥ 5 fish per day typically correspond to the major emigration events of the year class, with a	**Action:** Within 24 hours of meeting the trigger criteria, the DCC gates will be closed for 7 consecutive days. Gates will reopen if the KCI or SCI remain below the trigger

		significant proportion of the annual emigrating population of winter-run Chinook salmon passing Knights Landing occurring during these events.	threshold for the entire 7-day period. If during the 7-day closure, the trigger is again exceeded, then a new 7-day closure will be initiated.
Protection of Rearing Fish in vicinity of the DCC Gates		Sacramento area standardized beach seines or SCI = 0 for winter-run Chinook salmon and no upstream triggers have been exceeded following previous gate closures.	**<u>No action taken:</u>** If no captures of fish occur in the SCI or Beach seines after triggers have been exceed and the required duration of gate closures have been met without exceeding the triggers again, then the DCC gates shall remain open until a trigger criterion has been exceeded.
	Low trigger	Sacramento area standardized beach seine or SCI is equal to 1 or 2 winter-run Chinook salmon. This indicates that although winter-run Chinook are in the area surrounding the location of the DCC gates, the fish are typically holding or rearing and not actively migrating downstream in large numbers.	**<u>Action: Gates Operated Diurnally</u>** After prior triggers are no longer exceeded, and the DCC gate closures have met their required duration without re-triggering gate closures, then the DCC gate will be operated diurnally to protect fish in the vicinity of the gates
	Alternative trigger	Standardized area beach seine catch is greater than 2 but no fish have been captured in the Sacramento River Trawl. This indicates that winter-run are still present in the vicinity of the DCC gates and are using the area to hold and rear.	**<u>Action: Gates Operated Diurnally</u>** After prior triggers are no longer exceeded, and the DCC gate closures have met their required duration without re-triggering

			gate closures, then the DCC gate will be operated diurnally to protect fish in the vicinity of the gates.

Diurnal operations in response to tidal conditions

	Day (6am-6pm window) approximately up to 6 hour window for opening DCC gates within12 hour diurnal period.	Night (6pm-6am)
Ebb	Preferred operations of DCC gates will occur during the ebb tidal phase during daylight periods. Periods of gate openings should avoid the period of slack water surrounding the low tide and high tide (± 1 hour). This phase of the tide has been shown to create hydraulic conditions at junctions that enhance fish entrainment. Best to use period of the Ebb tide with the strongest downstream flow. Avoid overlapping this phase of the tide with crepuscular periods. Fish migratory movement is elevated during the crepuscular period	Do not open DCC.
Slack	Avoid this period of the tide, fish may be holding in the vicinity of the DCC and the increased movement by fish (milling behavior) will create conditions for greater exposure to entrainment. Avoid crepuscular periods for reasons stated above.	Do not open DCC.
Flood	This a less optimal period of DCC gate operations for fish protection since flow convergence will occur with the water moving upstream on the flood tide meeting water still moving downstream at the beginning of the flood tide. This will send more water into an open DCC channel and extend the zone of entrainment across a significant proportion of the Sacramento River channel. If gates are opened 1 to 2 hours after the change of flow direction at the bottom of the tide, you are likely to have less impact due to opening during this period. Avoid crepuscular periods	Do not open DCC.

Supporting information

The U.S. Bureau of Reclamation (Reclamation) provided a current status of the species for Sacramento River Winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon, California Central Valley steelhead (*O. mykiss)*, and Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*) in its supporting analysis for the Temporary Urgency Change (TUC) Petition.

In response to Reclamation's and the Department of Water Resources (DWR) request for the TUC Petition, an interagency group of fisheries biologists from NOAA's National Marine Fisheries Service, Reclamation, California Department of Fish and Wildlife, and California Department of Water Resources (Interagency Team) met and developed the following proposed Delta Cross Channel (DCC) gate operational triggers, in consideration of their need to provide minimum health and safety supplies, conserve water for later protections of instream uses and water quality, and the need to protect the endangered winter-run Chinook salmon.

Because of the anomalous dry hydrology in water year 2014 (WY2014) and lack of sufficient precipitation driven pulse flows in the Sacramento River to trigger behavioral responses in juvenile winter-run Chinook salmon that stimulates downstream migration, some believe that the majority of juvenile winter-run are still rearing in the upper Sacramento River, awaiting the appropriate environmental cues to migrate. However, others believe that the winter-run juveniles are slowly migrating downstream in persistent low numbers towards the Delta. As a result, Reclamation's assessment of the current status and distribution of winter-run Chinook salmon has indicated that there are from <5% to >30% of the winter-run population currently in the Delta, with the remainder above the monitoring locations of the Tisdale Weir and Knights Landing rotary screw traps (RSTs). In previous dry years, migration past the Knights Landing location has been delayed into late January or February, awaiting a pulse event (see Table 1).

Table 1. Percentage of annual recovery of Winter-run Juveniles at Knight Landing by date

						Water Year						
	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Water Year type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN
Date first WR @ KL	11/6/2000	11/16/2001	10/11/2002	10/6/2003	10/29/2004	10/11/2005	10/6/2006	12/12/2007	12/29/2008	10/15/2009	10/11/2010	10/10/2011
25% @ KL	1/19/2001	11/27/2001	12/17/2002	12/9/2003	12/11/2004	12/3/2005	12/15/2006	12/31/2007	1/26/2009	10/28/2009	12/8/2010	1/23/2012
50% @ KL	1/29/2001	12/11/2001	12/22/2002	12/11/2003	12/13/2004	12/6/2005	12/17/2006	1/12/2008	2/24/2009	1/20/2010	12/17/2010	1/25/2012
75% @ KL	2/23/2001	1/4/2002	1/4/2003	12/20/2003	1/5/2005	12/24/2005	12/30/2006	1/28/2008	2/27/2009	1/26/2010	12/23/2010	1/27/2012
100% @ KL	4/25/2001	4/24/2002	4/21/2003	4/5/2004	4/22/2005	4/18/2006	3/13/2007	3/3/2008	4/6/2009	4/16/2010	4/9/2011	4/11/2012

In most years, precipitation events trigger emigration events. Recovery of winter-run juveniles at Knights Landing increases with these precipitation events that increase flows in the Sacramento River. These flows fluctuations have been typically measured at Wilkins Slough where a monitoring gage is located. Wilkins Slough is located upstream of the Knights Landing RST location and provides real time measurements of flow. A team of scientist from multiple federal and state agencies was convened in 1994 and over the course of more than 10 years developed the Salmon Decision Tree, to provide a framework for making operational decisions using the Knights Landing catch data and physical measurements such as the Wilkins Slough river flow data to determine when older juveniles, which include winter-run Chinook salmon juveniles, are entering the Delta and may need protection from water operations. This decision tree was modified in the 2009 NMFS biological opinion for the long term operations of the

Central Valley Project (CVP) and State Water Project (SWP, CVP/SWP Opinion). The Salmon Decision Tree team developed triggers based on standardized numbers of fish captured in the Knights Landing RSTs as well as monitoring efforts occurring downstream of that location in the Delta (Sacramento River trawls and beach seines). During the development of the Salmon Decision Tree criteria, the timing and magnitude of the passage of older juvenile Chinook salmon, *i.e.*, those fish larger than the minimum winter run Chinook salmon size criteria, were assessed from the Knights Landing RST monitoring data. In addition to the presence of the salmonids, physical data such as water temperature and river discharge were examined. The Knights Landing RST data have been collected since the fall of 1995 by CDFG staff using paired traps. The monitoring study has been conducted annually, collecting data to develop information on timing, composition (race and species) and relative abundance of juvenile Chinook salmon and steelhead emigrating from the upper Sacramento River. The traps have typically been placed in the river from early October through June of each year to coincide with the periods of salmonid out migration from the Sacramento River basin, however in some years the traps have been run for a longer period of time. The Salmon Decision Tree group also used data from the monitoring efforts conducted by the U.S. Fish and Wildlife Service (FWS) in the Sacramento River near the City of Sacramento as part of the Juvenile Salmon Monitoring Program/Delta Juvenile Fish Monitoring Program. The FWS conducts a river trawl using either a mid-water trawl or Kodiak trawl to sample fish (Sacramento trawl) and a beach seine at several shore locations in the Sacramento region (Sacramento Area beach seines). During the salmon emigration period, the sampling effort is intensified to 3 times per week.

The Salmon Decision Tree work group used data from these monitoring studies to develop the trigger criteria for the Decision Tree. The Knights Landing data was standardized to the number of older juvenile Chinook salmon (defined as fish larger than the minimum size length for winter-run Chinook salmon at date, *i.e.*, >70mm) captured in one trap day (24 hours). The number of older juvenile fish captured in each RST is enumerated, and then the cumulative number of fish is divided by the number of hours the two RSTs were operated between sampling days divided by 24. For example, if the two traps are fished for 2 days there is a maximum of 96 hours that the 2 traps could have been fished: (2 days x 24 hours per day x 2 traps = 96 hours total time fished). If 100 fish were caught between both traps, then the catch per trap day is: 100 ÷ (96 hours/ 24 hours per day) = 25 fish per trap day. In a similar fashion, the catch from the Sacramento trawl and Sacramento area beach seines are standardized to one catch day with 10 tows per sampling day for the trawl data and eight hauls per day for the beach seine data. The daily catch data is adjusted so that the effort per day is always equivalent, taking into account any variance in the number of tows or hauls actually completed each day. These data are then referred to as the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) respectively. The Salmon Decision Tree work group found that the older juvenile Chinook salmon arrived at the Knights Landing RST location in "pulses" that were associated with precipitation driven increases in the river flow at Knights Landing (see Figure 1). The work group developed numerical criteria that served as the thresholds for closure of the DCC gates, and are the basis for the threshold triggers used in the current operations table. In addition to the numerical values for the Knights Landing and Sacramento Catch indices that trigger operational responses, the work group developed physical hydrological triggers that indicated that older juvenile salmonid migration was imminent. This included a flow criterion at Wilkins Slough of 7,500 cfs and a water temperature of 13.5^{o}C. In a recent paper by del Rosario *et al.* (2013), analysis of the Knights Landing data suggest that catch spikes of as little as 5% cumulative catch are observable and are nearly coincident with rapid increases in flow greater than 14,125 cfs. In light of the very dry hydrology for 2014, flows of this magnitude are unlikely, barring a significant precipitation event. The Interagency Team decided, based on professional judgment, that a lower flow might serve as an alert for active downstream migration, in this case, and developed a standard in which flow increases of 45% over a period of 5 days at Wilkins Slough would signify a physical trigger for indicating movement of fish downstream past Knights Landing. Past data regarding small pulses of less than 10,000 cfs at Wilkins Slough from low flows indicated that there was movement of fish, but not as pronounced as the larger flows.

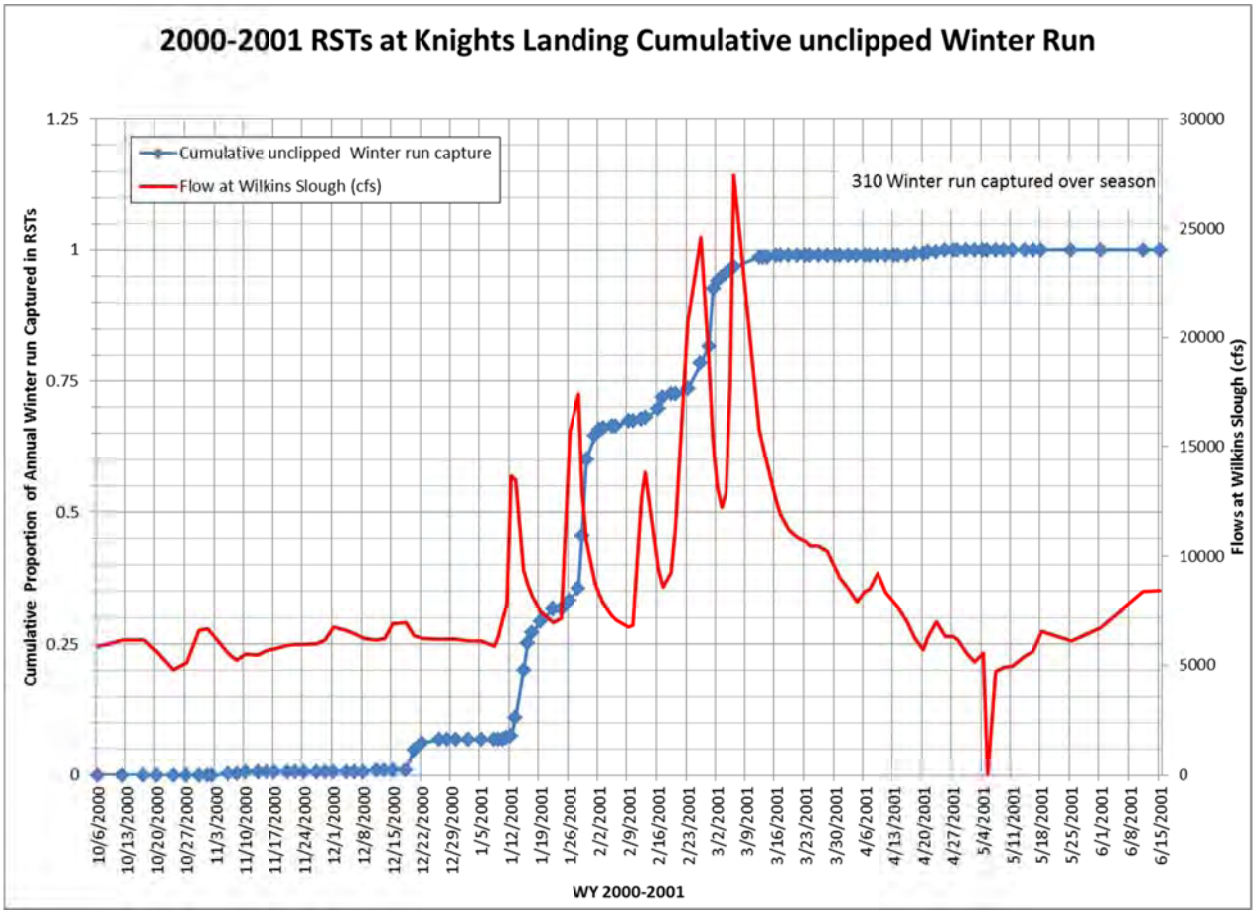


Figure 1. Knights Landing rotary screw trap cumulative captures of winter-run Chinook salmon for water year 2001, a dry year.

The first and second triggers indicate that a significant emigration event is occurring (see Figures 1 and 2). When the indices of 3 or 5 fish per trap day are exceeded, the cumulative number of fish increases rapidly and as previously described occurs with a co-occurring pulse in flow as measured at Wilkins Slough. We expect that in 2014, a smaller flow pulse as measured at Wilkins Slough will stimulate migratory behavior and a resultant increase in winter run captures will occur. The trigger thresholds of 3 and 5 fish per trap day will allow operators to have notice that a pulse of fish are moving down through the system and the protective actions of closing the DCC gates can be implemented.

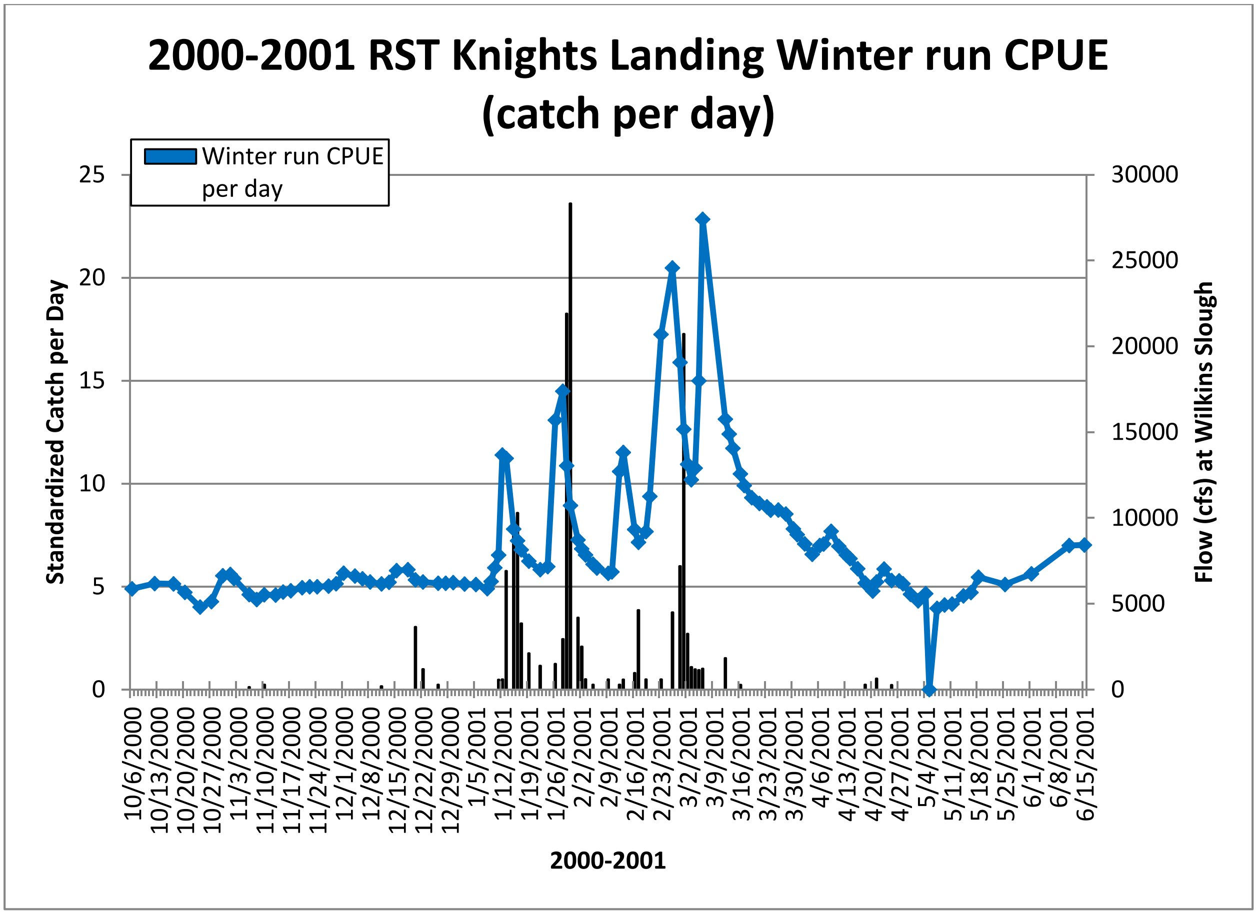


Figure 2. Catch of winter-run Chinook salmon at Knights Landing measured as catch per unit effort for water year 2001.

As juvenile Chinook salmon move downstream, they are more likely to move at night rather than during the day. Several studies have indicated such behavior (Martin *et al*. 2001, Chapman *et al*. 2013). Results from the 2012 Georgian Slough non-physical barrier study illustrate that behavior when looking at fish. Entrainment into Georgiana Slough was highest during the night as compared to the day time hours. Fish tended to hold during the day and were less vulnerable to entrainment into Georgiana Slough.

References:

Chapman, E.D., A.R. Hearn, C.J. Michel, A.J. Ammann, S.T. Lindley, M.J. Thomas, P.T. Sandstrom, G.P. Singer, M.L. Peterson, R.B. MacFarlane, and A.P. Klimley. 2013. Diel Movements of out-migrating Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout smolts in the Sacramento/San Joaquin watershed. Environmental Biology of Fish. 96: 273-286.

del Rosario, R.B, Y.J. Redler, K. Newman, P.L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 11(1): 24p.

Martin, C.D., P.D. Gaines and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U.S. Fish and Wildlife Service, Red Bluff, California.

Enclosure 3

Additional Monitoring Relative to Delta Cross Channel Operations
January 31, 2014

Below are specific additional monitoring activities confirmed to be completed in order to facilitate Delta Cross Channel Gate Operations.

Knights Landing Rotary Screw Trap
Rotary Screw Trapping at Knights Landing, 24 hours per day, 7 days per week to provide salmon outmigration trends. 24 hour sampling start January 31, 2014. This effort is led by Department of Fish and Wildlife.

Sacramento Kodiak Trawl
Kodiak trawling at Sacramento will be completed to provide salmon presence information. A total of 10, 20-minute tows per day will be completed. Sampling is confirmed to start week of February 3 and will be completed on Monday, Wednesday, Thursday, and Friday of the first week. Boat Operator assistance is needed to complete trawling on Tuesday. Future sampling frequency to be discussed. This effort is led by the U.S. Fish and Wildlife Service.

Sacramento Area Beach Seine
Daily beach seining in the Sacramento region at up to 8 specific seine sites is confirmed to be completed to provide salmon presence information. Sampling is confirmed to start week of February 3 and will be completed on Monday, Tuesday, Wednesday, Thursday, and Friday of the first week. Future sampling frequency to be discussed. This effort is led by the U.S. Fish and Wildlife Service.

Acoustic Receivers
A request for receiver equipment has been sent and deployment has yet to be scheduled. Status of USGS Chinook release studies is unknown at this time and more information will be gathered over the weekend. Kevin Reece, DWR is leading this effort.

All preliminary sampling summaries including date of sample, sample effort, and catch by salmon race will be sent following sampling activities each day to Barbara.Byrne@noaa.gov, and Jeff.McLain@noaa.gov. Sampling summaries will also be forwarded to DOSS group.