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UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF CALIFORNIA
FRESNO DIVISION

THE CONSOLIDATED SALMONID CASES	Lead Case No. 09-cv-1053-LJO-DLB
	DECLARATION OF MARIA REA IN SUPPORT OF JOINT MOTION TO EXTEND THE REMAND SCHEDULE
THE CONSOLIDATED DELTA SMELT CASES	Lead Case No. 09-cv-407-LJO-DLB

I, Maria Rea, declare as follows:

1. I am the Area Office Supervisor for the Central Valley Office (CVO) of NOAA's National Marine Fisheries Service (NMFS), Southwest Region.

2. I have reviewed the Court's January 30, 2013 Order in response to the Joint Motion to Extend the Remand Schedule, and I submit this declaration to address the Court's questions raised in that Order. (Doc. 1098). My declaration follows on the declaration of Rodney R. McInnis, filed December 20, 2012 (Doc. 713-5), as part of the Joint Motion to Extend the Remand Schedule (Doc. 713), and provides additional detail explaining how: (1) circumstances have changed in significant, unforeseen ways since the judgments were entered;

(2) the changed circumstances make compliance with the remand schedules contrary to the public interest; and (3) the requested continuance is tailored to the changed circumstances.

I. Circumstances Have Changed Significantly Since the Judgment Was Entered

3. The Court asked whether, since the final judgment was entered, there has been a paradigm change in the way the agencies work with each other and stakeholders and if so, what has changed. In my opinion, there has been a significant change in the way the agencies work with each other and stakeholders. Not surprisingly, the years of litigation on NMFS's 2009 salmonid biological opinion (BiOp) created a very polarized atmosphere between NMFS and the litigants, including the California Department of Water Resources (DWR), with very different perspectives on what constitutes best available science. When I submitted my previous declarations that led to the current remand schedule (September 26 and December 2, 2011), I did not anticipate that a new Collaborative Science and Adaptive Management Process (CSAMP) and Collaborative Adaptive Management Team (CAMT) would be proposed. Nor did I think that DWR would take a leadership role in co-chairing a new South Delta Salmonid Research Collaborative (SDSRC), and invite all parties, including NGOs/defendant intervenors to participate.

4. In addition, I did not anticipate that the study that resulted from the 2012 Joint Stipulation for the Central Valley Project/State Water Project (CVP/SWP) operations would recommend the development of new behavioral models and experiments related to South Delta operations. Nor did I anticipate that the subsequent independent review of that study would make similar recommendations. I also did not anticipate the extended time that it would take lead researchers using acoustic tag technology, as required by Reasonable and Prudent Alternative (RPA) action IV.2.2, to complete their analyses and reports. The extension would provide time to address these issues, none of which were anticipated when the current remand schedule was developed.

5. In this declaration I will explain the relationship of the SDSRC to the larger CSAMP process proposed by federal agencies and DWR as the basis for the three-year

extension. I will also explain in further detail why the extension is necessary in order for NMFS to engage in the CSAMP process, and the consequences of the requested extension not being granted. NMFS is also submitting the declaration of Dr. Michael Schiewe, who has been retained by my office as Senior Scientific Advisor, to provide the court with additional explanation of the importance of the scientific work that is planned for the SDSRC and CSAMP process, and, therefore, the opportunity created by the requested extension.

II. The Changes in Circumstances Make Complying With the Existing Remand Schedules Detrimental to the Public Interest.

6. The Court asked how the changes in circumstances make compliance with the original judgment more onerous, unworkable, or detrimental to the public interest.

7. NMFS believes that promoting a collaborative process is critical to breaking the current Section 7 consultation/litigation cycle. Continued litigation stalls constructive efforts to improve the health of the Delta and its species. 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 Endangered Species Act (ESA) listed species.

8. If the Court does not grant the requested extension, NMFS will adhere to the schedule previously ordered by the court to issue a draft BiOp by October 2014 and a final BiOp by February 1, 2016, but will be unable to commit to the CSAMP process. The Court's order requires NMFS to undertake a significant number of new analyses and corresponding revisions to the BiOp, and/or the RPA. These new analyses and revisions require a substantial amount of technical work to be conducted, with limited staff resources. In addition, NMFS has to undertake these new analyses while at the same time utilizing scarce staff resources for the Bay Delta Conservation Plan (BDCP) process. Without the extension NMFS staff resources would be dedicated to completing new analyses that resulted from the Court-ordered remand, providing support to the independent review panel annual reviews, incorporating recommendations from the National Academy of Sciences review, collaborating on the development of the life cycle model, and developing a revised BiOp and possible RPA, including addressing any updates due to implementation of the RPA since 2009. While our mandate under the ESA is to use the best available science, it is within the agencies' discretion to support new science, which we anticipate will significantly improve the consultation package and build stakeholder buy-in to the outcomes of the consultation process. As discussed below, the extension would provide time to

address these most pressing areas of scientific uncertainty, as highlighted in recent independent scientific peer reviews and as raised within the respective consolidated salmonid and Delta smelt cases.

9. The overall goal of the three-year extension is to provide an opportunity to develop and implement a collaborative science and adaptive management process—the CSAMP—that better utilizes cooperation and expertise of non-agency stakeholders and scientists to identify and inform key areas of uncertainties related to species needs and CVP/SWP water operations, through carefully planned experiments, analyses, and adaptations. By advancing the state of scientific understanding, we believe that the new salmon BiOp can be made more robust. Nonetheless, while the CSAMP is intended to supplement the state of available scientific and commercial data as it relates to issues covered in the BiOp, and to determine if there are alternative methods of achieving equivalent or improved biological protection for listed species with less impact to water supply, such experiments and/or adaptations would be fully consistent with the current 2009 BiOp, as they would be done according to the adaptive management process described in that BiOp, and would need to provide equal or greater protection to the species under the specific RPA action. Although the CSAMP process is not written in detail at this time, in order to be consistent with the BiOp, it is my understanding that it would necessitate a detailed written analysis accompanying any experiment and/or adaptation of an RPA action with specific findings regarding equal or greater protection for the species. Recommended changes outside the range of flexibility specified in the implementation procedures of the RPA must receive written review and concurrence by NMFS and may trigger re-initiation.

10. In addition to gathering new scientific information, the CSAMP will also put into practice and test the feasibility of the collaborative science processes currently contemplated for the BDCP, and would be used to inform the future NMFS BiOp, which, under the extension, would be issued in February of 2019.

11. The CSAMP process calls for the establishment of the CAMT. The specific details of the CSAMP and CAMT are not developed at this time. Indeed, given the nature of collaborative processes, it would be premature and inappropriate for NMFS to attempt to unilaterally define the CAMT's procedures in detail, since the focus and operating procedures of the CAMT will be defined by the group. Nonetheless, based on discussions I have had with my peers and outside stakeholders, I anticipate that the CSAMP process will follow standardized and

generally-accepted protocols for a collaborative science process. To that end, the CAMT will likely utilize an adaptive management approach similar to that described in the draft Delta Plan developed by the Delta Stewardship Council. This nine-step approach, which fits within three broader categories of "plan," "do," and "evaluate and respond," are described in Exhibit 1.

12. It is also anticipated that the CAMT will provide a role in synthesizing and overseeing ongoing Delta science efforts, such as the SDSRC, which has been formed by NMFS and DWR as an outgrowth of the joint stipulation supported by the court last year and implemented in April and May 2012 (Doc. 660), the Delta smelt turbidity entrainment prediction tools, fall and summer outflow studies, and existing monitoring programs. The SDSRC will be a key subgroup of the CSAMP process.

13. The CAMT may also define additional expectations or guidelines for adaptive management experiments with respect to use of conceptual models, requiring independent peer review, and open and transparent solicitation of proposals. CAMT may also define its role as tracking and advising on baseline scientific analyses that are being planned now in anticipation of the BDCP being finalized.

14. The Court asked why granting a three-year continuance to pursue the Proposal is more beneficial to the public interest than issuing a new salmonid BiOp. As explained above, I am concerned that issuing the BiOp as ordered will lead to further litigation, which is contrary to the public interest.

15. In addition to potentially breaking the cycle of litigation, the CSAMP will improve scientific understanding over the long term, and new information gained from this process also will be useful for implementing, and adaptively managing, the existing RPAs within the BiOps over the short term. For example, Exhibit 2, which is a true and correct copy of a table provided to me by the California Department of Fish and Wildlife (DFW), shows new and ongoing scientific efforts that the agencies (NMFS, U.S. Fish and Wildlife Service (FWS), U.S. Bureau of Reclamation (Reclamation), DWR and Department of Fish and Wildlife (DFW)) plan to discuss with the larger CAMT membership if the court extension is granted in order to further define its scope and responsibilities.

16. Given limited technical staff resources, NMFS cannot commit to the CSAMP process and also meet the current remand schedule. The remand schedule did not anticipate NMFS staff involvement in developing any new research or science beyond the ongoing life

cycle model development. Unless new science findings are available, additional time is not built into the remand schedule to support the development of new science and research directed at remand issues. Without the three-year extension, NMFS will not have resources to participate in the CAMT under the CSAMP.

17. Moreover, under the current schedule, studies that are being developed or implemented may not be completed in time to fully inform the BiOp, since several of the studies are seasonally based on the timing of fish migration and water flow. For example, year three of RPA Action IV.2.2, the Six-Year Acoustic Tag Experiment, will be implemented this spring. However, to date, a report has not been available that summarizes and analyzes the results from the first two years of implementation due to delays in processing acoustic tag data. The delays in processing were not foreseen by NMFS.

III. A Three-Year Continuance Is Tailored To the Changes In Circumstances

18. The Court also asked why DWR and Federal Defendants are asking for three years to incorporate the Proposal. NMFS does not maintain that three years are necessary to incorporate the CSAMP into the BiOp as the Court suggests. Rather, the agencies' request for a three-year extension was deliberate, and based on the time necessary to implement the CSAMP. After the three year extension has ended, NMFS would resume the BiOp schedule according to the current timelines.

19. The 2009 BiOp included an adaptive management approach through the annual review and amendment process. The goal of adaptive management is to link goals and objectives with implementation and monitoring in order to learn and adapt actions, as necessary. The desire now is to broaden the annual review process to a more collaborative, stakeholder process through the CAMT, and to learn from annual review lessons, including the need to build the necessary time upfront to develop a more robust science process, is in keeping with the goals of adaptive management.

20. This approach takes more time initially to collaboratively define goals and develop models to describe linkages between goals and actions. The intent of the three-year extension is to use the first year developing the CAMT and conceptual models in order to inform what and how the research will be undertaken. The second and third year of the extension is for implementation and analysis of the research to inform the Biological Assessment (BA) and the BiOp.

21. In order to better inform the court on the work that must be completed during the requested three-year extension, I am providing a detailed schedule, which is attached as Exhibit 3. The schedule is divided into three phases. Phase 1 runs concurrently with phases 2 and 3. Phase 1 is the collaborative science development and implementation phase. The schedule also shows how the Sacramento River winter-run Chinook salmon life cycle model, which has been the subject of the previous court ruling on the BiOp, will continue to be developed by the NOAA/NMFS Southwest Fisheries Science Center and how the results will be integrated into both the consultation package submitted by Reclamation and the subsequent BiOp. The consultation package could consist of a BA or some other equivalent format.

22. Key milestones in Phase 1 are: completion of new experimental designs by January 1, 2014; implementation of the first year of the experiment by June 30, 2014; implementation of the second year of the experiment and complete analysis and reporting of the first year results by June 30, 2015; and complete analysis and reporting of the second year's experiment by June 30, 2016.

23. Phase 2 is Reclamation's New Project Description, consultation package, and National Environmental Policy Act (NEPA) phase. The key milestone in this phase is submission of a final consultation package, including any new project description and/or RPA actions, to NMFS by December 31, 2015. This milestone will allow Reclamation to include the results from the first year of the collaborative science experiment into the consultation package.

24. Phase 3 is NMFS Biological Opinion phase. Key milestones in this phase include: 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. Integration of the results from the second year of the collaborative science experiment will occur as NMFS drafts the effects analysis by August 25, 2016. Within NMFS, we are constantly looking for ways to adjust, modify and accelerate the schedule in Exhibit 3, and we remain open to further modifications if circumstances allow.

25. In addition to forming the CAMT, the three-year extension would allow NMFS, with DWR, to continue and fully staff the SDSRC. NMFS views this collaborative effort as a subgroup of the larger CAMT process. NMFS and DWR formed and are co-sponsoring this effort as an outgrowth of the 2012 Joint Stipulation for CVP/SWP operations, which provided

for a special study and real-time adjustments to Old and Middle River (OMR) flows based on sentinel acoustically-tagged steelhead last April and May (Stipulation Study).

26. The objectives of the Stipulation Study were to: (1) Evaluate potential effects of OMR flows during April and May on the reach-scale survival, migration rate, and net migration direction of acoustically tagged juvenile steelhead and Chinook salmon in the lower San Joaquin River, Turner Cut, Columbia Cut, Middle River and Old River; (2) Estimate route entrainment of juvenile steelhead and salmon into Middle River, Turner Cut, Columbia Cut, and Old River under different tidal conditions and OMR flows; and (3) Perform daily and weekly data processing of detection data for acoustically tagged steelhead and Chinook salmon at key locations for use in monitoring the movement of juvenile salmonids through the Delta in order to provide information that can be used to adaptively manage OMR flows within the adaptive range specified in the Joint Stipulation. *See* Exhibit 4 (a true and correct copy of the summary of study results).

27. In October of 2012, NMFS and DWR convened various groups (*e.g.*, scientific, management, stakeholder, project operators) to discuss lessons learned from the implementation of the Stipulation Study and the subsequent analyses. *See* Exhibit 5 (a true and correct copy of the Lessons Learned September 25, 2012 Meeting Summary Draft).

28. Important lessons learned from the Stipulation Study included: (1) more time should be provided in between studies, so that studies should be implemented no more frequently than every other year; and (2) there are not that many experts that can conduct the type of analyses and statistics required, and therefore, a considerable amount of time (a year to a year and a half) is necessary between the conclusion of a study and the final report. The extra time provided by the extension would allow for the development of a more robust study design that considers the results of this study and time for the limited expert staff to review new information and prepare a final report.

29. A preliminary report from the study team was presented to the 2012 Independent Review Panel (IRP) for the RPA Annual Review in November of 2012, and analyses of the data collected are on-going. The 2012 IRP for the RPA Annual Review came to similar findings. *See* Exhibit 6 (a true and correct copy of the Report of the 2012 Delta Science Program Independent Review Panel on the Long-term Operations Opinions Annual Review December 1, 2012). The IRP also emphasized the importance of better understanding the relationship between fish

behavior and real-time operations, including further modeling and analysis that may take more time than is available under the current remand schedule.

30. Building on these lessons, NMFS and DWR co-sponsored the first meeting of the SDSRC in November of 2012. The stated purposes of the group are to: bring together lead researchers and agency staff to review and discuss questions related to salmonid survival and hydraulic conditions in the South Delta; discuss conceptual theories and the need for ongoing analyses of existing data sets; develop modeling related tools; and discuss new management-driven research needs, including an experimental design to be implemented in Spring of 2014. The group met for a second time on January 29, 2013. The declaration of Dr. Michael Schiewe provides additional detail on the scientific importance, tasks, timelines and products expected from this group.

31. Without an extension, NMFS will be required to significantly scale back its participation in the SDSRC, a key subgroup in the CSAMP process, since the staff involved in the SDSRC are the same limited staff that are responsible for developing the remand BiOp analyses and document.

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.

Executed this 14th day of March, 2013 in
Sacramento, California

Maria Rea

Maria Rea
Supervisor
Central Valley Office
National Marine Fisheries Service

EXHIBIT 1

Appendix A
Adaptive Management and the Delta Plan

The Delta Reform Act seeks to provide a strong science foundation to inform decisions of the Council, seen in both provisions for a science program and an independent science board (Water Code section 85280):

> *85280 (a) The Delta Independent Science Board is hereby established in state government*
>
> *85280 (a)(3) The Delta Independent Science Board shall provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs that shall be scheduled to ensure that all Delta scientific research, monitoring, and assessment programs are reviewed at least once every four years.*
>
> *85280 (b)(4) The mission of the Delta Science Program shall be to provide the best possible unbiased scientific information to inform water and environmental decisionmaking in the Delta. That mission shall be carried out through funding research, synthesizing and communicating scientific information to policymakers and decisionmakers, promoting independent scientific peer review, and coordinating with Delta agencies to promote science-based adaptive management. The Delta Science Program shall assist with development and periodic updates of the Delta Plan's adaptive management program.*

The Delta Reform Act requires the inclusion of science-based adaptive management in the Delta Plan as defined and stated in Water Code sections 85308(f) and 85052:

> *85308(f) Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.*
>
> *85052 "Adaptive management" means a framework and flexible decisionmaking process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives.*

The Delta Reform Act also requires that the Delta Plan is based upon and implemented using the best available science:

> *85308 The Delta Plan shall meet all of the following requirements:*
>
> > *(a) Be based on the best available scientific information and the independent science advice provided by the Delta Independent Science Board.*
> >
> > *(e) Where appropriate, recommend integration of scientific and monitoring results into ongoing Delta water management.*
>
> *85302(g) In carrying out this section, the council shall make use of the best available science.*

Appendix A Adaptive Management and the Delta Plan

The Delta Reform Act requires a strong science foundation to inform Delta Stewardship Council (Council) decisions. This includes providing scientific expertise to support the Council and other agencies through the Delta Science Program and Delta Independent Science Board (Water Code section 85280). The Delta Reform Act also requires that the Delta Plan be based on and implemented using the best available science (Water Code sections 85308(a) and (e) and 85302(g)) and requires the use of science-based, transparent, and formal adaptive management strategies for ongoing ecosystem restoration and water management decisions (Water Code section 85308(f)).

Best Available Science

The Delta Reform Act requires the Council to make use of the best available science in implementing the Delta Plan. Best available science is specific to the decision being made and the time frame available for making that decision. Best available science is developed and presented in a transparent manner consistent with the scientific process (Sullivan et al. 2006), including clear statements of assumptions, the use of conceptual models, description of methods used, and presentation of summary conclusions. Sources of data used are cited and analytical tools used in analyses and syntheses are identified. Best available science changes over time, and decisions may need to be revisited as new scientific information becomes available. Ultimately, best available science requires scientists to use the best information and data to assist management and policy decisions. The processes and information used should be clearly documented and effectively communicated to foster improved understanding and decision making.

Steps for Achieving the Best Science

Science consistent with the scientific process includes 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

The best science is understandable; it clearly outlines assumptions and limitations. The best science is also reputable; it has undergone peer review conducted by active experts in the applicable field(s) of study. Scientific peer review addresses the validity of the methods used, the adequacy of the methods and study design in addressing study objectives, the adequacy of the interpretation of results, whether the conclusions are supported by the results, and whether the findings advance scientific knowledge (Sullivan et al. 2006).

There are several sources of scientific information and tradeoffs associated with each (Sullivan et al. 2006, Ryder et al. 2010). The primary sources of scientific information, in a generalized ranking of most to least scientific credibility for informing management decisions, include the following:

- Independently peer-reviewed publications including scientific journal publications and books (most desirable)
- Other scientific reports and publications
- Science expert opinion
- Traditional knowledge

Each of these sources of scientific information may be the best available at a given time and contain varying levels of understanding and uncertainty. These limitations should be clearly documented when scientific information is used as the basis for decisions.

Guidelines and Criteria

There have been several efforts to develop criteria for defining and assessing best available science. In 2004, the National Research Council Committee on Defining the Best Scientific Information Available for Fisheries Management prepared a report (National Research Council Report) that concluded guidelines and criteria must be defined in order to apply best available science in natural resource management (National Research Council 2004). Major findings and recommendations included establishing procedural and implementation guidelines to govern the production and use of scientific information. The guidelines were based on six broad criteria: relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review.

Best available science for proposed covered actions and for use in the Delta Plan should be consistent with the guidelines and criteria in Table A-1. These criteria were adapted from criteria developed by the National Research Council. Proponents of covered actions should document their scientific rationale for applying the criteria in Table A-1 (i.e., the format used in a scientific grant proposal).

Table A-1
Criteria for Best Available Science

Criteria	Description
Relevance	Scientific information used should be germane to the Delta ecosystem and/or biological and physical components (and/or process) affected by the proposed decisions. Analogous information from a different region but applicable to the Delta ecosystem and/or biological and physical components may be the most relevant when Delta-specific scientific information is nonexistent or insufficient. The quality and relevance of the data and information used shall be clearly addressed.
Inclusiveness	Scientific information used shall incorporate a thorough review of relevant information and analyses across relevant disciplines. Many analysis tools are available to the scientific community (e.g., search engines and citation indices).[a]
Objectivity	Data collection and analyses considered shall meet the standards of the scientific method and be void of nonscientific influences and considerations.
Transparency and openness	The sources and methods used for analyzing the science (including scientific and engineering models) used shall be clearly identified. The opportunity for public comment on the use of science in proposed covered actions is recommended. Limitations of research used shall be clearly identified and explained. If a range of uncertainty is associated with the data and information used, a mechanism for communicating uncertainty shall be employed.
Timeliness	Timeliness has two main elements: (1) data collection shall occur in a manner sufficient for adequate analyses before a management decision is needed, and (2) scientific information used shall be applicable to current situations. Timeliness also means that results from scientific studies and monitoring may be brought forward before the study is complete to address management needs[c]. In these instances, it is necessary that the uncertainties, limitations, and risks associated with preliminary results are clearly documented.

Table A-1
Criteria for Best Available Science

Criteria	Description
Peer review	The quality of the science used will be measured by the extent and quality of the review process. Independent external scientific review of the science is most important because it ensures scientific objectivity and validity. The following criteria represent a desirable peer review process[e]. Coordination of Peer Review. Independent peer review shall be coordinated by entities and/or individuals that (1) are not a member of the independent external review team/panel and (2) have had no direct involvement in the particular actions under review. Independent External Reviewers. A qualified independent external reviewer embodies the following qualities: (1) has no conflict of interest with the outcome of the decision being made, (2) can perform the review free of persuasion by others, (3) has demonstrable competence in the subject as evidenced by formal training or experience, (4) is willing to utilize his or her scientific expertise to reach objective conclusions that may be incongruent with his or her personal biases, and (5) is willing to identify the costs and benefits of ecological and social alternative decisions. When to Conduct Peer Review. Independent scientific peer review shall be applied formally to proposed projects and initial draft plans, in writing after official draft plans or policies are released to the public, and to final released plans. Formal peer review should also be applied to outcomes and products of projects as appropriate.

a. McGarvey 2007
b. National Research Council 2004, Sullivan et al. 2006
c. National Research Council 2004
d. Meffe et al. 1998
e. Adapted from Meffe et al. 1998

It is recognized that differences exist among the accepted standards of peer review for various fields of study and professional communities. When applying the criteria for best available science in Table A-1, the Council recognizes that the level of peer review for supporting materials and technical information (such as scientific studies, model results, and documents) included in the documentation for a proposed covered action is variable and relative to the scale, scope, and nature of the proposed covered action. The Council understands that varying levels of peer review may be commonly accepted in various fields of study and professional communities.

Adaptive Management

Adaptive management is defined in the Delta Reform Act as "a framework and flexible decision making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives" (Water Code section 85052). Adaptive management can be applied at a program, plan or project level.

Adaptive management is a strategy that provides for making management decisions under uncertain conditions using the best available science rather than repeatedly delaying action until more information is available. Adaptive management allows for continuous learning resulting in management decisions based on what was learned, rather than adopting a management strategy and implementing it without regard for scientific feedback or monitoring. Adaptive management is an approach to resources management that increases the likelihood of success in obtaining goals in a manner that is both economical and effective because it provides flexibility and feedback to manage natural resources in the face of often considerable uncertainty.

BARRIERS TO ADAPTIVE MANAGEMENT

While there have been several attempts to develop and implement adaptive management strategies in the Bay-Delta system and elsewhere, most have been unsuccessfully implemented. Adaptive management is not easy, quick or inexpensive (National Research Council 2010). An adaptive management strategy for the CALFED Ecosystem Restoration Program (ERP) was developed in 2000 (CALFED Bay-Delta Program 2000), but implementation of the program's adaptive management elements was never achieved (Healey et al. 2008). Healey et al. (2008) identified several barriers to implementing CALFED's adaptive management strategies. One such barrier was the struggle to change the traditional agency approach to managing problems, which limited the ability to take essential steps outside of normal agency operations, such as pre-project modeling and identification of specific outcomes, along with post-project monitoring and evaluation. Other barriers to implementing adaptive management under CALFED's ERP included a lack of secure funding and mechanisms for implementing large-scale adaptive management experiments, lack of stakeholder buy-in in the form of landowner assurances (e.g., economic viability and compensation for land use changes), changes in support for the projects under administration changes, and high implementation costs.

Additionally, the CALFED funded Adaptive Management Forum Scientific and Technical Panel (2004) identified both, the regulatory environment along with human resources and communication as barriers to implementing adaptive management. They found that current permitting requirements for threatened and endangered species, water quality, flows and flow regimes, and floodway management and conveyance do not allow the design flexibility and speed of response required for adaptive management. To overcome this constraint the Panel recommended that, regulatory exemptions or special status need to be negotiated for innovative and creative approaches to adaptive management. The Panel also identified the need for specialized staffs to design and implement adaptive management experiments, analyze and share the results of monitoring programs, and effectively communicate lessons learned. The Panel recommended recruiting specialized staff for these purposes as a means for overcoming this barrier.

CALFED's struggle to implement its adaptive management strategies is not uncommon. Walters (2007) concluded that nearly all 100 adaptive management efforts examined worldwide failed to implement adaptive management. Three main factors contributing to the widespread implementation difficulties in adaptive management programs were identified: 1) failure of decision makers to understand why adaptive management programs are needed, 2) lack of leadership for the complex process of implementing an adaptive approach, and 3) inadequate funding for the increased ecological (and often economic) monitoring needed to successfully compare the outcomes of alternative polices (Walters 2007). To overcome each of these barriers, Walters (2007) recommends identifying and nurturing adaptive management leaders dedicated to successful implementation, creatively investing in innovative monitoring programs, and forcing decision makers to confront uncertainty and think carefully about how to reduce risks in decision making under conditions of uncertainty.

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To be effective, governance to support and implement adaptive management in the Delta must be flexible and have the capability to make timely changes to policies and practices in response to what is learned over time (e.g., the Delta Plan adaptive management approach described in Chapter 2). Governance for adaptive management should provide a decision-making structure that fosters communication among scientific experts, independent scientific reviewers, the relevant decision making authorities (e.g., state and federal fisheries agencies on issues related to aquatic ecosystem restoration) and a balanced approach to the involvement of interested stakeholders.

A Three-phase and Nine-step Adaptive Management Framework

The Council will use the three-phase and nine-step adaptive management framework in Figure A-1 that is described in detail below. The Council will use this framework to evaluate the usefulness of adaptive management for reviewing proposed covered actions involving ecosystem restoration and water management along with developing, implementing, and updating the Delta Plan (See Chapter 2). Ecosystem restoration and water management covered actions should include an adaptive management plan that considers all nine steps of this framework; however, they need not be rigidly included and implemented in the order described here and should not be used as a means to prevent action, but rather as a tool to enhance decision making. The intent is to build logical and clear information exchange and decision points into management actions that increase options and improve outcomes. In developing an adaptive management plan, the best available science should be used to inform the various steps of the adaptive management process.

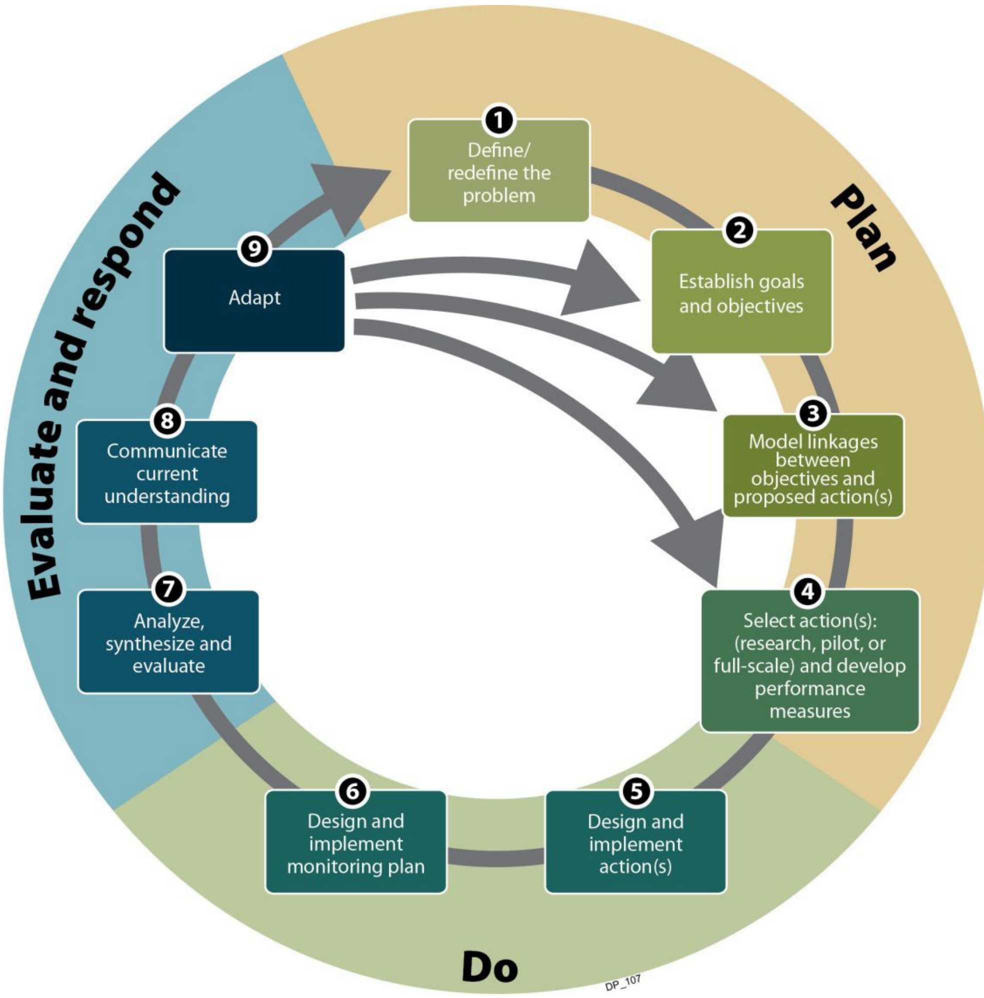


Figure A-1
A Nine-step Adaptive Management Framework
The shading represents the three broad phases of adaptive management (Plan, Do, and Evaluate and Respond), and the boxes represent the nine steps within the adaptive management framework. The circular arrow represents the general sequence of steps. The additional arrows indicate possible next steps for adapting (for example, revising the selected action based on what has been learned). This framework and the description of each step are largely derived from Stanford and Poole (1996), CALFED Bay-Delta Program (2000), Abal et al. (2005), and the Bay Delta Conservation Plan Independent Science Advisors on Adaptive Management (2009).

Plan

The *Plan* phase of the adaptive management framework is presented as four steps.

1. Define/Redefine the Problem

The first step of effective adaptive management is to clearly define the problems that will be addressed in the form of a problem statement. The problem statement should clearly link to program goals and to specific objectives, which should be developed by proponents in an open manner. The boundaries of the problem (e.g., its geographic and temporal scales) should be defined in the problem statement.

2. Establish Goals and Objectives

Clear goals and objectives must be established by proponents of proposed covered actions for ecosystem restoration and water management and be based on the best available science (See GP 1 in Chapter 2). Goals are broad statements that propose general solutions. Objectives are more specific than goals, and are often quantitative, specific narrative statements of desired outcomes allowing evaluation of how well the objectives are being achieved.

3. Model Linkages between Objectives and Proposed Action(s)

Models formalize and apply current scientific understanding, develop expectations, assess the likelihood of success, and identify tradeoffs associated with different management actions. Models can be conceptual, statistical, physical, decision support, or simulation. Models link the objectives to the proposed actions and clarify why an intended action is expected to result in meeting its objectives. Models provide a road map for testing hypotheses through statements that describe the expected outcome of an action.

Both qualitative (conceptual) and quantitative models can effectively link objectives and proposed actions by illuminating if and how different actions meet specific objectives. Conceptual models are particularly useful for decision makers, scientists, and the public because they illustrate the most critical cause-and-effect pathways. Conceptual models provide an articulation of the hypotheses being tested and how various actions might achieve particular objectives. Conceptual models also help to develop performance measures, which are qualitative or quantitative information that tracks status and trends toward meeting objectives. Conceptual models should be used in adaptive management planning because they help explain how other types of models, research, and actions will be used to explore hypotheses and address specific existing and anticipated uncertainties.

Recent conceptual models developed specifically for the Delta include comprehensive models developed as part of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). The DRERIP models were designed to aid in the identification and evaluation of ecosystem restoration actions in the Delta, and include both ecosystem models (processes, habitats, and stressors) and species life history models. Another set of conceptual models was developed to plan the IEP's Pelagic Organism Decline (POD) investigations and to synthesize the POD results into "stories" about what may have happened to cause the rapid decline of multiple open-water fish species.

4. Select Action(s) (Research, Pilot, or Full-scale) and Develop Performance Measures

The process for selecting an action or several actions to meet objectives includes an evaluation of the best available science represented in the conceptual model. This evaluation should guide development of the action. Consideration should be given to the following:

- Level of the action(s) to be taken (research, pilot-scale project, or full-scale project)
- Geographical and temporal scale of the action(s)
- Degree of confidence in the benefits
- Consequences of being wrong

The scale of the action selected should be informed by the certainty of the relevant scientific information, consider the reversibility of the action, and account for the potential cost of delaying larger-scale actions. For example, when the best available science cannot predict the outcome of an action with a reasonable degree of certainty, and irreversible consequences exist for incorrectly predicting the outcomes of an action, further research or a pilot-scale action is likely more appropriate than a full-scale action, unless the cost of delaying a larger-scale action is very high (for example, a species of concern goes extinct or urban water supplies are cut off). In some instances, choosing to take no action could be the best selection (when no foreseen benefit would result from a research, pilot-scale, or full-scale action). Where possible, the action(s) selected should test cause-and-effect relationships in the conceptual model so that the model can be adapted using the information learned from implementing the action(s).

Performance measures derive from goals and objectives, and help to address the status and trends of progress toward achieving the goals and objectives. Performance measures can be placed in three general classes:

- Administrative: performance measures that describe decisions made by policy makers and managers to finalize plans or approve resources (funds, personnel, projects) for implementation of a program or group of related programs
- Output (also known as driver): performance measures that evaluate factors that may be influencing outcomes and include on-the-ground implementation and management actions
- Outcome: performance measures that evaluate ecosystem responses to management actions or natural outputs

The distinction between performance measure types is not rigid. In some cases, an outcome performance measure for one purpose may become an output performance measure for another purpose.

Development of informative performance measures is a challenging task. Performance measures must be designed to capture important trends and to address whether specific actions are producing expected results. Performance measures are selected based on the conceptual model. In addition the monitoring plan should be designed so that the information collected supports performance measure analysis and reporting.

Efforts to develop performance measures in complex and large-scale systems with many ecosystem types like the Delta are commonly multi-year endeavors; however, initial performance measures provide value for initial assessments of progress made in the interim. The process for developing performance measures should address the rationale for each performance measure, metrics, method for analysis, baseline and reference conditions, expected outcomes, timeline for evaluation, and a communication/visualization element. The development of performance measures should be informed by the best available science and involve key stakeholders.

Do

The *Do* phase of adaptive management includes two steps that occur in parallel.

5. Design and Implement Action(s)

The design and implementation of action(s) include clearly describing specific activities that will occur under the selected action(s) and how they will link to the monitoring plan. Design includes creating a plan for implementing the action(s) and monitoring responses resulting from the action(s). The design of the action(s) should be informed by existing uncertainties, and should be directly linked to meeting the goals and objectives.

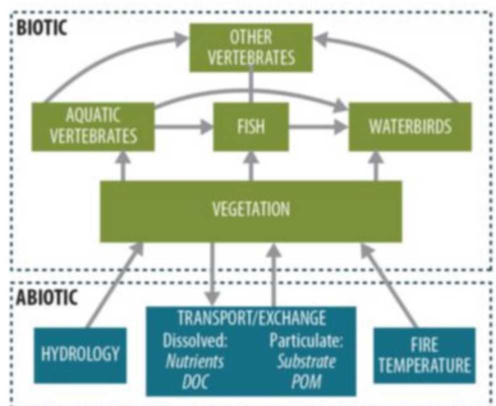
KISSIMMEE RIVER RESTORATION PROJECT

The Kissimmee River Restoration Project uses an adaptive management process that provides a positive example of adaptive management in practice. The project thoughtfully modeled linkages between objectives and proposed action(s) and successfully designed and implemented a comprehensive monitoring plan with clear and quantifiable expectations. As a result, the intended goals of the restoration effort are being met and documented. South Florida Water Management District Executive Director Melissa Meeker, who oversees the restoration project has reported that, "The abundant wildlife now seen along the Kissimmee is a powerful indicator of the benefits of long-term investments in restoration. The District's documentation of these improvements provides us and our restoration partners—as well as the public—with critical insights into the ecosystem's ongoing recovery."[1]

Environmental monitoring conducted since completing phase one of restoration construction (backfilling the canal and reconnecting and recarving river channels) in 2001 has resulted in the following indicators of success as of February 2012:

- The number of wading birds observed increased by 64 percent. Three species long-absent from the river are now documented regularly.
- Shorebird species commonly observed jumped from 2 to 11.
- Waterfowl sightings increased dramatically—by 29 times compared to pre-restoration sightings.
- Wetland vegetation, which once covered only 37 percent of the Phase I restoration area prior to construction, has fully achieved the restoration target of 80 percent coverage.

February 9, 2001, photo of implemented phase one Kissimmee River Restoration Project showing the backfilled canal, degraded soil area, remnant river channel, the connector channel, and wetland areas.



General conceptual model of ecosystem structure and interactions for the Kissimmee River and floodplain (Dahm et al. 1995)

These results suggest that after construction is complete in 2014 and hydrologic conditions are fully restored in 2015, the region is on track to achieve its goal of restored ecological integrity in the Kissimmee River and its floodplain. In the 1960s, the Kissimmee River, located in south-central Florida, was channelized for flood-control purposes (Toth et al. 1998). In the 1990s, planning began for a 15-year restoration project. The restoration design included 70 km of river channel and 104 km^2 of floodplain—the largest attempted river restoration project in the world (Dahm et al. 1995). Adaptive research, monitoring, and evaluation programs were developed to provide a scientific foundation for fine-tuning each phase of the restoration effort (Toth et al. 1998). To "model linkages between objectives and proposed action(s)," conceptual models were developed to anticipate the restored Kissimmee River ecosystem, predict patterns of response for abiotic and biotic variables, and consider methods and performance measures for evaluating progress toward restoration in the river basin (Dahm et al. 1995).

The Kissimmee River Restoration Evaluation Program (KRREP) provides a practical example of the "design and implementation of a monitoring plan" step used in adaptive management. The KRREP is a comprehensive monitoring program designed to evaluate ecosystem responses to the restoration project through comprehensive monitoring and assessment of data collected before and after major construction phases (South Florida Water Management District 2011). If the KRREP determines that changes in the river and floodplain ecosystems after construction are not achieving expected results, adaptive management strategies are considered for implementation. More information about the Kissimmee River Restoration Project is available on the program web site:
http://my.sfwmd.gov/portal/page/portal/xweb%20protecting%20and%20restoring/kissimmee%20river.

[1] http://www.sfwmd.gov/portal/pls/portal/docs/16721677.PDF (Accessed 03/02/2012)

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6. Design and Implement Monitoring Plan

A well-designed monitoring plan includes a data management plan. A data management plan describes the process for organizing and clearly documenting observations, including how data are collected; the methods, quality assurance, and calculations used; the time and space scales of the variables; and accurate site locations and characteristics. Data management is critical for analyses, syntheses, and evaluations.

A well-designed monitoring plan goes beyond data collection and data management. A monitoring plan often includes targeted research to answer why certain results are observed and others are not. A monitoring plan also includes clear communication of the information gathered and current understanding drawn from this information. A complete monitoring plan includes:

- Compliance monitoring (required by permits)
- Performance monitoring with pre-project monitoring (measuring achievement of targets)
- Mechanistic monitoring with concurrent targeted research (testing the understanding of linkages in the conceptual model)
- System-level monitoring (holistic, integrative and long term)

These types of monitoring can measure and communicate various types of information, including administrative/inputs (such as dollars awarded and spent or projects funded), compliance/outputs (such as tons of gravel added or acres exposed to tidal action), and effectiveness/outcomes (such as actual outcome expected from implementing an action at the local scale, suites of actions at the system-wide scales, and status and trends assessments). The monitoring plan design must include the development of monitoring metrics that can be integrated and summarized to inform decision makers and the public as described in step eight, *Communicate Current Understanding*.

Monitoring plan design requires making tradeoffs between resources spent on monitoring and resources spent on actions and analyses. To aid in this evaluation of tradeoffs, a rigorous pre-analysis using simulation models can show the information value of different variables that might be monitored. These values assessments can then be used to compare the benefits from monitoring certain variables against the benefit of using resources for other actions.

Implementation of actions and monitoring should be closely coordinated. Before an action is implemented, initial conditions should be clearly documented to the extent practical so that a baseline is established. Baseline data includes characterization of natural variation observed in the examined system over space and time. For many ecological and hydrological variables, an extensive set of baseline data is available because of the efforts of the Interagency Ecological Program and repositories of information such as those available from the U.S. Geological Survey and the California Department of Water Resources. The implementation of action(s) and monitoring should be clearly executed and communicated to the public. Status and trends metrics that compare conditions before and after action implementation are often good assessment and communication tools.

Evaluate and Respond

The *Evaluate and respond* phase of adaptive management includes three key steps.

7. Analyze, Synthesize, and Evaluate

Analysis, synthesis, and evaluation of the action(s) and monitoring are critical for improving current understanding. Analysis and synthesis should incorporate information on how conditions have changed, expectedly and unexpectedly, as a result of implementing the action(s). Because measurable change might not occur on short timescales, evaluations should also examine whether actions prevented further deteriorating conditions that would have occurred if no actions were taken. The evaluation should examine whether performance measures indicate that one or more of the objectives have been met as a result of the implemented action(s), and if so, why. If an objective is not met, the potential reasons why it was not met should be clearly identified and communicated. Analyses should be cumulative. As each year's data becomes available, analyses should assess whether the probability of the desired outcome has changed and, if so, how this affects decisions about the action. The results of the analysis, synthesis, and evaluation step could be published in technical peer-reviewed papers and reports for the purpose of external review, disclosure, and accessibility where results warrant this level of communication. Scientists and technical experts will be critical for carrying out this step.

8. Communicate Current Understanding

Communication of current understanding gained through analysis, synthesis, and evaluation of implemented action(s) and monitoring is a key step for informing and equipping policy makers, managers, stakeholders, and the public to appropriately respond and adapt. This step spans the *Do* and the *Evaluate and respond* phase of adaptive management because the communication of current understanding and related recommendations for change requires both policy and technical expertise. The information communicated should be technically sound, well synthesized, and translated into formats conducive to informing a nontechnical audience (e.g., a report card format or a general science outlet such as a newsletter). The information should then be disseminated to those directly involved in the adaptive management process for the plan, program, or project and to those interested in the outcome of the action.

Technical staff and decision makers should be regularly involved in the exchange of information as data are analyzed and synthesized. Communication should be ongoing and occur at appropriate intervals at which an improved understanding could help refine other steps of the adaptive management framework.

The key to successful communication is a skilled and dedicated interdisciplinary person or team who understands the technical information learned, the functional needs of the decision makers, and how to best transmit this information. Communication should utilize various media (e.g., web-based materials, social media, outreach opportunities, public forums, etc.) and strive to meet the goals of transparency and clarity.

9. Adapt

Proponents of covered actions for ecosystem restoration and water management should be engaged and prepared to adapt to changes in current understanding and changes in current conditions (e.g., environmental or socio-economic). Informed and equipped with new results and understanding, decision makers should reexamine the other steps of the adaptive management framework and revise these steps where current understanding suggests doing so. Possible next steps could include redefining the problem statement, amending goals and objectives, altering the conceptual model, or selecting an alternative action for design and implementation. Also, decisions to adapt might be needed at various time intervals for the same adaptive management experiment. For example, decisions might need to be made daily (e.g., Delta water operations), yearly (e.g., implementation of landscape-scale restoration), or decadal (adaptive management of landscape-scaled restoration design).

Knowing when to adapt is not always obvious. Adaptive management actions should have a planned time frame that includes when to adapt (based on understandings of the system and its uncertainties), and that time frame should be abandoned only if the results show that the action is doing more harm than good or the anticipated benefit is not noted within a reasonable timeframe beyond what was expected. In general, one year's results, however anomalous, are seldom enough to demonstrate that the action should be subject to adaptive measures. Furthermore, when the analysis, synthesis, and evaluation of information learned from implementing an action indicates that no benefit results from the undertaken action, resources should no longer be spent on that action no matter how popular the action might be.

HEALTHY WATERWAYS

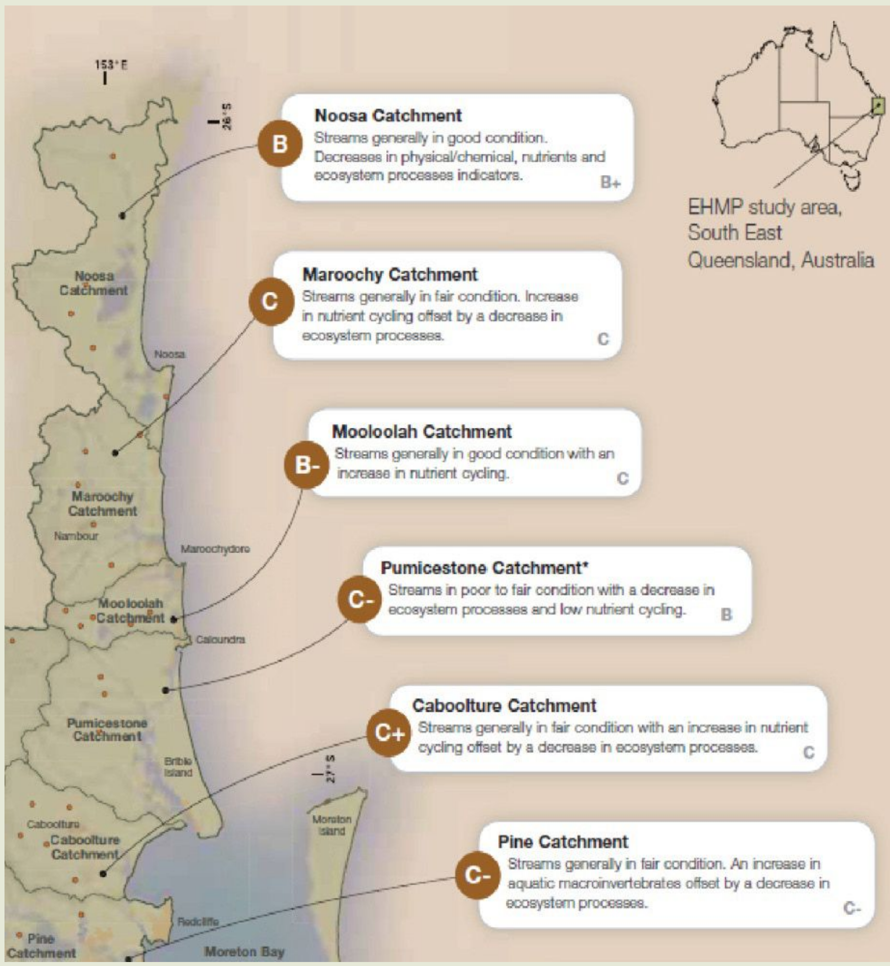
In South East Queensland, Australia, Healthy Waterways is an organization using an adaptive management process that provides a positive example of adaptive management that might be practiced for the Sacramento–San Joaquin Delta. Healthy Waterways has excelled at two specific steps of adaptive management: "communicate current understanding" and "adapt." Achievements of the Healthy Waterways Partnership to date include an extensive public awareness and education program, urban stormwater or catchment management plans for all major catchments in South East Queensland, and local and state government investment in upgrading 25 wastewater treatment plants leading to about a 40 percent reduction in nitrogen load to waterways.

Healthy Waterways has collaborative partnerships and works to improve the health of waterways, catchment, and ecosystems that support the livelihoods and lifestyles of the region's people. An adaptive management framework developed by Healthy Waterways' partners has served as the operating philosophy and cornerstone of program implementation for over a decade.

Healthy Waterways' practice of adaptive management has led to improved understanding about how to deal with resource management issues and the flexibility necessary for changing socioeconomic and socioecological relationships occurring in South East Queensland (Abal et al. 2005).

Healthy Waterways' communication of current understanding is facilitated through a commitment to public education and outreach, annual public report cards, and the use of leading technology to analyze, interpret, and communicate information through the health-e-waterways dynamic report cards (http://www.health-e-waterways.org/). These communication efforts have led to adapting management actions based on current ecosystem understanding; these actions are subsequently evaluated in annual report cards.

Details about Healthy Waterways and its adaptive management elements are available at www.healthywaterways.org.



Healthy Waterways 2010 Annual Report Card Sample
(2010 grades are brown, 2009 grades are gray)

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Decisions made within the adaptive management process for ecosystem restoration and water management actions should be made by decision makers for the entity responsible for implementing adaptive management. Adaptive management decisions relevant to revising and updating the Delta Plan will be made by the Council.

References

Abal, E. G., S. E. Bunn, and W. C. Dennison, editors. 2005. Healthy Waterways Healthy Catchments: Making the Connection in South East Queensland, Australia. Moreton Bay Waterways and Catchments Partnership, Brisbane. p. 240.

Adaptive Management Forum Scientific and Technical Panel. 2004. Final Report: Adaptive Management Forum for Large-Scale Channel and Riverine Habitat Restoration Projects. p46. Available from http://www.fws.gov/stockton/afrp/documents/AMF_%20FINAL_REV5.pdf. Accessed March 2012.

Bay Delta Conservation Plan Independent Science Advisors on Adaptive Management. 2009. Bay Delta Conservation Plan Independent Science Advisor's Report on Adaptive Management. Page 14. http://www.bdcpweb.com/Libraries/Background_Documents/BDCP_Adaptive_Management_ISA_report_Final.sflb.ashx. Accessed May 2011.

CALFED Bay-Delta Program. 2000. Ecosystem Restoration Program Plan: Strategic Plan for Ecosystem Restoration. CALFED Bay-Delta Program: Sacramento, CA. 75 pp.

Dahm, C. N., K. W. Cummins, H. M. Valett, and R. L. Coleman. 1995. An ecosystem view of the restoration of the Kissimmee River. Restoration Ecology 3: 225–238.

Healey, M. 2008. Science in policy development for the Bay-Delta. Page 174 in M. C. Healey, M. D. Dettinger, and R. B. Norgaard, editors. The State of Bay-Delta Science 2008. CALFED Science Program: Sacramento, CA.

Healey, M., M. Dettinger, and R. Norgaard, editors. 2008. The State of Bay-Delta Science 2008. CALFED Science Program: Sacramento, CA.

McGarvey, D. J. 2007. Merging precaution with sound science under the Endangered Species Act. Bioscience 57: 65-70.

Meffe, G. K., P. R. Boersma, D. D. Murphy, B. R. Noon, H. R. Pulliam, M. E. Soule, and D. M. Waller. 1998. Independent scientific review in natural resource management. Conservation Biology 12: 268-270.

National Research Council, Committee on Defining the Best Scientific Information Available for Fisheries Management. 2004. Improving the use of "Best Scientific Information Available" Standard in Fisheries Management. National Academy Press, Washington D.C. Available from http://www.nap.edu/catalog.php?record_id=11045#toc. Accessed June 2011.

National Research Council. 2010. A scientific assessment of alternatives for reducing water management effects on threatened and endangered fishes in California's Bay Delta. National Academies Press. Washington, D.C. Available from http://www.nap.edu/catalog.php?record_id=12881. Accessed November 2011.

Ryder, D. S., M. Tomlinson, B. Gawne, and G. E. Likens. 2010. Defining and using "best available science": a policy conundrum for the management of aquatic ecosystems. Marine and Freshwater Research 61: 821-828.

South Florida Water Management District. "Kissimmee River." Retrieved 05/06/2011, from http://www.sfwmd.gov/portal/page/portal/xweb%20protecting%20and%20restoring/kissimmee%20river. Accessed June 2011.

Stanford, J. A., and G. C. Poole. 1996. A protocol for ecosystem management. Ecological Applications 6:741-744.

Sullivan, P. J., J. M. Acheson, P. L. Angermeier, T. Faast, J. Flemma, C. M. Jones, E. E. Knudsen, T. J. Minello, D. H. Secor, R. Wunderlich, and B. A. Zanetell. 2006. Defining and implementing best available science for fisheries and environmental science, policy, and management. American Fisheries Society, Bethesda, Maryland, and Estuarine Research Federation, Port Republic, Maryland. Available at http://www.fisheries.org/afs/docs/policy_science.pdf. Accessed June 2011.

Toth, L. A., S. L. Melvin, D. A. Arrington, and J. Chamberlain. 1998. Hydrologic manipulations of the channelized Kissimmee river—Implications for restoration. Bioscience 48:757-764.

Walters, C. J. 2007. Is adaptive management helping to solve fisheries problems? Ambio 36:304-307.

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EXHIBIT 2

The following two tables list: (1) ongoing research and monitoring activities associated with, or relevant to, the BiOp RPAs in the Bay-Delta; and (2) anticipated near-term BDCP science needs. These tables do not reflect a comprehensive listing of all Bay-Delta research and monitoring activities. Rather, they are intended to add in identifying potential gaps and beginning to frame potential future needs for informing adaptive management and future operational decisions for BDCP.

Table 1 – Ongoing BiOp RPA, and other relevant Bay-Delta research and monitoring activity

Work Effort	Participants	Notes
1. South Delta Research Collaborative	Maria and Dale – co-leads DFW, FWS, DWR, NOAA Contractors consultants.	To bring together lead researchers and agency staff to review and discuss questions related to salmonid survival and hydrologic conditions in the south Delta, to discuss conceptual theories and the need for ongoing analyses of existing data sets, develop modeling-related tools, and discuss new management-driven research needs for experimental design to be implemented in spring 2014.
2. Delta Smelt Turbidity-Entrainment Prediction Tools	FWS (Mike, Matt, Jenn), John Rosenfeld, John Cain, Terry Erlywine, Dave Fullerton, Frances Brewster, DWR operations folks, NOAA as an observer.	Goal is to test and refine models to do a better job of predicting when turbidity in South Delta will be going up and reducing -OMR's in advance to minimize entrainment of DS adults into the south Delta. Resulted from early high entrainment in late 2012, and subsequent OMR restrictions of -2000.
3. FLASH (Fall and summer outflow)	IEP agencies (MAST team) DWR didn't participate due to litigation	Currently an IEP activity, study plan developed in summer 2011, and implemented in fall of 2011, ongoing, results of initial year were summarized and presented by the IEP MAST team. Initial study plan developed by FWS-BOR relying on IEP infrastructure but with opportunity (short) for outside input and a review by Delta Science Program panel. Will ultimately inform the need for fall X2 requirement in FWS DS BO, and or the decision tree for BDCP.
4. North Delta Screening Issues	Randal Neudeck (MWD), DFW, NOAA, DWR , FWS?, BOR?	Design and implement survival studies in the area of the new units to generate information on existing “baseline “ survivals across year types which will inform the application of the

		performance standards once testing and operations commence. Convene an independent science review workshop in 2012/2013 of fish screening experts to benefit from the range of experience in existing large screen projects in the United States. Consider multi-year staged construction and operation of screens over a test period to ensure performance standards are being achieved.
5. Salmon Life Cycle Model	NMFS – Southwest Fisheries Science Center	Ongoing life cycle model development.
6. Delta Smelt Life Cycle Modeling	Ken Newman and others	
7. Habitat-Foodweb Studies	No coherent overall organization	Current work is being conducted through BREACH III, by DWR, and through IEP discretionary projects selected through a PSP. FRPA (DWR/DFW) also is looking at developing monitoring approach for habitat restoration as is SFWCA for the Yolo Ranch. This all needs to be better coordinated.
8. Floodplain Studies	IEP, ERP	Work currently underway in the Yolo Bypass funded by IEP, ERP, BOR, and DWR, focused on synthesizing past studies and the Knaggs Ranch flooded rice fields. IEP currently has a work group focused on these studies. Much of this work contributes to BO requirements for Bypass fish enhancement, but also support CM2. There will also be work conducted by UC Davis in conjunction with TNC floodplain restoration work on the Consumnes and at McCormick Williamson.
9. Water Quality	IEP, RWQCB	IEP currently collects info for D-1641 compliance. RWQCB is currently developing Regional Monitoring Program for the Delta, which should cover much of what BDCP would be concerned about. IEP has funded some ammonia work through its PSP. Attention and emphasis could be improved. anything water quality related through the RMP requires coordination with, and involvement by Point Dischargers and the State and regional boards.

10. Existing Monitoring Programs	IEP, DSC, ERP	This is currently being done and coordinated among the agencies through IEP. Short coming currently is adequate input/participation from stakeholders. IEP currently charged with developing a more effective strategy for engagement along with a strategic plan. IEP at direction of Directors also looking at overall program priorities. PSPs could be better coordinated to focus on priority issues.
11. CASCaDE: Computational Assessments of Scenarios of Change for the Delta Ecosystem	USGS	Set of linked models to assess Delta ecosystem response to climate change. CASCaDE II refines and extends modeling capabilities to assess Delta ecosystem response to changes in climate and physical configuration.

Table 2 – Anticipated near-term BDCP science needs

1. Spring outflow studies	No focused effort underway	Key question for BDCP, nothing in place to formulate conceptual models or hypotheses to be tested.
2. Entrainment issues	No focused effort underway	May be addressed by South Delta Research Collaborative, and RPA's, but there are questions in BDCP south Delta operations around green and white sturgeon that resulted in more protective south delta operational requirements in CS5 that are included in the current revised proposed project. North Delta Bypass flows could also be included in this related to Sacramento juvenile salmon migration into the central delta.
3. Predation	No coherent overall organization	DWR and NOAA using the Southwest Science center have developed a proposed study for south Delta, some coordination with DFW, funding hasn't been secured. NOAA SW Science Center is currently implementing predation studies at Sac. Freeport diversion and upstream on the Sacramento. DFW working with DSP, NOAA, DWR, FWS is developing a predation workshop to assess the state of current understanding and provide guidance for future studies and methods for evaluating effectiveness. Once a draft charge to the Panel is developed it will be released to broader stakeholder community for input before convening the workshop. DFW also through the stripper settlement with Kern water interests is on the hook for funding $1 million in predation studies, we hope that those will be instituted following the workshop, but plaintiffs may not agree. There is a Technical Panel, (Marty Gingras, Pat Coulston, Jim Anderson, Chuck Hansen, and Dennis Murphy) who would develop a charge and select projects/studies.
4. Habitat Monitoring	No focused effort underway	Develop standardized protocols for monitoring different habitat restoration efforts.

EXHIBIT 3

NOAA's National Marines Fisheries Service's (NMFS) Timeline for a Three-year Extension to the Schedule for Completion of the Remanded Biological Opinion on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Pursuant to the Court's Order Re Motion to Extend Remand Schedule

Description	Target Dates
Collaborative Science Development and Implementation	
Year 1 Science - Form CAMT and develop key questions and experimental designs	January 1, 2014
Year 2 Science – Implementation, analysis, and reporting	June 30, 2015
Year 3 Science – Implementation, analysis, and reporting	June 30, 2016
Reclamation Section 7 Consultation Package *	
Integrate Life Cycle Model from NMFS-Southwest Fisheries Science Center, as available, into consultation package	December 31, 2015
Integrate Year 2 Science Report, as available, into the consultation package	December 31, 2015
Prepare and submit final consultation package to NMFS	December 31, 2015
NMFS Biological Opinion	
Complete new effects analysis for all geographic Divisions for Biological Opinion (BiOp) as informed by new consultation package and Year 3 Science Report	July 18, 2016
Complete species specific analysis and integration and synthesis for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, Southern Distinct Population Segment of North American green sturgeon, and Southern Resident killer whales	January 22, 2017

NOAA's National Marines Fisheries Service's (NMFS) Timeline for a Three-year Extension to the Schedule for Completion of the Remanded Biological Opinion on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Pursuant to the Court's Order Re Motion to Extend Remand Schedule

Complete incidental take statement	May 14, 2017
Complete section 7 review and clearance process of the staff draft BiOp	September 29, 2017
Issue draft BiOp to Reclamation and to independent scientific peer review	October 1, 2017
Complete independent scientific peer review	March 25, 2018
Revise BiOp following the receipt and incorporation/consideration of comments from Reclamation and recommendations from the independent scientific peer review and integrate new science as available	September 14, 2018
Complete section 7 review and clearance process of the Revised BiOp	January 30, 2019
Issue final BiOp	February 1, 2019

*Consultation package could consist of a biological assessment or some other format.

EXHIBIT 4

Results of Joint Stipulation Agreement on South Delta Operations for 2012
June 4, 2012

BACKGROUND: In January 2012, Public Water Agencies (PWA), State of California and Federal agencies filed a joint stipulation regarding project operations during April and May 2012 in the litigation relating to the Biological Opinion (BiOp) on long-term operations of the State Water Project and Central Valley Project (the Projects) issued by NOAA's National Marine Fisheries Service (NMFS). The parties stipulated that, if a rock barrier were installed at the head of Old River, the SWP and CVP would operate within an adaptive range of Old and Middle River (OMR) flows in lieu of operating to the inflow:export ratio specified in the Reasonable and Prudent Alternative (RPA) of the NMFS BiOp.

The objectives of the joint stipulation were (1) to provide minimum protections for out-migrating juvenile steelhead by managing flow conditions in the Delta in a manner expected to allow salmonids to successfully exit the Delta; (2) attempting to increase water exports consistent with (1), above; and (3) generating real-time tracking information to better understand how pumping rates, flows in Old and Middle River and juvenile migrations relate to one another. In addition to installing a rock barrier, the stipulation called for OMR flows to be managed at an adaptive range between -1,250 and -3,500 cubic feet per second (cfs) during April, and between -1,250 and -5,000 cfs during May. Export levels would be adjusted to ensure adequate protection was afforded to out-migrating steelhead.

THE PROCESS: A planning committee, comprised of representatives from the Federal and State agencies, as well as technical experts from non-governmental organizations and the PWA, was involved in two workshops (an acoustic tag workshop on February 3, 2012, and a technical workshop on OMR management on February 7, 2012), and subsequent discussions regarding the design of the acoustic tag experimental study and potential triggers for OMR management during spring 2012. This resulted in two approaches for managing OMR flows for the protection of San Joaquin basin steelhead: one based a method using the particle tracking model (PTM) for the period April 1-15, and another based on in-season monitoring of acoustically-tagged steelhead for the period April 16-May 31.

The acoustically-tagged sentinel steelhead experiment was the first of its kind to study the fine scale movements of acoustically-tagged steelhead within and throughout the Delta, and to utilize some of the data to inform in-season management and water operations. Receivers to monitor the sentinel steelhead migration were established at a location specifically selected as an indication that the steelhead were migrating toward the pumps. This spot in the southern Delta is known as Railroad Cut. The reason why PTM was used for April 1-15, 2012, was that the experiment with tagged fish was delayed two weeks due to an unanticipated equipment requisition problem.

Real-time operations were then carried out by weekly and/or daily decision-making for April and May, 2012. On Monday afternoon of each week, the Delta Conditions Team (DCT), was convened by California's Department of Water Resources (DWR), to provide any information to assist the Delta Operations for Salmonids and Sturgeon (DOSS) technical group in evaluating the potential effects of planned water operations. On Tuesday morning of each week, the DOSS group, consisting of technical staff from all relevant Federal and State agencies, met to advise the Water Operations Management Team (WOMT) and NMFS. The WOMT then met Tuesday afternoon of each week, and consisted of management representatives from all relevant Federal and State agencies. NMFS then made the final determinations on OMR flows shortly thereafter and explained them in writing and posted them on the NMFS' website.

RESULTS: The overall results included a modest increase in water exports of approximately 57,000 acre feet over what would have occurred under the NMFS BiOp, significantly improved real-time tracking of migration patterns of the juveniles over the course of differing flow and pumping regimes, and higher than expected straying of juvenile steelhead into the south Delta.

The original determination for the acoustic study period was to manage OMR flows in real-time through constant monitoring of sentinel acoustically-tagged steelhead under experimental flows of -3500 cubic feet per second (cfs) from April 16-30, -1250 cfs from May 1-15 and -5000 cfs from May 16-31. The first set of 166 tagged fish was released into the San Joaquin River on April 15-16. Four days later, 13 tags had been detected by the receivers which surpassed the trigger of 9 set by NMFS. Therefore, OMR flows were required to be reduced to -1250 cfs from April 22-30, 2012. All total for the two-week period, over 30% of the tags (49) were detected as heading toward the southern Delta, not downstream toward the San Francisco Bay.

In response, DWR and the PWA proposed raising the trigger number and switching the experimental periods for May, so that May 1-15 would operate OMR at -5000 cfs and May 16-31 would be -1250 cfs. DOSS and NMFS agreed to the following operations: the switch in experimental OMR flows; a new trigger set at 24 fish, based on data from the first experimental period and adjustments to the mortality rate in the calculation of the trigger number; operating at the experimental OMR flow for at least 5 days, even if the trigger was met; and limiting the action response of OMR at -1,250 cfs to 5 days before OMR can resume to the initial experimental flow. The second set of 167 acoustically-tagged steelhead were released on May 1-2. By May 4, the newly raised trigger was met and OMR flows were again reduced to -1250 cfs from May 8-12, 2012. For this period, over 30% of the tags (51) in total were detected as heading toward the southern Delta, not downstream toward the San Francisco Bay.

Due to the high number of tags detected and other regulatory constraints (i.e., State Water Board), the Projects were not able to implement the higher (more negative) OMR flows within the allowable range set out in the study design. Therefore, in consideration of information provided by members of the DCT, and DOSS advice, the Federal and State agencies came up with a proposal that created the greatest experimental value for the acoustic study while still maintaining minimum protections for steelhead. The result was increasing the trigger number again to 31 (based on further adjustments to the mortality rate in the calculation of the trigger number), operating to an OMR of -5,000 cfs from May 16-20, even if the new trigger was surpassed, and if the trigger was exceeded, reducing flows to -1250 cfs for five consecutive days beginning as soon as possible after May 20. The third and final set of 167 acoustically-tagged steelhead was then released on May 15-16. By May 21, the new trigger was met. OMR flows were then reduced to -1250 cfs from May 23-28. Overall, over 25% of the tags (42) were detected as heading toward the southern Delta, not downstream toward the San Francisco Bay.

LESSONS LEARNED: The joint stipulation originated as a direct and substantial response to the OCAP litigation and desire for a new approach to OMR operations and management. All parties believed this was a substantial good faith effort to find a better way to achieve operations that provided for salmonid survival, improve water supply and generate more precise information relating pumping operations and juvenile migration patterns. The process allowed for real-time adaptive management and was transparent, inclusive and scientifically supportable. The result was the development of an enhanced system to track and monitor juvenile fish migrating through and out of the Delta to improve an understanding of the rate steelhead are moving through South Delta channels and the responses of the fish to various levels of flows and pumping.

A sizable portion of the tagged fish, more than expected, turned into the southern Delta under all conditions. While the results were not what were predicted, this process and information it generates should allow the parties to refine operating parameters over time to meet both juvenile survival and water supply objectives more efficiently.

While the full analysis and conclusions of the acoustic study is still ongoing, there are a few facts and observations that are worth noting:

- All total, water exports were higher under the stipulation by greater than 57,000 acre feet compared to operations under the San Joaquin flow to export ratio in the BiOp;
- For the experimental period of April 15-May 31, NMFS determinations and real-time management allowed for 21 days of OMR flows at -5000cfs, 19 days at -1250cfs and 6 days at -3500cfs;
- In actuality, however, water exports were actually controlled by restrictions imposed by the State Water Board almost half of that time and operations did not occur at the above levels;
- Work will continue this summer, per the stipulation, on efforts to learn more about the fine-scale movement of steelhead throughout the wider delta; and
- The NMFS BiOp RPA has been in effect for over 3 years now and, while it's too early to make conclusions, the early salmon counts for 2012 show an increase in adult escapement and more fish returning to the system.
- The export levels were adjusted to ensure adequate protection was afforded to out-migrating steelhead.

NEXT STEPS: The parties continue to analyze and discuss the results of the spring acoustic study and are working on the remaining parts of the stipulation, including summer studies and habitat restoration. NMFS expects that the data from the acoustic study, in combination with results from other experimental studies, can be used to evaluate some of the many assumptions that were used this year and inform management approaches for operations in 2013.

EXHIBIT 5

DRAFT 092912
LESSONS LEARNED FROM 2012 APRIL-MAY OPERATIONS
September 25, 2012 - MEETING SUMMARY

ATTENDEES
DWR – Dale Hoffman-Floerke, John Leahigh, Mike Ford, Andy Chu, Tracy Pettit, Kathy Kelly, Kevin Reece, Heidi Rooks, James Gleim
FWS: Roger Guinee, Leigh Bartoo, Erin Gleason, Victoria Poage
NMFS: Maria Rea, Barb Byrne, Garwin Yip, Ryan Wulff, Jane Freeman, Mike Schiewe (contractor)
Reclamation: Paul Fujitani, Josh Israel, Liz Kiteck
DFG: Jason Roberts
State Water Contractors: Curtis Creel,
San Luis-Delta Mendota Water Authority: Ara Azhderian
NRDC: Doug Obegi

MEETING OBJECTIVE/PURPOSE
NMFS and DWR co-led the meeting and explained that the purpose was to discuss lessons learned from 2012 April-May Water Operations and implementation of the Joint Stipulation. In addition to reflecting on lessons learned, the meeting would also focus on recommendations or goals for 2013, including the potential for a new joint stipulation or project, new collaborative science ideas and increased transparency. It was reiterated that NMFS and DWR wanted to get feedback from federal/state agencies and stakeholders to inform decisions on 2013. No decisions have yet been made, but the results of this meeting, and previous technical meetings on lessons learned, will inform those decisions. Regional leadership is expected to begin those discussions in early October.

LESSONS LEARNED
Reporting from Technical "lessons learned" meeting
NMFS gave a summary of the 9/12/2012 technical meeting that discussed this topic. The general consensus from that meeting was that the lack of time for preparation, planning and implementation caused significant logistical problems and challenges. One year would be preferable, with 6 months at the minimum, to effectively plan and implement a successful new study. In addition, due to the lack of time, the analysis from the 2012 tag detection study will not be able to address all study objectives.

Specifically, some of the major challenges with the study included:

- Staffing – Lack of time, in conjunction with the fact that many studies were going on in the region simultaneously, led to strain on resources (43 staff involved) and forced some individuals to work outside their area of expertise.
- Safety- Houseboat was boarded by state and federal officials because of proximity to the shipping channel. Wakes from large cargo ships ripped out the houseboat anchors. We can address this issue in the future but need time to plan appropriately.
- Tag and Receivers – Due to the quick turnaround time between funding and study implementation, equipment arrived only 24-36 hours before it needed to be used. This timing prevented testing of deployed receivers prior to the first release and added logistical challenges to the tagging process since tag programming time was very limited.
- Fish – Most hatcheries need 12-18 months advance notice for fish requests and require that you use all of the requested fish. The 2012 study used fish initially dedicated to other purposes.

In conclusion, it was noted that, in addition to adequate planning and preparation time, agreeing on a desired objective at the outset is imperative. You are likely to get a vastly different study design if your goal is operational flexibility than if your goal is aimed at understanding a specific mechanism (e.g. effect of flows on survival) relevant for long-term management of the species. Technical staff suggested spending a year to fully develop a study design, with explicit study questions/objectives

2012 Study Analysis
NMFS reported that a draft report will be disseminated in October, containing preliminary and partial results of the 2012 sentinel steelhead study analysis. It was emphasized that the report would focus on tag detection data at the Turner Cut junction and contain a few preliminary analyses on the direction the fish traveled in the Old and Middle River corridors under different OMR conditions. It was explained that there are some identified limitations that will need to be taken into consideration. These include the fact that 1)it is merely a preliminary look at one particular junction and subset of fish; 2) no predator filter has been applied yet; and 3) there is limited survival information in the interior delta because of a lack of dual receiver arrays.

In addition, it will take some time to thoroughly analyze the massive amount (over one million rows) of data as currently much of the data management has to be done manually. The good news is that we are starting to get a sense of the constraints for working with so much data and have started to discuss how we might be able to automate data selection from large data sets in order to help expedite analysis. It was also noted that the refinements in data analysis during the second phase of the analysis could results in a change in conclusions from this first report.

Because of the amount of data gathered, lots of decisions need to be made during data analysis that may affect results.. For example:

- Data limited to tag detections within 15 days of release;
- If a tag passes a receiver multiple times, we (depending on the analysis) used the last or first time it passed the receiver; and
- Averaging the period for flow conditions.

Process and Administrative Issues (DCT/DOSS/WOMT/Determinations)
Parties acknowledged that significant resources and time was spent last year on the process and administrative issues. Some expressed that it wasn't until implementation of the NMFS technical memorandum that they began to understand the ramifications of what was proposed. The NMFS briefing on the technical memorandum did a good job of explaining what was in it, but not how we arrived at those decisions. Others noted that this was in part due to the fact that, while the acoustic tagging and OMR workshops were very well-attended, the majority of the attendees did not contribute to the discussion or formulation of the technical memorandum. It was suggested that future proposals could be more structured (both in process and substance) so that the outcome is more predictable and collaborative. Others noted that implementation was further complicated by the adjustments that were made during April and May in response to preliminary data and operational constraints and that it might be worth designing a set of operations that is more proscriptive during April and May.it was consideration of water supply improvement that resulted in the frequent real-time adjustments to operations and the study design.

Some expressed the view that, while a forum for frank discussion was needed at a management level, there was some confusion over the way information was being transmitted and processed. The process from DCT to NMFS determination was very quick, but clunky. It was suggested that a flow chart that depicted how information is conveyed throughout the process could increase transparency and efficient communication. Some expressed the view, however, that they were not sure how you could actually streamline the process further. There was some confusion over the way information was being transmitted and processed. The delays we had in 2012 (partially resulting from elevation of issues beyond WOMT, internal deliberation and briefings, and clearance of NMFS determination letters for Rod's signature) would be inevitable in any process. It was suggested that Regional leadership/decision makers should participate in WOMT so that discussions and preliminary decisions at WOMT won't have to be elevated/brought to the directors.

Project Operations for Apr/May

Parties then discussed whether the management problem of staying out of litigation could be balanced with implementing a study that asks the right scientific questions, and, if so, could it be used for real-time operations? When trying to accomplish this in 2012, we may have placed too much emphasis on real-time operations and ended up shorting the science. It was suggested that future proposals should put more emphasis on the experiment versus reacting in a real-time manner. Other noted that the focus of real-time operations was to provide increased flexibility and that if you tightened up the study design it could improve the science but decrease the flexibility.

It was noted that it was unexpected by the technical folks that participated in developing the study design that so many fish would hit the trigger so fast. Others agreed and acknowledged that the preconceptions were very different than what actually occurred. Some parties expressed the view that another unexpected aspect of operations was the lack of extended operations at the originally specified ranges. It was noted that was partly due to unforeseen circumstances involving D-1641 requirements and coordination on San Joaquin tributary releases.

It was stated that managing expectations is important for everyone (weather, fish behavior, communications, etc.) and that the goal was to increase operational flexibility while still protecting fish. Unfortunately, the concurrence of many things at once added to confusion. It was suggested that in the future, more coordination between the Delta and upstream issues would help. Another recommendation was to have this integration happen both during the design of the study and during implementation. For example have subgroups (hydrology, biology and combined) meet regularly. Others expressed that some uncertainties might still exist (for example the Reclamation agreement that provides the option to access Merced water to help meet the Vernalis standard expires after 2013 and there might be new requirements from the SWRCB in the next few years)and a study design would need to be adjusted accordingly.

Goals/Recommendations for 2013

NMFS and DWR reiterated that no decision had yet been made but that high level talks would happen in early October. Some parties expressed that they would prefer a decision quickly so that we can start to work on the study design immediately based on the discussion today. In addition, some thought that there was a greater need for more management, policy and scientific integration in 2013, both before and after study design, to facilitate implementation and communication. Other recommended that we do not have enough time to do a good job in 2013 and will most likely face similar challenges to those faced in 2012. It was suggested that we operate under the Biological Opinions for 2013 and start planning now for a well-designed study in 2014. Others noted that there may be some logistical and other issues that arise between now and 2014 that would need to be addressed.

It was noted that the first thing that needs to be done, for 2013 or 2014 is to decide whether the primary objective is: real-time operations or testing a hypothesis that is relevant for long-term management of the species. Some parties expressed their preference for less real-time adaptive management and increased focus on the structure of the experiment and all possible scenarios (including D1641 and upstream issues) that may occur. Others noted that there were other studies going on in the region (e.g. 6-year telemetry study) and there may be a way to build off or utilize those ongoing efforts. Some parties recommended that before a decision was made, that all stakeholders get a chance to have a forum for frank discussion with Regional agency leadership.

NMFS and DWR thanked everyone for their comments, insight and participation and stated that a written summary would be sent around to all participants.

EXHIBIT 6

Report of the 2012 Delta Science Program Independent Review Panel (IRP) on the Long-term Operations Opinions (LOO) Annual Review

Prepared for: **Delta Science Program**

December 1, 2012

Panel Members:

James J. Anderson, Ph.D., University of Washington
James A Gore, Ph.D., (Panel Chair) University of Tampa
Ronald T. Kneib, Ph.D., (Lead Author), RTK Consulting Services & Univ. of GA (Senior Research Scientist Emeritus)
Mark S. Lorang, Ph.D., University of Montana
John M. Nestler, Ph.D., Fisheries and Environmental Services & USACE Engineer Research and Development Center (Retired)[1]
John Van Sickle, Ph.D., U.S. Environmental Protection Agency Western Ecology Division (Retired)

Scope and Intent of Review: This report represents findings and opinions of the Independent Review Panel (IRP) assembled by the Delta Science Program to inform the National Marine Fisheries Service (NMFS) and the U.S. Fish & Wildlife Service (USFWS) as to the efficacy of the water operations and regulatory actions prescribed by their respective Long-term Operations Opinions' (LOO) Reasonable and Prudent Alternative Actions (RPAs) as applied from October 1, 2011 through September, 30 2012 (Water Year 2012). This year's annual review focused primarily on implementation of NMFS's RPAs for Clear Creek (RPA Actions I.1.1 – I.1.6) and the Spring 2012 Delta Operations joint stipulation agreement for water operations and fisheries that was required to be executed in water year 2012 in lieu of NMFS's RPA Action IV.2.1.

After reviewing a required set of written documents (Appendix 1), the IRP convened at a public workshop in Sacramento, CA on 31 October - 1 November 2012. The first day of the 2-day workshop provided a forum for the IRP to consider updated information and new research findings and to discuss issues related to the application of RPA actions. On the second day the IRP deliberated in a private session beginning at 8:30 a.m. in order to prepare and present their initial findings at the public workshop at 2:00 p.m., after which there was an opportunity for agency representatives, members of the public and the IRP to comment and otherwise exchange impressions and information.

[1] Dr. Nestler will provide advice to the Panel on subjects relative to his expertise on eco-hydraulics and coupled hydrodynamics and fish behavior modeling. He is not tasked with written assignments for the report development.

Subsequent IRP communication and deliberations were conducted via email and conference call in the course of drafting this final report.

EXECUTIVE SUMMARY

The review panel appreciates the unique challenges and constraints faced by all of the agencies attempting to balance existing commitments and mandated coequal goals of (1) providing a reliable water supply for California and (2) protecting, restoring and enhancing the Delta ecosystem from which water resources are derived for a multitude of human uses. We continue to commend all of the agencies charged with this daunting task for their efforts to date as they strive to cooperate and integrate activities directed at achieving this goal within the context of persistent change in environmental and socioeconomic conditions.

The dry 2012 water year presented a greater challenge to achieving specific RPA targets than was the case in the previous year and confirmed concerns expressed in Anderson et al. (2011) that some physical targets may not be routinely achievable. After three years of operating under the RPA actions, observations are available for a small sampling of both wet and dry years. Although it still remains too early to make definitive assessments of long-term effects on listed species populations, signs linking specific RPA actions to improved conditions remain elusive. Nonetheless, as noted by the two previous OCAP IRPs, the current LOO IRP emphasizes the continued need to explicitly link the success or failure of meeting physical targets prescribed in the RPAs to the biological/ecological responses of the listed species.

The IRP was encouraged by a perceived movement toward research aimed at measuring the survival and behavior of fishes within a spatially-explicit landscape relevant to water operations. Inclusion of more ecological and behavioral responses of the fish populations or life stages targeted by the RPA actions continues to be recommended as multiple years of observations become available.

The regular evaluation of goals and objectives is as much a part of an adaptive management strategy as are decisions to alter actions when justified by novel observations and response data that deviate from expectations. It is not too soon to step back and consider whether the intentions of habitat restoration efforts are tracking toward expected outcomes. If positive effects on listed species are not detectable following a series of “good” water years in the future, concerns about the detectability of effects under less favorable conditions will persist.

Findings from recent research reported at the 2012 LOO Workshop corroborated previous expectations of nonconformity in behavior of salmonid smolts and passive particles within the context of water flows and routing through the Delta. Consequently,

the application of passive particle models as a means of adjusting water operations to protect out-migrating salmonid smolts in real-time is not recommended. The IPR encourages a shift in the water management paradigm to include a more fish centric behaviorally and ecologically based perspective.

The IRP appreciated the opportunity to concentrate on a focal subset of RPA actions this year but wondered about progress, biological responses and consequences in applying the many other prescribed actions within the watersheds. The inclusion of maps for geographic orientation to the portion of the system under discussion was helpful to a degree and appreciated, but still fell short of expectations.

Finally, the time allotted at the workshop for panel deliberations (5.0-5.5 hrs) on the second day was again much appreciated and provided adequate time for the IRP members to organize thoughts and reach some consensus prior to presenting preliminary findings in the afternoon. We continue to encourage a similar time allotment for deliberation by future panels.

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INTRODUCTION

The Sacramento-San Joaquin watersheds and Delta comprise a complex system of distributaries, reservoirs, human-engineered channels, levees and a mix of agricultural and urban areas that have replaced former wetlands and floodplains. Significant structural alterations of the ecosystem date back to the mid-nineteenth century. Many of the anthropogenic changes in the Delta and its upstream tributaries were designed to store, redirect and convey water to meet human demands within the region, with little consideration for other biotic components of the ecosystem.

The chronic multi-decadal alteration of the natural ecosystem associated with meeting the demands of an increasing human population within and beyond the Central Valley watersheds have contributed to profound changes in the system's aquatic fauna, including a persistent decline in certain species of native fishes. Consequently, some of these jeopardized species have been afforded protection under the Endangered Species Act (ESA).

Within the historical context of engineered water resource management, formal legislative recognition that water and other habitats should be managed to restore and enhance the ecosystem as a coequal goal with providing a reliable water supply to California (Delta Reform Act) represents an ambitious and novel conceptual approach to water management within the region. Ultimately, the ability to meet this mandate appears to rest largely on adjusting existing water operations within the context and constraints of a system developed and engineered to primarily achieve one of these goals. If an appropriate combination of localized spatial and temporal deliveries of water cannot be found to maintain or restore the necessary ecological conditions to support the desirable species populations, the most feasible alternative may be to accept the ecosystem components that are sustainable within the constraints and limitations imposed by historical uses of the available limited resources.

***Background on the LOO RPA review process*:** NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) have each issued Biological Opinions on long-term operations of the Central Valley Project (CVP) and State Water Project (SWP, hereinafter CVP/SWP; Long-term Operations Opinions) that include Reasonable and Prudent Alternatives (RPA) designed to alleviate jeopardy to listed species and adverse modification of critical habitat. NMFS' Opinion requires the U.S. Bureau of Reclamation (USBR) and NMFS to host a workshop no later than November 30 of each year to review the prior water year's operations and to determine whether any measures prescribed in the RPA should be altered in light of new information (NMFS' OCAP Opinion, section 11.2.1.2, starting on page 583). Amendments to the RPA must be consistent with the underlying analysis and conclusions of the Biological Opinions and must not limit the effectiveness of the RPA in avoiding jeopardy to the ESA listed species or result in adverse modification of critical habitat.

The purpose of both Long-term Operations Opinions (LOO) is to present the responsible agency's biological opinion on whether USBR's and DWR's long-term operations of the CVP/SWP are likely to jeopardize the continued existence or adversely modify the designated critical habitat for the ESA listed species under each agency's jurisdiction. Because both Long-term Operations Opinions concluded that the long term operations of the CVP/SWP are likely to jeopardize the continued existence or adversely modify designated critical habitats, the USFWS and NMFS prescribed RPAs to minimize CVP/SWP operations related effects to the level where these effects do not appreciably reduce the likelihood of jeopardizing the continued existence of ESA listed species or adversely modifying critical habitat. The RPA in NMFS' Long-term Operations Opinion (2009 RPA with 2011 amendments) includes both broad and geographic division specific RPA Actions. The RPA Actions in both Long-term Operations Opinions provide specific objectives, scientific rationales, and implementing procedures.

Since the Long-term Operations Opinions were issued, NMFS, USFWS, USBR, U.S. Geological Survey (USGS), California Department of Fish and Game (CDFG) and the DWR have been performing scientific research and monitoring in concordance with the implementation of the RPAs. Technical teams and/or working groups, including the geographic divisions specified in the NMFS' Long-term Operations Opinion, have summarized their data and results following implementation of the RPA Actions within technical reports. The data and summary of findings related to the implementation of the RPAs provide the context for scientific review regarding the effectiveness of the RPA Actions for minimizing the effects of water operations on ESA listed species and critical habitat related to the operations of the CVP/SWP. However, not all technical reports were included in the official review materials to be considered by the 2012 LOO IRP (see Appendix 1).

In January 2012, Public Water Agencies (PWA), State of California and Federal agencies filed a joint stipulation regarding project operations during April and May 2012 in the litigation relating to NMFS' Long-term Operations Opinion. The parties stipulated that if a rock barrier were installed at the head of Old River, the CVP/SWP would operate within an adaptive range of Old and Middle River flows in lieu of operating to the inflow:export ratio specified in RPA Action IV.2.1 of NMFS' Long-term Operations Opinion.

At the request of USFWS and NMFS, the Delta Science Program (DSP) employed the services of an independent science review panel to assist NMFS and USBR in reviewing the effectiveness of the implementation of NMFS Long-term Operations Opinion RPA and documents associated with the implementation of the joint stipulation. The role of the Independent Review Panel (IRP) is to provide a technical review to the agencies involved in implementing NMFS' Long-term Operations Opinion RPA.

The intent of the annual review is to inform National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) as to the efficacy of the prior year's water operations and regulatory actions prescribed by their respective Reasonable and Prudent Alternatives (RPAs), with the goal of developing lessons learned, incorporating new science, and making appropriate scientifically justified adjustments **to the RPAs or their implementation** to support water year 2013 real-time decision making.

General scope and charge to the 2012 LOO IRP: The previous two annual reviews have considered all of the RPA Actions but this year's panel charge focused on a subset of the RPAs primarily related to water operations and populations of Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead (*Oncorhynchus mykiss*) within portions of the San Joaquin and Sacramento watersheds and Delta.

This year's annual review deals with the implementation of NMFS' Long-term Operations Opinion's Clear Creek RPA Actions (I.1.1 – I.1.6) and the Spring 2012 Delta Operations in lieu of NMFS' RPA Action IV.2.1 per joint stipulation (Spring 2012 Delta Operations) for operations and fisheries for water year 2012 (October 1, 2011 through September 30, 2012) and considers:

(1) Whether implementation of the Clear Creek RPA actions met the intended purposes of the actions;

(2) The agency's responses to and implementation of independent review panel recommendations from the prior year's Long-term Operations Opinion Annual Review on the Clear Creek RPA actions;

(3) Study designs, methods, and implementation procedures used; and

(4) Recommendations for adjustments to implementation of the RPA Actions or Suite of Actions for meeting their objectives.

Five questions (some multi-part) were posed to the 2012 IRP panel and defined the scope of the panel's charge. This report addresses each of the questions posed and provides additional observations and opinions where they seemed relevant and potentially useful from a scientific perspective.

***Acknowledgements*:** The members of the IRP appreciate and acknowledge the efforts of the agency and technical team representatives and contractors who prepared the written materials and delivered the workshop presentations that were the basis for this report. We recognize that much of the material had to be compiled, analyzed and organized in a relatively short time. Despite the many competing demands on the workshop participants, the materials were presented professionally, concisely, on schedule and often were responsive to the previous IRP's recommendations for format changes. The panel wishes to express a special thanks to the Delta Science Program, Peter Goodwin (Lead Scientist), Sam Harader (Program Manager) and the entire staff for providing the organization and logistical support to facilitate our task. In particular, Lindsay Correa (Environmental Scientist), as usual, expertly attended to a wide variety of technical and provisional details in support of the IRP's efforts before, during and following the workshop.

LOO IRP COMMENTS ON RPA ACTIONS IN WATER YEAR 2012

General comments and observations

Some of the NMFS RPA actions and Joint Stipulation commitments have yet to be implemented or completed and so the 2012 IRP is unable to develop an opinion as to whether or not they have or will meet their intended purpose. These include:

(1) Action I.1.2. Channel Maintenance Flows from re-operation of the Whiskeytown Glory Hole spills to include mean daily spills of 3250 cfs for one day to occur 7 times in a 10-yr period. This action was targeted for implementation in winter 2013 and will likely be delayed until 2014, so once again was not implemented and cannot be evaluated.

(2) Action I.1.3. Spawning Gravel Augmentation was once again performed but there was little information available to evaluate whether it is meeting the intended purpose. The written report from the Clear Creek Technical Team (CCTT) contained a note to "[insert section here]" that may have been intended to provide salmonid or macroinvertebrate responses to the RPA. During the LOO 2012 workshop in Sacramento the CCTT indicated that the data were not currently available.

(3) Action I.1.4. Replacement of Spring Creek Temperature Control Curtain in Whiskeytown Lake. This action was completed by the Bureau of Reclamation in June 2011, but there was no test of its effectiveness that would allow an evaluation of the intended purpose of the action. Furthermore, the intended effect of the curtain was to lower water temperatures delivered to the Sacramento River and not necessarily Clear Creek, which was the focus of this year's annual review.

(4) Action I.1.6. Adaptively Manage to Habitat Suitability/IFIM Study Results. Although the IFIM Study is completed, results were not provided for evaluation, so the IRP is unable to formulate an opinion this year.

(5) In the Joint Stipulation Order (Case 1:09-CV-01053-LJO-DLB, Document 660, filed 01/19/12, p 6 and 7 of 11), DWR committed to developing a study for a pilot predator removal and control program to be submitted to NMFS and CA-DFG for review and comment and "if a rock barrier is installed (at the head of Old River), a predator monitoring study will evaluate predation associated with the installation and operation of the rock barrier". At the workshop there was some verbal mention of these activities having been carried out, but no data were provided to the IRP for evaluation.

Hydrographic analysis

Annual planning and decisions on water operations are based, in part, on qualitative categories (e.g., wet, above normal, below normal, dry and critical) of water availability derived from indices of unimpaired runoff measured during two periods within the year, with an adjustment for the previous year's conditions. However, the approach provides little room for forecasting conditions in an upcoming water year, except perhaps for an implicit expectation of a relatively dry year (i.e., 60% of the WY categories are less than "normal"). The ability to plan for alternative decisions on water use based on predicted near-term climate conditions (e.g., global patterns in sea water temperatures driving El Niño-Southern Oscillation events) would contribute to the improvement of real-time responses required to meet the intentions of RPA Actions.

Given the wealth of annual flow records available to various technical groups, it is almost imperative that a more concise analysis of rainfall patterns and overarching landscape-level climatic patterns be accomplished in order to create the most effective adaptive management strategy. One of the goals of restoring the system will be to recreate or simulate previously existing hydrographic cues; that is, an effective benchmark period must be created. In most cases, the previous 20 to 40 years are not useful tools. . The effect of climatic change and other phenomena make this arbitrary period an inappropriate target which sets target flows. With increasing observations of linkage between long-term oscillations in oceanic temperature and/or changes in climatic trends *(*e.g., Werritty 2002, Hannaford and Marsh 2006, and Maurer et al. 2004), it is increasingly important to understand regional runoff patterns so that an effective benchmark target can be identified (Kelly and Gore 2008). Maurer (2007) and Cayan et al. (2008) have done extensive modeling of potential climate change scenarios and could offer insights into changes in runoff that might affect management decisions. The IRP suggests that a review of annual flow records to detect any predictable patterns influenced by the Pacific Oscillation as well as proposed scenarios for climate change in California will be useful exercises to "fine-tune" future management options.

IRP responses to questions defining the charge and scope of the 2012 LOO annual review

The 2012 Annual Review focused on NMFS' Long-term Operations Opinion's Clear Creek RPA Actions (I.1.1 – I.1.6) and the Spring 2012 Delta Operations:

Implementation of actions

1) **How well did implementation of the Clear Creek RPA Actions and Spring 2012 Delta Operations meet the intended purposes of the actions?**

Clear Creek RPA Actions

There were six Clear Creek RPA Actions to consider this year, but some were not conducted (e.g., Action I.1.2, Channel Maintenance Flows) or the information necessary to determine whether the intended purposes were met was sparse or lacking.

Spring attraction flows (Action I.1.1) provided pulses of 400 and 800 cfs from Whiskeytown Lake instead of the minimum of two 600 cfs pulses described in the RPA Action. The intention of this action is to attract adult spring-run Chinook holding in the Sacramento River into Clear Creek. Although the pulses moved gravel downstream (a stated secondary purpose), the CCTT report (Page 5, para. 4) opined that fish monitoring results were inconclusive - just as they were in 2010 - due to low adult counts. The IRP agrees that the 2012 counts were disappointingly low. However, one can still statistically evaluate the effects of pulses on the counts. In 2012, nine fish were seen before the first pulse, 13 after the first pulse, and 39 after the second. If the pulses had had no effect, then one would expect these 61 fish to have been equally distributed among the three surveys, with about 61/3 = 20 fish seen in each survey. However, a chi-squared goodness of fit test (Zar 2010) rejects this equal-distribution null hypothesis (P<0.001, chi-squared = 26.1, df=2). Thus, there is evidence for a nonrandom difference in counts between the surveys, presumably (but not necessarily) due to the pulse flows. This same test, using "exact" P-values, can also be applied to the even-lower counts of 2010 and 2011.

Channel maintenance flows (Action I.1.2) were not performed and were once again delayed until 2014. Discharges of about 3000 cfs were common events in the past and discharges above 5000 cfs are most likely required to establish geomorphic threshold crossing events. A one day spike of 3,250 cfs will not complete much in the form of geomorphic work other than water some rocks and result in negative ecological impacts to Clear Creek. Small pulses of 400 to 800 cfs have stage increases of 0.5 - 1 ft at the confined location of the Igo gauging station. These would barely be measurable differences in terms of stage along the floodplain sites where most of the spawning and rearing habitat exists.

Spawning gravel augmentation (Action I.1.3) was intended to enhance and maintain previously degraded spawning habitat for spring-run Chinook and CV Steelhead. In 2011, 10,000 tons of gravel was placed at 5 sites in Clear Creek. Again there was no reliable metric to determine whether or not these augmentations are replacing or enhancing the quality of the spawning habitat for the targeted salmonid species or other fish and macroinvertebrate assemblages. Despite this lack of reliable metrics to gauge success, there is a clear intention to continue the spawning gravel augmentation project, with a concern expressed about the future source of gravel. The current plan is to use mine tailings that will be washed to remove the finer sediments containing mercury and potentially other contaminants and use a retention pond to permanently isolate those contaminants from the watershed. It is unclear how the quality of spawning habitat might be affected.

Replacement of the Spring Creek Temperature Control Curtain (SCTCC) (Action I.1.4) was intended to reduce adverse impacts of project operations on water temperatures for listed salmonids in the Sacramento River. The USBR replaced the SCTCC in Whiskeytown Lake on schedule in June 2011 at a cost of $3 million. However, unidentified “technical problems” with monitoring equipment apparently precluded pre-project monitoring to evaluate the effectiveness of this action. Effects, if any, of the SCTCC on temperatures in Clear Creek were not considered. However, in connection with the discussion on this temperature curtain, the IRP was informed that the Oak Bottom temperature control curtain (OBTCC) in Whiskeytown Lake was also damaged and in need of replacement or repair. While the agencies involved seemed to agree that the OBTCC should be replaced, no plan was advanced to test its effectiveness in meeting the intention of this action. It is unclear how the effectiveness of these temperature control curtains on water temperatures will be determined in either the Sacramento River or in Clear Creek.

Thermal Stress Reduction (Action I.1.5) was intended to improve conditions in Clear Creek for over-summering steelhead and spring-run Chinook during holding, spawning and embryo incubation. Seasonal temperature target maxima in Clear Creek at the USGS Igo gauge (about 6.5 miles downstream of Whiskeytown Dam) were set at 60° F during June 1 to September 15, and 56° F during September 15 to October 31. Thus far during 2009-2012, the temperature target was achieved consistently during the June to mid-September period, but frequently failed to be met during mid-September to October. In 2012, the temperature during this period exceeded the target maxima 69% of the time. During 2009-2011, temperatures exceeded the target 38% to 72% of the time. In prior years (2001-2008) temperatures at the Igo gauge exceeded the temperature target during September and October only 7% of the time. Once again there was mixed success in meeting the physical targets set by this RPA Action and no biological response data on which to base an opinion as to the intended effects on salmonids.

The Clear Creek Technical Team (CCTT) put forth a complex hypothesis that involved potential impacts of an interaction involving the Oak Bottom and Spring Creek temperature control curtains and the effects of “power-peaking” at generating stations above Whiskeytown Lake as a possible explanation for the failure to meet the conditions of Action I.1.5 during mid-September to October in recent years. There seemed to be agreement among the agencies that the Oak Bottom Temperature Control Curtain (OBTCC) was in need of replacement but there was no consensus regarding the role of power-peaking in current conditions.

There was a paucity of hard evidence provided to the IRP on which to form an opinion as to the scientific soundness of alternative hypotheses to explain the temperature observations at the Igo gauge.

Adaptively Manage to Habitat Suitability/IFIM Study Results (Action I.1.6) was intended to improve habitat conditions for spring-run Chinook and steelhead by adaptive management of flow conditions that favor salmonid survival. This Action is associated with what is perhaps the least definable objective. Also the IFIM Study which began in 2004 has been completed but reports on the findings were not available to the 2012 IRP. Consequently, there is no basis on which to develop an opinion as to the effectiveness of this RPA Action at this time.

Spring 2012 Delta Operations

There were three objectives to the Spring 2012 Joint Stipulation agreement:

(a) to provide for minimum protection of out-migrating juvenile steelhead by managing flow conditions in the Delta in a manner expected to allow salmonids to successfully exit the Delta;

(b) to increase water exports consistent with the protection mentioned in (1) above;

(c) to generate real-time tracking information in order to better understand how pumping rates, flows in Old & Middle Rivers, and juvenile steelhead migrations relate to one another.

The agreement called for installing a rock barrier at the head of Old River and managing flows in Old & Middle Rivers within an adaptive range of -1250 to -3500 cfs during April and -1250 to -5000 cfs during May. A predation study associated with the rock barrier was also required as part of a predator control study. The rock barrier was not completely impermeable and had several open culverts through which water and fish could pass into Old River.

In terms of meeting the intended purpose of the joint stipulation, increased water exports (a portion of Objective b) was achieved. Exports were ca. 57,000 acre ft greater than would have occurred under the NMFS RPA Action IV.2.1 (inflow:export ratio). <u>The water provision side of the stipulation was achieved.</u> While this was described as a "modest" increase in water supply, its significance should be considered within the context of the 2012 water year (WY) being categorized as "critical" and only upgraded to "dry" near the middle of May and the end of the joint stipulation period. NMFS determined that no further adjustments were needed as a result of the change in WY classification.

As for meeting the intended purpose of the biological portion of the agreement (protection of juvenile steelhead and clarification of the relationships between fish migration and inflows/exports), the IRP was unable to determine the level of success or failure for several reasons including the following.

The decision to install a rock barrier at Head of Old River (HORB) was based upon an assumption that it would not enhance predation on salmonid smolts; a previously tested non-physical barrier (bubble curtain) was shown to enhance the risk of predation mortality on smolts, which was the primary reason given for not using that approach.

Estimates of mortality used in setting the triggers for the number of tagged smolts that could be entrained by water operations depended on the assumption that the HORB did not enhance predation risk. Although testing that assumption was one of the conditions of the Joint Stipulation agreement, the 2012 IRP was not informed as to the outcome of any study to test predation associated with the rock barrier.

Furthermore, findings of the 2011 VAMP acoustic tag study, which estimated route-specific survival rates of tagged Chinook smolts, found that the highest survival rate through the Delta was via Old River. Most (64%) of the tagged smolts surviving to Chipps Island did so via artificial transport from the CVP holding tank. The HORB was intended to inhibit migration of smolts via Old River (the shortest route to the CVP holding tank) and as a consequence enhanced negative OMR flows, which may have encouraged higher smolt entrainment into the southern Delta via alternative routes. Data presented by the VAMP study showed that forcing smolts through the Delta by blocking the entrance to Old River decreased survival, presumably due to predation through the central Delta region.

The Spring 2012 plan for water operations focused on characterizing smolt movement with mean project operations, OMR flows, pump exports and I/E ratio. The plan appeared to be based upon the assumption that fish movements and survival would be correlated with measures of mean flow. However studies cited in the Tech Memo demonstrated weak correlations between smolt movement and particle tracking model studies and between project operations, OMR flows and smolt movement and survival. Studies available in the literature and many published in the region have demonstrated that fish movement across a wide range of taxa exhibit behavioral response to tidal oscillations. These behaviors facilitate either the retention of species in the Delta, or upstream/downstream movements necessary to complete their life cycles. The importance of tidal dynamics on smolt migration and interactions with predators and pumps received limited attention in the 2012 operations. When it was addressed it was in the context of tidal effects on passive particle movements.

It was emphasized by the 2010 OCAP IRP (Anderson et al. 2010, p 24) and confirmed by the Acoustic Tag Study conducted in April-May 2012 that steelhead smolts do not behave like passive particles and it was simply inappropriate to rely on the PTM to direct water operations intended to protect out-migrating juvenile steelhead. The effects on steelhead smolt survival could not be determined and this action cannot be described as providing any level of protection for steelhead.

The IRP believes that discerning behavioral responses of smolts and predators to tidal oscillations is crucial for understanding variation in salmonid survival within the Delta, and abundant information is available on the significance of tidal factors. Consequently, the IRP concludes that the best available information was not used in planning the 2012 Delta Operations.

<u>2011 IRP recommended adjustments for Clear Creek Actions</u>

2) **Where the 2011 Independent Review Panel made recommended adjustments to implementation of the Clear Creek RPA Actions,**
    a) **Were the adjustments made?**
    b) **How well did these adjustments improve the effectiveness of implementing the actions?**

The Clear Creek technical Team (CCTT) report and presentation frequently acknowledged the suggestions of the 2011 IRP. The recommended suggestion regarding gravel size in the spawning gravel augmentation program were followed but there were no biological response data upon which to base an opinion regarding whether or not this suggestion improved effectiveness of the action.

Although the CCTT agreed with the 2011 IRP's suggestion for improved temperature and flow modeling in the system, especially for Whiskeytown Lake, this has yet to be undertaken.

Also, the IRP suggestion to give a more natural hydrograph shape to the pulse release flows was not done. The 2012 IRP reiterates these last two suggestions.

Effectiveness of coordinating real-time operations with CCTT input

3) **How effective was the process for coordinating real-time operations with the Clear Creek technical team analyses and input as presented in NMFS' Long-term Operations Opinion [NMFS' 2009 RPA with 2011 amendments (pages 8-9)]?**

The CCTT Report lists topics associated with coordinated long-term operations on eight dates between December 15, 2011 and September 20, 2012 but there appeared to be no real-time operation effects related to analysis and input. However, there appeared to have been at least two incidents relevant to the implementation of actions. These were (a) a week-long period (June 3-11, 2012) during which warmer than intended water was released from Whiskeytown Lake due to an upper release gate being "inadvertently" left open, and (b) operations at the Redding power station which apparently is not under the control of USBR. The presentations from the CCTT and USBR made at the workshop in Sacramento on October 31, 2012 along with subsequent discussions with the IRP suggested that there may be a need for improved coordination between real-time operations and some of the RPA Actions intended to benefit salmonid populations in Clear Creek.

Indicators, study designs, methods and implementation procedures

4) **(a) Were the scientific indicators, study designs, methods, and implementation procedures used appropriate for evaluating the effectiveness of the Clear Creek RPA Actions and the Spring 2012 Delta operations?**

The approach in the Tech Memo was clearly articulated. Whether it was supported by the best available science prior to the study is less clear. In general, there can be little certainty as to the effectiveness of the indicators, study designs, methods and implementation procedures without reliable and accurate measures of biological responses.

Clear Creek RPA Actions

In general, the CCTT report tended to consider progress toward meeting RPA Action targets as a measure of success, which could be appropriate for actions intended to follow some expected trajectory over time (e.g., multi-year projects) but most actions are not defined in that manner.

A list of restoration goals have been created by the CCTT, but these goals must be continuously reviewed as studies are completed or different goals and endpoints are identified. These goals cannot remain static and the IRP urges the CCTT to review these goals annually to determine if the objectives and endpoints remain realistic. “River restoration” has been variously defined in the literature over the past three decades, ranging from “the complete structural and functional return to a pre-disturbance state” (Cairns 1991) to something less than ideal [“a return to an ecosystem which closely resembles unstressed surrounding areas”] (Gore 1985). Four overall targets can be identified (modified from Brookes and Shields [1996]):

Target	Definition	Management Approach
Full Restoration	Complete functional and structural return to an identified pre-disturbance conditions	Direct intervention, natural recovery, or enhanced recovery
Rehabilitation	Partial return to an identified pre-disturbance condition	Direct intervention or enhanced recovery
Enhancement	Any improvement in physical or biological quality	Mainly direct intervention
Creation	Development of a resource that did not previously exist, including “naturalization’ which creates a configuration of contemporary magnitudes and rates of riverine processes	Direct intervention

Gore and Shields (1995) argue that rehabilitation is probably the most likely obtainable target, yet the most expensive, while creation or abandonment of the project, is least expensive but most manageable. Targets continually shift in this broad spectrum of possibilities and the CCTT should consider modifying these targets as a component of their adaptive management strategy.

One of the goals of this project is the completion of the IFIM studies in order to create an adaptive management strategy. The successful completion of this study should allow the analysis of the appropriateness of other activities such as gravel augmentation and the achievement of restoration goals. It is imperative that the results of IFIM studies be reported. An adaptive management plan provides the flexibility that allows managers to respond to future change. These strategies must adapt to the actual results of the Clear Creek restoration plan as it progresses, yet one of the fundamental tools for the development of these strategies, after 16 years of restoration planning and work remains incomplete. The location, duration, and availability of habitat (as expressed as weighted usable area in PHABSIM or other habitat simulations]) over time under various operational scenarios can become a valuable planning tool.

Ultimately, completion of the IFIM study will require the correct choice of index period; that is, the previous historical records that best replicate natural hydrographs in the region, assuming that restoration of the hydrograph is, indeed, an acceptable restoration target. The choice of index period can be important as it must include a target condition prior to alteration *and* include the effects of regular climatic changes such as the Pacific Oscillation (see comparable work by Kelly and Gore, 2008, in the Southeastern US) and the effect of changing land use in PHABSIM predictions (Casper et al. 2011). For example, with changes in the Atlantic Multidecadal Oscillation, PHABSIM predicts a significant change in both fish and macroinvertebrate communities with each cycle (Warren and Nagid 2009) with shifts in dominant functional feeding groups and species composition, among macroinvertebrates, and top carnivores in the fish community. Such modeling results allow the focus of management strategies to shift as natural hydrographic conditions change.

During the CCTT presentation and later discussions at the workshop in Sacramento, it appeared that the team did not yet have an effective way to assess the effect of the temperature control curtains on temperatures of water releases from the reservoir into either the Sacramento River or Clear Creek. Also, there was a greater emphasis on relatively small (a few degrees) decreases in the temperature of the water released from Whiskeytown Lake rather than on stream water temperature when it reached targeted reach boundaries such as the Igo gauge, approximately 6.5 miles downstream or the lower reaches of Clear Creek approximately 12 miles from the dam.

Gravel augmentation has been a very active restoration activity in Clear Creek since 1996 (150,000 tons) and is planned to be continued into the future ($4.5 million). At this point there is insufficient data to support the ecological effectiveness of the gravel augmentation activities. It appears that two related responses follow this restoration activity. Spawning increases a couple percentage points and then just as rapidly declines (Fig. 9 CCTT 2012 report).

The CCTT 2012 report alludes to physical monitoring since 1996 and Figure 10 and 11 in that report show that pulse flows since 2009 have moved gravel in the Dog Gulch site just below Whiskeytown Dam, but there was less movement of gravel in the Peltier site just downstream. The IRP was unable to determine the type of data that were collected to distinguish the spread of gravel from the existing stream bed or how the magnitude of movement was assessed.

Spawning seems to occur very near the channel banks which may be a species preference or it could be that these areas had less gravel. At the 2012 LOO workshop, it was indicated that the channel was deeper at the edges as a result of how the gravel was placed and perhaps how the river flow encountered the gravel deposits. However, this only underscores the need to step back and quantitatively evaluate a set of metrics aimed at testing the restoration goals.

An independent 2005 review specifically of gravel augmentation practices in the Central Valley listed 20 unanswered questions concerning gravel augmentation practices (Lave et al. 2005.). One of the largest data gaps for Clear Creek, and most likely for the other sites, is linking threshold entrainment to discharge and routing/deposition of gravel through Clear Creek system.

The long-term future source of material for the gravel augmentation activities will come from mining tailings and hence there may be a potential to introduce additional mercury contamination to the system. The direct transfer of mercury - and other metals from sediments - through the aquatic food chain is a concern wherever past mining is prominent, such as in the Clear Creek basin. Fine sediments contain the higher levels of mercury then gravel and the fine bed sediments of Clear Creek have been shown to contain mercury levels 2 to 10 times natural background levels (Moore 2002).

Gravel augmentation seems to encourage spawning and hence the excavation of redds. There is also an expectation that gravel augmentation will result in favorable alterations of channel morphology. Both small- and large-scale morphological changes to the bed can result in an increased flow of hyporheic water through the surface sediment. Merz et al. (2004) reported on the possible benefits of gravel augmentation on spawning bed enhancement showing that it increases survival and growth of Chinook salmon embryos in the Mokelumne River. Other authors have shown the exchange of hyporheic water enhances the formation of riffle complexes with measurable impacts in terms of moderating riverbed water temperature (Grant et al. 2006a, b, Hanna et al. 2009). Brown et al. (2007) showed that spatial variation in sediment source resulting from flood transport of mine tailings along with temporal changes in hydrology, combine to dictate the role of the hyporheic zone in the transport and retention of arsenic.

In the lower reaches of Clear Creek bed sediments have mercury concentrations that are already above background levels and high flows that scour the bed reintroduce fine sediments into the flow. This coupled with gravel augmentation could be enhancing geomorphic change that in turn enhances hyporheic water flow through sites that encourage spawning soon after mobilization of the gravel. If so, gravel augmentation and flushing flows could be encouraging spawning in gravels where intra-gravel flow contaminated fines passed through incubating salmon embryos. The total net effect on salmon reproduction from the restoration activities of gravel augmentation coupled with flooding is unknown but it is not unlikely that gravel augmentation to encourage salmon spawning in an already highly contaminated creek bed could adding an additional layer of stress detrimental to the survival of the very species it is trying to help.

Indeed, Moore (2002) in discussing Clear Creek specifically states:

> *"Understanding the distribution of such widespread contamination is essential to river restoration, especially where dredging, filling, excavation, floodplain construction and changing sediment dynamics may lead to remobilization of contaminants from the riverbed/floodplain, making them more bioavailable. Specific river restoration efforts can also be stymied by bed-sediment contamination, especially those designed to increase/recreate fish spawning habitat. An example is the dependence of some salmonids on areas of upwelling through a gravel bed. If the bed is contaminated with mercury or other heavy metals, geochemical reactions within the bed can release contaminants to the water that irrigates fish eggs. This increased metal loading can decrease reproduction and productivity at spawning sites."*

The IRP recognizes that the plan is to wash the gravel used in the augmentation and remove the more heavily contaminated fine sediments, storing them in containment areas. However, this commits one or all of the agencies involved to the perpetual obligation of preventing the concentrated contaminants from entering the watershed.

The CCTT Report also included speculation about what may be learned through the use of both video and sonar. There are many "may"s here. The IRP suggests that CCTT members posit some specific, realistic outcomes from these two monitoring sources and think through exactly what conclusions could be drawn before investing substantial financial resources in video and sonar monitoring programs.

Spring 2012 Delta Operations

The study design for real-time operations using acoustic tagging material was inadequate to develop real-time operations. The operations were based on the arrival of fish at specific points in the inner Delta which were adjusted over the season because the fish arrived at the target points earlier than expected.

The general project operations have been managed in terms of the mean flows in OMR and in the San Joaquin River. This has been the fundamental approach for operations of the system for years but has resulted in inadequate protection for fishes. In part, this is because attempts to understand the movement and survival of fish through the Delta to date have not considered effects of tides, which are the dominant control on flow velocities and mean direction of flow.

Delta survival of steelhead, and especially Chinook, was extremely low based on tagging studies. Characterizations of survival in terms of river km or mean flow are inadequate because the rapid travel time and complex routing of fish through different reaches cannot be explained by these mean measures. The IRP suggests the travel, routing and survival of fish through the system needs to account for migrant behavior and the behaviors of the predators in response to the strong tidal influences in the Delta (see Appendix A2.2: Selective Tidal-Stream Transport).

The acoustic tagging experiment also had logistic and possibly methodological difficulties from the start, so reliability of the results is questionable for reasons that will be explained subsequently. Second, when difficulties were encountered, there was an attempt to use an “adaptive management” approach in real-time that only seemed to complicate the situation. Adaptive management requires that something be learned before adjustments are made, it was not intended to simply take another course when things are not going as intended in real time. There were two substantial examples of this:

(1) When the acoustic tagging study could not begin on April 1, the Particle Tracking Model (PTM) was substituted as a means of providing input into decisions regarding water operations for the purpose of protecting juvenile steelhead. As mentioned earlier, there was no means of determining whether or not this approach provided even minimal protection for out-migrating smolts.

(2) The original plan for the acoustic tag study was to run water operations in a manner that allowed OMR flows in the range of -1250 to -3500 cfs in April and -1250 to -5000 cfs in May. However, when the tagging study had logistical difficulties that delayed its start for 2 weeks a series of decisions was made that altered the experimental design.

After the first release of tagged smolts on April 16, when OMR flows of -3500 cfs were planned the number of tags entrained in the south Delta exceeded the trigger within 4 days and after a delay of 2 more days OMR flows were reduced to -1250 cfs through April 30. At this point, a decision was made to raise the trigger and switch the experimental treatment level to OMR flows of -5000 cfs instead of the -1250 cfs planned for May 1-15. Two days after release of the second group of tagged smolts the trigger was once again exceeded and, because of other constraints on water operations, flows were reduced to -1250 cfs for the remainder of the period (May 8-12) following a 5 day delay. The response was to raise the trigger once again and schedule operations to flows of -5000 cfs for the finally period as originally planned. Five days after the final release of tagged smolts, the highest trigger was exceeded and flows were reduced to -1250 cfs during May 23-28. Consequently, the apparent attempt at real-time “adaptive management” during this experiment resulted in a substantial alteration of the original experimental design that weakened the test for effects of flow on steelhead smolt survival and routing as follows:

Time Period	Original Plan	As Conducted – Spring 2012
April 1-15	-1250 cfs for 14 days	-1800 cfs Apr 1-7; -2500 cfs Apr 8-14; No Tags
April 16-30	-3500 cfs for 14 days	-2446 cfs for 7 days
May 1-15	-1250 cfs for 14 days	-2933 cfs for 7 days
May 16-31	-5000 cfs for 14 days	-5193 cfs for 7 days

Note that the changes implemented did not allow for any measurement of tagged smolt survival and routing under the lowest OMR flows (-1250 cfs) and the intermediate flow treatment level (-3500 cfs) was not achieved. Instead, two of the flow treatment levels were so similar (-2446 cfs and -2933 cfs) as to be functionally identical and there was no minimum flow regime included in the experiment as conducted. However, this did not seem to deter reaching the conclusion that there was no relationship between OMR flows and smolt entrainment to the interior Delta. This is too broad a conclusion to draw from the altered experimental design. It remains entirely possible that entrainment is related to OMR flows within any range between -2446 cfs and >0 cfs and becomes asymptotic at some threshold level of negative OMR flow.

Also, many of the study’s initial conclusions are not adequately supported by the analyses because they fail to make use of statistical testing or confidence intervals. The analyses should be redone with greater statistical rigor, where possible. It is possible to test for evidence of a flow effect within the range of flow levels tested using the available data. We suggest recoding release groups 1 and 2 as “intermediate” OMR flow, and group 3 as “high” OMR flow. Then Groups 1 and 2 can be considered as independent replicates (n=2) of an “intermediate” flow treatment level, with Group 3 providing the only replicate (n=1) of a “high” flow treatment level.

Methodological issues with the acoustic tag study on steelhead smolts conducted under the 2012 Joint Stipulation Agreement.

The IRP recognizes that there were logistical, meterological and other difficulties beyond the control of the Department of Water Resources and their collaborators and contractors in conducting the Spring 2012 acoustic tag study. The LOO IRP also acknowledges that previous OCAP IRPs have consistently recommended studies to link biological responses and the physical targets in the RPA Actions. The attempt to move in this direction with the acoustic tag study was commendable and the following comments should not be interpreted as a criticism of those who attempted it.
As with most experiments, the credibility and reliability of the findings depends substantially on whether or not assumptions are reasonable or tested. The following were assumptions stated in the workshop presentation by Kevin Clark as applying to the Spring 2012 acoustic tag study:

(1) Tag detection probability at each location is high (>80%) and similar to the 2010 VAMP findings.

(2) Detection probability may vary among receiver arrays but not between release groups within arrays.

(3) No predator detection filter was required (i.e., all detections were assumed to be live steelhead, not tags carried by predators that had consumed tagged smolts).

(4) OMR flow differences between Group 3 and Groups 1 + 2 were sufficient to test the hypothesis that flows affect fish behavior.

(5) Sentinel hatchery steelhead and wild steelhead smolts behave similarly.

(6) Hatchery smolts released in the tidal portion of the San Joaquin River behave like river-run steelhead.

As to the first and second assumptions, the two studies used very different acoustic tags and receivers. The Joint Stipulation Study used VEMCO tags (V5) which transmit at 180KHz and VAMP uses Hydroacoustic Technology Model 795Lm tags which transmit at 307KHz. Both frequencies are suitable for use in freshwater but the detectable signal range of tags transmitting above 100KHz tends to be degraded with increasing salinity, turbidity, boat noise, etc. There was no mention of range tests conducted on the field arrays to verify this assumption. In tidal environments, one can also expect detection range to be affected by tidal movement and may differ at high and low tides (for a good example see Pautzke 2008). These assumptions can and should be tested. If environmental variation within the Delta affected the detection range of the receivers that resulted in a systemic bias, it could result in reduced tag detections being incorrectly perceived as mortality. When detection probabilities are < 100% and are not properly accounted for, survival estimates are expected to be biased lower (Drenner et al. 2012).

The third assumption conflicts with observations from the VAMP acoustic tagging studies (Vogel 2010, 2011) which now attempts to apply a predator filter that accounts for a considerable number of tag detections.

The fourth assumption was considered earlier. The two points representing treatment level flows in this experiment are relatively high and so the findings only apply to OMR flows that are more negative than -2446 cfs. There is a large range of flows more positive than this value within which a relationship between flow and smolt behavior could still exist. This is a severe limitation on the findings of the Joint Stipulation Study.

The fifth and sixth assumptions are unlikely true, as several studies have demonstrated differences in the behavior and survival of out-migrating wild and hatchery salmonid smolts (e.g., Chittenden et al. 2008; also see reviews by Melnychuk et al. 2010 and Drenner et al. 2012).

Several other potentially important assumptions were not mentioned. Among these were that: (a) tagging does not affect survival, (b) there was little or no mortality from handling, (c) tag expulsion was minimal, (d) the tag burden (weight of tag:weight of smolt) was appropriate and similar across groups, and (e) that tags did not affect swimming performance or predator avoidance.

In a recent review of tagging studies to examine the behavior and survival of salmonids, it was noted that only 10.6% of studies reported in the 207 papers assessed tagging and handling effects and only about a third of the studies even acknowledged them (Drenner et al. 2012). Given that one of the logistical challenges mentioned in the joint stipulation study was a paucity of experienced personnel available to implant acoustic tags, this could have been a potentially important source of mortality and tag loss in this study. Given the constraints to conduct the study in Spring 2012 under difficult circumstances, it may be impractical to expect such an assumption to be rigorously tested, but lacking evidence to substantiate this and other assumptions provides reason to doubt the accuracy of the findings.

Information on the size of smolts used in each group was not provided, but VEMCO V5 acoustic tags weigh an average of 0.65 g. Ideally, tag burdens of no more than 2% are recommended for most species, and burdens in excess of ca. 5% are generally not recommend for salmonid smolts (e.g., Adams et al. 1998), suggesting that appropriate smolt sizes for V5 acoustic tags would be > 13 g. There have been very few studies assessing the effects of tag burdens on the behavior and survival of salmonids (Drenner et al. 2012). However, early short-term swimming performance and higher predation rates have been associated with juvenile Chinook salmon carrying surgically-implanted transmitters for radio telemetry (Adams et al. 1998).

Statistical issues with the acoustic tag study on steelhead smolts conducted under the 2012 Joint Stipulation Agreement.

Data analysis issues were not specifically addressed in the charge to the 2012 LOO IRP but the IRP believed it was necessary to comment on this aspect of the recent studies because statistical rigor is crucial for objectively interpreting apparent patterns in the results. For example, Figure 5 in the “Status Report for 2012 Acoustic Telemetry Stipulation Study” shows cumulative detections at different receiver arrays. Cumulative distributions can exaggerate differences between time series counts. In the upper panel, the green and blue curves appear quite different, and yet the time series differ only by a few fish on days 2 and 3. Because the counts are low, it is important to place confidence intervals on these curves, before claiming they differ. In addition, with low sample sizes, it is more realistic to plot cumulative counts as a stair-step rather than a smooth curve.

These same comments apply to the cumulative count figures in the PowerPoint presentation (e.g., slide 31, 37, 39) given on this topic at the workshop in Sacramento on October 31, 2012. Because of low counts, the confidence intervals on the curves in these figures will likely all overlap substantially.

It would also have been useful to place confidence intervals on the estimated proportions in Figure 6 in the same Status Report, and in all other figures that display similar estimates (Zar 2010). To test whether proportions differed across the three junctions, the IRP suggests fitting a logistic regression model with probability of entering the interior Delta as the response variable, and junction and flow level as the explanatory variables. Recoding groups 1 and 2 together as “Intermediate flows”, and group 3 as “Higher flow”, it would be possible to test for the hypothesized difference between the 2 flow levels and reach a supportable conclusion, at least within the range of flows observed.

The boxplots in Figure 11 of the Status Report on the 2012 Acoustic Telemetry Study are unclear with respect to the sources of variation represented. The IRP was unable to determine the sample sizes in each case, but if small (n < 10), then boxplots can be misleading, and perhaps the data should just be plotted as distinct points. Also, this figure includes data from earlier releases ("six year release groups"), then release group ID's 1, 2, 3 and their relation to flow have no clear meaning.

At the top of p. 18 of the Status Report, "a generalized linear model with binomial error structure" was applied to tag detections at receiver array 9 compared to either array 12 or 14. The IRP did not understand exactly what was being tested by this model.

The 2011 VAMP acoustic tagging study of Chinook salmon smolts.

The 2012 IRP recognizes that evaluating the Vernalis Adaptive Management Program (VAMP) studies was not specifically within this year's charge. However, during the workshop in Sacramento (October 31, 2012) the IRP was presented an update from Rebecca Buchanan on the findings of the 2011 VAMP Acoustic Tagging Study which estimated survival of hatchery-reared acoustically tagged Chinook salmon smolts along different potential emigration routes from Mossdale to Chipps Island. Within the context of the workshop, it was difficult to avoid making comparisons between the VAMP and Joint Stipulation Acoustic Tagging Studies given the similarities in the intentions and objectives of the research projects.

The VAMP findings were that overall survival along all routes combined was less than 2% in 2011 and that survival was greater through the southern Delta than through the mainstem of the San Joaquin River. Also, plots of findings from three years of the VAMP acoustic tag study (2008, 2010 and 2011) suggested that higher river flows at Vernalis resulted in lower survival of smolts along the San Joaquin River route. These results contrast with those from earlier coded wire tag (CWT) mark-recapture estimates (analysis by Newman) which have been the basis of the NMFS Biological Opinion on salmonids and to provide the rationale for RPA Actions involving water operations in the Delta (see Report on Spring 2012 Delta Operations in lieu of Action IV.2.1 per Joint Stipulation).

In the VAMP 2011 tagging study, detailed route-specific survival rates tended to decrease in down-river segments and were greatest along the Old River route leading to the CVP tank from which tagged smolts were transported by truck to Chipps Island. The findings, if reliable, suggest that transport from collection facilities associated with water operations provides the best survival chances for Chinook salmon smolts in the San Joaquin watershed. Moreover, it suggests that the use of rock and/or other barriers at the head of Old River on the San Joaquin River that force smolts into the Delta interior where survival is less than 2% should be reconsidered. Indeed, it seems plausible from findings of recent acoustic tagging studies that higher smolt survival will be achieved through encouraging migration down Old River and towards the CVP tank.

The IRP is unaware of any current measure of smolt survival subsequent to transport and release at Chipps Island, but studies conducted in the Columbia River watershed have suggested that there was little evidence of “delayed” mortality associated with transport induced stress in spring Chinook smolts (Rechisky et al. 2012). The same study also suggested that survival to adulthood could still be impaired by early ocean entry as a result of transport. In the 2011 VAMP acoustic study, transported smolts reached Chipps Island in less than half the time (average of 2.6 days, n=24) as those taking an unassisted river route (average 6.3 days, n=8), so route-specific consequences for survival to adulthood remain uncertain.

The VAMP acoustic tagging program has been conducted annually since 2008 and so these studies have an experience advantage over the Spring 2012 Joint Stipulation Study (i.e., less likely to have experienced surgically-related sources of mortality and tag expulsion due to skill levels of personnel), but nonetheless are subject to many of the same criticisms regarding certain key assumptions, especially those related to array-specific detection probabilities under different environmental conditions. In fact, the use of HTI Model 795Lm acoustic tags, which transmit at a frequency of 307KHz would be expected to have an even smaller detection range in the tidal estuary than the VEMCO tags (180 KHz) used in the Joint Stipulation Study. Unless there have been array-specific range tests conducted across the entire environmental gradient that were not available to the IRP, there is reason to doubt the claim of high detection probabilities for every route and river segments between arrays, especially in tidal environments where salinity and perhaps turbidity are greater than in the freshwater reaches. A first step in addressing this issue would be to focus range detection tests on arrays associated with areas identified as mortality “hotspots” where survival was considered to be at or near zero.

There are a few other considerations that complicate comparisons between the VAMP acoustic tag studies and the CWT studies analyzed by Newman (2008). Perhaps the most important difference is that CWT studies depend on actual recaptures of tagged smolts so survival of individuals to the recapture point is a certainty. Acoustic tag studies – with the exception of smolts transported from the CVP tank – track tags and not smolts. The tags could be transported within predators that consumed smolts or could go undetected by a given receiver array due to imperfect detection probabilities.

Although there are filters that can be applied to adjust for these discrepancies, these are still estimates associated with a level of uncertainty.

Another difference between the CWT and acoustic tag studies is the route endpoint which was Jersey Point for the CWT studies and Chipps Island (over 10 miles farther down-estuary) for the VAMP acoustic tag studies. If smolt survival was low between Jersey Point and Chipps Island, it would help explain the difference in survival among the studies. However, the 2011 VAMP data are not consistent with this hypothesis given that smolt survival within that segment was estimated to be about 69% (see slide 22 in PowerPoint presentation by Buchanan et al., LOO Annual Review, October 31, 2012). Alternatively, differences may be due to inter-annual variation in smolt survival, which is known to be highly variable in other systems (e.g., Chittenden et al. 2010).

In any case, substantial uncertainties remain regarding the effects of water operations on the survival and behavior of out-migrating salmonid smolts. Conflicting findings of different studies and methodological issues associated with the approaches used to evaluate survival and routing behavior of out-migrating salmonid smolts have not yet provided a clear path to suggest that fine-tuning water operations will provide a successful means of maintaining or restoring salmonid populations that migrate through the southern Delta.

Clear Creek Technical Team Report specific questions

Were the approaches used to develop the recommended actions to reduce water temperatures scientifically appropriate?

The CCTT report provided a number of suggestions aimed at reducing water temperatures in discharges from the Whiskeytown Reservoir. The presumed effects of replacing the Oak Bottom Temperature Control Curtain (OBTCC) and power peaking on Clear Creek temperatures (Fig. 16 in the CCTT Report) were largely speculative and need to be verified through modeling, analysis of existing temperature data and controlled experiments, if possible.

Releases of colder water from lower in the reservoir as temperatures warm in the summer seems to be a common sense recommendation but still requires some verification with respect to the available volume of cooler bottom water in storage and how far downstream the intended effects on temperature are likely to extend under different climatic conditions, ranging from sunny and hot to cloudy and cooler.

What recommended adjustments to actions and implementation procedures for reducing water temperatures might be scientifically appropriate for the next year, while maintaining equal or greater protection for fish?

Any of the suggestions "might be" scientifically appropriate but require some objective testing to be certain. The IRP suggests that CCTT consider options for assessing the potential temperature-specific pools of water available, through modeling and real-time monitoring within Whiskeytown Reservoir and upstream.

Given that there seems to be consensus among the agencies in favor of repair/replacement of the OBTCC, the 2012 LOO IRP can see no reason to object but would strongly recommend that this action be conditioned on an evaluation of effectiveness that includes measurements before and after installation of a replacement curtain.

Spring 2012 Delta Operations specific questions

Was the approach to real-time operations, including the use of a rock barrier at the Head of Old River (HORB) and acoustic tagged fish for triggering real-time decisions, while providing equal or greater protection to out-migrating steelhead smolts under RPA Action IV.2.1, clearly articulated and supported by best available science in the NMFS February Tech Memo and supporting documentation?

The approach was clearly articulated in the February Tech Memo and supporting documentation but there was little basis for assessing the effects of the HORB on the intention of providing equal or greater protection for out-migrating smolts.

Survival models played a prominent role in decisions about the rock barrier and Old River flows, as evidenced in materials provided to the IRP. The models are also the kernel of the "HORB and survival exploration tool" spreadsheet. However, none of the material reviewed by the IRP discussed the uncertainties of these models, apart from the statement that survival estimates may be somewhat too high for present-day conditions (Report on Spring 2012 Delta Operations, Appendix D, pg. 3). Because of their management importance, the IRP believes it is critical to quantify and communicate the uncertainties of these models.

In addition, the IRP traced the constant survival estimates (flat lines in Figure 2 of the Report on Spring 2012 Delta Operations) back to the Newman (2008) report. However, the IRP could not locate the figure's flow-dependent survival equations in that report, nor could we find the idea of estimating a weighted average (mixed model) of the flow-dependent and flow-independent models.

In Appendix C (Summary of expected benefits of the Spring 2012 Delta Operations Report), the interpretation of relative survival in OMR vs. San Joaquin was unclear. Smolt survival was apparently lower (again, no uncertainty estimates) in the San Joaquin in 2009-2010, with an acoustic barrier in place. And San Joaquin survival in 2008 was higher when no barrier was in place. Nevertheless, a rock barrier (HORB) was installed at the Head of Old River in 2012,"… based on a preponderance of the data". What data constitutes "a preponderance" of evidence is unclear. Perhaps all comparable through-Delta survival estimates, from all years, should be tabulated and presented with key environmental conditions (barrier presence, flows, tagging method, etc.), to reveal the true variation in survival estimates and possible reasons for that variation.

There were several reasons one could reasonably speculate that the effects of the HORB were detrimental to survival of smolts. Given that the VAMP acoustic tag study results have indicated that Chinook smolt survival through the Delta is substantially greater when smolts are transported to Chipps Island from the CVP holding tank, routing smolts via the shortest river segments to the holding tank would seem the best option for protecting out-migrating salmonid smolts.

The HORB inhibits passage along one of the shortest routes to the holding tanks from the upper San Joaquin watershed. Also, the HORB increases negative Old and Middle River flows and potential opportunities for smolts to become entrained along routes in the southern Delta, where survival is considerably lower.

Also, it has simply been assumed that the HORB does not result in enhanced predation mortality on smolts as was shown to occur with the non-physical barrier tested in previous years. All of the calculations and recalculations of route-specific mortality on acoustic tagged smolts that resulted in increasing the number of entrained smolts required to trigger real-time decisions for adjusting water operations were all based on the assumption that the HORB was not associated with increased mortality from predators or other factors. Lacking evidence to the contrary, it is difficult to conclude that the HORB provided equal or greater protection for smolts.

Finally, even after the triggers for tagged smolts were exceeded, there were frequently substantial lags of several days before pumping operations were reduced. Taken together, it is difficult to conclude that the approach taken in the Spring 2012 operations provided even minimal protection for out-migrating smolts. Negative effects of such artificial stresses may have even enhanced the higher natural mortality expected in a dry (or critical) water years such as 2012.

Were the weekly adjustments made consistent with the Tech Memo and supported by the available data and information, while providing necessary protections?

Weekly adjustments to operations appeared to be made within the season because the rapid movement of fish into the Delta was unexpected.

Is the overall approach of using acoustically tagged fish to adjust weekly operations scientifically supportable?

It was not clear to the IRP how water operations coordinated on the movement of acoustically tagged fish was protecting the passage of smolts. The study found that fish entrainment into the inner Delta was not related to pumping operations, suggesting that weekly adjustment of operations by fish movement is not scientifically supportable.

Were the scientific indicators (e.g., fish behavior or drivers of habitat conditions) used appropriate for evaluating the effectiveness of the Spring 2012 Delta Operations?

The lack of a relationship between fish movement and particle tracking model results and the lack of relationships between OMR inflows/exports and smolt movement/survival suggest that these were insensitive indicators for evaluating effectiveness of Delta operations on salmonids in Spring 2012.

Were the scientific indicators and methods used for classifying and detecting "smolt-type" vs. "predator-type" tags in real time appropriate for informing the Spring 2012 Delta Operations?

The Joint Stipulation study using acoustic tag did not determine if detected tags represented smolts or predators that had recently consumed tagged smolts. The approach to determining behavior relative to the tidal component may provide some classification regime. The 2012 IRP also noted that estimated survival - even without adjusting for predators (i.e., assuming no predation of observed tags) - was so low that the run may not be sustainable. Thus, although the classification of tag status is important, especially for identifying smolt movement patterns, the results may be of limited value in evaluating the impact of Delta operations on salmon and steelhead.

How well did the particle tracking model predict fish behavior relative to acoustically tagged data?

The acoustic tracking data as analyzed provide little information of fish behavior. However information in the tidal component of the particles may provide an approach to interpreting fish behavior. See Appendix 2 at the end of this report.

What are the most important analyses to complete for the 2012 data set? What scientific methods for analyzing voluminous response data (e.g., tag detections throughout the acoustic receiver array) and treatment conditions data (e.g., magnitude and direction of flow near specific receivers) might be more appropriate for evaluating the effectiveness of the Spring 2012 Delta Operations?

The question assumes that the 2012 data set is sufficiently reliable and contains important information extractable by analysis.

An important analysis is to evaluate survival and routing relative to Delta hydraulics including the mean and tidal flow components on a reach specific basis. See Appendices 2.1 and 2.2.

What scientific indicators and methods used for classifying and detecting "smolt-type" vs. "predator-type" tags in real time might be more appropriate for informing the Spring 2012 Delta Operations?

How to detect smolt-type vs. predator-type behavior is a subset to the larger issue of how tides affect predatory-prey interactions in the river and Delta. See Appendix 2.3 for further discussion.

What adjustments to the particle tracking models, as informed by the acoustically tagged fish studies, might be more effective for predicting fish behavior and informing future acoustic study design?

Information on mean and oscillatory (tidal) components of the flow over reaches and at reach junctions are likely to provide important information predator-prey and migration behavior as influenced by tides. See Appendices 2.3 and 2.4. However, the 2012 IRP reiterates the suggestion of the 2010 OCAP IRP that rather than making adjustments to the PTMs, a behavioral model for how species in the Delta respond to their local environment should be developed from first principles.

How should the experimental design be adjusted in future years to test key habitat drivers of smolt behavior and survival, and support weekly operational decision making?

Behavior-based fish movement modeling is gaining increasing acceptance as a potentially important tool in water and living resource management in the Bay-Delta and Sacramento River. Despite its potential, behavioral modeling is still a relatively new and developing technology whose optimum future use will depend on decisions made in the near-term. The IRP believes that actions need to be taken soon to help ensure that this technology contributes to future difficult management decisions.

Fish movement modeling and its many possible derivatives such as time-dependent or distant-dependent mortality forecasting should be considered in its broadest context. A useful way to understand fish movement modeling is to relate it to Computational Fluid Dynamics (CFD) modeling. CFD modeling is used to develop a virtual representation of a flow field which is then input to mathematical algorithms that attempt to capture sensory acquisition, sensory processing, and cognition.

Time varying, multi-dimensional CFD codes may be many thousands of lines long so that their connection to a behavioral model may be difficult and time-consuming. It is important for the region to formulate and address the strategic questions inherent in using fish movement models to address the many pressing questions faced by the region. Poor decisions made without fully understanding either the full range of possible modeling approaches, or before the full range of tentative uses are identified, can result in future performance or application challenges.

An effective way of addressing this would be through a series of technology workshops in which uncertainties in the optimum development and application of fish movement models can be identified and discussed. These workshops should include experts in fish movement modeling at different scales, fish tagging experts to answer questions about collection, calibration and validation of data, CFD modelers to answer questions concerning optimum hydraulic modeling, regional living resource experts to identify and refine potential applications, and living resource managers to describe important management questions that must be addressed. Each workshop should produce a guidance document that can be used to strategically develop behavioral modeling with specific application to the Bay-Delta watersheds.

The results of tagging studies to date (through the 2012 study), show little correlation between operations and fish movement, and so do not currently support using salmon to manage operations on a weekly basis. In Appendices 2.1 to 2.4 the IRP presents hypotheses on how migration and survival may be influenced by tidal oscillations in the river and Delta. If ongoing or future research identifies significant mechanisms affecting fish on tidal cycles, then managers might consider adjusting Delta operations on this scale. However, considerable work will be required to evaluate this hypothesis, and if supported, to design a tidally-based management program.

The 2012 IRP also raises the question of whether salmon populations are sustainable in the San Joaquin River (Appendix 2.5). While the IRP realizes that the Biological Opinion for the operations of the SWP and CVP is not charged with addressing the viability of the run, the IRP believes the question eventually needs to be addressed in this or another process.

5) How should multi-year data sets on NMFS' Long-term Operations Opinion RPA Action implementation be used to improve future implementation of the Clear Creek RPA Actions?

The hydrologic system that is used to control the flow of water in Clear Creek below Whiskeytown reservior is extremely complex, involving 3 reservoirs two tunnels, flow and temperature demands in the Trinity, Sacramento Rivers and power production for the City of Redding. In addition, water management in this river system must contribute to meething the co-equal goals of providing a reliable supply of water for human needs and provide for healthy ecosystem functioning. Componding the physical complexity is the high level of interagency involvement, communication and data sharing required to operate the system at peak potential. Moreover, decisions need to be made based on forecasting water supply months ahead of time.

Because of this complexity in system structure, opertational demands and interannual climate variation, it would be useful to develop an expert decision system to assist in making operational decisions on how water is routed through the system

Existing physical water routing models based on Computational Fluid Dynamics (CFD) could be developed in such a way as to link the hydrologic system of reservoirs, tunnels and river outflows to climate modeling and prediction output. This would allow for better strategic planning and action rather than relying primarily on reactive operation. One suggestion is to seek the input of an expert in this type of modeling to help guide an initial phase of investigation into models and feasibility.

A major problem addressed by the 2011 OCAP IRP (Anderson et al. 2011) was the need to enhance communication and data sharing through a common web-based clearing house along with easily accessible monitoring data to assess and ensure regulatory compliance. This same message has been voiced by all agencies, consultants, participipating scienctists, academic institutions and other review panels (Lave et al. 2005.). However, no progress in this direction seems to have been made. What is needed is a web-based collaboration tool that can buid multidisciplinary collaboration, centralize data and information, including development of robust yet easy to use search and display tools, that communicate complex information from large-scale modeling results and network sensors in a way that allows various stakeholders to view decisions and their effects. These tools exist and can be applied to resolve not only issues related to Clear Creek but the whole Central Valley system.

The IRP suggests that the Delta Science Program could facilitate a workshop where industry and academic leaders in this field can present their approaches and potential solutions to the agency partners. Perhaps the Clear Creek working group could provide a test bed model to start building such a web-based collaboration tool.

Another significant need for the Clear Creek group and restoration effort is that of an independent synthesis of all the restoration work and systems management to date. There has been 16 years of restoration effort in Clear Creek below Whiskeytown reservoir without an apparent synoptic review of that work. Instead, the CCTT continues to emphasize perpetual spawning gravel augmentation and changes to the timing and magnitude of reservoir releases without an objective assessment of what has been accomplished to date.

Temperature control in Clear Creek is directly related to the manner in which water flow is managed within the Trinity-Whiskeytown reservoir complex. A temperature control curtain has been replaced in Whiskeytown reservoir near the Spring Creek Tunnel intake and is expected to force more cold water toward that outflow. However, there has not been any data to corroborate that assumption. It is not known how this repair action has or could impact temperature control actions in Clear Creek through operation of the upper and lower intake gates at the Glory Hole intake tower. However, water temperature measured at the Whiskeytown outflow while water intake was shifted between the upper and lower intakes indicates that changes in water temperature outflow can be achieved (Figs. 6 and 16 of the CCTT 2012 report). Indeed, even a mix of water (refered to as middle gate) from both intakes shows an immediate change in water temperature that brackets the entire temperature regime from May to November measured over the past 12 years (Fig. 16, CCTT 2012 report). This suggests that water temperatures in Clear Creek can be controlled to benefit spring-run Chinook and steelhead, but it remains to be seen how far downriver temperature reductions can be maintained.

What is not clear from the CCTT 2012 report is how to assess the potential to achieve this in different water years and whether cooler temperatures in Clear Creek can be extended below the Igo gauging station throughout the summer.

Two planned pulsed flows of 400 cfs and 800 cfs from Whiskeytown reservoir were released in May and June of 2012 with the intent of attracting spring-run Chinook salmon into the upper reaches above Igo. Snorkel data conducted before and after the pulsed flows showed that Chinook salmon moved upstream but it was unclear that they did so in response to the pulsed flows. Reaching such a conclusion would require comparable snorkel surveys without pulsed flows, which could not be done simultaneously.

The 2012 LOO IRP reiterates the suggestion of the 2011 OCAP IRP that if pulsed flows are going to be released they should follow a more gradual rising limb with a longer smooth falling limb.

REFERENCES

Adams, N.S., D.W. Rondorf, S.D. Evans, J.E. Kelly and R.W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 55:781-787.

Anderson, J. J., E. Gurarie, and R. W. Zabel. 2005. Mean free-path length theory of predator-prey interactions: Application to juvenile salmon migration. Ecological Modelling 186:196-211.

Anderson, J.J., R.T. Kneib, S.A. Luthy and P.E. Smith. 2010. Report of the 2010 Independent Review Panel (IRP) on the Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria and Plan (OCAP) for State/Federal Water Operations. Prepared for: Delta Stewardship Council, Delta Science Program. December 9, 2010. 39 p.

Anderson, J.J., J,A, Gore, R.T. Kneib, M.S. Lorang and J. Van Sickle. 2011. Report *of the 2011 Independent Review Panel (IRP) on the Implementation of Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria And Plan (OCAP) for State/Federal Water Operations*. Final report submitted to the Delta Stewardship Council (report can be found on the Delta Science Program web page: http://deltacouncil.ca.gov/event-detail/3877).

Bennett, W. A., W. J. Kimmerer, and J. R. Burau. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low-salinity zone. Limnology and Oceanography 47:1496-1507.

Brookes, A. and F.D. Shields, Jr. 1996. *River Channel Restoration. Guiding Principles for Sustainable Projects.* Wiley, Chichester.

Brown, B. V., H. M. Valett, and M. E. Schreiber (2007), Arsenic transport in groundwater, surface water, and the hyporheic zone of a mine-influenced stream-aquifer system, Water Resources Research 43, W11404, doi:10.1029/2006WR005687

Cairns, J. 1991. The status of the theoretical and applied science of restoration ecology. *The Environmental Professional* 13: 186-194.

Casper, A.F., B. Dixon, J. Earls and J.A. Gore. 2011. Linking a spatially explicit watershed model (SWAT) with an in-stream fish habitat model (PHABSIM): A case study of setting minimum flows and levels from a low gradient, sub-tropical river. *River Research and Applications* 27: 269-282.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree and K. Hayhoe. 2008. Climate change scenarios for the California region. *Climatic Change* 87 (Suppl 1): S21-

S42.

Chittenden, C.M., M.C. Melnychuk, D.W. Welch and R.S. McKinley. 2010. An investigation into the poor survival of an endangered coho salmon population. PLoS ONE 5(5):e10869. Doi:10.1371/journal.pone.0010869.

Chittenden, C.M., S. Sura, K.G. Butterworth, K.F. Cubitt, N. Plantalech Manel-La, S. Balfry, F. Ǿkland and R.S. McKinley. 2008. Riverine, estuarine and marine migratory behavior and physiology of wild and hatchery-reared coho salmon *Oncorhynchus kisutch* (Walbaum) smolts decending the Campbell River, BC, Canada. Journal of Fish Biology 72:614-628.

Clements, S., T. Stahl, and C. B. Schreck. 2012. A comparison of the behavior and survival of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout *(O. mykiss*) in a small estuary system. Aquaculture 362–363:148-157.

Drenner, S.M., T.D. Clark, C.K. Whitney, E.G. Martins, S.J. Cooke and S.G. Hinch. 2012. A synthesis of tagging studies examining the behavior and survival of anadromous salmonids in marine environments. PLoS ONE 7(3): e31311. Doi: 10.1371/journal.pone.0031311.

Gibson, R. N. 2003. Go with the flow: tidal migration in marine animals. Hydrobiologia 503:153-161.

Gore, J.A. (Ed.) 1985. *The Restoration of Rivers and Streams*. *Theory and Experience*. Butterworth Publ., Inc., Boston, MA. 280 p.

Gore, J.A. and F.D. Shields, Jr. 1995. Can large rivers be restored? *BioScience* 45: 142-152.

Grant, G.E., R. Haggerty, S. Lewis, B. Burkholder and P. Wampler. 2006a. Potential effects of gravel augmentation on temperature in the Clackamas River, Oregon. Report to Portland General Electric, Portland, Oregon, dated June 1, 2006, 10 p.

Grant, G., B. Burkholder, A. Jefferson, S. Lewis and R. Haggerty. 2006b. Hyporheic flow, temperature anamolies, and gravel augmentation: preliminary findings of a field investigation on the Clackamas River, Oregon. Report to Portland General Electric, Portland, Oregon, dated December 6, 2006, 20 p.

Hanna, D.M., I.A. Malcolm and C. Bradley. 2009. Seasonal hyporheic temperature dynamics over riffle bedforms. Hydrological Processes 23(15):2178-2194.

Hannaford, J. and T. Marsh. 2006. An assessment of trend in UK runoff and low flows using a network of undisturbed catchments. *International Journal of Climatology* 26: 1237-1253.

Hedger, R. D., I. Uglem, E. B. Thorstad, B. Finstad, C. M. Chittenden, P. Arechavala-Lopez, A. J. Jensen, R. Nilsen, and F. Økland. 2011. Behaviour of Atlantic cod, a marine fish predator, during Atlantic salmon post-smolt migration. ICES Journal of Marine Science: Journal du Conseil 68:2152-2162.

Kelly, M.H. and J.A. Gore. 2008. Florida river flow patterns and the Atlantic Multidecadal Oscillation. River Research and Applications 24: 598-616.

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

Lave, R.,Harve, S. McBain, D. Reiser, L. Rempel and L. Sklar (2005). Key uncertainties in gravel augmentation: geomorphological, and biological research needs for effective river restoration. Report for the CALFED Rivers, Rocks and Restoration Workshop in July of 2004

Lima, S. L. 2002. Putting predators back into behavioral predator–prey interactions. Trends in Ecology and Evolution 17:70-75.

Maurer, E.P. 2007. Uncertainty in hydrologic impacts of climate change in the Sierra Nevada, California, under two emission scenarios. *Climatic Change* 82: 309-325.

Maurer, E.P., D.P. Lettenmaier and N.J. Mantua. 2004. Variability and potential sources of predictability of North American runoff. *Water Resources Research* 40(9): W09306, DOI: 10.1029/2003WR002789.

Melnychuk, M.C., D.W. Welch and C.J. Walters. 2010. Spatio-temporal migration patterns of Pacific salmon smolts in rivers and coastal marine waters. PLoS ONE 5(9): e12916. Doi: 10.1371/journal.pone.0012916.

Mesick, C. 2001. The effects of San Joaquin River flows and Delta export rates during October on the number of adult San Joaquin Chinook salmon that stray. Contributions to the Biology of Central Valley Salmonids 2:139-161.

Merz, J.E., J.D. Setka, G.B. Pasternack and J.M. Wheaton. 2004. Predicting benefits of spawning habitat rehabilitation to salmonid (*Oncorhynchus* spp.) fry production in a regulated California river. Canadian Journal of Fisheries and Aquatic Sciences 61:1433-1446.

Moore, J.N. 2002. *Trace metals in sediments from mine-impacted rivers: Clear Creek, California project*. Final Report for Award No. 02-WRAG-001. 33 p.

Moore, A., E. C. E. Potter, N. J. Milner, and S. Bamber. 1995. The migratory behaviour of wild Atlantic salmon (*Salmo salar*) smolts in the estuary of the River Conwy, North Wales. Canadian Journal of Fisheries and Aquatic Sciences 52:1923-1935.

Newman, K.B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. Project Report for CalFed Science Program Project number SCI-06-G06-299.

Pautzke, S.M. 2008. Distribution of migratory striped bass in Plum Island Estuary, Massachusetts. M.S. Thesis, University of Massachusetts, Amherst, 105 p.

Poff, N. L., J. D. Allan, M. A. Palmer, D. D. Hart, B. D. Richter, A. H. Arthington, J. L. Meyer, K. H. Rogers and J. A. Stanford. 2003. River flows and water wars: Emerging science for environmental decision making. Frontiers in Ecology and the Environment 1(6):298–306.

Rechisky, E.L., D.W. Welch, A.D. Porter, M.C. Jacobs-Scott, P.M. Winchell and J.L. McKern. 2012. Estuarine and early-marine survival of transported and in-river migrant Snake River spring Chinook salmon smolts. Scientific Reports 2:448. Doi: 10.1038/srep00448.

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. 72 p.

Vogel, D.A. 2011. Evaluation of acoustic-tagged juvenile Chinook salmon movements in the Sacramento-San Joaquin Delta during the 2010 Vernalis Adaptive Management Program. 72 p.

Warren, G.L. and E.J. Nagid. 2009. Habitat Selection by Stream Indicator Biota: Development of Biological Tools for the Implementation of Protective Minimum Flows for Florida Stream Ecosystems. Florida Fish and Wildlife Conservation Commission, FWRI Library Code: F2195-05-08-F.

Wells, J. T. 1995. Chapter 6 Tide-Dominated Estuaries and Tidal Rivers. Pages 179-205 *In* G. M. E. Perillo, editor. Developments in Sedimentology. Elsevier.

Werritty, A. 2002. Living with uncertainty: climate change, river flows and water resource management in Scotland. *Science of the Total Environment* 294: 29-40.

Zar, J.H. 2010. Biostatistical analysis, 5^{th} ed. Pearson,– Prentice-Hall, Upper Saddle River, New Jersey, 960 p.

APPENDIX 1 – Materials for IRP Review

Review Materials Available to the 2012 LOO Independent Review Panel

I. The following documents were provided in electronic format as required reading by the IRP prior to the 2-day workshop in Sacramento, CA on 31 October -1 November 2012:

1) Draft 2012 Clear Creek Technical Team Report for the Coordinated Long-Term Operation BiOp Integrated Annual Review

2) Spring 2012 Delta Operations in lieu of NMFS' RPA Action IV.2.1 per joint stipulation
   - Appendix A: Joint stipulation
   - Appendix B: RPA Action IV.2.1
   - Appendix C: Summary of expected benefits from alternative operations
   - Appendix D: NMFS Technical Memorandum issued March 16, 2012
   - Appendix E: Tabular summary of Spring 2012 operations and cumulative tag detection data
   - Appendix F: NMFS Determination for Operations per Joint Stipulation During April 1-7, 2012
   - Appendix G: NMFS Determination for Operations per Joint Stipulation During April 8-14, 2012
   - Appendix H: NMFS Determination on April 12, 2012
   - Appendix I: NMFS Determination on April 27, 2012
   - Appendix J: NMFS Determination on May 4, 2012
   - Appendix K: NMFS determination on May 11, 2012
   - Appendix L: Water supply impacts of operations under Joint Stipulation relative to RPA Action
   - Head of Old River Barrier and survival exploration tool

3) Preliminary Report (Phase 1 Analyses) for the 2012 Acoustic Telemetry Stipulation Study

II. The following additional reports were made available in electronic format for supplemental use in providing historical context for the IRP:

- Smelt Working Group (SWG) Annual Report on the Implementation of the Delta Smelt Biological Opinion on the Coordinated Operations of the Central Valley Project and State Water Project ("OCAP" Biological Opinion) Water Year 2012
- Sacramento River Temperature Task Group (SRTTG) Annual Report of Activities
- American River Group (ARG) Annual Report of Activities

- Stanislaus Operations Group (SOG) Annual Report of Activities
- Delta Operations for Salmonids and Sturgeon Group (DOSS) Annual Report of Activities
- Report of the 2011 Independent Review Panel (IRP) on the Implementation of Reasonable and Prudent Alternative (RPA) Action Affecting the Operations Criteria And Plan (OCAP) for State/Federal Water Operations (December 9, 2011)
- Federal Agencies' Detailed Response to the 2011 Independent Review Panel's Report (June 20, 2012)
- Report of the 2010 Independent Review Panel (IRP) on the Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria and Plan (OCAP) for the State/Federal Water Operations
- Joint Department of Commerce and Department of the Interior Response to the Independent Review Panel's (IRP) 2010 Report of the Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria and Plan (OCAP) for the State/Federal Water Operations
- NMFS' 2009 RPA with 2011 amendments
- USFWS Biological Opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project (pages 279-282 and 329-356)
- RPA Summary Matrix of the NMFS and USFWS Long-term Operations Opinions RPAs
- National Academy of Science's March 19, 2010, report
- VAMP peer review report
- State Water Board's Delta Flows Recommendations Report
- NMFS RPA, Appendix 2-B, Task 4: Green Sturgeon Research
- 2011 OCAP Review Materials, Background Information and Presentations (http://deltacouncil.ca.gov/science-program/2011-ocap-review-materials-background-information-and-presentations)
- 2010 OCAP Annual Review Materials and Presentations (http://deltacouncil.ca.gov/events/science-program-workshop/workshop-ocap-integrated-annual-review)

APPENDIX 2 – Framework for Addressing Salmonid Issues

Framework for addressing effect of Old and Middle River flows on reach-scale survival rate

A2.1: XT Survival Model

The current paradigm for characterizing movement of smolts through the Delta reaches relies on mean flow to characterize the movement and routing of fish. The tagging studies in 2012 and earlier years clearly indicate that this characterization is inadequate. Below is a mechanistic approach to consider smolt movement, routing and survival through the Delta in terms of the dynamics of encounters of predators and smolts as based on the XT survival model (Anderson et al. 2005).

The underlying equation characterizes survival in terms of both the distance traveled x and the time t to travel through a reach. The concept is that if smolt (prey) mortality over a distance is the result of predators then survival depends on both the mean travel time and the relative random velocity between the predator and smolt. Survival is

$$S = \exp\left(-\frac{x}{\lambda}\sqrt{1+\left(\frac{\omega}{U}\right)^2}\right) \qquad (1)$$

where ω is the root mean-squared (rms) random component of velocity of the predator relative to the smolt, U is the mean velocity of the smolt through a river reach and x is the reach distance. The final term λ is the mean free-path length a smolt travels before a predation event and is defined

$$\lambda = \frac{1}{\pi r^2 \rho} \qquad (2)$$

where ρ is the predator density per unit volume, and r is the predator-smolt interaction distance that on the average results in a predation event. The interaction distance r depends on the visual field of the predator and therefore depends on light levels and turbidity.

Because in Equation (1) survival depends on the ratio of two velocities to understand what controls survival, an understanding of the velocities is important. To illustrate their nature assume that the predators are territorial while smolts move with the water and exhibit selective tidal-stream transport (discussed in A2.2). Then the random predator-prey velocity ω is essentially the mean tidal velocity and the smolt velocity *U* is the reach length divided by the smolt's mean travel time through the reach. When $U/\omega > 1$, the mean smolt velocity is large compared to the tidal velocity so a predator gets only one chance at a passing smolt. However, when $U/\omega < 1$ the tidal velocity is larger than the mean smolt velocity and the tidal flow can bring the smolt into the predator's territory multiple times.

Figure A2.1 illustrates how smolt velocity and tides interact. Based on Equation (1), *x* and λ are constant for a reach so the shape of the survival curve depends only on U/ω. When U/ω is large, survival approaches its maximum value $S_{\max} = \exp(-x/\lambda)$ which depends only on reach distance, predator density and the capture distance, but not on either the smolt velocity or the tidal velocity. When U/ω drops below 1, (i.e., the tides become important) survival precipitously declines. Note that in total smolt survival depends on five variables, not simply smolt mean velocity. Furthermore, survival does not directly relate to particle velocity *V.* In other words, smolt velocity is only one of five variables affecting survival and the impact of particle movement on smolt survival is ambiguous.

The current operation schemes focus on controlling particle travel time which is controlled through project exports, the E/I ratio, and OMR flow. The 2012 stipulation study examined the survival and movement of acoustically-tagged steelhead in relation to project exports and OMR flows. The study demonstrated that under the conditions examined, fish travel time was not related to particle movement nor was route selection of the fish related to Delta operations. While the study to manage Delta operations considered smolt survival, with its focus on fish travel time, it did not consider other factors that control survival through reaches. In particular, smolt survival depends on the relative predator-smolt encounter velocities, as outlined above, and routing. Below we consider factors that determine fish migration velocity (Appendix 2.2), predator-smolt encounter velocities (Appendix 2.3) and fish routing (Appendix 2.4).

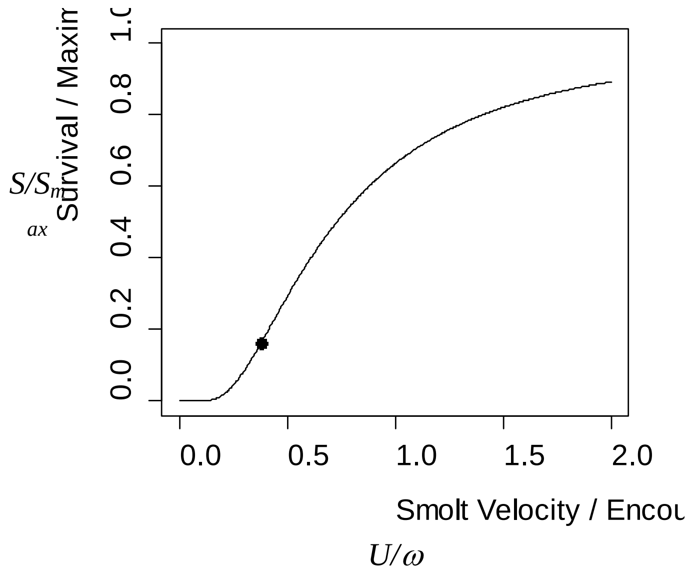

Figure A2.1. Relative reach survival depends on the ratio of the mean smolt migration velocity *U* to the relative predator encounter velocity ω. Maximum survival S_{max} depends on reach length *x* and mean free-path length before a predator encounter λ . Estimate of relative survival of fall Chinook from San Joaquin River to Chipps Island denoted by (●).

A2.2: Selective Tidal-Stream Transport (STST)

The stipulation study using acoustically tagged steelhead smolts clearly demonstrated particle and fish movements were poorly correlated. For example, calculated with hydraulic models, particles take 20 to 40 days to move through the Delta while observations on fish passage time are typically 10 days and can be less (Figure A2.2). It is well known that fish and zooplankton perform vertical migrations over the tidal cycle to remain in the Delta (e.g., Bennett et al. 2002, Kimmerer et al. 2002). Additionally many fish species (Gibson 2003), including salmon smolts (Moore et al. 1995) exhibit selective tidal-stream transport (STST) during migration. Here we illustrate the feasibility that salmon and steelhead smolts use STST to move quickly through the Delta.

In selective tidal-stream transport (STST) an animal moves in and out of low velocity regions of the water column on selective parts of the tidal cycle to facilitate upstream or downstream movement. To speed downstream migration salmon smolts move into the higher velocity surface layer on ebb tides and lower velocity near shore regions on flood tides (Clements et al. 2012).

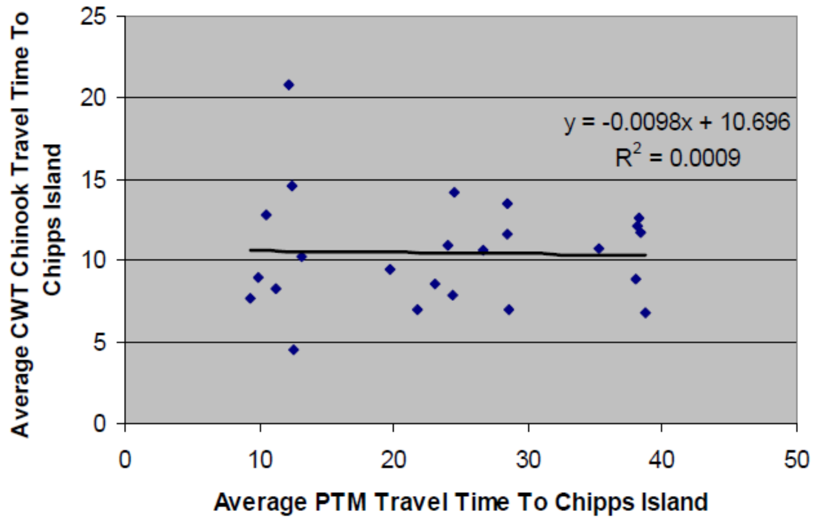

Figure A2.2. Release CWT Chinook salmon in the lower San Joaquin River and the associated Particle Model arrival time to Chipps Island in (LOO Annual Review 2012) Appendix H page H-24).

To demonstrate the feasibility that smolts use STST migrating through the Delta, assume the fish move with the ebb tide and hold in low velocity areas during the flood tide. The resulting across-ground velocity of a smolt can be expressed

$$U = V + \varphi v \qquad (3)$$

where V is the mean particle velocity experienced by the smolt, v is the rms tidal velocity and φ measures the contribution of STST behavior to migration. In the simplest view, φ is a measure of the fraction of the tidal cycle that smolts hide in low velocity regions. If $\varphi = 0.5$ then the smolts effectively hide in low velocity areas during the entire flood tide and drift downstream during the ebb tide. Values less than 0.5 indicate tidal selective movement occurs during only part of flood tide or that the smolts move into low velocity, but not zero-velocity areas on the flood tide. Figure A2.3 illustrates an idealized behavior where a smolt moves into a zero-velocity region during 3 hrs about the peak flood tide. Additionally, if STST is estimated over multiple reaches, φ represents an average of reach properties and behavioral responses.

Thus, Equation (3) hypothesizes that the difference between the observed smolt velocity and the mean particle velocity can be explained by the smolt STST behavior. To evaluate this hypothesis consider the difference in the estimated travel time of particles and CWT smolts traveling from the Lower San Joaquin River to Chipps Island (Figure A2.2) which gives T_{smolt} = 10 d, T_{ptm}= 25 d. Assuming the distance traveled by the smolts is approximately 2 x10^5 ft, then the average fish and particle velocities over the reach are $U = T_{smolt}/x$ = 0.23 ft/s and $V = T_{\text{ptm}}/x$ = 0.11 ft/s. Measurements of water velocity including tidal and mean flow indicate a typical maximum tidal velocity of 1 ft/s (Figure A2.4) which gives a rms tidal velocity of *v* = 0.7 ft/s. Then arranging Equation (3) to give $\varphi = (U - V)/v$ the STST index is φ = 0.17.

In other words the travel time of fish through the San Joaquin River can be explained by the fish exhibiting a moderate amount of selective tidal-stream transport.

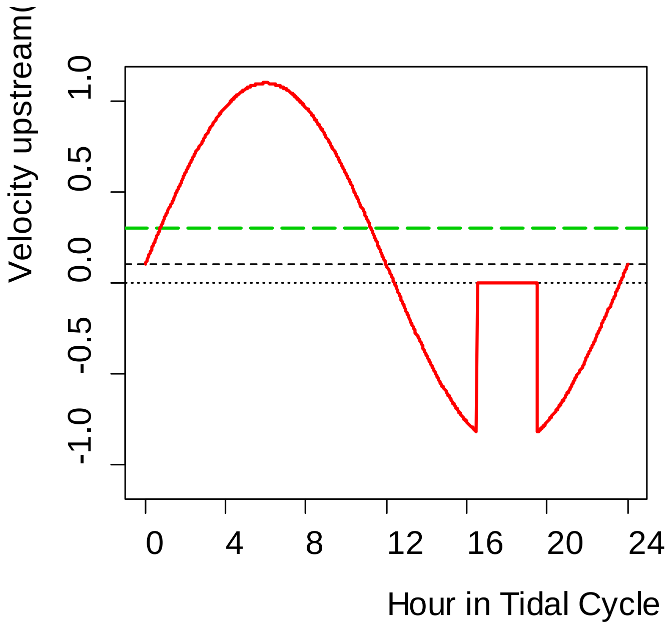

Figure A2.3. Illustration of selective tidal-stream transport. The reach water velocity is composed of a tidal component and residual (- - -) from the mean river flow. Smolt velocity (——) follows the water velocity until upstream velocity exceeds a threshold triggering fish to move into a low velocity area. The average smolt velocity over the tidal cycle (— — —) exceeds the average water velocity (- - - -).

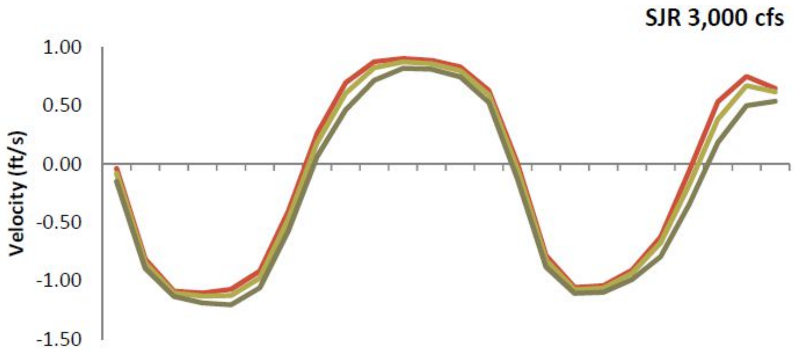

Figure A.2.4. Instantaneous average velocity values across 24 channel segments from the mouth of Middle River to Export facilities. Velocity data for each channel were taken from a single day (May 7, 2007) (LOO Annual Review 92012) Appendix A, page D-50).

Discussion of STST behavior.

The parameter φ quantifies STST behavior over the Delta and the correlation of φ with environmental conditions should provide insight to the mechanisms controlling fish migration behavior. For example, we might hypothesize that fish are able to detect the direction downstream by asymmetric changes in the environmental properties over a tidal cycle. The signal may include asymmetric patterns in the vertical or temporal distributions of turbidity and micro turbulence. For example, turbulence should be highest on the flood tide, possibly triggering movement into a low velocity region. Furthermore, in tidal rivers and estuaries the flood tide may move through progressively smaller cross-sectional areas causing the tidal currents to become progressively more asymmetric in both speed and direction (Wells 1995), which could facilitate detection of the tidal signal. Furthermore, if asymmetry in the channel configuration alters the signal triggering behavior then the complexity of the Delta may result in complex STST behavior. For example, fish moving from the San Joaquin River into Franks Tract may first experience a strong signal of tidal direction but once inside the track where the channel widens the signal may virtually disappear. With heterogeneity in STST signal strength we expect φ to vary over reaches and flow conditions.

Action.

The IRP suggests researchers evaluate the relationships of φ with differing environmental and hydraulic properties of the reaches. As a null hypothesis to the STST behavior, assume fish swim downstream independent of tidal conditions. In this case there would be no correlation of φ with Delta geometry. Note that the null hypothesis is also biologically possible if salmon navigate using the geomagnetic signals that indication location. However, even if fish use geomagnetic navigation they may do so in the context of STST behavior.

A2.3: Predator-Smolt Encounters

Equation (1) proposes that the importance of the downstream velocity of the smolts in determining their migration survival depends on the encounter velocity of the smolts to predators. Furthermore, the probability of encounters and predation events is expected to change over tidal and diel cycles and depend on the avoidance strategy of the smolts and the search strategy of the predators. While numerous studies have documented STST behavior, the panel is unaware of specific studies exploring predator-prey interactions in STST conditions. In a general sense, the smolt STST strategy is to move out of the Delta and avoid predators while the predator STST strategy is to remain in the Delta and encounter prey. Competing predator and prey strategies have been viewed as a predator-prey shell game that depends on the ability of the predator to adjust its strategy to the temporal flux of prey (Lima 2002). A recent study suggests a type of shell game may occur in Atlantic cod foraging on Atlantic salmon during their post-smolt estuary migration (Hedger et al. 2011). The cod exhibited a more focused foraging distribution during the smolt outmigration, but their distribution was not influenced by the tides, i.e. they held station against the tides. Delta predators may use a similar mechanism. We illustrate the implications of such strategies in the example below that combines the XT survival model and the STST hypothesis.

We begin by defining the random encounter velocity between predator and prey (Anderson et al. 2005) as

$$\omega = \sqrt{u_{smolt}^2 + u_{pred}^2} \qquad (4)$$

where u_{smolt} and u_{pred} are the rms random velocities of smolts and predators respectively. With STST behavior, relating smolt rms random velocity to acoustic tag observations may be problematic since in the model part of the tidally-correlated movement of the smolts is attributed to the mean movement. However, approximations of the rms random velocities can be developed based on assumptions of the behavior of predators and smolts. Assume that predators hold station during the ebb tide such that smolts pass through a gauntlet of predators, while on the flood tide the smolts are stationary and the predators move with the flow searching for prey. Assume the combined effect of these two strategies depends on STST behavior and the rms tidal velocity, which we take as a surrogate for the random search velocity of the predators. Then, the random predator-smolt encounter velocity might be expressed $\omega = (1-\varphi)v$ and the ratio of mean smolt migration velocity to the predator-smolt random encounter velocity is

$$\frac{U}{\omega} = \left(\frac{V}{v} + \varphi\right) \Big/ (1-\varphi) \qquad (5)$$

Using the example for travel time of CWT Chinook from the lower San Joaquin River to Chipps Island gives $U/\omega = 0.38$.. Including Equation (5) in Equation (1), survival over the reach is on the order of 16% of the maximum survival, S_{max} (Figure A2.1). If the maximum observed survival through the Delta is on the order of S_{max} = 20% then survival should be 3%, which is about what was observed in 2012.

The salient point is the XT predation model and selective tidal transport hypothesis together provide a mechanistic explanation for both the observed rapid movement and low survival of smolts in the Delta.

If smolts and predators exhibit distinct behavioral patterns relative to the direction and velocity of the water currents over tidal cycles then classification of smolt and predatory-type tags may require correlations of tag movement with the proximal water velocities. Distinct behavior patterns may be most evident on peak flow or slack water periods.

Action.

Much information is known about the behavior of organisms on tidal oscillations, but little is known about the effects of tidal oscillations on predator-prey interactions. The panel suggests that prior to additional field work in this area a workshop be held bringing experts together on tidal physics, foraging ecology and predator-prey theory. The panel suggests a mix of local, national and international experts comprise the workshop membership.

A2.4: Fish Routing

The 2012 joint stipulation study found that movement into the inner Delta appeared independent of the OMR flow which suggests that route selection is influenced by proximal conditions at the junctions of the channels. We hypothesize that routing is determined mainly by the response of the fish to the flow field as structured by the channel shape and the flow, which is comprised of the pure tidal flow and the residual flow generated by river flow and pump operations. Thus, it is reasonable to hypothesize that the behavioral factors that produce STST are also important in route selection at reach junctions.

The IRP proposes studying route selection at two spatial-temporal scales: a *reach scale* involving the asymmetric patterns of hydrodynamics of the tidal cycle and a *junction scale* that considers the flow structure over the scales directly perceived by fish during the passage through junctions. Frameworks for studying entrainment at reach and junction scales need to be based on working hypotheses of how hydraulic and behavioral factors interact to determine routing. Examples of reach and junction scale hypotheses are briefly outlined below. These are not intended to be complete or necessarily correct; their purpose is to illustrate general approaches and levels of detail that may be needed in designing analyses and frameworks at each scale. The panel encourages this two-pronged approach as a way to derive a working understanding of fish routing mechanisms while developing analysis that can draw on the existing, coarser scale data available through CWT and the finer scale acoustic tagging studies. As an aside, the panel suggests that mechanisms of STST and route selection in salmon will also have value for understanding the movement of resident Delta fish such as delta smelt and longfin smelt.

Reach scale analysis framework.

As an example of a reach scale routing hypothesis begin with the assumption that if smolt STST occurs in reaches it also occurs in junctions. Based on the STST hypothesis detailed in Appendix 2.2 smolts exhibit asymmetric behavior to selectively move downstream by moving into low velocity regions when triggered by signals indicating a flood tide. Note also, that reversal of OMR flows may disrupt and confuse this signal. The strength of the STST should be reach specific and might be quantified by φ (Equation 2) characterizing the fraction of a tidal cycle over which fish seek lower velocity regions. For a working hypothesis, assume that routing at a reach junction depends on the reach-specific φ, the junction hydrodynamic *v*, and the junction geometry, expressed here as cross-sectional area *A* (Figure A2.5). Then an equation expressing the fraction *f* of fish routed through reach 1 might be written

$$f_1 = \frac{\varphi_1 v_1 A_1}{\varphi_1 v_1 A_1 + \varphi_2 v_2 A_2} \qquad (6)$$

and fraction passing through reach 2 becomes $f_2 = 1 - f_1$. The important feature of this framework is that routing involves three factors, behavioral, hydraulic and geometric properties. The challenge is to formulate measures that are mechanistically meaningful and measurable. Three trial hypotheses/analyses (developed in conversation with R. Buchanan) are outlined below:

Hypothesis 1: assume φ_i from reaches Equation (3) applies to Equation (6) and the $\varphi_i A_i$ is the junction volume transport averaged over a tidal cycle.

Hypothesis 2: assume reach-specific φ_i and v_i represent rms velocities.

Hypothesis 3: assume φ_i is junction-specific and must be characterized by correlating fish and water movements with the junction.

Again, these approaches are presented to illustrate an approach for conducting analyses based on underlying transport mechanisms.

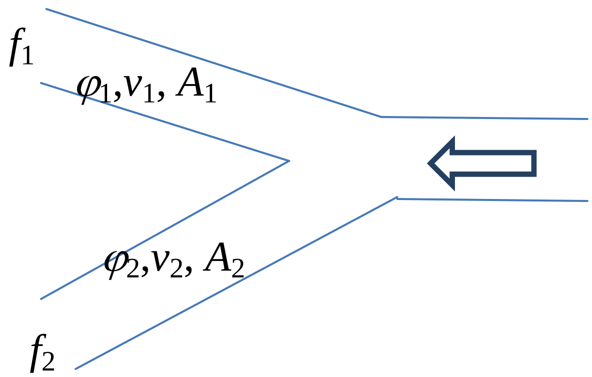

Figure A2.5. Reach routing model based on STST behavior and tidal dynamics.

Junction scale analysis framework.

An alternative, higher resolution, approach is available through the melding of computational fluid dynamics models with models of the rheotactic response of fish. Such studies are being carried out in the Sacramento River by David Smith of the Army Corps of Engineers Cognitive Ecology and Ecohydraulics Research group el.erdc.usace.army.mil/emrrp/nfs/index.html. A description of ecohydraulics to study fish routing derived from the research groups follows:

> The Eulerian–Lagrangian–agent Method (ELAM) provides a framework to analyze fish habitat occupancy as a function of environmental change. We create a 'virtual reality' of the environment and then analyze/forecast habitat occupancy as a function of discharge, channel morphology, habitat complexity, and water quality using a fish habitat selection algorithm coupled to a particle–tracking model (PTM). We model the cognition, adaptation, and learning of fishes along with their physiological sensory capabilities instead of using habitat suitability criteria or reach–scale habitat classification (e.g., pool, riffle, run, shear zone, etc). Reach–scale habitat occupancy patterns are resolved from responses to physical and chemical stimulus at the microhabitat scale. Thus, we can forecast fish response to changes in river channel morphology derived from hydrographic manipulation or construction of engineered structures. Traditional habitat suitability criteria and reach–scale habitat classifications limit flexibility and the level of fidelity that can be used in analysis of a restoration project. The ELAM approach is a "plug–and–play" tool that supports management decisions in a theoretically– and mathematically–rigorous manner (el.erdc.usace.army.mil/emrrp/nfs/fishhabitat.html).

For further discussion, see the response to question “How should the experimental design be adjusted in future years to test key habitat drivers of smolt behavior and survival, and support weekly operational decision making?”

A2.5: Is the San Joaquin River a salmon sink?

The low Delta passage survival of fall-run Chinook and steelhead on the order of 1-3%, begs the question as to whether the San Joaquin River can support salmon populations in the future or whether it is a sink habitat receiving adult Chinook from other Central Valley rivers. The high stray rate of the hatchery raised fall Chinook (e.g., Mesick 2001) may suggest natural production in the system is not being maintained or will not be in the future with increased Central Valley warming by climate change. The IRP recommends that this possibility be consider through an analysis of source-sink population dynamics of the Sacramento/San Joaquin populations.