Public Comment
Sthrn Delta Ag & SJR Flow
Deadline: 5/23/11 by 12 noon

State of California

The Resources Agency

Memorandum

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Date: May 23, 2011

To: Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Via: electronic mail and hand delivery

From: Department of Water Resources

Subject: Comments on the Revised Notice of Preparation and Notice of Additional Scoping for Potential Amendments of 2006 Water Quality Control Plan

The Department of Water Resources (DWR) appreciates the opportunity to provide comments on the State Water Resources Control Board's (State Water Board) Revised Notice of Preparation and Notice of Additional Scoping Meeting (Notice) regarding review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). DWR's comments include recommendations as to the scope and content of the environmental information to be included in the State Water Board's Substitute Environmental Document (SED) for the Board's review of the potential amendments to the San Joaquin River flow and southern Delta salinity objectives in the Bay-Delta Plan.

In general, DWR continues to support the review process and the efforts of the State Water Board's staff to identify and develop the information and tools necessary to establish reasonable objectives and a program of implementation. DWR looks forward to working with the State Water Board and its staff to ensure that the Board has a full understanding of the factors that affect the beneficial uses along the San Joaquin and in the southern Delta, and is fully apprised of the potential beneficial and harmful impacts associated with any changes to existing objectives or implementation of new objectives. In addition, as discussed below, DWR believes that the potential amendments to the Bay-Delta Plan should be analyzed and possibly revised to address issues of fact, law and policy raised by the draft modifications.

SAN JOAQUIN RIVER FLOW OBJECTIVE

1. DWR Questions Whether A "Flow-Only" Approach Is Appropriate

After thinking through the State Water Board's current approach to protecting fish and wildlife beneficial uses along the San Joaquin River (and in light of the Delta Stewardship Council's current focus on setting and implementing "flow standards"), DWR questions whether: 1) "flow-only" objectives are appropriate in a water quality control plan, and 2) if considered appropriate, are "flow-only" objectives the best approach to efficiently manage the system to protect those beneficial uses.

With regard to point one, DWR recognizes that many may regard this as an already settled question. The 1995 Bay-Delta Plan included several flow-only objectives, including river flow objectives and Delta outflow objectives. In a passing comment on whether water flow can be regulated as a water quality objective, the court in *State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674 (*Robie* Decision) noted its approval, stating "'the rate and quantity of flow ... are physical properties or characteristics of the water" which 'have an impact on the beneficial uses of' water in the Bay-Delta. (Citation omitted) Thus, a flow objective sets the amount of water that must be flowing in a watercourse at a given time 'for the reasonable protection of beneficial uses of [the] water.'" (*Id.* at 701 (quoting the State Water Board in its 1995 Bay-Delta Plan).)

Notwithstanding the court's embrace of flow-only water quality objectives, DWR brings up this issue to state its concern that the potential draft modifications seem to lead us away from the basic purpose of the Porter-Cologne Water Quality Control Act (Water Code Section 13000 et seq.) (Porter-Cologne Act) and, in turn, are using the Act to control water-related phenomena that are better and more appropriately addressed in other contexts and statutory schemes.

The Porter-Cologne Act was "an evolutionary step in the public control of the degree to which available water resources are to be used as a receptacle and transport mechanism for society's wastes." (Robie, *Water Pollution: An Affirmative Response by the California Legislature* (1970) 1 Pacific L.J. 2 at 34.) "The basic policy of the law is to protect water quality by the reasonable regulation of waste discharges." (*Ibid.*) With this policy in mind, the Legislature declared that the "quality of all the waters of the state shall be protected for use and enjoyment by the people of the state." (Wat. Code, § 13000.) The policy focus and sense of the "water" in "quality of the water," however, is the condition or character of the substance of the water in the watercourse, referred to as the "water column." Water quality parameters of the water column are traditionally its chemistry, constituents, and physical character (principally temperature). Flow, on the other hand, its quantity, rate, velocity, direction, etc., are not characteristics of the water in the watercourse, but of the watercourse itself.

The physical behavior of the watercourse, including flow, depth, stage and other aspects of riverine hydrodynamics, do provide a context for understanding the relative contribution of water quality degradation impacts on beneficial uses, such as fish resources. However, beyond their usefulness in providing that perspective, it is troublesome to say that flow alone should play a role in a water quality control plan. Certainly, the physical characteristics of the watercourse are of public and regulatory concern; but they are concerns that fall more naturally and fittingly within the policy and legislative frameworks of water rights, flood control, and navigation, and far less so within the sphere of water quality policy interests and concerns, such as "pollution," "contamination," "discharges," and "degradation."

Essentially, by making flow itself a water quality objective, the State Water Board has expanded the scope of the Porter-Cologne Act beyond that which it was intended to control. With the advent of flow objectives, water quality control has moved from controlling the degree to which available water resources are used as a receptacle and transport mechanism for waste, to now controlling the availability of water itself.

Moreover, this expanded scope leaves open the door to having such phenomena as water level, depth, and the geometry of a channel come under the purview of water quality control.

DWR believes that this was not the intent of the Porter-Cologne Act and, in addition of a general reading of the Act itself, the State Water Board's own standard term E helps demonstrate this. Following enactment of the Porter-Cologne Act, the State Water Board developed the following provision, known as Standard Term E:

> The quantity of water diverted under this permit and under any license issued pursuant thereto is subject to modification by the SWRCB if, after notice to the permittee and an opportunity for hearing, the SWRCB finds that such modification is necessary to meet water quality objectives in water quality control plans which have been or hereafter may be established or modified pursuant to Division 7 of the Water Code. No action will be taken pursuant to this paragraph unless the SWRCB finds that (1) adequate waste discharge requirements have been prescribed and are in effect with respect to all waste discharges which have any substantial effect upon water quality in the area involved, and (2) the water quality objectives cannot be achieved solely through the control of waste discharges.

The above standard term provision is particularly insightful for several reasons. First, it demonstrates that the State Water Board at least initially did not foresee flow, i.e., the quantity of water, would actually be a water quality objective. Standard Term E simply does not make sense if the objective to be achieved is flow. As stated in the provision, the State Water Board will not take action affecting the quantity of water diverted under a permit unless it first finds that adequate waste discharge requirements have been implemented and water quality control objectives cannot be achieved through those discharge prescriptions. These preconditions to the Board taking action essentially become meaningless if flow is the objective at issue--the only way to achieve a flow objective is to provide the required flow.

Second, it is clear from the above provision, that the use of water is expected to help achieve water quality objectives, as opposed to the quantity of water actually being the objective. This expectation fits well with the above discussion in that it recognizes water quantity can affect water quality (helping achieve a water quality objective), but it is not an inherent quality of water (and thus is not a water quality objective itself).

Lastly, in DWR's opinion, this specific provision demonstrates the proper approach to achieving water quality objectives and, in turn, protecting beneficial uses. According to Standard Term E, the State Water Board will resort to using water to help achieve a water quality objective only after it has been demonstrated that other (i.e., physical) measures have been put in place and have been shown to be ineffective in achieving an objective. DWR believes that this approach is consistent with the fundamental principle of California water policy, that water should not be taken from one beneficial use to serve another where non-water (physical) solutions or water-efficient physical solutions are available. This brings the discussion, at least in part, to the second point raised above.

Notwithstanding the appropriateness of "flow-only" objectives, DWR also questions whether a "flow-only" approach will efficiently manage the system to protect the Bay-Delta's fish and wildlife beneficial uses. It is generally the consensus that the existing regimen of Delta flows and diversion cannot efficiently or adequately serve the multiple competing uses of Delta waters. However, as DWR has emphasized many times before, in addressing the current problems and identifying solutions, it is imperative that the State Water Board distinguish those problems and/or solutions which have flow patterns or diversions at their root from those which are inherently connected with flow itself.

It is only through a careful analysis of flow and its intended benefits, and full understanding of the causal mechanisms that flow supports that we may begin to understand how the Delta's ecosystem is "broken" and how in the short-term or in the long-term we may adequately and efficiently protect it. It is also key to understanding how near-term criteria may relate to the long-term solution to be developed in the Delta Plan and Bay-Delta Conservation Plan (BDCP). Casting the question simply as one only of flow and not digging deeper to understand the causal mechanisms related to the flow regimen plants the State ever more firmly in the gridlock of competing interests and misses the opportunity to explore and develop measures which accommodate rather than divest competing beneficial uses of water.

In light of 1) the inappropriateness of the Board's reliance upon water quality authorities exclusively to support a planning effort which includes non-water quality parameters such as flow, and 2) the need to examine the different functions where flows may be required to develop an efficient overall flow regime, DWR recommends that the State Water Board adapt its current approach to allow for the development of objectives that are based on causal mechanisms, such as habitat, predation and diversion avoidance, etc., where flow may be used to achieve an objective but is not necessarily the objective itself. Having a causal basis for water quality objectives and, in turn, the flow necessary to achieve them, should make the ultimate water quality control plan more effective and readily adaptable to improvements in knowledge and changing conditions in the Delta. (See Fleenor, et al., *On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta* (2010).) Moreover, a more explicit causal basis for objectives, and the flows necessary to achieve them, will likely create "incentives for improved scientific understanding of the system and its management as well as better integration of physical, chemical, and biological aspects of the problem." (*Id.* at 27.)

DWR recognizes that the current state of knowledge may not allow for full development of such an approach. However, the lack of knowledge should not prevent recognizing that such an approach is necessary and developing a plan that allows for incorporation of causal-based objectives as the knowledge is developed. By doing this, the State Water Board will be better positioned to move away from the correlative empirical relationships and other statistical relationships that have not served us well thus far.

An encouraging prospect that may help provide the necessary information is the development of quantitative life-cycle models for various fish species. Such models are recognized as the best method to evaluate the effects of an action upon a fish population's growth rate. (See *Memorandum of Decision Re Cross Motions for Summary Judgment*, at 45 (Dec. 14, 2010) (Wanger Delta Smelt Decision).) "[A] Population growth rate analysis is the generally accepted method utilized by fisheries biologists to evaluate the impact of a stressor on a fish species' population. (*Ibid.*) Moreover, a "quantitative population dynamics/life cycle model can help distinguish human actions that have a significant impact on population size from those that have little impact on population size, because competition for a resource that is independent of the human activity may cause significant mortality at one stage in the species' life cycle, meaning that human actions that kill fish at that life stage may have little impact on the population level later in the life history." (*Id.* at 45-46.)

It is DWR's understanding that an appropriate life cycle model has not yet been developed for salmonids. Nonetheless the lack of such a model should not prevent the State Water Board from recognizing its necessity in this process and even encouraging the fishery agencies to develop an appropriate model.

2. Export Effects On San Joaquin Salmonid Survival Is Minimal

Throughout the process to review and potentially modify the San Joaquin River flow objectives, the State Water Board has stated that a comprehensive discussion or analysis of such issues as the flow split at the Head of Older River (HOR) and the effects of diversion by DWR and the U.S. Bureau of Reclamation (USBR) on flows through Old and Middle Rivers (OMR) is not necessary because these issues are not the subject of the State Water Board's current review. DWR has agreed with the Board that these issues are outside the scope of the current review but they continue to be discussed as possible issues for future proceedings.

For example, the State Water Board's Draft Technical Report on Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity contains several conclusions regarding the effects of OMR reverse flows on fish (See Draft Technical Report at 51-52 (Oct. 29, 2010)). However, many of the conclusions found in that section are either not supported by the best available science or misstate the findings of the studies cited. Further, there is substantial information, which is discussed below, that indicates the effects from exports on salmon behavior in the Delta is not significant.

In Attachment 2 of the State Water Board's Notice, the potential draft modifications state the following:

> Although the most downstream compliance location for the San Joaquin River flow objective is at Vernalis, the objective is intended to protect

> migratory fish in a larger area, including areas within the Delta where fish that migrate to or from the San Joaquin River watershed depend on adequate flows from the San Joaquin River and its tributaries. To assure that flows required to meet the San Joaquin River narrative flow objectives are not rediverted downstream for other purposes, the State Water Board may take water right and other actions to assure that those flows are used for their intended purposes.

This language read together with information included in the Draft Technical Report suggests that export effects downstream of Vernalis may be the subject of future Board actions. Although DWR agrees that the Board should defer addressing such actions, DWR provides information in these comments to help inform the Board of the current studies regarding SWP and CVP operations and impacts on salmonid survival in the Delta.

In the Draft Technical Report, page 51, the Board summarizes its conclusions regarding the effect of exports on fish survival, stating:

> High net Old and Middle River (OMR) reverse flows can have several negative ecological consequences. First, net OMR reverse flows draw fish, especially the weaker swimming larval and juvenile forms, into the SWP and CVP export facilities. The export facilities have been documented to entrain most species of fish present in the upper estuary (Brown *et al* 1996). Second, net OMR reverse flows reduce spawning and rearing habitat for native species. Any fish that enters the central or southern Delta has a high probability of being entrained and lost at the pumps (Kimmerer and Nobriga, 2008). Third net OMR reverse flows have led to a confusing environment for migrating salmon leaving the SJR basin.

The Draft Technical Report then cites to the Reasonable and Prudent Action IV.2.3 (RPA which restricts OMR reverse flows) set forth in the National Marine Fisheries (NMFS) 2009 Salmon Biological Opinion (Salmon BiOp), for further evidence of the effects of exports on fish survival. As explained below, twenty years of scientific research on salmon survival through the Delta has failed to show any significant negative statistical relationship between exports and salmonid survival. Thus, DWR believes, based on these studies, that the conclusions in the Draft Technical Report on OMR are not supported by the best available science and the Draft Report should be revised.

A. The "Zone of Influence" Concept Regarding Export Facilities and Salmon Migration is Faulty

The State Water Board conclusions on Page 51 of the Draft Technical Report are based on the concept that it is necessary to keep salmonids away from the "zone of influence" of the export facilities. This concept is based upon the hypothesis that more negative Old and Middle River (OMR) flows draw an increasingly significant portion of salmonids from their normal migratory route towards the export facilities, and therefore limiting the amount of negative OMR flow is necessary to protect migrating salmonids. DWR believes this concept is faulty for two reasons. First, in order to support the hypothesis that exports draw salmonids off of their normal migratory route, entities have improperly relied upon the Particle Tracking Model (PTM) to correlate the behavior of salmonids, which move rapidly and volitionally, to that of neutrally buoyant particles. Second, there are other studies which more accurately reflect the behavior of out migrating salmonids, and the studies strongly suggest that the PTM is an inappropriate tool to assess out migrating salmonid behavior.

The "zone of influence" concept is based upon an incorrect analysis and use of the PTM. The PTM is the subject of a leading peer-reviewed article entitled "Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta using a Particle Tracking Model" (Kimmerer and Nobriga 2008). The Draft Technical Report cites this article as the basis for the statement on page 51, "Any fish that enters the central or southern Delta has a high probability of being entrained and lost at the pumps." In addition, NMFS considered this article as useful for analyzing the potential "zone of effects" for entraining emigrating salmonids in its 2009 Salmon BiOp. However, in the article Kimmerer and Nobriga rejected the use of a zone of influence stating, "[w]e are, furthermore, not inclined to define a 'zone of influence' of the pumps on the basis of our results, since the probability of entrainment depends on time horizon which, in many cases, is too long to be useful for analyzing the movements of larval fish. By the end of the modeled time period, the fish would already have metamorphosed, and their behavior would have become more complex." (Kimmerer and Nobriga 2008, p. 18) It stands to reason that since salmonid smolts are large fish with more complex swimming behavior than larval fish, the time horizon is likewise too long to be useful for analysis of salmonid movement.

Other research has specifically evaluated the applicability of PTM results to salmonid smolts and found the PTM an inappropriate indicator of their behavior. In "Survival of Chinook Salmon Smolts in the Sacramento-San Joaquin Delta and Pacific Ocean" (Fish Bulletin 179, Vol.2, (2001)) biologists Baker and Morhardt were critical of the concept of using neutrally buoyant particles as an indicator of salmonid smolt behavior. The authors stated, "San Joaquin smolts pass through the Delta in a median time of 11 days, some arriving at Chipps Island as early as five days after release at the point where the San Joaquin River joins the Delta, and some taking as long as 26 days…This is considerably shorter than the transit time for neutrally-buoyant tracer particles." (Baker and Morhardt 2001, p.173.) In describing the rapid migration of smolts relative to neutrally buoyant particles, they state, "This is in accordance with the striking difference between the passage of time of smolts and passive particles; smolts actively swim toward the ocean." They further comment on a simple model of smolt behavior and movement of water in tidally driven portions of the Delta stating, "the most straightforward model, that the movement of smolts mirrors the movement of water, has been shown to be incorrect. Smolts and water travel through the Delta at very different rates and end up at very different places." (Baker and Morhardt 2001, p.173.)

DWR also conducted an analysis comparing observed coded wire tag (CWT) recoveries with predicted recovery timing and location using the PTM. DWR provided this analysis to NMFS during the consultation period of the BiOp development process (See attached DWR Exhibit 1, DWR letter to NMFS (April 20, 2009).) DWR's analysis had the following conclusion:

> The result of the comparison of timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island shows that there is no correlation. This is shown in the last two figures of this attachment. There are factors other than hydrodynamics affecting juvenile Chinook emigration through the south Delta not accounted for in the PTM. Based on the 24 experiments graphed in this evaluation, the PTM results are an adequate surrogate for 'timing' of salmonid emigration in only very high flow years like 1995, 1998, and 2006 because these higher flow events caused the PTM results to match the normal rapid movement of salmon out of the system. But for the rest of the years, intermediate and low flow years, the PTM results predicted salmon in the system longer than they really are.

The foregoing discussion demonstrates why the Kimmerer and Nobriga 2008 article and other PTM studies analyzing salmon smolts in the Delta do not support the concept that the export facilities create a "zone of influence" effecting salmonid smolt behavior. In addition, nowhere do the authors state or make any assertion that supports the statement contained in the Draft Technical Report that "any fish that enters the central or southern Delta has a high probability of being entrained and lost at the pumps." DWR respectfully requests that this statement be removed from the report, since it is not an accurate statement as to the conclusion of the report, and scientific studies do not support it.

B. Relationship Between Exports and Survival

Over the past twenty years, researchers have analyzed the relationship between project exports and salmonid survival. The studies conducted during that time have either failed to establish any significant statistical relationship between exports and survival, or, more surprisingly, have shown a positive relationship between exports and survival. The major articles analyzing these studies are summarized below.

1. Kjelson, Loudermilk, Hood, and Brandes, "The Influence of San Joaquin River Inflow, Central Valley and State Water Project Exports and Migration Route on Fall-Run Chinook Smolt Survival in the Southern Delta During the Spring of 1989" (DFG 1989)

> *"Survival of tagged smolts released under low export conditions was not greater than for those released under high export conditions (Table 4).* This was an unexpected result as we believed conditions for survival should have improved when exports were lowered, since direct losses at the Project facilities were decreased, flow in the mainstem San Joaquin was increased and reverse flows in the Delta were eliminated."
> (Kjelson et al, p.12, emphasis added.)

2. Brandes and McLain, "Juvenile Chinook Salmon Abundance, Distribution, and Survival in the San Sacramento-San Joaquin Estuary," Fish Bulletin 179, Vol. 2 (2001)

"To determine if exports influenced the survival of smolts in the San Joaquin Delta, experiments were conducted in 1989, 1990 and 1991 at medium/high and low export levels. *Results were mixed showing in 1989 and 1990 that survival estimates between Dos Reis and Jersey Point were higher with higher exports whereas in 1991 between Stockton and the mouth of the Mokelumne River (Tables 11 and 12) survival was shown to be lower (0.008 compared to 0.15) when exports were higher.* . . . In addition, results in 1989 and 1990 also showed that survival indices of the upper Old River groups relative to the Jersey Point groups were also higher during the higher export period, but overall still about half that of the survival of smolts released at Dos Reis (Table 11)."
(Brandes and McClain, p. 86, emphasis added.)

3. San Joaquin River Group Authority, "2005 Annual Technical Report" p. 66-67

"Regression of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, but *both relationships indicated survival increased as exports increased*."
(2005 Annual Technical Report, pp.66-67, emphasis added.)

4. California Department of Fish and Game, "Final Draft 11-28-05 San Joaquin River Fall-run Chinook Salmon Population Model" , Fig 24, p. 68; quote on page 15

"There is *no correlation* between exports and adult salmon escapement in the Tuolumne River two and one-half years later (Figure 24)."
(DFG, p.16, Figure 24 at p. 68, emphasis added.)

5. Mesick, McLain, Marston and Heyne, "Draft Limiting Factor Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River" (Sponsored by USFWS, NMFS, and DFG) (February 27, 2007)

"[P]reliminary correlation analyses suggest that the combined State and Federal export rates during the smolt outmigration period (April 1 to June 15) have relatively little effect on the production of adult recruits in the Tuolumne River compared to the effect of winter and spring flows. Furthermore, reducing export rates from an average of 264% of Vernalis flows between 1980 and 1995 to an average of 43% of Vernalis flows and installing the head of Old River Barrier between 1996 and 2002 during the mid-April to mid-May VAMP period did not result in an increase in Tuolumne River adult recruitment (Figures 3 and 17)."
(Mesick et al, p. 25, emphasis added.)

6. **Ken B. Newman (USFWS), "An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies" (Sponsored by a grant from the CalFed Science Program) (March 31, 2008)**

"The Bayesian hierarchical model analyzed the multiple release and recovery data, including Antioch, Chipps Island, and ocean recoveries, simultaneously....*There was little evidence for any association between exports and survival, and what evidence there was pointed towards a somewhat surprising positive association with exports.*"
(Newman, pp. 75-76, emphasis added.)

7. **Baker and Morhardt, "Survival of Chinook Salmons Smolts in the Sacramento-San Joaquin Delta and Pacific Ocean" Fish Bulletin 179, Vol. 2 (2001)**

Baker and Morhardt 2001 concludes that "[t]here is no empirical correlation at all between survival in Lower San Joaquin River and the rate of CVP-SWP export" (Baker and Morhardt at 179) and that "no relationship between export rate and smolt mortality, suitable for setting day- to- day operating levels, has been found." (Baker and Morhardt, p. 181.)

In addition to the above studies, on March 19, 2010, the National Academy of Science's Committee on Sustainable Water and Environmental Management in the California Bay-Delta issued a report entitled "A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endanger Fishes in California's Bay Delta," available on-line at www.nap.edu/catalog/12881.html. This report assessed the effectiveness of the San Joaquin River flow-to-export ratio limit in the NMFS 2009 BiOp, Reasonable and Prudent Alternative (RPA) Action IV.2.1, and concluded there was a weak influence of exports on salmon survival, stating:

> The controversy lies in the effectiveness of the component of this action that reduces water exports from the delta. The effectiveness of reducing exports to improve steelhead smolt survival is less certain, in part because within the VAMP (Vernalis Adaptive Management Plan) increased flows and reduced exports are combined, and in part because steelhead smolts are larger and stronger swimmers than Chinook salmon smolts. Furthermore, it is not clear in the biological opinion how managing exports for this purpose would be integrated with export management for other actions. The choice of a 4:1 ratio of net flows to exports appears to be the result of coordinated discussions among the interested parties. *Given the weak influence of exports in all survival relationships (Newman 2008), continued negotiation offers opportunities to reduce water use in this specific action without great risk to salmon.* Further analysis of VAMP data also offers an opportunity to help clarify the issue.

> *The committee concludes that the rationale for increasing San Joaquin River flows has a stronger foundation than the prescribed action of concurrently managing inflows and exports.* We further conclude that the implementation of the 6-year steelhead smolt survival study (action IV.2.2) could provide useful insight as to the actual effectiveness of the proposed flow management actions as a long-term solution.
> (National Academy of Science Report, p. 45, emphasis added.)

Furthermore, in December 2010, the Delta Science Program (DSP) was asked to provide scientific advice intended to assist both NMFS and USFWS by reviewing the efficacy of implementing the RPAs in the Biological Opinions. A DSP Panel held a two day workshop to consider additional and updated information and new research findings and to discuss issues related to the application of the RPA actions. The Panel also received written comments from stakeholders. Among the actions the Panel reviewed was a preliminary proposal by NMFS to adjust various actions in the Salmon BiOp, including Action IV.2.3 (action constraining OMR flows).

The Panel issued a report on its findings entitled "Report of the Independent Review Panel (IRP) on the Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria and Plan (OCAP) for State/Federal Water Operations" (December 9, 2010). In its report, a copy of which is attached to these comments as DWR Exhibit 2 IRP Report Dec. 13, 2010., the Panel stated that it was reluctant to endorse the calendar-based OMR trigger of the Action IV.2.3 without studying the monitoring data more carefully, and that "Regarding Action IV.2.3 in general, the Panel feels additional acoustic tagging studies in the north Delta would be valuable to better understand the importance of exports and negative OMR flow levels in affecting salmonid survival in the Delta for Sacramento River Juvenile Chinook salmon." (IRP Report at 24.)

The Panel made the following comments regarding the use of the PTM to analyze the effects of exports on salmonid behavior:

> Regarding the issue of particle tracking raised by DWR, the Panel Agrees with DWR that particle-tracking modeling studies using neutrally buoyant particles are <u>*not*</u> a good surrogate for the fine-scale migratory behavior of salmonid smolts or for estimating the transit time of smolts through the Delta. (emphasis in original). What little that is known about the migratory process of smolts in estuaries is that their movements are in steps, characterized by swimming in the direction of the current followed by periods of holding in areas of low current velocity. These are not behaviors described by neutrally buoyant particles. On the other hand, in the process of migrating to the sea, smolts are thought to cue almost entirely on downstream flow direction. Because neutrally buoyant, particle tracking modeling gives clear indications of flow directions, it can be a useful tool in helping forecast how movements of smolts through the Delta may be influenced by flow.
> (IRP Report at 25, emphasis added).

The hypothesis that exports have a significant impact on salmonid survival has been scrutinized in the ongoing litigation over the NMFS 2009 Salmon BiOp referred to as the *Consolidated Salmon Cases*. In December 2010, the Federal Eastern District Court in California held a hearing on motions for summary judgment in the *Consolidated Salmon Cases*, and as part of the proceedings DWR filed a declaration by Bradley Cavallo (see attached to these comments DWR Exhibit 3 (Cavallo Decl. (dated Aug. 6, 2010). In his declaration, Mr. Cavallo discusses the studies concerning the effect of exports on juvenile salmonid survival, which are also cited above, and states "Without exception, quantitative analysis from mark-recapture experiments and correlative analysis of spawning escapements have found no evidence for statistically or biologically significant adverse effects on the survival of salmonids related to south Delta export rates (citations omitted). In contrast, these same studies, as well as others which did not quantitatively evaluate effects (e.g, Kjelson et al. (1982), Kjelson and Brandes (1989), have consistently found evidence for a positive effect of SJR flows on survival of juvenile salmonids." (Exhibit 3, Cavallo Decl., Para. 5). Mr. Cavallo further discusses the rationale for Action IV.2.3, which was based upon the use of the PTM. (Exhibit 2, Cavallo Decl., Para. 28 through Para. 81.) He concludes, "Collectively, these facts suggest that a reasonable biologist would not predicate OMR flow restrictions upon expected benefits to SR juvenile salmonids. It is very unlikely that that [sic] OMR flow restrictions described in Action IV.2.3 will yield any substantial benefits to SJR or SR juvenile salmonids." (Exhibit 2, Cavallo Decl., Para. 81).

In March 2011, a preliminary injunction hearing was held on the Salmon BiOp RPA Action IV.2.1, and DWR filed two additional declarations from Mr. Cavallo regarding the best available science on the effect of exports on salmonid survival. While it was agreed by the parties to the litigation that due to this year's hydrology there was no need for the Court to issue a ruling in the matter, the information contained in Mr. Cavallo's declarations is informative to the Board's process and the declarations are attached to these comments as DWR Exhibit 4 (Cavallo Decl. (dated Feb. 3, 2011)) and DWR Exhibit 5 (Cavallo Decl. (dated Feb. 28, 2011))

In Cavallo's February 3, 2011 declaration he evaluates NMFS' contention that exports profoundly influence net flows in the Delta, and the related conclusion that resulting flow changes cause harm to juvenile salmon. Mr. Cavallo then presents two alternative analyses to the PTM results and qualitative assessments by an analysis of DSM2 HYDRO and a Delta Passage Model, which Mr. Cavallo developed. Mr. Cavallo explains in his declaration that he used DSM2 HYDRO to complete an evaluation of export and river inflow effects on Delta flow conditions. (See Exhibit 4, Cavallo Decl., Para. 7 through Para. 17). Mr. Cavallo concludes this analysis by stating:

> Collectively, these results confirm my previous observation that, 'given the rapid and directed movements of salmonid smolts, it is both inappropriate inaccurate to use the fate of particles integrated over weeks or months to even roughly assess salmonid smolt effects' (citation omitted.) The long time period over which PTM integrates the fate of particles greatly exaggerates the perception of export impacts on juvenile salmonids. Indeed, recent

> telemetry studies shows that salmon smolts spend minutes or hours at channel junctions (citations omitted) and only days migrating through longer Delta reaches (citations omitted). Given the fractional changes in negative flows which occur along the primary migration route of the San Joaquin River there is little reason to expect an adverse impact such has been hypothesized by NMFS to support Actions IV.2.1 and IV.2.3. (February 3, 2011 Cavallo Decl., Para. 16).
>
> The results of the DSM2 HYDRO analysis presented here are entirely consistent with and help to explain the difficulty of nearly all investigations have had in finding evidence of adverse export effects on the survival and route selection for San Joaquin River salmonids. The very small changes in negative flows which occur along the mainstem of the San Joaquin River as exports increase may be all but an undetectable effect on migrating juvenile salmonids. Given these results, it is perhaps not surprising that Vogel (2004) (AR cite omitted) Newman (2008) (AR cite omitted) and others have been unable to observe evidence for an adverse export effect.
> (February 3, 2011 Cavallo Decl., Para. 17).

C. Relationship Between Flows and Survival

While studies fail to show a statistically significant relationship between exports and salmonid survival, studies have shown a positive relationship between San Joaquin River flows and survival. Department of Fish and Game (DFG) confirmed this finding in a comprehensive 2005 study reported in "San Joaquin River Fall-run Chinook Salmon Population Model (November 2005)." In the report DFG observed that "[i]n every instance where salmon production was high, Vernalis flows are in excess of 10,000 cfs. Conversely when salmon production was low, Vernalis flow levels are less than 2,000 cfs (Figure 19). The question then becomes is it the flow, or the exports?" (DFG 2005, p. 14.)

In an attempt to answer the question, DFG took a close look at smolt survival data on the San Joaquin River (SJR), and found that:

> Smolt survival data collected during the VAMP shows that juvenile survival increases as exports increase (Figure 19). In addition smolt survival as a function of the exports to Vernalis flow ratio has a low correlation (Figure 20), indicating that Delta export level, relative to Delta inflow level, does not influence juvenile salmon survival on a regular, normal, or repetitive pattern. (DFG 2005, p. 14.)

After reviewing the VAMP data, DFG observed that "[h]ere again, the variable seems to be controlling salmon production (e.g. survival) is spring Delta inflow, *not spring Delta export*." (DFG 2005, p. 14, emphasis added.)

DFG then reviewed all available salmon smolt survival data and adult salmon escapement data and stated that:

> In conclusion, while the influence of Delta exports upon SJR salmon production is not totally clear, overall it appears that Delta exports are not having the negative influence upon SJR production that they were once thought to have. Rather it appears that Delta inflow (e.g. Vernalis flow level) is the variable influencing SJR salmon production, and that increasing flow level into the Delta during the spring months results in substantially increased salmon production. (DFG 2005, p. 14.0.)

DFG created the salmon population model described in its report in response to the State Water Board's request that DFG evaluate management actions (including river flows and exports) necessary to meet San Joaquin River Chinook salmon population goals. (Notably, the Board's Draft Technical Report refers to the DFG report and study.) DFG states in its report Executive Summary:

> The Department evaluated various parameters that have been identified as influencing abundance of escapement of fall-run Chinook salmon into the SJR, such as ocean harvest, Delta exports and survival, abundance of spawners, and spring flow magnitude, duration and frequency. The Department found that *non-flow parameters have little, or no, relationship to fall-run Chinook salmon population abundance in the SJR and that spring flow magnitude, duration, and frequency all had significant influence upon SJR fall-run Chinook salmon abundance in the SJR*. The Department used the significant relationship between Vernalis spring flow volume, duration, frequency, and SJR fall-run Chinook salmon abundance to construct a simple regression-based spreadsheet SJR fall-run Chinook salmon population production model. (DFG 2005, p. 4, emphasis added.)

Based upon this conclusion, DFG found the role of exports in salmon survival to be so insignificant that it did not include exports as a factor in its salmon population model, and immediately before the section describing the model development, states:

> These findings that spring Vernalis flow magnitude, duration, and frequency are strongly associated with SJR salmon abundance, *in combination with the lack of substantial cause and effect relationships between either Delta exports*, ocean harvest, and/or density dependence related to spawner abundance, indicate that it is appropriate to develop a conceptual SJR salmon population prediction model that includes spring Vernalis flow magnitude, duration, and frequency, *and excludes* ocean harvest, *Delta exports*, and in-river spawner abundance (e.g., referencing density dependent mortality.)
> (DFG 2005, p. 17, emphasis added.)

In sum, DWR continues to recommend that the State Water Board not address actions beyond those currently before the Board regarding San Joaquin River flow, however, to the extent the Board considers these issues in this process or possibly in future proceedings, the Board should include the above information, and any new information which may be presented, in its current analysis.

3. Unimpaired Flow As A Basis For Operating A System

While theoretically feasible, DWR believes there are several hurdles that must be overcome before water project operators can use computed unimpaired flow for real time operations. DWR offers the following recommendations and insights that are intended to help such an approach be reasonably implemented, if the Board should adopt this approach:

A. The methods developed to date for computing unimpaired flows will require revisiting to overcome deficiencies in the current assumptions and to standardize and streamline the different data sources.

B. The uncertainty inherent in measuring the observed data (e.g., streamflows, precipitation) and computed parameters (e.g., evapotranspiration, depletions, stream-aquifer interaction) needs to be considered. Also, the quicker a computed value for unimpaired flow is required, the greater the number of assumptions needed to determine the value. Therefore, establishing the standards so that the errors made in the forecast mode can be rectified in hindsight should be considered.

C. Remote sensing and telemetered data have a great potential to be part of the process; however, the maturity of the technology for real-time operations will need to be assessed.

D. Buy-in from stakeholders on an agreed upon approach is essential for successful implementation.

SOUTHERN DELTA SALINITY

While DWR is generally pleased with the potential modification of the numerical salinity objectives in the Southern Delta, we are concerned with other aspects of the potential draft modifications to these objectives.

First, there is a serious question whether water levels and, to a lesser extent, water circulation are proper subjects of water quality objectives. According to DWR's understanding, water levels have never before been associated with affecting salinity in the southern Delta. The only time water levels have been addressed in recent history is in Decision 1641 (D1641). There, water levels were addressed in the context of whether to approve the Joint Points of Diversion (JPOD). According to D1641, it was demonstrated that JPOD could result in lower water levels and, as such, it required that the SWP and CVP develop a water level response plan to ensure no harm came to water users in the area. In this approach, however, no link was made between water levels and salinity. Water level should not be a water quality objective.

Likewise, it is unclear whether water circulation is appropriately addressed in the water quality context. More importantly, however, is that the current proposal makes no effort to quantify the impacts of the SWP and the CVP on water circulation in the southern Delta and, instead, assumes it is sufficient for them to be fully responsible for implementing this new objective. In response to this assignment of responsibility, DWR is conducting a computer modeling analysis to better determine whether and to what extent SWP and CVP exports actually influence the null-zones and poor circulation.

Such modeling serves two purposes. First, if the modeling demonstrates that null zones exist with no project exports and the affect of the exports is to essentially move the location of the existing null zones, assigning full responsibility to the CVP and SWP for the null zones is not reasonable based on fault related to creating null zones. Second, better defining responsibility for the null zones will allow the State Water Board to establish actions others should take to address the water quality concerns in the Southern Delta. The language of the potential draft amendment recognizes that local discharges and activities help create the salinity and circulation problems. However, the current potential modification to the objectives does not include assigning responsibility on those interests that help create the problem. This is unreasonable and the modification should be revised in recognition of these activities.

Below are DWR's specific comments on the potential draft amendments.

1. Numerical Salinity Objectives

DWR is supportive of the potential draft amendments to the numeric salinity objectives as detailed on Table 2 of Attachment 2. DWR has long opined that the numerical salinity objectives contained in the recent Bay-Delta Plans were overly protective of agricultural beneficial uses and thus unreasonable.

As we stated in our February 8, 2011 comments, the State Water Board has not been in a better position to review and modify the salinity objectives and their program of implementation since the objectives were first established in 1978. The state of knowledge as to what water quality is needed to protect southern Delta agriculture has been significantly updated through various studies, including the recent report developed by Dr. Hoffman. The potential draft modifications to the numerical salinity objectives accurately reflect the current state of knowledge, are reasonably protective of agricultural beneficial uses, and DWR supports their implementation.

2. Water Level as a Water Quality Objective

DWR believes it is inappropriate to assign water level as a water quality objective in a water quality proceeding (See, Attachment 3 of Notice, Table 2). As discussed more thoroughly in the first section of these comments under the San Joaquin River Flows, the Porter-Cologne Act was not intended to address the characteristics of the watercourse, such as the stage of a water body. By making water level a water quality objective, the State Water Board continues to increase the scope of the Act beyond that which it was intended address.

This new approach is of great concern given that as far as DWR is aware, water levels have not been associated with elevated salinity levels in the southern Delta. The temporary barriers and permanent operable gates were developed in response to DWR's alleged impacts on water levels and circulation in the southern Delta. However, the problems caused by low water levels are associated with the ability of the southern Delta water users to divert water and are not associated with elevated salinity and DWR has taken various actions to address these diversion issues unrelated to water quality requirements. While the Board no doubt has the authority to take action necessary to protect the consumptive uses in the southern Delta, the approach to make water levels a water quality objective is flawed by equating its water quality planning function with the protection of water rights.

3. Responsibility for Water Circulation

DWR again raises the question of whether a watercourse characteristic such as circulation is the appropriate subject of a water quality objective (See, Attachment 3 of Notice, Table 2). As explained before, agricultural barriers generally improve localized water quality in the south Delta since salts otherwise trapped in the null zone areas would be transported out of the area due to the enhanced circulation created by the barriers. While this explanation demonstrates that circulation, and the physical solutions that help with circulation, can help implement a water quality objective, it does not provide adequate reasoning to make circulation *the* objective.

In addition, it still has not been clearly explained why the SWP and CVP continue to be held fully responsible for circulation and null zones in the south Delta. If null zones are a primary reason for assigning responsibility to DWR and the USBR, then a thorough understanding and analysis of the actual impacts in this context is necessary. To this end, DWR is conducting and will provide to the Board a computer modeling analysis that will illustrate the effects SWP and CVP pumping has on circulation, in general, and on the creation or movement of null zones. The analysis will include comparisons with and without the temporary barriers.

4. Comprehensive Operations Plan

In general, DWR agrees that the program of implementation should include a comprehensive plan to address salinity in the southern Delta. However, responsibility for achieving the objectives should be assigned among several entities shown to affect southern Delta salinity, and not just the projects. DWR finds it unreasonable that the State Water Board would even entertain assigning responsibility to DWR and the USBR to develop and implement an operations plan that will "avoid localized concentration of salts associated with agricultural water use and municipal discharges." (Notice Attachment 3 at 3.) Just as Judge Racannelli concluded on a similar issue, DWR believes that this implementation program is "flawed by reason of the Board's failure, in its water quality role, to take suitable enforcement action against other users as well." (*United States v. State Water Resources Control Board* (1986) 182 Cal.App.3d 82, 127.) Thus, if the Board chooses to proceed with establishing a water circulation objective, DWR encourages the Board at the very least to develop a comprehensive program to implement such an objective "which will include the projects *and* other users along the watercourse." (*Ibid.*)

5. Monitoring and Special Studies

DWR also recommends than any additional reporting and studying requirements be evaluated in conjunction with the many reports, monitoring and coordination DWR currently conducts in response to State Water Board requirements. These include:

- A construction and operations plan for the Temporary Barriers Project (TBP) is provided to the SWRCB under WR 2010-0002 each January for approval by the Executive Director.
- Monthly South Delta Coordination Meetings with staff from DWR, South Delta Water Agency, SWRCB, and the USBR staff to discuss the past and future TBP operations, particularly the impacts, if any, on SDWA.
- Weekly TBP updates transmitted to agencies and stakeholders to communicate the status of barrier installation and removal, culvert operations, water level modeling and forecasting, and real-time water level monitoring.
- DWR staff monitors water levels, water quality, fish movement and behavior and predation, and hydrodynamics in south Delta channels. This monitoring is accomplished real-time (CDEC) and through modeling and fish studies. Annual reports for the TBP monitoring are prepared as well as separate fish monitoring study reports.
- A monthly report is sent to the SWRCB of daily average and 30-day running average values for salinity at the four compliance locations.

DWR appreciates the opportunity to comment on the revised Notice and potential draft amendments, and looks forward to working with the State Water Board as the environmental review process moves forward. If you or your staff have questions on these comments or would like additional information please contact me at (916) 653-8826 or esoderlu@water.ca.gov.

Sincerely,

Erick Soderlund
Staff Counsel

Attachments

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

April 20, 2009

Mr. Ronald Milligan, Operations Manager
Central Valley Operations Office
U.S. Bureau of Reclamation
3310 El Camino Avenue
Sacramento, California 95821-6340

Section 7 Consultation DWR's Additional comments on draft NMFS' Salmonid Biological Opinion

Dear Mr. Milligan:

The Department of Water Resources (DWR) provides the following additional comments on the National Marine Fisheries Services' (NMFS) revised draft Biological Opinion for effects of CVP and SWP on salmonids and green sturgeon sent to DWR in March 2009 (March draft Bi Op). DWR provided comments on the draft Bi Op in letters sent to the U.S. Bureau of Reclamation (Reclamation) on January 13, 2009, February 2, 2009 and March 20, 2009.

Attachment 1 to this letter is an additional comment on Action IV.2.2 of the March draft Bi Op Reasonable and Prudent Alternative (RPA). This comment discusses results of a comparison DWR made between Particle Tracking Model (PTM) results and coded wire tag (CWT) experiments conducted by USFWS for the VAMP from 1995 to 2006. The result of the comparison shows that there is no correlation between the timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island. Therefore, there is no scientific justification for the use of the PTM results as a surrogate for salmon movement through the Delta. DWR recommends that NMFS modify Action IV.2.2 to use real-time monitoring to determine the timing of San Joaquin steelhead emigration through the south Delta and base the duration of project restrictions on the CWT Chinook emigration data obtained during the historic VAMP experiments. In addition, the USFWS currently conducts a Kodiak trawl at Mossdale three days per week from January through March, and June through December each year. In April and May, the California Department of Fish and Game (DFG) operates the Kodiak trawl and increases the effort to five days per week. Usually, ten tows are conducted per day. If NMFS agrees to use the monitoring data to implement this proposed RPA action, DWR would consider supporting a program to increase the Kodiak trawl sampling effort in the month of March from three days per week to five days per week, and increase the sampling effort from ten tows per day to twenty tows per day from March through June 15. This effort would be carried out in coordination with USFWS, DFG, and NMFS, with the costs shared by Reclamation.

Attachment 2 is a technical memorandum dated April 1 which was prepared by Cramer Fish Sciences at the request of DWR. It focuses on two major issues related to the RPA: 1) an assessment of steelhead Delta passage timing; and 2) a model-based assessment of the proposed Delta winter run Chinook and steelhead actions. This is a separate memorandum from the March 18 technical memorandum prepared by Cramer Fish Sciences and included in DWR's March 20, 2009 letter. With respect to steelhead passage timing, the analysis concludes that the peak emigration of natural origin steelhead occurs after March with a peak occurring in June. Given that hatchery origin steelhead from the Mokelumne River, Nimbus, and Feather River hatcheries are not considered part of the Central Valley steelhead ESU, NMFS should tailor the RPA action specifically to the known timing of natural origin steelhead. The results of the model-based analysis for the fish released in the Sacramento River suggest no biologically significant or consistent difference in survival under operation scenarios with both the USFWS December 2008 BO actions and the proposed NMFS RPA actions when compared to operation scenarios of the USFWS December 2008 BO action alone in any water year evaluated. For simulated fish releases in the San Joaquin River, greater differences in predicted survival between scenarios were found. However, the difference was not due to the proposed NMFS RPA actions but to the USFWS measures in their December 2008 BO. Although the results are preliminary, when taken collectively they suggest that the benefits of the proposed NMFS RPA actions for Delta juvenile salmonids may not yield the desired outcome in terms of magnitude or direction of survival benefits. This uncertainty, especially when viewed with the additional reduction caused to SWP and CVP water supply, indicates the proposed RPA actions included in the scenarios should be refined or removed.

Attachment 3 is a revision to the estimated water supply impacts that would result from the implementation of the proposed RPA, along with the revised modeling assumptions for the CALSIM simulations. In these studies, we used as a base the OCAP Study 7.0. The updated results indicate that when compared to OCAP Study 7.0, the average combined water supply impact to the SWP and the CVP of the NFMS proposed RPA is roughly 900 taf to 1.1 Maf (or about 16% to 19%). By taking an alternative approach and layering the NFMS proposed RPA on top of the terms of the USFWS 2008 Bi Op RPA that have been provisionally accepted by Reclamation, the average combined water supply impact of the NMFS draft RPA to the SWP and CVP is roughly 150 taf to 750 taf, or about 3% to 15% above the impact of the USFWS 2008 Bi Op RPA depending on the range of adaptive actions implemented by the USFWS under the terms of the Bi Op. When compared to OCAP Study 7.0, the average combined water supply impact of the collective USFWS RPA and NMFS draft RPA to the SWP and CVP is roughly 1.3 Maf to 1.6 Maf (or about 23% to 29%).

Again, it should be noted that these estimated impacts are incomplete, and we would expect them to be greater because they do not include reoperation of CVP reservoirs as specified in the draft NMFS RPA. In addition, these studies do not include any assessment of the USFWS Fall X2 measure which has not been accepted by Reclamation as reasonable or prudent.

DWR is analyzing the economic impacts of the draft Bi Op, and we expect to be able to provide you and NMFS with an analysis of both the near-term and long-term (year 2030) economic effects of the draft Bi Op as well as by the end of this week.

Sincerely,

Katherine F. Kelly
Chief, Bay-Delta Office
California Department of Water Resources

Enclosures:

Attachment 1 - Additional comment on Action IV.2.
Attachment 2 - April 1, 2009 Cramer Fish Sciences Technical Memorandum
Attachment 3 – Revised Estimate Water Supply Impacts and Modeling Assumptions

cc: Ms. Maria Rae
Sacramento Area Office
National Marine Fisheries Service
640 Capitol Mall, Suite 8-300
Sacramento, California 95814-4706

Mike Chotkowski
U.S. Bureau of Reclamation

Attachment 1

Additional Comments Action IV.2.2; 4:1 SJR to Exports ratio

Action IV.2.2 imposes a limitation of combined exports to ¼ of the flow in the San Joaquin River from March 15 through June 15 in all but dry and critical water year types, and ½ in dry and critical years. The purpose of the action is to protect emigrating juvenile San Joaquin steelhead. NMFS proposes to use Particle Tracking Model (PTM) results to determine the flows necessary to allow 50% of the particles to reach Chipps Island as a surrogate for steelhead emigration.

DWR requests that NMFS modify Action IV.2.2 to use real-time monitoring to determine the timing of San Joaquin steelhead emigration through the south Delta and base the duration of project restrictions on the historical CWT Chinook experiment results. As described below, DWR compared PTM results with coded wire tag (CWT) experiments conducted by USFWS for the VAMP from 1995 to 2006. The result of the comparison shows that there is no correlation between the timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island.

DWR argues against the use of PTM results to simulate salmonid behavior because particles are most similar to "packets of water" moving in the system, whereas juvenile salmonids are actively swimming organisms with behavioral characteristics that PTM does not simulate. To determine the efficacy of PTM results simulating salmonid behavior, DWR compared 24 juvenile Chinook experimental releases in the lower San Joaquin River to associated PTM results. The 24 experimental releases were conducted for the VAMP from 1995 to 2006. These experimental releases were conducted using coded wire tagged (CWT) hatchery origin juvenile Chinook released at Mossdale and Durham Ferry, upstream of the export facilities, and recaptured at Chipps Island, downstream, at the western boundary of the Delta. The purpose of the VAMP experiments was to try to determine the effects of flow and exports on juvenile Chinook. Since there are no such juvenile steelhead experiments on the lower San Joaquin River, we use Chinook as the closest surrogate for juvenile steelhead.

The following 24 figures are a comparison of the daily passage at Chipps Island of CWT juvenile Chinook and particles from associated PTM results for individual experimental releases. All the releases occur during the months of April and May. The fish releases were made at Mossdale from 1995 through 2004, and then at Durham Ferry, just upstream, from 2005 through 2006. There are usually 2 experimental releases each year, but there were 3 in 1995 and 1998, and only 1 in 1997 and 2004. All the PTM studies used the same release dates and hydrology as the fish studies and used a constant 5,000 particles in each of the PTM studies. There are no figures past 2006, because after 2006, FWS started using radio tagging instead of CWT tagging. Both the CWT and PTM data are presented in terms of percentages of CWT recoveries and particle passage at Chipps to standardize and evaluate the results from year to year. The left y axes are the percentage of CWT Chinook recovered at Chipps, and the right Y axes are the percentage of particles passing Chipps Island on a daily time step.

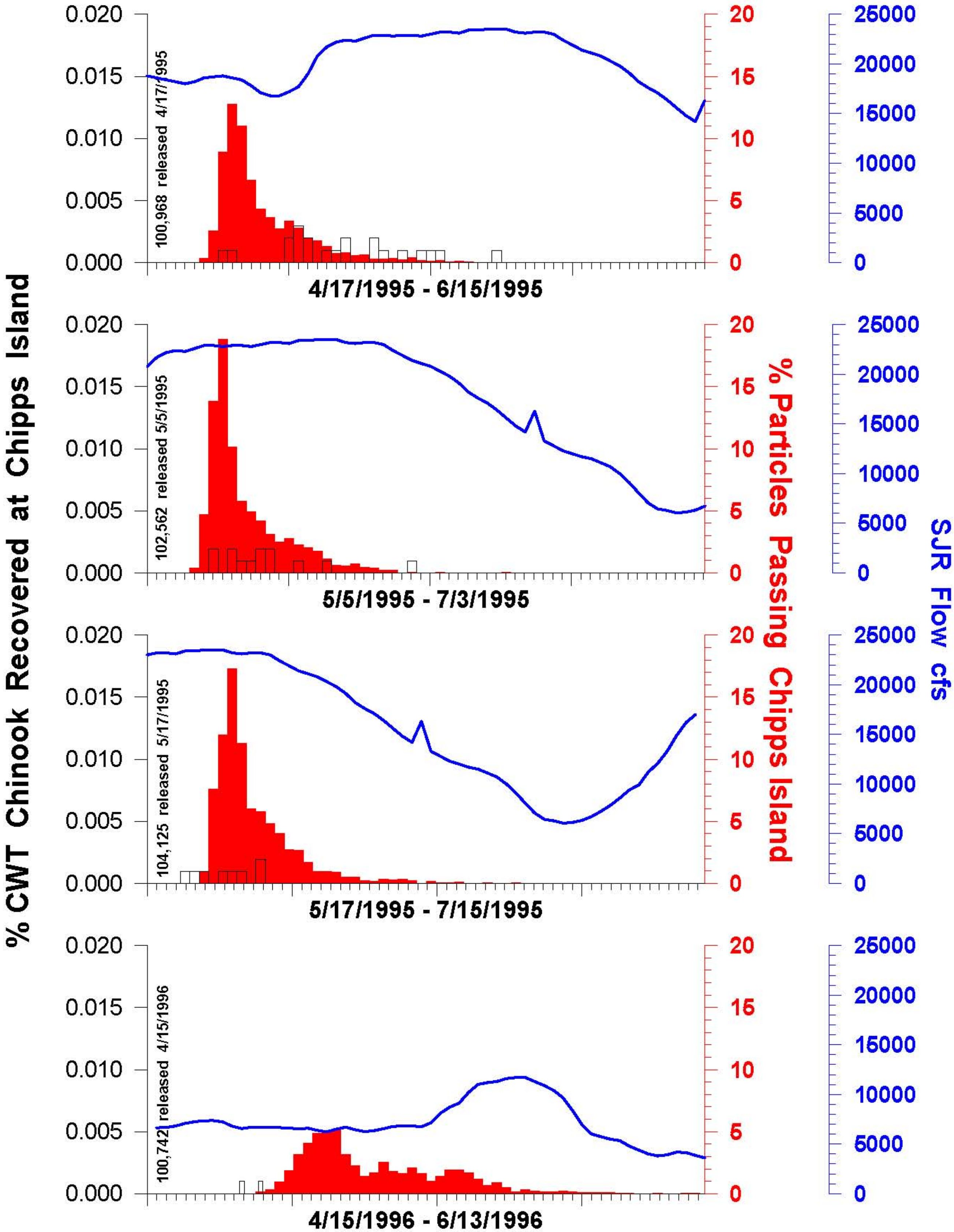
Two characteristics are apparent from the 24 graphs: the trend of the timing of CWT Chinook recoveries at Chipps Island compared to PTM results, and the trend of the magnitude of CWT Chinook recoveries at Chipps Island compared to PTM results.

The only years for which the timing of the CWT recoveries at Chipps were associated with the timing of the particles past Chipps were 1995, 1998 and 2006. Those were the three very high San Joaquin River flow years; flows greater than 20,000 cfs. The rest of the years, the CWT timing of recoveries at Chipps was much earlier than the particle timing past Chipps. Most years, there was little overlap between the CWT recoveries and particles passing Chipps. In the lowest flow years, 2000 through 2004, there was no overlap between the timing of the CWT recoveries at Chipps and the passing of particles past Chipps. In those lowest flow years, the CWT Chinook pass Chipps Island within about two weeks, regardless of the PTM results. The CWT Chinook are actively swimming downstream when compared to the neutrally buoyant particles.

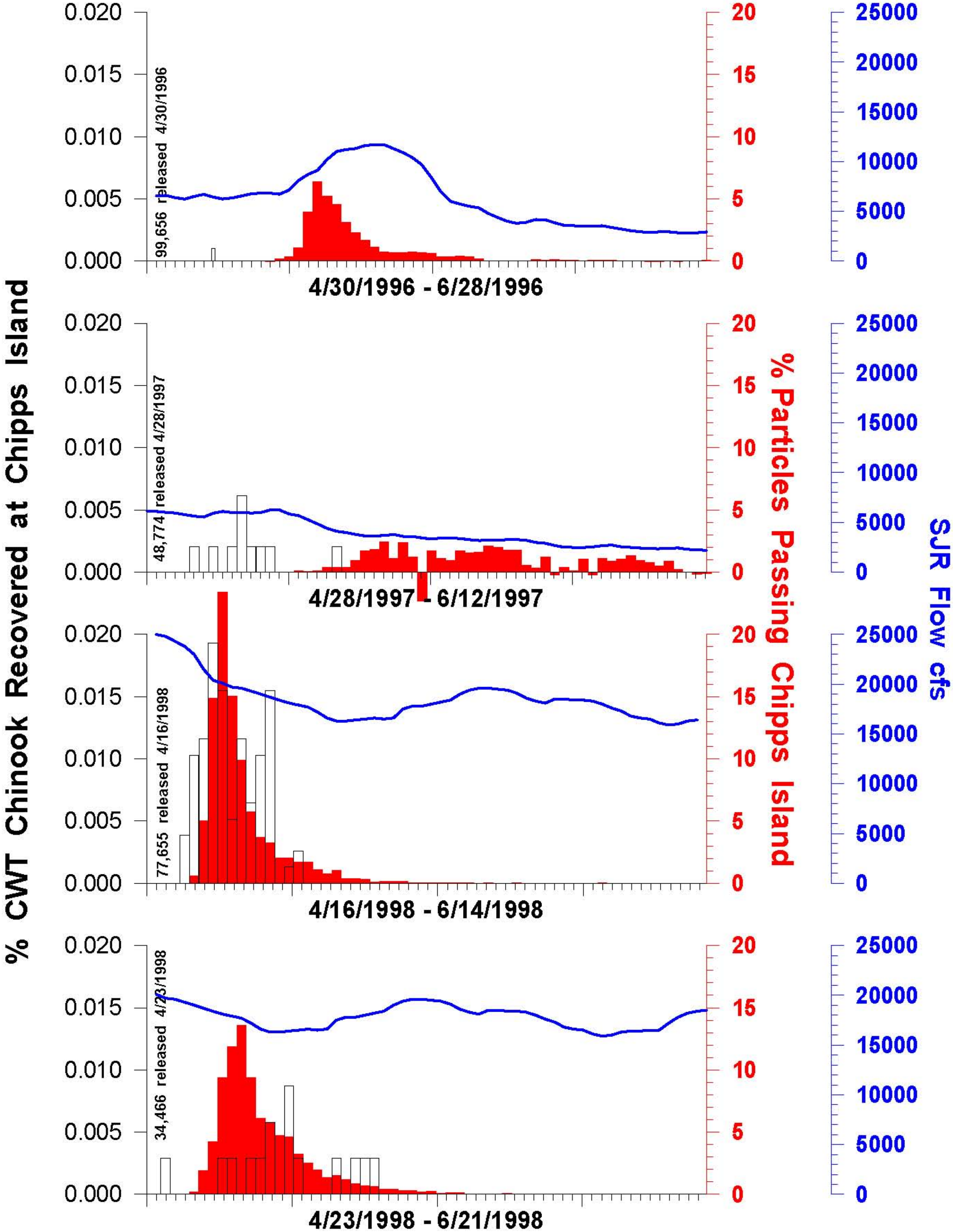
The magnitude of recoveries of CWT Chinook at Chipps Island compared to the magnitude of particles passing Chipps Island were also not well associated. The only year for which the magnitude of CWT Chinook recovered at Chipps was relatively similar to the magnitude of particles passing Chipps Island was 1998. For the other two high flow years, 1995 and 2006, the recoveries of CWT Chinook at Chipps Island was relatively low. For the low flow years 1999 through 2001, the recoveries of CWT Chinook was relatively high compared to particles passing Chipps Island.

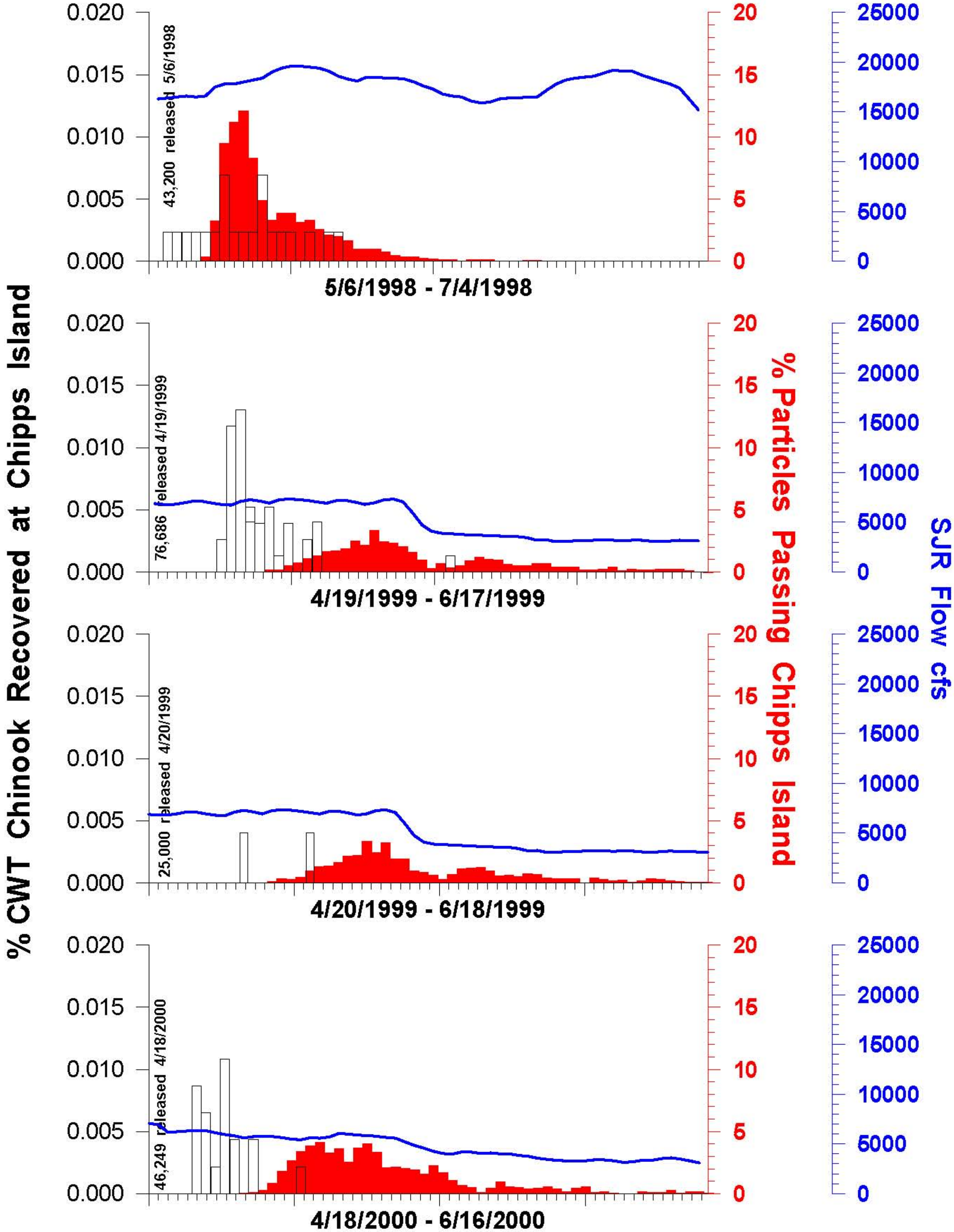
The result of the comparison of timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island shows that there is no correlation. This is shown in the last two figures in this attachment. There are factors other than hydrodynamics affecting juvenile Chinook emigration through the south Delta not accounted for in the PTM. Based on the 24 experiments graphed in this evaluation, the PTM results are an adequate surrogate for "timing" of salmonid emigration in only very high flow years like 1995, 1998 and 2006. But for the rest of the years, intermediate and low flow years, the PTM results would result in significant project regulation 3 to 6 weeks beyond emigration timing.

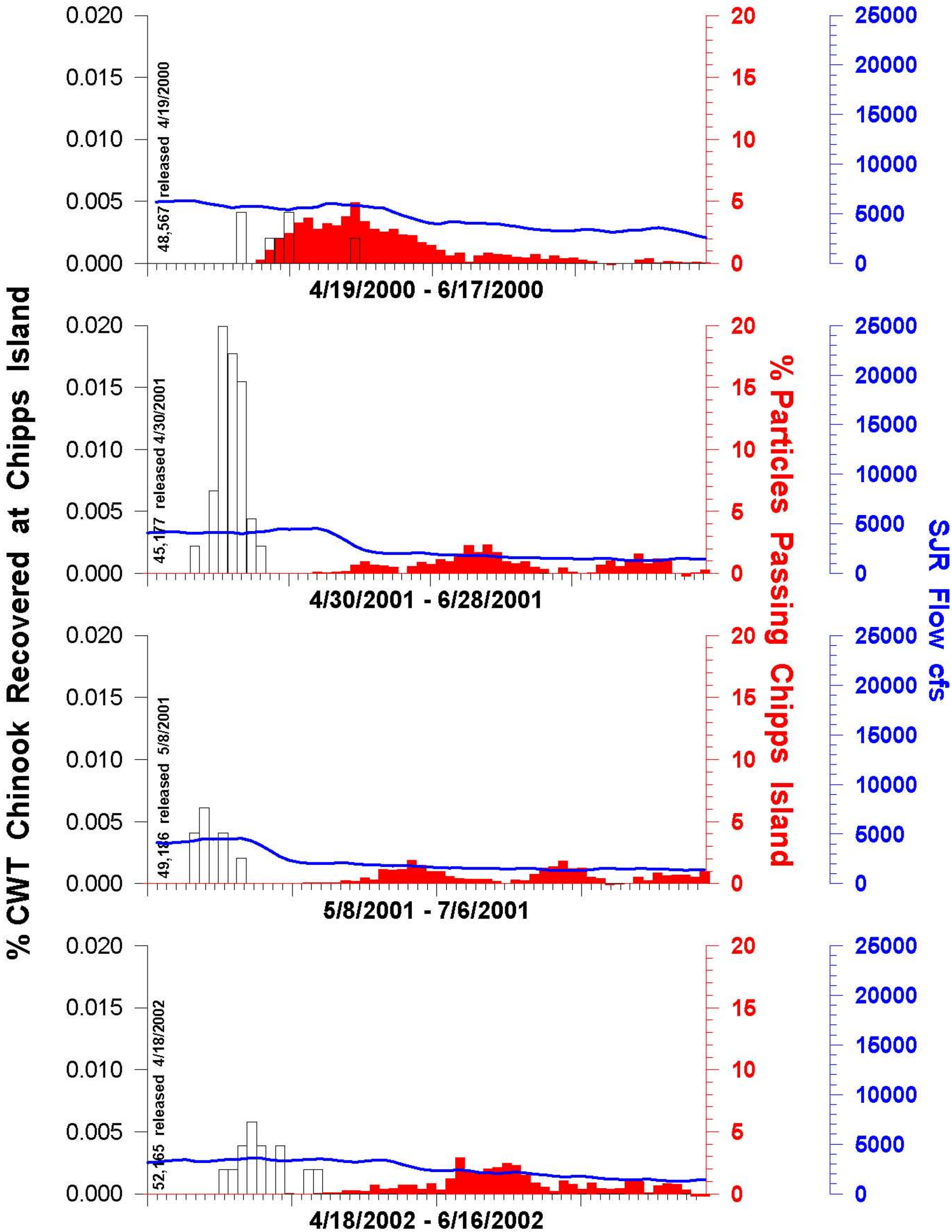
Therefore, DWR requests that NMFS adopt an alternative action to IV.2.2. to use real-time monitoring to determine the timing of San Joaquin steelhead emigration through the south Delta and base the duration of project restrictions on the historical CWT Chinook experiments.

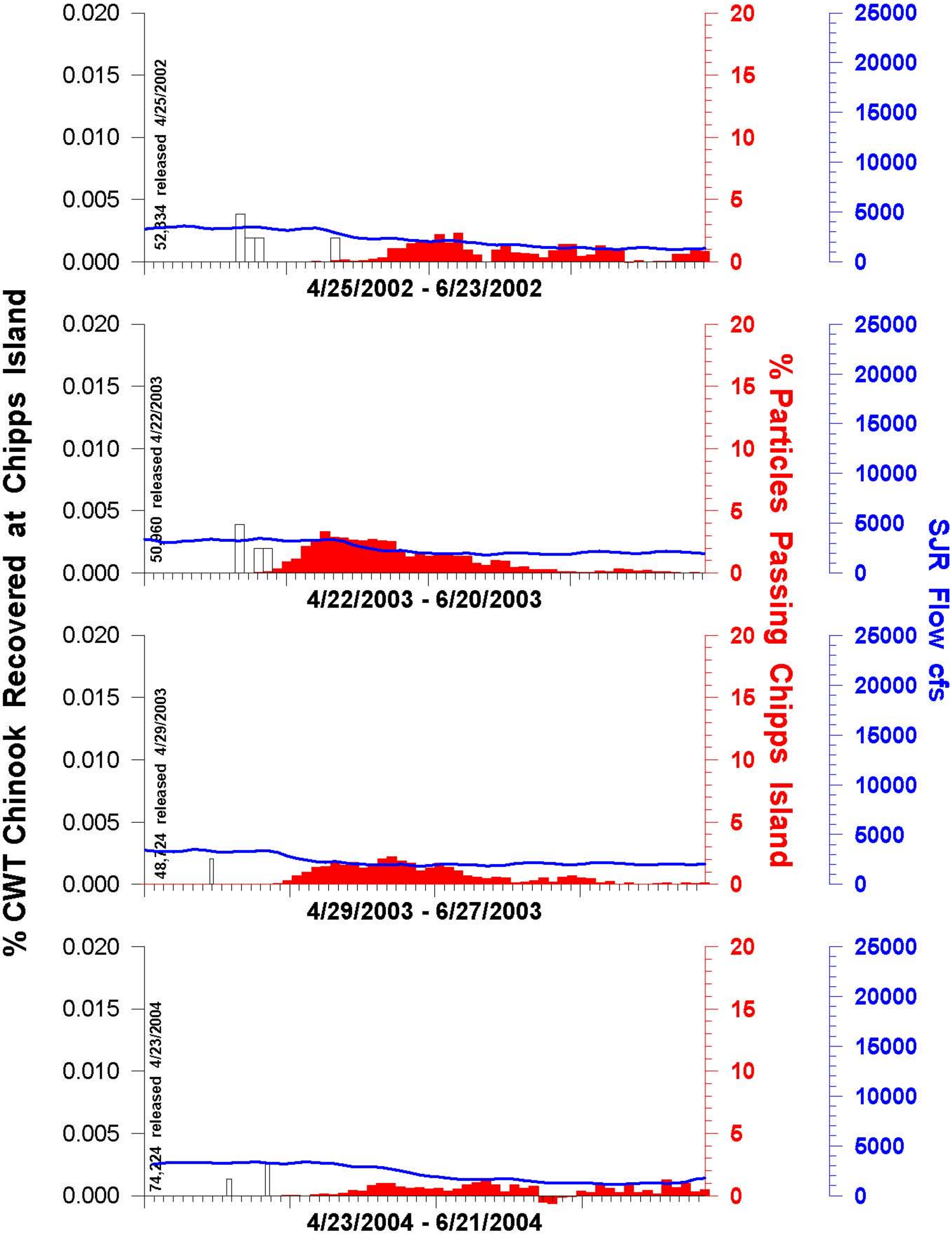


% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
100,968 released 4/17/1995
4/17/1995 - 6/15/1995
102,562 released 5/5/1995
5/5/1995 - 7/3/1995
104,125 released 5/17/1995
5/17/1995 - 7/15/1995
100,742 released 4/15/1996
4/15/1996 - 6/13/1996
0.000
0.005
0.010
0.015
0.020
0
5
10
15
20
0
5000
10000
15000
20000
25000

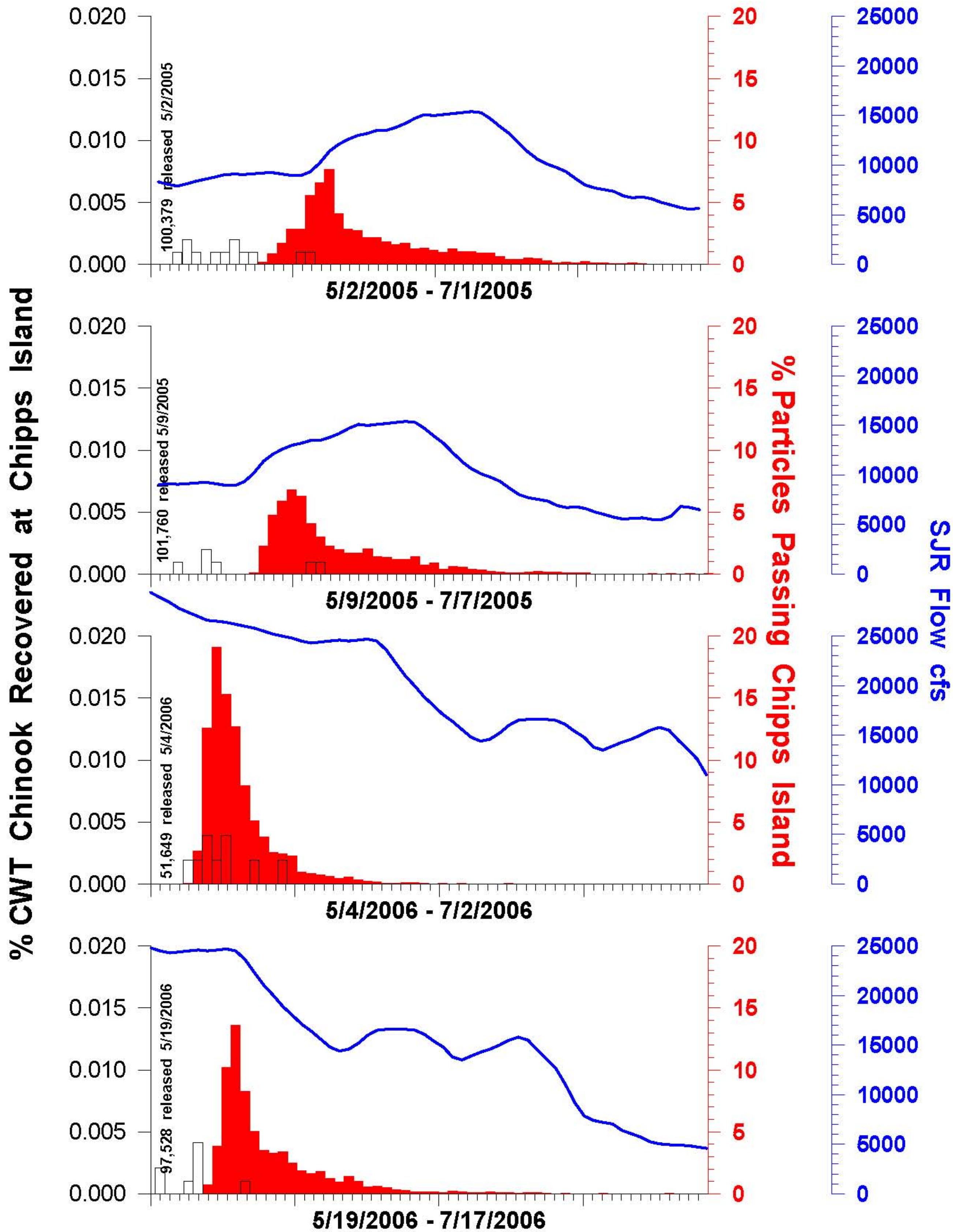

% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
99,656 released 4/30/1996
4/30/1996 - 6/28/1996
48,774 released 4/28/1997
4/28/1997 - 6/12/1997
77,655 released 4/16/1998
4/16/1998 - 6/14/1998
34,466 released 4/23/1998
4/23/1998 - 6/21/1998

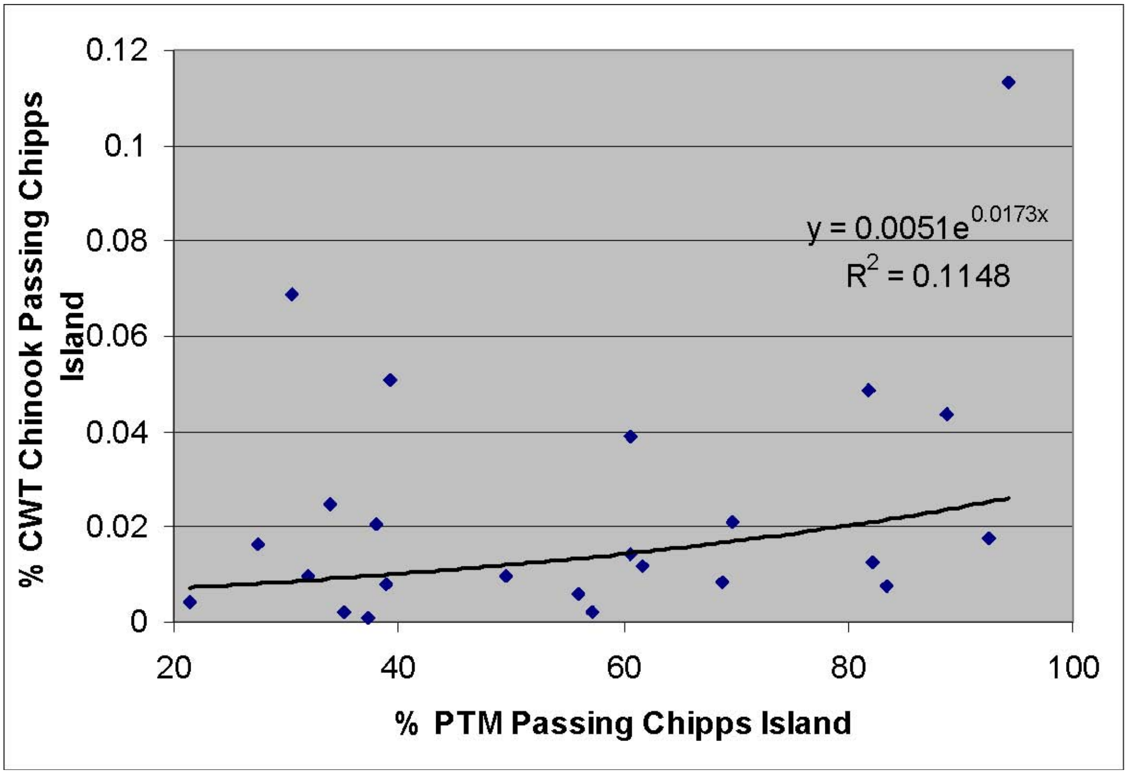

% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
43,200 released 5/6/1998
5/6/1998 - 7/4/1998
76,686 released 4/19/1999
4/19/1999 - 6/17/1999
25,000 released 4/20/1999
4/20/1999 - 6/18/1999
46,249 released 4/18/2000
4/18/2000 - 6/16/2000
0.000
0.005
0.010
0.015
0.020
0
5
10
15
20
0
5000
10000
15000
20000
25000


% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
48,567 released 4/19/2000
4/19/2000 - 6/17/2000
45,177 released 4/30/2001
4/30/2001 - 6/28/2001
49,186 released 5/8/2001
5/8/2001 - 7/6/2001
52,165 released 4/18/2002
4/18/2002 - 6/16/2002
0.000
0.005
0.010
0.015
0.020
0
5
10
15
20
0
5000
10000
15000
20000
25000

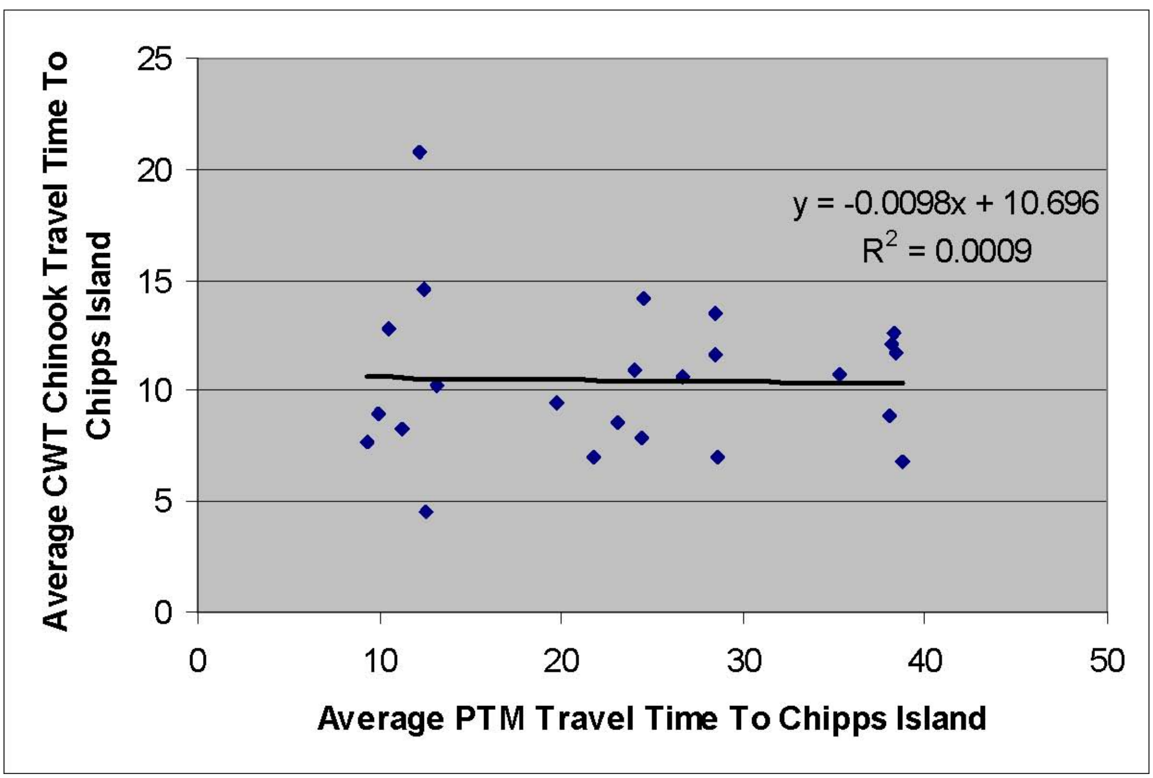


% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
52,834 released 4/25/2002
4/25/2002 - 6/23/2002
50,960 released 4/22/2003
4/22/2003 - 6/20/2003
48,724 released 4/29/2003
4/29/2003 - 6/27/2003
74,224 released 4/23/2004
4/23/2004 - 6/21/2004


% CWT Chinook Recovered at Chipps Island
% Particles Passing Chipps Island
SJR Flow cfs
100,379 released 5/2/2005
5/2/2005 - 7/1/2005
101,760 released 5/9/2005
5/9/2005 - 7/7/2005
51,649 released 5/4/2006
5/4/2006 - 7/2/2006
97,528 released 5/19/2006
5/19/2006 - 7/17/2006
0.000
0.005
0.010
0.015
0.020
0
5
10
15
20
0
5000
10000
15000
20000
25000



0.12
0.1
0.08
0.06
0.04
0.02
0
20
40
60
80
100
% CWT Chinook Passing Chipps Island
% PTM Passing Chipps Island
y = 0.0051e^0.0173x
R^2 = 0.1148



25
20
15
10
5
0
0
10
20
30
40
50
Average CWT Chinook Travel Time To Chipps Island
Average PTM Travel Time To Chipps Island
y = -0.0098x + 10.696
R^2 = 0.0009

Attachment 2

Cramer Fish Sciences

Technical Memorandum

CRAMER FISH SCIENCES®
Oregon • California • Washington • Idaho • Alaska

Technical Memorandum

TO: **California Department of Water Resources**
FROM: Brad Cavallo (lead), Joe Merz, Cameron Turner, and Paul Bergman
SUBJECT: Analyses of Reasonable and Prudent Alternatives of the draft OCAP Biological Opinion
DATE: April 1st, 2009

Our review and critique of the draft OCAP Biological Opinion's (BiOp) Reasonable and Prudent Alternatives (RPA) focuses on two major technical issues: 1) an assessment of steelhead Delta passage timing, 2) a model based assessment of proposed Delta winter run Chinook and steelhead actions.

1. Steelhead smolt outmigration through the Sacramento-San Joaquin Delta

The OCAP RPA recommends several actions with the expressed intent of improving through Delta survival for outmigrating Central Valley steelhead smolts. Specifically, action Suite IV.1 recommends modified operations of the Delta Cross Channel from October through January primarily for the benefit of winter run Chinook and steelhead. The RPA further indicates that, "about 8 percent of the annual CV steelhead emigration from the Sacramento River Basin occurs [between November and January]". While this statement is true, it ignores available, pertinent data related to the unique emigration timing of natural origin Central Valley steelhead. Since all hatchery produced steelhead are released in-river and all receive an adipose fin clip, it is important to examine differences in emigration timing between hatchery and natural origin steelhead. Such an analysis of trawling data from the Sacramento River and Chipps Island, and from south Delta export facilities suggests significant differences in emigration timing between hatchery and natural origin steelhead.

Examining the proportion of unclipped steelhead smolts (natural origin fish) from Sacramento and Chipps Island trawls by month from 1999 to 2007 illustrates that most natural origin steelhead emigrate after March, with a peak occurring in June (Figure 1). Similarly, data from State and Federal south Delta export facilities indicate that December through January represent the lowest period of natural origin steelhead smolt emigration, with peak natural origin steelhead smolt emigration occurring after March (Figure 2, Figure 3). Given that hatchery origin steelhead from Mokelumne River, Nimbus, and Feather River Hatcheries are not considered part of the Central Valley steelhead ESU, NMFS should tailor RPAs to specifically target known timing of natural origin steelhead.

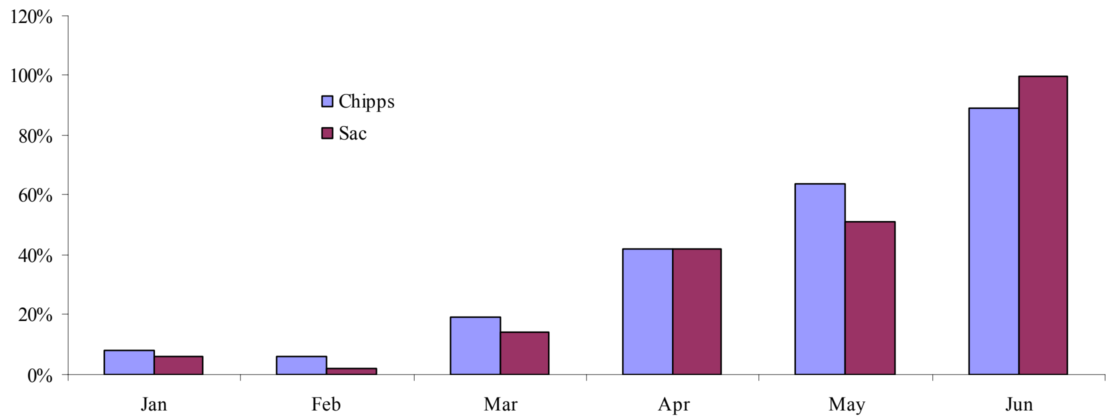


Figure 1. The percentage of *O. mykiss* captured each month in the Sacramento River and Chipps Island trawls that were unclipped (1998 through 2007).

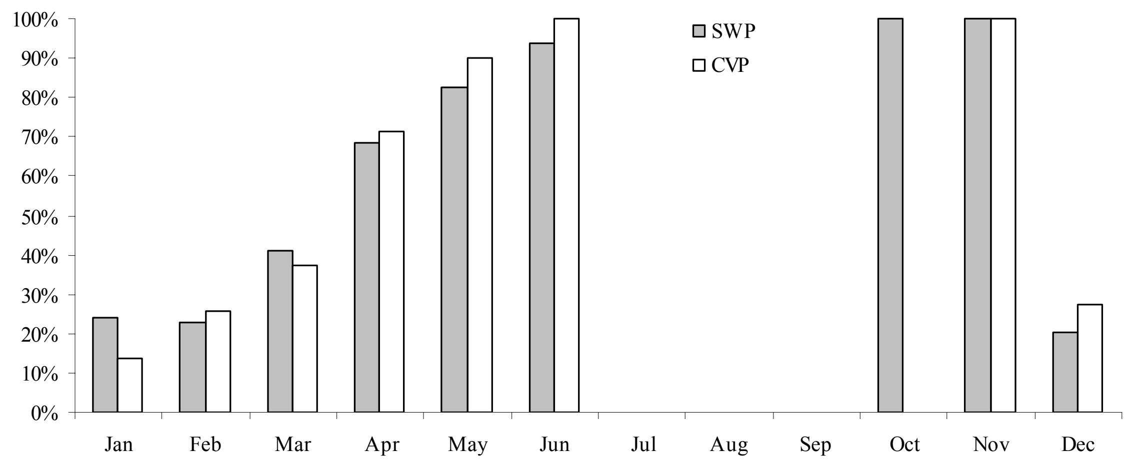


Figure 2. The proportion of salvaged steelhead at the State Water Project and Central Valley Project that were not adipose fin clipped. These are monthly averages between 1998 and 2007.

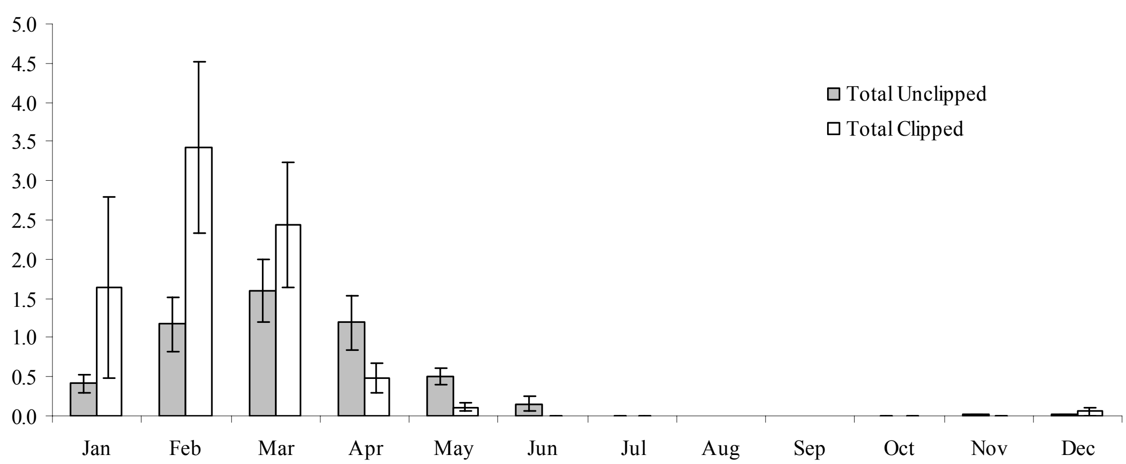


Figure 3. The average monthly CPUE of unclipped and clipped steelhead observed at the state and federal salvage facilities, 1998 through 2007. Bars indicate standard error. CPUE = number of fish/total acre feet diverted.

2. **Modeling assessment of proposed actions to benefit winter run Chinook and early emigrating steelhead smolts**

The objective of our quantitative assessment was to compare simulated survival of juvenile salmonids migrating through the Delta between alternative water management scenarios proposed as RPAs in the OCAP BiOp. Analyses of the proposed NMFS actions (in conjunction with previous USFWS requirements) were conducted using CalSim II and Delta Simulation Model II (DSM2-HYDRO). The base model used in this analysis originated from the modeling conducted for the 2008 OCAP Biological Assessment (BA) (Reclamation 2008). The BA includes the details on the CalSim II assumptions and modeling in Chapter 9 and Appendix D. Daily flow values for the alternative water management scenarios were obtained from DSM2-HYDRO model runs performed by the California Department of Water Resources. The data spanned water years 1976-1991.

A total of four scenarios (Table 1) were examined to assess delivery reductions due to the Delta actions specified in the NMFS draft RPA and the USFWS BO. All four studies include a specific level of Old and Middle River (OMR) restriction that bound the RPA specified in the USFWS BiOp. Two of the scenarios then layered on the proposed NMFS Delta related RPAs allowing the incremental impacts to be estimated.

Study Name	Base Study	NMFS Action IV.2.1	NMFS Action IV.2.2	NMFS Action IV.2.3	USFWS Action 1	USFWS Action 2	USFWS Action 3 (Pre-VAMP)	USFWS Action 3 (Post-VAMP)
Scenario 0: FWS/NMFS Low	OCAP 7.0	35% EI in Jan	**Mar 15 to Jun 15**: 2:1 in D, C Wys; 4:1 in W, AN, BN Wys	**Feb 1 to Jun 30:** OMR>-5000 cfs	**Dec 18 to Dec 31:** OMR>-2400 cfs	**Jan 1 to Feb 28:** OMR>-5000 cfs	**Mar 1 to May 15:** OMR>-5000 cfs	**May 16 to Jun 30:** OMR>-5000 cfs
Scenario 1: FWS/NMFS High	OCAP 7.0	35% EI in Jan	**Mar 15 to Jun 15**: 2:1 in D, C Wys; 4:1 in W, AN, BN Wys	**Feb 1 to Jun 30:** OMR>-2500 cfs	**Dec 18 to Dec 31:** OMR>-2000 cfs	**Jan 1 to Feb 28:** OMR>-1250 cfs	**Mar 1 to May 15:** OMR>-1250 cfs	**May 16 to Jun 30:** OMR>-1250 cfs
Scenario 2: FWS Low	OCAP 7.0	None	None	**Feb 1 to Jun 30:** OMR>-5000 cfs	**Dec 18 to Dec 31:** OMR>-2400 cfs	**Jan 1 to Feb 28:** OMR>-5000 cfs	**Mar 1 to May 15:** OMR>-5000 cfs	**May 16 to Jun 30:** OMR>-5000 cfs
Scenario 3: FWS High	OCAP 7.0	None	None	**Feb 1 to Jun 30:** OMR>-2500 cfs	**Dec 18 to Dec 31:** OMR>-2000 cfs	**Jan 1 to Feb 28:** OMR>-1250 cfs	**Mar 1 to May 15:** OMR>-1250 cfs	**May 16 to Jun 30:** OMR>-1250 cfs

Table 1. Descriptions of scenarios used to assess probable survival benefits for outmigrating smolts (winter run Chinook or steelhead) through the Sacramento-San Joaquin Delta.

Salmonid Migration Survival Model Description

In order to assess how winter run Chinook and steelhead smolt survival to Chipps Island might be influenced by the proposed RPAs, we conducted a model-based assessment using the Delta Passage Model developed by Cramer Fish Sciences and available DSM2-HYDRO data. The Delta Passage Model was completed in Fall 2008 and was presented at the CALFED Science Conference in October. The model has not been peer reviewed, but is built using the most current and best available published studies related to the salmonid migratory behavior and reach specific mortality rates. The Delta Passage Model represents a system dynamics approach to integrating, understanding, and exploring salmon migration through the hydrodynamically complex Sacramento-San Joaquin Delta. Habitat, predators and flow conditions in the Delta are known to profoundly influence salmonid populations by impairing survival among outmigrating juveniles. Attempts to understand and quantify Delta salmonid mortality have been conducted for more than thirty years and have culminated in numerous reports (Kjelson and Brandes 1989, Baker et al. 1995, Brandes and McLain 2001, Newman and Rice 2002 , Newman 2003, Newman 2008, Kimmerer 2008, Vogel 2008, Perry and Skalski 2008). The core purpose of the Delta Passage model is to provide a common, transparent framework upon which knowledge may be integrated and displayed.

The Delta Passage model…

- Simulates migration and mortality of juvenile Chinook salmon from the Sacramento River and San Joaquin River through the Delta.
- The model operates on a daily time step, using simulated flow through Delta channels.
- Tidal influences on hydrodynamics and fish behavior are not addressed as the model seeks to represent average fish response over days, not hours.
- The model is composed of 10 reaches and five reach junctions (Figure 4).
- Fish behavior at reach junctions and mortality within reaches is modeled probabilistically using empirical estimates of variance.
- For each selected scenario, 100 Monte Carlo simulations are generated, providing estimates of salmon survival to Chipps Island and confidence intervals.

With the exception of flow into the Tracy and Banks pumping plants, water movement though the Delta is modeled in the Delta Passage Model using daily flow output from the hydrology module of the Delta Simulation Model II (DSM2-HYDRO). Flow into the Tracy and Banks pumping plants is modeled using daily flow output from the CALSIM II model. The nodes in the DSM2-HYDRO and CALSIM II models that were used to provide flow for specific reaches in the Delta Passage Model are shown in Table 2.

Delta Passage Model reach	DSM2-HYDRO node	CALSIM II node
Sac1	RSAC155	--
SS	SLSBT011	--
Sac2	RSAC128	--
DCC	DCC	--
Geo	Georgiana_SL	
Mok	RSMKL008	--
Sac3	RSAC123	--
Sac4	RSAC101	--
SJ1	RSAN112	--
Old	ROLD074	--
SJ2	RSAN063	--
Tracy Exports	--	D418_TD
Banks Exports	--	D419_TD
SJ3	RSAN014	

Table 2. Correspondence between reaches in the Delta Passage Model and nodes in the DSM2-HYDRO and CALSIM II models.

Smolt migration speed in the *Delta Passage* model is reach-specific as informed by acoustic tagging studies. For North Delta reaches **Sac1**, **Sac2**, **Sac3**, **SS**, **Geo**, and **Mok** mean migration speed is predicted as a linear function of flow (Figure 5). Observed flows and migration speeds from acoustic studies for reach **Sac1** were used to create a best-fit linear relationship (Figure 5). Because migration speed data is unavailable for all other North Delta reaches, this linear function is applied North Delta-wide. Due to strong tidal influences in reach **Sac4** (between Rio Vista and Chipps Island) we chose to have mean migration speed independent of reach inflow. For reach **Sac4,** mean migration speed is set constant at 22.634 km/day, the average speed of smolts in the **Sac1** reach from the acoustic study data. Average migration speeds observed in acoustic studies are used to set mean migration speed for San Joaquin River reaches **SJ1** and **SJ2**. For **SJ3**, mean migration speed is set the same as **SJ2** because no migration speed data is available. Stochasticity/uncertainty for migration rate is modeled using error estimates from acoustic tracking experiments. Migration speed variance from acoustic study data is used along with mean migration speed to define a normal probability distribution that is sampled from each day to determine the daily migration speed in each reach (Table 3).

Migration pathways at reach junctions **A**, **B**, **C**, and **E** smolts are diverted into reaches proportional to the flow diverted. Perry and Skalski (2008) found that acoustically tagged Chinook smolts moved proportionally with flow for North Delta releases (see figure 4 from Perry and Skalski 2008). Stochasticity/uncertainty is modeled using the largest error estimates for all acoustic tracking experiments at a given reach junction. Movement of fish toward the state and federal pumps at junction **D** is informed by Kimmerer (2008) analysis of releases of coded wire tagged Chinook smolts in the Delta. Kimmerer (2008) found that percent salvage of Coleman National Fish Hatchery smolts increased non-linearly with export flow (see figure 9 from Kimmerer 2008). In our model, the percentage of fish moving towards the pumps is predicted from total Delta exports using Kimmerer's nonlinear function. The status of two migration barriers, the Delta Cross Channel (DCC) and the Head of Old River Barrier (HORB), is determined by user inputs.

Daily smolt survival is predicted as a logarithmic function of flow (Figure 6). The choice of a logarithmic relationship between flow and survival was made based on the flow/survival relationship developed by Newman (2003) from CWT Chinook smolt releases in the North Delta. To obtain flow measurements for association with the survival estimates from acoustic tag experiments we used a mean of daily flows from the 10 days following the release for each experiment (10 days including the day of release). Daily flow data was obtained from USGS or CDEC flow gauges. A flow-survival relationship for each reach was created by fitting a logarithmic curve to the available reach-specific acoustic tag and flow data. The constraints of slope ≥ 0 and y-intercept ≥ 0 were used. Curve-fitting was performed using the Solver tool in Microsoft Excel. Stochasticity/uncertainty is modeled using error estimates from acoustic study data. The mean daily survival is used along with the reach-specific standard deviation to define a normal probability distribution that is sampled from each day to determine the daily survival rate at each reach. The entrainment rate of fish at the pumps is 70%, with 30%

of fish being salvaged. In our model, salvaged (saved) fish are monitored but do not re-enter the Delta system.

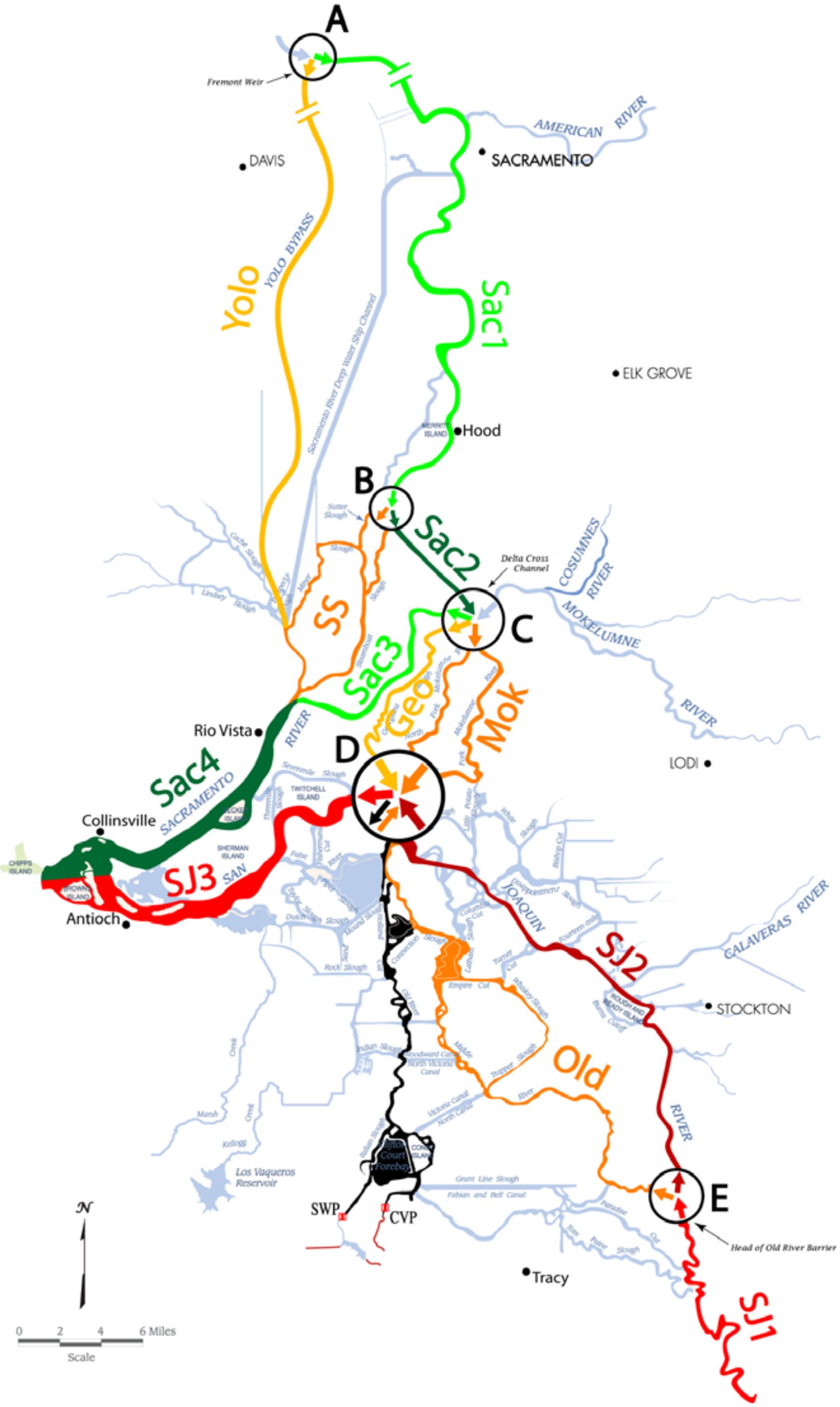


Figure 4. Map of the Sacramento-San Joaquin Delta showing the modeled reaches and junctions of the Delta Passage model. Reaches in the model are represented as colored segments of waterway. Reach labels are colored to match the reach. Junctions in the model are represented as circles containing arrows that correspond to the various flows entering and exiting each junction. Junctions are labeled by black letters, A-E.

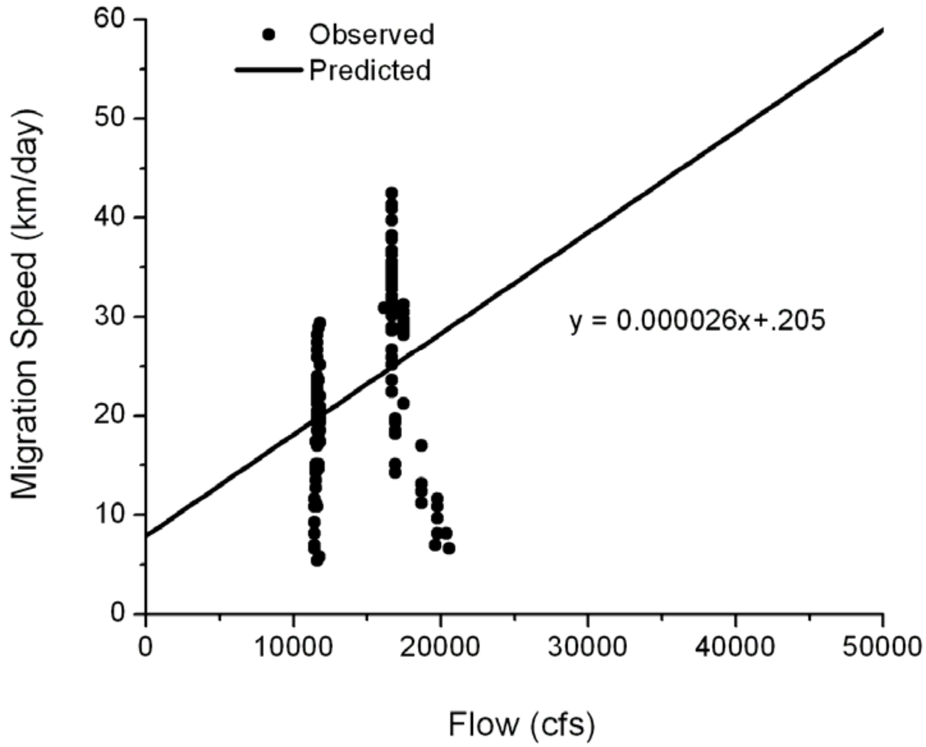


Figure 5. Linear function used to predict migration speed from flow for reaches in the North Delta. Observed data is from acoustic study data for the Sac1 reach between West Sacramento and the entrance of Sutter Slough.

Reach	Mean (km/day)	Standard Deviation
Sac1	Linear function of flow	9.105
SS	Linear function of flow	9.105
Sac2	Linear function of flow	9.105
Sac3	Linear function of flow	9.105
Sac4	22.634	9.105
Geo	Linear function of flow	9.105
Mok	Linear function of flow	9.105
SJ1	30.938	0.266
SJ2	21.630	0.411
SJ3	21.630	0.411

Table 3. Mean and standard deviations used to define a normal probability distribution that is sampled from each day to determine the daily migration speed in each reach.

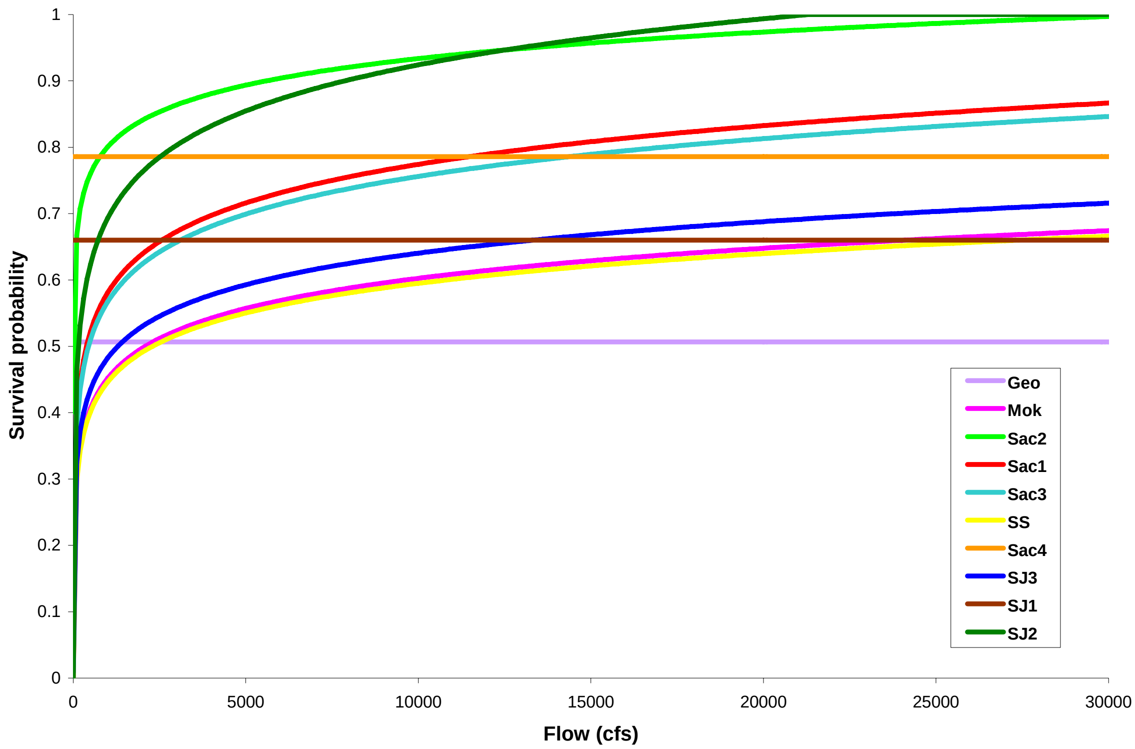


Figure 6. Reach-specific survival proportion as a logarithmic function of flow for all reaches. The mean daily survival is used along with the reach-specific standard deviation to define a normal probability distribution that is sampled from each day to determine the daily survival rate at each reach

Delta Passage Model Settings

In the Delta Passage Model, one million simulated smolts were released each year into both the Sacramento River and the San Joaquin River, respectively. The simulated release locations were West Sacramento on the Sacramento River and Durham Ferry on the San Joaquin River. At West Sacramento, the timing of release each year was modified from the passage distribution of juvenile Winter-Run Chinook salmon at the Red Bluff Diversion Dam (RBDD). The average RBDD timing distribution from brood years 1997-2006 was shifted by three months to approximate the natural timing of arrival at the Delta by Winter-Run Chinook salmon. At Durham Ferry, the timing of release each year was a normal distribution approximating the natural timing of arrival at the Delta by steelhead as indicated by Chipps Island trawls. Timing of smolt inputs to the model are shown in Figure 7. For each year the total proportion of fish surviving to Chipps Island was calculated independently for releases in the Sacramento River and releases in the San Joaquin River. In addition, Monte Carlo simulations were used to produce one-hundred separate realizations for each of the four scenarios.

Delta Passage Model Results

Monte Carlo simulations along with the probabilistic functions built into the Delta Passage Model make it possible to estimate means and variance for predicted survival outcomes. For example, Figure 8 depicts observed outcomes from one-hundred realizations of Scenario 2 for fish entering the Delta from the San Joaquin River.

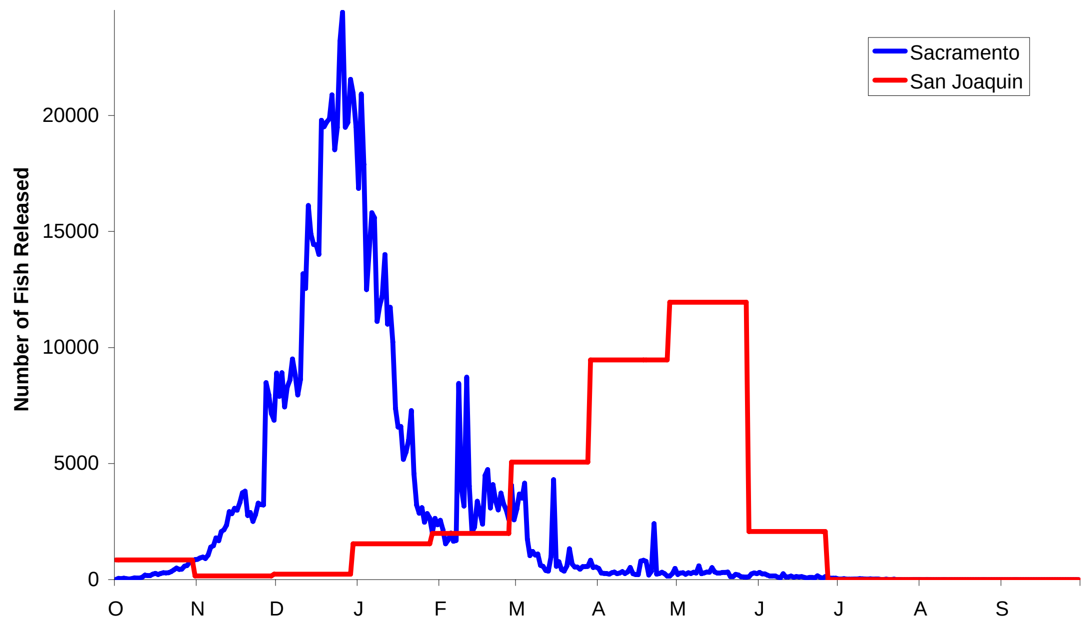


Figure 7. Annual timing distribution of simulated fish release at West Sacramento in the Sacramento River and Durham Ferry in the San Joaquin River.

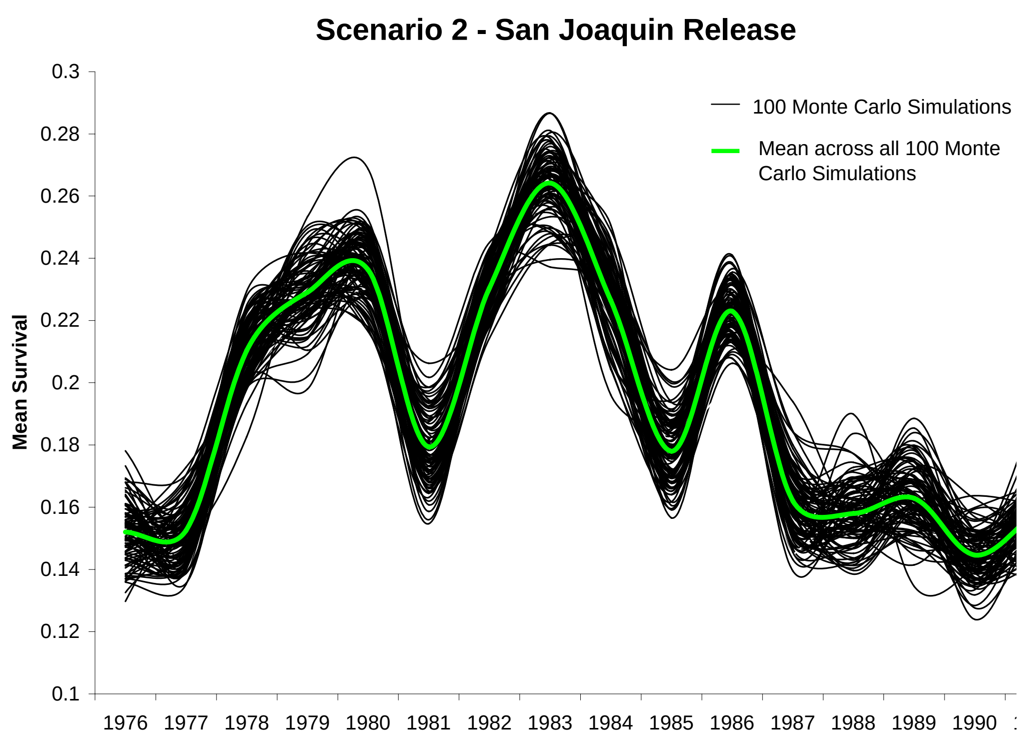


Figure 8. Mean survival from release at Durham Ferry to Chipps Island for each simulated Water Year showing results of all 100 Monte Carlo simulations for Scenario 2 and the San Joaquin release. Note that lines have been smoothed in Microsoft Excel.

While descriptive statistics for modeled survival estimates are useful for comparing scenario outcomes, the results should be interpreted cautiously. The functional relationships included in the model are based upon a handful of acoustic tagging studies and do not represent the full breadth of possible outcomes which might occur if environmental stochasticity were better understood or if behavior differences between tagged hatchery fish and wild untagged fish were addressed . Despite these limitations, the Delta Passage Model is a useful tool which effectively integrates complex relationships otherwise difficult to visualize or understand.

These results of model simulations are summarized by year and scenario with means and standard deviations as shown in Figure 9 and Figure 10. Detailed results from each modeled scenario are provided in Table 4.

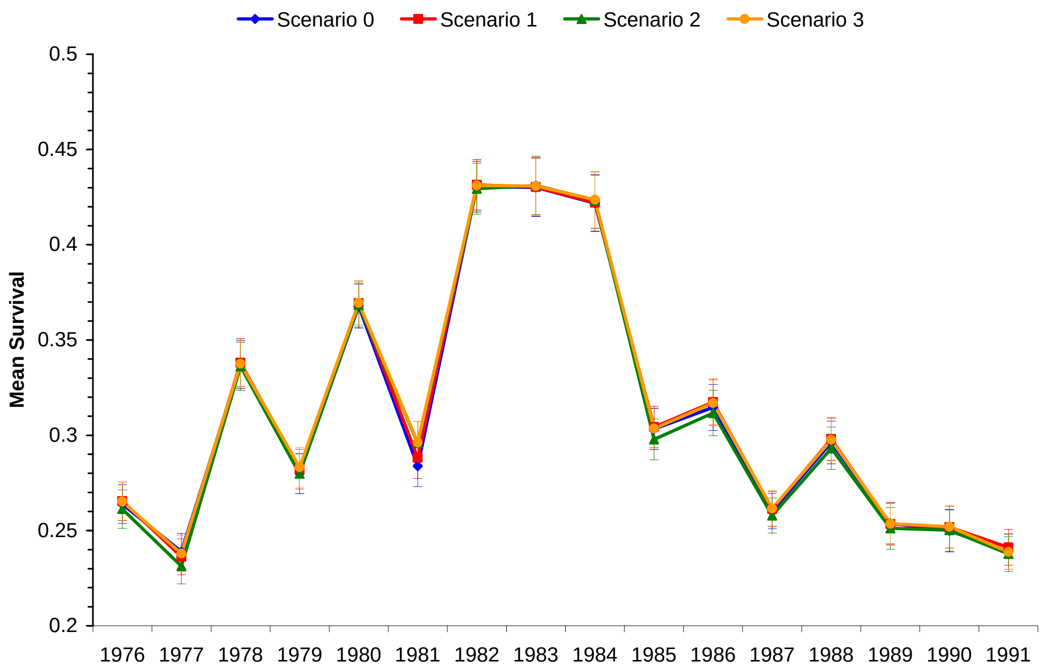


Figure 9. Mean survival from release at West Sacramento to Chipps Island for each simulated Water Year.

Results from fish released in the Sacramento River suggest no biologically significant or consistent difference in survival between the alternative scenarios in any water year (Figure 9). Close examination of data in Table 4 illustrates that predicted mean survival for Scenario 1 (seemingly most protective) was on average only 0.2% higher than that observed for Scenario 2 (seemingly least protective).

Simulated fish releases in the San Joaquin River found greater differences in predicted survival between scenarios. Specifically, survival in Scenarios 2 and 3 were substantially higher than survival in Scenarios 0 and 1 during most years (Figure 10). The exact cause of higher survival in Scenarios 2 and 3 is unclear, but are somewhat unexpected since these scenarios do not include the proposed and supposedly beneficial NMFS RPAs. Survival differences between scenarios in the San Joaquin River and the Sacramento River may be attributable to one or more of the following:

- Different release timing distributions between the San Joaquin and Sacramento Rivers in the Delta Passage Model.

• Lower daily flow values in the San Joaquin and Old River reaches of the Delta Passage Model could result in greater survival sensitivity to flow if those flow values are more consistently located on the portion of the flow-survival curves where the linear slope is larger.
• Differences between water management scenarios are larger for the San Joaquin River area of the Delta than for the Sacramento River area of the Delta.

While these results are preliminary, collectively our findings suggest that the benefits of proposed Delta juvenile salmonid RPAs may not yield the desired outcome in terms of magnitude or direction of survival benefits. Since flow and fish behavioral dynamics in the Delta are very complex and difficult to understand in a purely conceptual or qualitative setting, a tool like the Delta Passage Model would likely be extremely useful for evaluating the effectiveness of these and other alternative Delta operational scenarios.

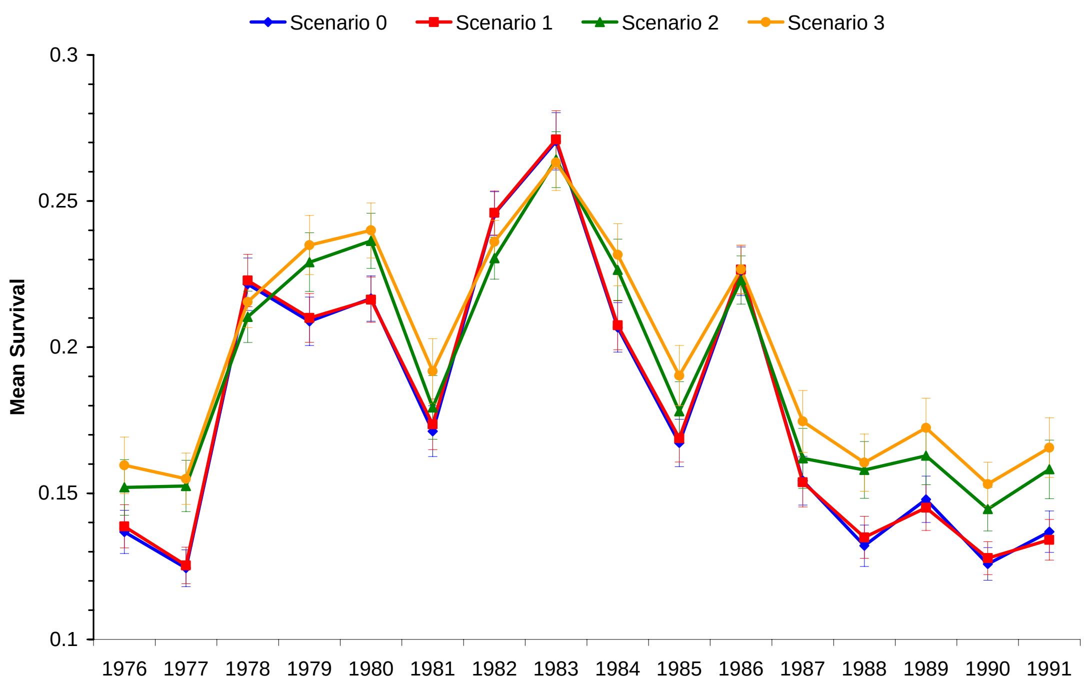


Figure 10. Mean survival from release at Durham Ferry to Chipps Island for each simulated Water Year.

Sacramento Release

Scenario	Stat	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	Mean	0.264	0.239	0.337	0.280	0.368	0.284	0.430	0.430	0.422	0.303	0.315	0.260	0.296	0.254	0.250	0.239
	SD	0.010	0.010	0.013	0.010	0.012	0.011	0.013	0.015	0.015	0.011	0.012	0.009	0.011	0.011	0.011	0.009
1	Mean	0.265	0.236	0.338	0.282	0.369	0.288	0.432	0.430	0.422	0.304	0.317	0.261	0.298	0.253	0.252	0.241
	SD	0.010	0.009	0.013	0.010	0.012	0.011	0.013	0.015	0.015	0.011	0.012	0.009	0.011	0.011	0.011	0.009
2	Mean	0.261	0.231	0.336	0.280	0.368	0.296	0.429	0.431	0.423	0.298	0.312	0.258	0.293	0.251	0.250	0.238
	SD	0.010	0.009	0.013	0.010	0.012	0.011	0.013	0.015	0.015	0.011	0.012	0.009	0.011	0.011	0.011	0.009
3	Mean	0.265	0.238	0.338	0.283	0.370	0.296	0.431	0.431	0.424	0.304	0.317	0.262	0.298	0.254	0.252	0.239
	SD	0.010	0.009	0.013	0.010	0.012	0.011	0.013	0.015	0.015	0.011	0.012	0.009	0.011	0.011	0.011	0.009

San Joaquin Release

Scenario	Stat	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	Mean	0.137	0.124	0.222	0.209	0.217	0.171	0.246	0.270	0.207	0.167	0.226	0.154	0.132	0.148	0.126	0.137
	SD	0.007	0.006	0.009	0.008	0.008	0.009	0.008	0.010	0.008	0.008	0.008	0.008	0.007	0.008	0.006	0.007
1	Mean	0.139	0.125	0.223	0.210	0.216	0.174	0.246	0.271	0.208	0.169	0.227	0.154	0.135	0.145	0.128	0.134
	SD	0.007	0.006	0.009	0.008	0.008	0.009	0.008	0.010	0.008	0.008	0.008	0.008	0.007	0.008	0.006	0.007
2	Mean	0.152	0.153	0.210	0.229	0.236	0.179	0.230	0.264	0.226	0.178	0.223	0.162	0.158	0.163	0.145	0.158
	SD	0.010	0.009	0.009	0.010	0.009	0.011	0.007	0.010	0.011	0.010	0.008	0.010	0.010	0.010	0.007	0.010
3	Mean	0.160	0.155	0.215	0.235	0.240	0.192	0.236	0.263	0.232	0.190	0.227	0.175	0.160	0.172	0.153	0.166
	SD	0.010	0.009	0.009	0.010	0.009	0.011	0.007	0.010	0.011	0.010	0.008	0.011	0.010	0.010	0.008	0.010

Table 4. Detailed results of the Delta Passage Modeling for proposed RPAs.

REFERENCES

Baker, P. F., Speed, T. P. & Ligon, F. K. (1995). Estimating the influence of temperature on the survival of Chinook salmon smolts migrating through the Sacramento-San Joaquin River Delta of California.. *Canadian Journal of Fisheries and Aquatic Sciences* **52**, 855-863.

Brandes, P. and J. Mclain. 2001. Juvenile Chinook salmon abundance and distribution, and survival in the Sacramento-San Joaquin Exstuary. In: Brown RL, editor. Fish Bulletin 179: Contributions to the biology of Central Valley Salmonids. Volume 2. Sacramento (CA): California Department of Natural Resources.

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

Kjelson, M. and P. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento San-Joaquin Rivers, California. In Levings C. et al., editors. Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105, pages 100-115.

Newman, K. B. 2003. Modeling paired release-recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. *Statistical Modelling* **3**, 157-177.

Newman, K. B. & Rice, J. 2002. Modeling the survival of Chinook salmon smolts outmigrating through the lower Sacramento River system. *Journal of the American Statistical Association* **97**, 983-993.

Newman, K. B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. Project number SCI-06-G06-299. U.S. Fish and Wildlife Service, Stockton, CA. Available: http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf (November 2008).

Perry, R. W. and J. R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River Delta during the winter of 2006-2007. U.S. Fish and Wildlife Service Report.

San Joaquin River Group Authority. 2007. 2007 Annual Technical Report.

Vogel, D. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the northern Sacramento-San Joaquin Delta, 2006-2007. California Department of Natural Resources Report.

Attachment 3

Revised Water Supply Impacts Analysis

DWR has changed the baseline for the purpose of analyzing potential water supply impacts associated with March draft Bi Op RPA actions. We believe a comparison with OCAP 7.0 of the Biological Assessment represents a better comparison than the previous baseline assumed and attached to our March 20, 2009 comments. The estimated water supply impacts, especially when combined with the actions in USFWS's Biological Opinion, are substantial.

The updated results indicate that when compared to OCAP Study 7.0, the average combined water supply impact to the SWP and the CVP of the NFMS draft RPA is roughly 900 taf to 1.1 Maf (or about 16% to 19%). By taking an alternative approach and layering the NFMS RPA on top of the terms of the USFWS 2008 Bi Op RPA that have been provisionally accepted by Reclamation, the average combined water supply impact of the NMFS draft RPA to the SWP and CVP is roughly 150 taf to 750 taf, or about 3% to 15% above the impact of the USFWS Bi Op RPA depending on the range of adaptive actions implemented by the USFWS under the terms on the Bi Op. When compared to OCAP Study 7.0, the average combined water supply impact of the collective USFWS RPA and NMFS draft RPA to the SWP and CVP is roughly 1.3 Maf to 1.6 Maf (or about 23% to 29%).

Again, it should be noted that these estimated impacts are incomplete, and we would expect them to be greater because they do not include reoperation of CVP reservoirs as specified in the draft RPA. A summary of the modeling assumptions for the CALSIM simulations is set forth below.

Modeling Assumptions

The initial analysis of the National Marine Fishery Service (NMFS) reasonable and prudent alternative (RPA) that would result in additional operational constraints in the Delta was completed with the CalSim II model. The base model used in this analysis originated from the modeling conducted for the 2008 OCAP Biological Assessment (BA) (Reclamation 2008). The BA includes the details on the CalSim II assumptions and modeling in Chapter 9 and Appendix D.

A total of six studies were conducted for this analysis. Two studies were used to estimate the reduction in SWP and CVP deliveries due only to the Delta actions specified in the NMFS draft RPA compared to OCAP Study 7.0. The other four studies were used to estimate the reduction in SWP and CVP deliveries due only to the Delta actions specified in the NMFS draft RPA compared to the Fish and Wildlife Service Biological Opinion (USFWS BO) RPA. All studies used Study 7.0 from the OCAP BA as a base model. Study 7.0 is the existing condition and represents the existing infrastructure and demands.

The modeling completed for USFWS RPA and NMFS draft RPA used only a D-1641 step. This is different from the modeling that was completed for the OCAP BA. The OCAP BA modeling included a Central Valley Project Improvement Act (CVPIA) 3406(b)(2) step, which estimated use of (b)(2) water, as well as an Environmental Water Account (EWA) step that modeled the current EWA and limited version of EWA. These steps were not modeled due to complexities in modeling new and proposed Delta actions and the uncertainty of how (b)(2) and EWA would be implemented.

OCAP Study 7.0 to NMFS draft RPA

A total of two studies were conducted to analyze the delivery reductions due to the Delta actions specified in the NMFS draft RPA compared to OCAP Study 7.0. These studies modified the base model to incorporate the logic needed to model the Delta portion of the RPA in the NMFS draft BO layered on top of D-1641.

The studies representing the NMFS RPA bound the range in the Old and Middle River (OMR) restriction described in Action IV.2.3. Each of these two models was modified to only include the following NMFS RPA:

- Action IV.2.1 – Maintain an export pumping rate to Delta E/I ratio of 35% or less in January.
- Action IV.2.2 – Maintain a San Joaquin River inflow to export ratio of 4:1 from March 15 through June 15 in all but dry and critically dry years, and a minimum 2:1 ration in dry and critically dry years.
- Action IV.2.3 – From February 1 through June 30, reduce exports, as necessary, to limit negative flows to -2500 to -5000 cfs in Old and Middle rivers, depending on presence of salmonids.

Table 1 summarizes these studies where the only changes between the two NMFS studies are the variation in OMR restriction described in Action IV.2.3.

Table 1 Applied Actions for each NMFS draft BO RPA.

Study Name	Base Study	Action IV.2.1	Action IV.2.2	Action IV.2.3
NMFS High Restriction	OCAP 7.0	35% EI in Jan	Mar 15 to Jun 15 2:1 in D, C WYs 4:1 in W, AN, BN WYs	Feb 1 to Jun 30 OMR>-2500 cfs
NMFS Low Restriction	OCAP 7.0	35% EI in Jan	Mar 15 to Jun 15 2:1 in D, C WYs 4:1 in W, AN, BN WYs	Feb 1 to Jun 30 OMR>-5000 cfs
OCAP Study 7.0	OCAP 7.0	None	None	None

Using the studies in Table 1, delivery reductions for the NMFS draft RPA were estimated by subtracting the total delivery of the OCAP Study 7.0 by the total delivery of the NMFS.

USFWS BO to NMFS draft RPA

A total of four studies were conducted to analyze the delivery reductions due to the Delta actions specified in the NMFS draft RPA compared to the USFWS BO. Each of these four studies was modified to incorporate the logic needed to model the Delta portion of the RPA in the USFWS BO. Two of these studies then layered on the proposed NMFS Delta related RPA.

All four studies include a specific level of Old and Middle River (OMR) restriction that bound the RPA specified in the USFWS BO. By layering the NMFS RPA onto the two USFWS studies, the incremental impacts were estimated.

USFWS BO

The D1641 step from each model was modified to operate to the USFWS RPA. Additional code was included in the model to restrict Banks and Jones pumping plants in order to meet the specified OMR target. The following is a summary of the ranges assumed in the modeling, and Table 2 summarizes the assumptions for each study.

- Action 1 – To protect upmigrating delta smelt. This action can start as early as December 1, based on the judgment of the USFWS, but after December 20 this action is based on turbidity and delta smelt salvage at the exports.

- Action 2 – To protect adult delta smelt that have migrated upstream and are residing in the Delta prior to spawning. This action would commence immediately after Action 1.

- Action 3 – To improve flow conditions in the Central and South Delta so that larval and juvenile delta smelt can successfully rear in the Central Delta and move downstream when appropriate. The initiation of this action is based on temperature and evidence of spawning.

Table 2 Applied Actions for each FWS BO RPA.

Study Name	Base Study	Action 1	Action 2	Action 3 (Pre-VAMP)	Action 3 (Post-VAMP)
FWS High Restriction (FWS-HR)	OCAP 7.0	Dec 18 to Dec 31 OMR>-2000 cfs	Jan 1 to Feb 28 OMR>-1250 cfs	Mar 1 to May 15 OMR>-1250 cfs	May 16 to Jun 30 OMR>-1250 cfs
FWS Low Restriction (FWS-LR)	OCAP 7.0	Dec 18 to Dec 31 OMR>-2400 cfs	Jan 1 to Feb 28 OMR>-5000 cfs	Mar 1 to May 15 OMR>-5000 cfs	May 16 to Jun 15 OMR>-5000 cfs

NMFS draft RPA

Each of the USFWS studies from Table 2 was modified to include the additional RPA from NMFS draft RPA. Additional code was included in the model to restrict Banks and Jones pumping plants in order to reduce levels down to 1/4 of the flow in the San Joaquin River in wet, above normal and below normal water years, and 1/2 of the flow in the San Joaquin River in dry and critical water years. The following is a summary of the RPA included in the modeling, with Table 3 summarizing the assumptions for each study.

- Action IV.2.1 – Maintain an export pumping rate to Delta E/I ratio of 35% or less in January.
- Action IV.2.2 – Maintain a San Joaquin River inflow to export ratio of 4:1 from March 15 through June 15 in all but dry and critically dry years, and a minimum 2:1 ration in dry and critically dry years.
- Action IV.2.3 – From February 1 through June 30, reduce exports, as necessary, to limit negative flows to -2500 to -5000 cfs in Old and Middle rivers, depending on presence of salmonids.

Table 3 Applied Actions for each NMFS draft BO RPA.

Study Name	Base Study	Action IV.2.1	Action IV.2.2	Action IV.2.3
NMFS / FWS High Restriction	FWS-HR	35% EI in Jan	Mar 15 to Jun 15 2:1 in D, C WYs 4:1 in W, AN, BN WYs	Feb 1 to Jun 30 OMR>-2500 cfs
NMFS / FWS Low Restriction	FWS-LR	35% EI in Jan	Mar 15 to Jun 15 2:1 in D, C WYs 4:1 in W, AN, BN WYs	Feb 1 to Jun 30 OMR>-2500 cfs

Using the studies in Table 3, delivery reductions for the NMFS draft RPA were estimated by subtracting the total delivery of the USFWS study by the total delivery of the NMFS.

Other Assumptions

For the NMFS studies it was assumed that a minimum health and safety pumping for Banks and Jones would be no less than 1500 cfs February through May, and 2000 cfs in June. The OMR restriction was assumed to be the minimum between the NMFS draft RPA and USFWS RPA.

It was assumed that San Joaquin River flows would remain the same as described by D-1641 and so the combined export of Banks and Jones would be decreased to meet the 4:1 in wet, above normal and below normal years, and 2:1 in dry and critical years. The splitting of available exports between the SWP and CVP under these new actions is not currently covered by formal agreement and so therefore only combined project deliveries were analyzed.

The CalSim II logic for operating to the NMFS Draft BO RPA is new and refinements are ongoing. However, this modeling effort does represent the best available at this time. The modeling did not attempt to model any other NMFS RPA action beyond the three listed above. Following is a list of potential improvements in order to better represent the NMFS as written.

- The San Joaquin River portion of the models was not modified in order to increase flows for pre-VAMP or post-VAMP. This would require taking water away from other prescribed uses. Implementing this in the model would likely only reduce the amount of time that SJR would be operating below the 4:1 or 2:1 criteria when the exports are operating at health and safety levels.
- The implementation of Shasta storage targets in September and April were not included in the models primarily because this would require adjusting rule curves and so under the allotted time this was not attempted. Implementing this would in effect reduce the flexibility of the reservoir for water storage in the model would likely reduce total deliveries.

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**

9 December 2010

Panel Members:

James J. Anderson, University of Washington
Ronald T. Kneib (Chair), RTK Consulting Services & Univ. of Georgia (Emeritus)
Stacy A. Luthy, University of the Pacific
Peter E. Smith, U.S. Geological Survey (Retired)

Scope and Intent of Review: This report represents the findings and opinions of the IRP assembled by the Delta Science Program to provide scientific advice intended to assist with a review of the efficacy of OCAP RPA implementation from June 2009 through September 2010. After reviewing a required set of written documents (listed in Appendix 1), the IRP convened at a technical workshop in Sacramento, CA on 8-9 November 2010. The 2-day workshop provided a forum for the panel to consider additional and updated information and new research findings and to discuss issues related to the application of RPA actions. The original schedule provided for the IRP to deliberate on the morning of the second day, but scheduling of workshop presentations constrained the panel's deliberations to a 2.5 hour period over lunch, after which the panel was asked to present initial assessments and impressions when the public workshop reconvened at 2:30 pm on 9 November. Subsequent panel communication and deliberations were conducted via email and conference call in the course of drafting the final report.

The intent of this first annual review is 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 in their respective OCAP RPAs during the 2010 water year. The panel also was encouraged to suggest appropriate adjustments to the RPAs or their implementation in the 2011 water year based on insights from the prior year's water operations and new scientific research findings.

The panel was not charged with evaluating the scientific basis or conceptual validity of the process underlying the original RPAs, nor any legal issues related to the development or application of the RPAs.

EXECUTIVE SUMMARY

The review panel appreciates the daunting challenge faced by all of the agencies attempting to balance California's existing commitments and growing human demands for water resources with the protection and restoration of aquatic habitat that is essential to ensure the present and future survival of the Delta ecosystem's non-human components and the ecosystem services that they provide to society. We commend their efforts to cooperate and integrate activities directed at achieving this goal and hope efforts will continue to improve collaboration.

The Panel also recognizes that this is the first year of implementing the OCAP RPA actions and it would be unrealistic to expect immediate and measurable changes in the population dynamics of the listed species in response to the RPA actions. That said, the Panel perceived a distinct focus on meeting the RPA objectives in terms of physical targets (i.e., flows and temperatures) with little explicit indication of integration with the biology/ecology of the listed species. We caution that the focus on meeting operational targets should not carry over into the planning of data needs and studies necessary to improve what should be very real connections between the RPA Actions and their effects on the listed species. The focus of management in the region needs to transition from a reliance on net flow triggers to the incorporation of relevant tidal and seasonal characteristics of the ecosystem at temporal and spatial scales relevant to the movement of fish through the Central Valley and Delta. In particular, the goal to avoid further jeopardy to listed species in the Delta should be focusing on first principles of fish behavior and cognitive ecology in order to drive efforts to disassociate fish from poor quality (i.e., sink) habitats that are an unintended consequence of water operations.

Currently, RPA actions tend to rely on physical metrics and triggers that are linked, at least in concept, to vital rates and life histories of the listed species. The challenge is to link RPA actions to vital rates within life stages, and ultimately to the population dynamics of the listed species within the ecosystem. This will require the refinement of tools for the accurate prediction of spatially-explicit variation in physical factors and the behavior of fishes. The panel was encouraged to learn of new models (e.g., NOAA/NASA temperature real-time model for river reaches) and ecological research (e.g., responses of delta smelt to tides and turbidity) that are moving in this direction. The panel strongly encourages the development of these types of novel tools and insights.

The effectiveness of RPA actions in meeting operational targets was usually adequate in 2010, but this was very nearly an average water year and it seems likely that many of the temperature and flow targets will not be met in substantially drier years. Under less favorable conditions, the effects on water exports are much more reliably predicted than effects on the populations of listed species.

The process of coordinating real-time operations with technical teams was not always transparent. The technical teams are meeting regularly to discuss available information and make recommendations, but it is sometimes unclear how the available expertise translates to operations especially in cases where the responsible agency makes a determination that contrasts with the advice of the technical team. Recommendations of the technical teams were at times based on historical patterns and the expert opinions of the current team members rather than having a basis in an objective template that could be followed and justified in subsequent years. The current teams may comprise individuals who have a great deal of long-term experience in the system, and their opinions regarding actions may be valid and useful, but in the future the composition of these groups will change and so there is a need to encourage progress toward developing more objective and transferable standards for the recommendation of when, where and to what degree RPA actions should be applied.

The panel does applaud the fact that most of the technical teams prepare detailed notes from their meetings that are made available online. This improves the transparency of the deliberation process by the technical teams and documents their decisions. We encourage this to continue.

We found it useful and helpful that there were specific proposals to adjust several RPA Actions that were presented to our panel at the workshop to help focus our review. For the future, it would be even better if proposals were presented to a panel prior to the workshop to assist in preparation. Providing the science support and logic behind any proposed adjustments is useful. The handout provided at the workshop by NMFS on their proposals was helpful, as were the written comments provided later by the Department of Water Resources (DWR). We only regret that perhaps more discussions on the pros and cons of these proposed adjustments did not occur during the open sessions at the workshop to better assist us in evaluating them.

Regarding the preliminary proposals for adjustments of various OCAP RPA actions, the panel had a range of opinions on the specifics, seeing merit in some (e.g., Proposal I.A –Part 2), but questioning the reasoning behind others (e.g., Proposal V.3). In some cases, the panel was reluctant to take a strong position on a proposal until such time as the DWR and other affected agencies had an opportunity to consult with NMFS.

Although not part of our formal charge, some recommendations are intended to improve the format of information presented to future panels. There is considerable benefit in standardizing the format for the presentation of materials to the panels in both written and oral form. Presentations regarding the RPAs should contain certain common threads that include: (1) geographic orientation to the portion of the Delta being discussed (it should not be assumed that all panel members can immediately geo-reference in the system as well as those who work in it frequently), (2) whether each RPA action that was intended to be applied was conducted or not, and why, (3) any known or measured responses of the fish populations or life stages targeted by the RPA actions. The latter may be a more reasonable request after multiple years of observations and data are available under the RPAs. Finally, it would be very useful to allow more time for panel deliberation while the group is assembled at the workshop; 2-2.5 hours over lunch was inadequate for the panel to organize its thoughts and develop a consensus on the many complex issues under consideration.

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INTRODUCTION

The Sacramento-San Joaquin Delta comprises a complex system of natural distributaries and 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 in its upstream tributaries were designed to store, redirect and convey water to meet human demands within the region.

Water in the Delta is essential habitat for resident and migratory fishes and an important resource supporting a variety of uses (e.g., agriculture, power generation, drinking water, etc.) that produce goods and services for the human population both within and outside of California. It is generally accepted that the chronic multi-decadal alteration of the natural ecosystem associated with meeting the demands of an increasing human population in the watershed 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 in the Delta, formal legislative recognition that water and other habitats should be managed to restore and enhance the Delta ecosystem as a coequal goal with providing a reliable water supply to California (SBX7, Nov 2009) represents a novel conceptual approach.

Background on the OCAP RPA review process: NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) each issued a Biological Opinion on the long-term Operations, Criteria, and Plan (OCAP) of the Central Valley Project (CVP) and State Water Project (SWP) that included Reasonable and Prudent Alternative (RPA) actions designed to compensate for or avert any project-caused: (1) jeopardy to listed species or (2) adverse modification of critical habitat for these species in accordance with section 7 of the Endangered Species Act (ESA). The specific RPA Actions in NMFS' OCAP Opinion (Section 11.2, pages 581-671) include both broad and geographic division specific RPA Actions. The specific RPA Actions in the USFWS' OCAP Opinion (Appendix B, pages 324-381) are organized by Delta smelt life stages. The RPA Actions in both OCAP Opinions provide specific objectives, scientific rationales, and implementing procedures. The NMFS Opinion primarily addresses issues involving wild winter- and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley steelhead (*Oncorhynchus mykiss*) and green sturgeon (*Acipenser medirostris*). The USFWS Opinion relates to jeopardy issues involving delta smelt (*Hypomesus transpacificus*).

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 information learned from the prior year's operations or research (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 U.S. Secretaries of Commerce and Interior have directed that this annual review be expanded to include a review of the implementation of the USFWS RPA as well.

Panel charge: The panel was charged with reviewing the implementation of the OCAP RPA associated with the NMFS Biological Opinion for the time period 4 June 2009 through 30 September 2010, and the RPA associated with the USFWS Opinion for 1 October 2009 through 30 September 2010. The charge focused on four categories: (1) effectiveness of the Actions for each RPA, (2) approaches (i.e., study designs, methods and implementation) taken in meeting the objectives of the RPAs, (3) coordination of real-time operations with the technical teams, and (4) potential improvements to the RPAs Actions.

Six questions were posed to the panel. These are provided verbatim in Appendix 2 of this report, but were addressed by the panel in a manner that was intended to minimize redundancy in responses related to each RPA while preserving the intent and purpose of the charge.

Acknowledgements: The members of the panel appreciate and acknowledge the efforts of the agency and technical team representatives 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 and on schedule. The panel wishes to express a special thanks to the Delta Science Program staff for providing the organization and logistical support to facilitate our task. In particular, Cliff Dahm (Lead Scientist) and Sam Harader (Program Manager) facilitated discussions at the workshop and Lindsay Correa (Environmental Scientist) deftly attended to a wide variety of technical and provisional details in support of the panel.

PANEL COMMENTS ON OCAP RPA ACTIONS IN WATER YEAR 2010

The panel was charged with responding to questions for each RPA. These were outlined in two forms: In Exhibit A, Attachment 1 of the formal charge to the IRP, our review was to focus on four issues in the implementation of OCAP RPAs and we were asked to respond to 6 questions (See Appendix 2).

In an attempt to minimize redundancy in our responses, we conflated the issues and reorganized the questions into four categories listed in Table 1 along with their relationships to the original questions in the charge.

We then developed Table 2 to organize the NMFS RPA Actions applied to the rivers and tributaries outside the Delta into topical groupings of temperature, flow, habitat restoration, barriers, habitat passage above dams, and other actions. Table 3 was developed for Actions relating to salmonids in the Delta, and Table 4 for Actions relating to delta smelt. There was too little information presented on green sturgeon this year to warrant a separate table. The RPA Actions are identified in the first column of each table. The NMFS Actions are listed by the numerical reference in the first column of the OCAP ACTION Summary: Master Matrix (http://www.deltacouncil.ca.gov/delta_science_program/pdf/workshops/OCAP_2010/RPA%20Summary%20Matrix%20of%20the%20NMFS%20and%20USFWS%20OCAP%20Opinion%20RPAs.pdf). The USFWS Actions dealing with delta smelt are listed as Actions 1 through 4.

The panel's opinion regarding an Action or suite of Actions is provided in the cells of the table. The opinion can be presented as a single word response (e.g., adequate) or annotated by a capital letter (e.g., A) that refers to an expanded narrative from a list of points following each table. Each table also includes one or more rows for general comments on an entire column in the table or a column under each topical group.

Blanks in the tables indicate that actions were either not implemented because of ongoing coordination, or the panel had insufficient information to formulate a response.

Table 1. Relationships of the categories in our analysis of the issues to specific questions in the IRP charge.

Our categories	Issues to review	Questions in IRP charge
I. Efficacy	(1) Effectiveness of Actions in meeting the objectives of the RPA	1(a) How effective was the implementation of RPA Actions?
II. Approach	(2) Study designs, methods and implementation procedures used	2(a) Were study designs appropriate for evaluating effectiveness of Actions?
		2(b) What study designs are more appropriate?
		2(c) How could indicators of RPA Actions be improved?
III. Coordination	(3) Effectiveness of process for real-time coordination with technical teams	1(b) How effective was real-time coordination of operations?
IV. Improvements	(4) Potential improvements to Actions to meet RPA objectives Actions	3 How can RPA Actions be improved?

Table 2. RPA outside Delta for salmon in WY 2010

			I	II	III	IV
Action	Description	River	Efficacy	Approach	Coordination	Improvements
			Temperature			
General comment			A	B		C
14-23, 31	Compliance	Sacramento	Adequate	E	Adequate,	D
11, 12	Compliance	Clear Creek	Adequate.		Adequate	F
46, 47, 48	Compliance	Stanislaus	Adequate		Adequate	
39	Compliance	American	Adequate	Very good	Very good	
40	Structural improvement	All dams	Adequate	Adequate	Adequate	
			Flow			
General comment			A	B		
8,	Pulse attraction	Clear Creek	Adequate	Very good	Adequate	
9, 13	Channel maintenance	Clear Creek	In planning			
48	Migration cues	Stanislaus	Very good	Very good	Very good	
38, 41		American	Adequate			
			Habitat restoration			
General comment						
33-35	Floodplain	Sacramento	Adequate			
10	Gravel	Clear Creek	Adequate			
49	Spawning habitat	Stanislaus	In planning			
50,51	Floodplain	Stanislaus	In planning			
		American				
25	Restore creek	Battle Creek	Adequate			
			Barriers			
General comment						
26-30	Delays at RBDD	RBDD	Adequate	Adequate	Adequate	None
36-37	Migratory delay	Sacramento				
			Habitat and passage above dams			
General comment						
67-78		All rivers	In planning			
24		Sacramento	In planning		Adequate	G
52		Stanislaus	No action			
42		American	No action			
			Other Actions			
43-45	Hatchery plan	American	In planning			
86	Funding program					

NARRATIVE NOTES FOR TABLE 2

A. As designed to achieve physical targets, the actions were generally effective.

B. Action is a physical compliance – it needs to be related to presence and bioenergetic responses of fish.

C. Improved temperature predictions were demonstrated by the NOAA/NASA study which should replace the concept of temperature compliance points with continuous spatial temporal predictions of temperature in the river and tributaries of the Central Valley. Linking the predictions from models with temperature and precipitation across seasonal and yearly scales should vastly improve the efficacy of within year and across year decisions on allocations of cool water resources in the system.

   The weakest link in the system appears to be how this high quality temperature information will be used by fisheries managers. The example presented in the review was a simplistic but useful first step. However, we see a temperature management system of greater potential. We recommend further development that links spatial-temporal life-stage specific fish distributions with the spatial-temporal temperature distributions. The system needs to include bioenergetic models that characterize effects of temperature on growth and survival across multiple life stages. While the underlying bioenergetic theory and information is available for this linkage, the effort is not trivial. For example, effect of temperature on growth will be complex because fish size affects both immediate survival and survival in later life stages. Furthermore, survival does not increase linearly with fish size but typically exhibits a threshold type response, such that the changes in size have little impact on changes in survival for the smallest and largest fish.

D. Need to link better forecasting of seasonal flow with down stream temperature modeling and then link effects of temperature on fish vital rates: egg, juvenile, and adult survivals, egg incubation time, juvenile growth. Strongly encourage implementation of the temperature forecasting and assessment program described by NOAA.

   We believe the temperature compliance needs to be improved by linking spatial/ temporal distribution of temperature in the river with the spatial/temporal distribution of fish. The NOAA/NASA presentation for improving predictions of stream temperature and linking these with fish would be a significant improvement to temperature control. However, this program too can be improved. The existing project considered effects of growth on juveniles. Effects of temperature on other life stages (adults, egg incubation, and also green sturgeon) need to be included in the system. Considerable work is available on the impact of daily temperature across salmon life stages (Marine and Cech, 2004; Murray and McPhail, 1988; Myrick and Cech, 2001, Sullivan et al. 2000; USEPA, 2001) and so there are no outstanding conceptual limitations to expanding the system. The panel emphasizes that an integrated real-time temperature compliance system that ingrates long (90 day and above) forecasts with real-time temperature predictions linked to biological models that consider growth, egg development rate and survival should be a goal for temperature compliance. Such a system comes under RPA 23 but the panel encourages a longer term program to integrate temperature flow management with fish biological needs throughout the Central Valley.

E. The temperature compliance points were qualitatively related to the distribution of winter-run Chinook. It is not known why the compliance point was established downstream (Jelly's Ferry) when aerial redd surveys in 2010 indicated redds were upstream of Airport Road Bridge.

   Preseason temperature planning is unclear. The documentation was inadequate to assess the efficacy of coordination in real time or the effectiveness of the action on fish. Because the temperature compliance point is adjusted over the year as the conditions in water storage, tributary flows and precipitation, reaching temperature compliance is difficult if the water is available and impossible if cold water storage is not available and temperature conditions over the year are unfavorable.

F. Compliance points should be re-evaluated and possibly moved to better match actual fish habitat usage.

G. While "fish population data" was listed in the presentation as a priority for data collection, the panel was not presented much about this topic, though the potential for competition and/or interbreeding of transported fish with native (or put and take fisheries) populations is of importance. We hope that risk assessment for major habitat degradation (e.g., the Cantara loop metam sodium spill in the Sacramento River in 1991) is also being considered.

Table 3. RPAs in Delta for salmon in WY 2010

			I	II	III	IV
Action	Description	Region	Efficacy	Approach	Coordination	Improvements
General comments						H
53, 54 ,55	Delta Cross Channel	Delta CC	Adequate	Partially Adequate		L
56, 57	Vernalis E/I	San Joaquin	Inadequate	I		
58	OMR flows	OMR	Adequate		J	L
59-63	Salvage efficiency and loss	CVP and SWP pumps CC Forebay	Under development		K	M
64	Delta operations group DOSS		Adequate			

NARRATIVE NOTES FOR TABLE 3

H. A lag time of 1-2 weeks real time monitoring of winter and late fall Chinook in reading coded wire tags (page 18 DOSS Technical Report) makes the real-time response to Chinook migration problematic. However, the delay results from reading data on the tag, not tag detection. The detection of tags is immediate and so the number of tagged fish represents data that is essentially available in real time. While there are likely important reasons to know the identity of specific fish (i.e., where, when or by whom it was tagged), the presence or changing numbers of tagged fish at a specific location provides information on timing of emigration that can be useful in implementing RPAs.

I. As stated in the DOSS Technical Report (page 19), the formulation of the second trigger was mathematically incorrect.

J. Adequate for salmon but action not currently coordinated with delta smelt program – coordination will require completion of work on delta smelt studies.

K. The management of Export/Import (E/I) program and impact on fish entrainment is uncertain.

L. Behavioral diversion barriers. The research on behavioral bubble barriers to divert fish at the head of Old River (HOR) and Georgiana Slough (GS) are critical research projects with some risk but significant potential. Behavioral diversion of salmon in a tidally fluctuating system is a great challenge and if successful would contribute to maintaining both salmon survival and water supplies to California. The essential goal, to route fish independent of flow, was first identified in the EWA review nearly a decade ago. Unfortunately, the level of effort to achieve this ability is below what is needed.

   The current approach to behavioral barriers in the Delta has been largely trial and error in which a system is envisioned and then deployed for testing; tracking trajectories or final destinations of tagged fish encountering the barrier. This approach has been used for decades in the Columbia River system at great cost and with limited success (Anderson 1988). Current studies in the Delta appear to be on a similar path. Developing efficient behavioral guidance systems requires an understanding of both the physical environment on scales relevant to fish and the temporal response of fish to the environment (Anderson 1988, 1991; Goodwin et al. 2006, 2007; Nestler et al. 2008; Kemp et al. 2006). Linking the environment to fish behavior requires a detailed description of the flow environment, the sensory signals relevant to the fish and knowledge of the fish's response to the sensory information. Linking these elements in a predictive model has been done in other systems (Goodwin et al. 2006) and the approach can be readily applied to the Delta.

However, such a program requires an integrated team with expertise in computational fluid dynamics, fisheries, animal behavior and computer modeling as well as expertise in laboratory studies of fish behavior and field expertise in fish diversion.

We understand that the VAMP review panel (Hankin and others, 2010) strongly recommended a return to a physical barrier at the HOR for the reason of routing more flow down the main stem of the San Joaquin River to improve outmigrant survival. Therefore, the GS barrier, to be implemented for the first time this winter (WY 2011), may have the greatest potential.

M. The proportion of fish in salvage varies based on alterations of such factors as the primary bypass ratio at the Tracy Fish Collection Facility (study using Chinook salmon; Reclamation, 2008). The Panel recommends further collaboration between the water and fish agencies in assessing the variable efficiency of salvage as related to water operations and the completion of studies proposed by Reclamation pursuant to the 2004 NMFS OCAP Opinion (e.g., Evaluation of the percent loss of salmonid salvage due to cleaning the primary and secondary louvers at the Tracy Fish Collection Facility, mentioned on page 343 of the current NMFS Opinion).

Table 4. RPA for delta smelt in WY 2010

		I	II	III	IV
Action	Description	Efficacy	Approach	Coordination	Improvements
General comments		T	N	T	O
Action 1a Limit OMR to -2000 cfs	Protect first flush based on turbidity and salvage	Inadequate	P		P
Action 1b	Protect after first flush based on salvage				
Action 2 OMR range -1250 to -5000 cfs	Protect after Action 1 based on fish data, delta conditions, salvage	Partially adequate	Q	Q	P, R
Action 3 limit OMR to -1250 or -5000 cfs	Minimize larval entrainment based on temperature and spent females	S	R		
Action 4	X2 management of adult habitat	No Action			

NARRATIVE NOTES FOR TABLE 4

N. The new delta smelt studies, which are coordinating sampling with the temporal patterns of tides and turbidity, represent a major advancement in research on this species and potentially for management of the Delta. Previous studies, on which the current RPA Actions are based, focus on net flows and turbidity, in particular the net flows in the OMR. The newest research, albeit currently limited in spatial and temporal scope, has demonstrated that delta smelt and other Delta species can respond to their local tidally driven environment which in turn may affect their movements within the Delta. A fresh perspective may even lead to improvement of sampling protocols for these species that will allow not only a better understanding of migration patterns within the Delta but also improve the accuracy of estimates of abundance. The panel strongly encourages this research and timely incorporation of the findings into new management strategies or possible future adjustments to the RPA Actions that may lead to reduced entrainment of delta smelt without further restrictions on water delivery.

O. The new studies measuring fish and water properties on tidal scales are innovative and important to providing the foundation for improved management of the Delta resources. Characterizing the spatial/temporal patterns of turbidity, salinity and flow at scales relevant to fish is an excellent initial step. However, the behavioral models that are so far being used in the Delta to link fish movement to the physical environment are inadequate. The Resource Management Associates (RMA) Smelt Behavior Model is based on unrealistic hypotheses for smelt movement, including the assumed response of delta smelt to horizontal gradients in turbidity and salinity and the stopping rule in the inner Delta. Detailed review comments on this model are contained in the 2-gates project review available at: http://www.science.calwater.ca.gov/events/reviews/review_2gates.html. The model builders have commendable expertise in modeling the physical environment but the top-down approach and a fine-tuning of the existing model with new data is discouraged. The use of the particle tracking model (PTM) to represent adult delta smelt behavior is also inadequate. In short, any rectified behavior, which moves fish upstream on the flood tide without realistically expressing the actual cues that induce the behavior, is simply inadequate. The goal should be to develop, from first principles, a behavioral model for how multiple species in the Delta, not just delta smelt, respond to their local environment. Such an effort will require a collaboration of experts from a variety of fields, including computational fluid dynamics, fisheries, animal behavior and computer modeling, as well as expertise in laboratory studies of fish behavior and fish diversion.

P. During 2010, Action 1 was never triggered because the average daily turbidity at Victoria Canal did not exceed 12 NTU for three consecutive days. Considering the close proximity of the Victoria Canal monitoring station to the south Delta pumps, this may have been a fortuitous occurrence because the data suggests that when the turbidity at that station exceeds 12 NTU it may be too late to avoid entrainment of at least some adult delta smelt that presumably would have moved into the south Delta with the higher turbidity water. During the first flush of 2010 (which began the week of Jan 24th), OMR flows were already curtailed to be no more negative than -5,000 cfs by the salmon Biological Opinion (RPA Action IV.2.3). That level of OMR flow was sufficient to prevent turbid Sacramento River water from being drawn down to the Victoria Canal station and triggering the Action. Without the salmon Action, however, it is likely that OMR flows would have been higher, and the delta smelt Action would have been triggered. Delta smelt protection should not rely on the salmon Action. The panel feels it would be wise to adjust slightly the trigger for Action 1 so that it gives an earlier warning for the first flush. Adjusting the trigger to be a three-day average of the monitoring stations at Prisoners Pt, Holland Cut, and Victoria Canal might be adequate, although some analyses should be done to confirm this and determine whether a trigger of 12 NTU is the appropriate magnitude. The SWG has suggested five alternative sites for use in WY 2011, which can be considered also. As the new research on delta smelt (see N above) attempting to link tidal activity, turbidity and fish movements becomes available it may provide useful additional guidance for Action 1. The SWG has acknowledged this and has already proposed to incorporate peak turbidity on the incoming tides as a consideration in their evaluation process of entrainment risk level for delta smelt. However, it is important to understand how fish behavior links to turbidity and tidal activity (for example, movements may not be related to turbidity on incoming tides). As much as possible, the goal should be to link fish behavior to the physical triggers.

The turbidity data from 2010 did show that an OMR flow objective as restrictive as -2,000 cfs may not be necessary in years of average or below average hydrology in order to keep turbidity in the south Delta low (below 12 NTU) and delta smelt entrainment minimal. In 2010, for example, OMR flows of -5,000 cfs proved adequate with a first flush of 57,000 cfs (on the Sacramento River at Freeport). These data suggest that the OMR flow objective required in Action 1 should really depend on the size of the first flush. The larger the first flush, the less negative the OMR flow objective that will be needed. The panel recommends that this idea be further investigated as additional years of turbidity data are collected and improved numerical models of sediment transport are developed and become capable of accurate turbidity prediction.

Q. In as far as salvage of delta smelt reached a level of concern (92) but did not exceed the incidental take limit of 123 fish, it could be concluded that the Action contributed to reducing take. However, it is also possible that the apparent success was due in part to the generally low abundance of delta smelt in the system. The incidental take limit is indexed to an estimate of delta smelt abundance from the Fall Mid-Water Trawl, but the accuracy of that value depends largely on the variance associated with the abundance estimate.

The SWG recommended, based on a team consensus (though not unanimous) and a total expanded salvage of 24 delta smelt, that OMR be set no more negative than -2000 cfs. The technical team believed that there was enough current and historical evidence to indicate that delta smelt were actively migrating and were vulnerable to further entrainment and salvage mortality. A peak in salvage was anticipated because the team believed that migratory adults already entrained into OMR, were vulnerable to pumping operations. Although no rationale was apparent, the USFWS rejected the SWG recommendation and instead determined that -4000 cfs was sufficient to protect the fish. By the following week, the anticipated peak in salvage had not materialized and it was concluded that it had been avoided. This is interesting because it suggested that an anticipated level of jeopardy was avoided even at an export flow double that recommended by the technical team.

There are two issues that arise from this instance. The first is a question of coordination with the technical team. The process by which the recommendation of the SWG was rejected is unclear even though the outcome appeared to be favorable (i.e., an anticipated level of jeopardy was avoided while export flows were not unduly affected). In fact, according to Table 2 of the SWG Report to the IRP, the USFWS determination of allowable export flows exceeded (i.e., OMR flows were more negative) that recommended by the SWG on 4 out of 17 times (about 24% of the time). The same table also shows that the observed OMR flow range exceeded the range allowable under the USFWS Opinion in 4 of 15 cases (about 27% of the time). However, it should be noted that the amount by which flows exceeded allowable limits was usually – though not always - minimal. It is also notable that observed flow ranges tended to be in the upper end of the allowable range on most occasions. This is partly due to the use of a 14 day running average in determining OMR flow ranges, but operating near the upper end of the allowable range does tend to invite incidents that exceed the set limits.

The second issue that arises from the discrepancy between flow recommendations of the SWG and the ultimate determination of allowable flows by the USFWS is the connection between the biology of the vulnerable delta smelt population and the action triggers. Lacking accurate real-time information on the population size and locations of vulnerable sub-populations, the SWG recommendations are based largely on historical patterns, salvage numbers and the individual experience/expert opinions of the individuals within the working group. The potential problems here are that while historical patterns might predict general trends, they are usually not sufficiently sensitive in predicting events in any given year, and composition of the SWG will inevitably change over time, as will the level of first-hand experience with studying delta smelt and the Delta ecosystem.

R. Salvage is certainly a qualitative indicator of mortality that can be linked to water operations, but it remains a questionable quantitative measure of population jeopardy. Currently, salvage is used as an indicator of entrainment with the assumption that some constant proportion of entrained fish is taken in salvage at the state and federal fish facilities. Recent research on delta smelt entrainment into the SWP has indicated that salvage may not be a "consistent index" (Tools for Delta Smelt Management Workshop: http://www.deltacouncil.ca.gov/delta_science_program/pdf/workshops/OCAP_2010/tech_teams/USFWS/Tools%20for%20Delta%20Smelt%20Management.Workshop%20Summary.pdf). The panel recommends expedient incorporation of the existing and newly emerging efficiency data into a new entrainment index.

Given the current precarious status of delta smelt, it seems unlikely that refinements in population estimates or model development will proceed quickly enough to improve the understanding of the relationship between water operations in the Delta and delta smelt populations. Until more refined methods relating delta smelt population dynamics to variation in the quantity and quality of its Delta habitat, there may be ways to develop an incremental improvement in the use of available information. For example, sophisticated refinements to tools are not necessary to recognize – even at the most basic level – that not all individuals salvaged represent an equal amount of jeopardy to the population. The expected lifetime contribution to reproduction in a population (i.e., Fisher's reproductive value) varies in a manner that can be calculated from age-specific survivorship and per capita fecundity at a given age (Kozlowski 1993). A pre-spawn adult female delta smelt or one containing mature or maturing eggs is a much greater loss to the future population than a larva, an adult male, or a spent female. Consequently, a scientifically defensible ecological connection between salvage and jeopardy would weight the protection afforded to different life stages in the population. In practical terms, it is advisable to adjust the allowable incidental take of delta smelt for different life stages. This also provides some flexibility in the RPA action when the water resource costs are high to protect individuals that are likely to contribute little to the future population size.

S. There is no metric by which to evaluate the effectiveness of the action on early life stages, which are not accurately counted among the salvage values.

T. The 2010 Water Year was considered below – but close to – average. Drier years are likely to present greater problems related to demand for proportionally higher exports and a greater pressure for legal remedies. Successful legal challenges to any of the actions have potential to: (1) inhibit the actual effectiveness of the action, (2) preclude any evaluation of efficacy, and (3) inhibit agency coordination (if agencies are on different sides of proceedings). Consequently, linking vital rates and the population dynamics of delta smelt to the physical flows targeted by the RPA actions needs to be a high priority for future studies involving delta smelt.

PANEL RESPONSES TO PROPOSALS FOR ADJUSTMENTS OF OCAP RPA ACTIONS

Proposal I.A **– Old and Middle River (OMR) Flow Management**

Issue #1: *Water was not exported at the maximum allowed last year when RPA Action IV.2.3 required OMR to be no more negative than -5,000 cfs. The operators were operating to a conservative OMR of no more negative than -4,000 cfs, because one swing of the tide can cause OMR to fluctuate by up to 1,000 cfs.*

NMFS Proposal I.A (part 1) for Adjusting OMR Actions*: One of the formulas (by DWR, USGS, or MWD) can be used to predict OMR in order to provide flexibility and enable operating OMR closer to the OMR limit. Actual OMR would need to be monitored also in order to confirm that the predicted and actual OMRs track closely.*

The panel understands the challenge that DWR and Reclamation face in attempting to avoid exceeding negative OMR flow objectives without keeping export levels at overly conservative (low) levels. Because the physical configuration of the SWP export facilities allows more control over the level of south Delta diversions than the Federal (CVP) facilities, it is DWR that often must shoulder the greater burden in fine-tuning diversion levels so as to meet OMR objectives.

The USFWS and NMFS asked for our comments on the above proposal to consider adjusting their OMR flow management actions to use an empirical equation to forecast levels of exports that will theoretically satisfy an OMR flow objective instead of requiring that the flow objectives be met with the actual measured OMR flows. The idea is that this adjustment would make managing project operations to meet flow objectives more straightforward and allow for some increase in exports because a factor of safety will not have to be built into operations to ensure compliance.

Before providing our specific comments on this proposal, we offer some background on Old and Middle River flows and the factors that affect their variability.

Background: The measured flows and water surface heights in both Old River and Middle River vary strongly with the tides. The OMR data for the winter (Dec-Mar) of water year 2010 are graphed in Figure 1 to illustrate this point. Maximum ebb (positive) flows and flood (negative) flows in both rivers during this period were in the range of 10,000 to 15,000 cfs, with tidal flows in Middle River slightly higher than those in Old River. The daily tidal range[1] in water surface heights varied between approximately 2 and 4 feet. The largest ranges in the tidal heights and flows occur on the spring tides and the lowest ranges on the neap tides. This spring-neap cycle occurs over a 14-day period and varies in magnitude on an annual basis (the greatest spring tides occur during late-December and late-June).

The more slowly varying flows and water surface heights shown by the thick black curves in Figure 1 were calculated hourly by a low-pass (Godin) filter that is used to remove the tidal oscillations from the time series. The OMR flows used in meeting the objectives defined in the biological opinions are calculated from these hourly filtered flows by first computing a daily mean flow for each river and then summing these daily values for Old River and Middle River. The combined daily total flow for both rivers is referred to as the “net” or “tidally averaged” OMR flows.

Hutton (2008) provides a good discussion of the factors affecting net OMR flows and evaluates the limitations and performance of the various empirical models available to predict them. OMR flows are affected most by the amount of water diverted from the south Delta and, to a lesser degree, by the inflow to the Delta from the San Joaquin River at Vernalis. Tides and meteorological factors can play a role also as discussed below. A key point is that for any reasonably accurate short-term (several days to a week) forecasting of OMR flow the actual daily diversions into Clifton Court Forebay (CCFB), ***not*** the daily SWP exports from the forebay, are needed. The forebay inflows (diversions) are not as easily managed as SWP export pumping and they can deviate significantly on a short-term basis from the exports as shown, for example, by the two months of data from 2001 plotted in Figure 2 (data for wy2010 were not available). Hutton (2008, Figure 7-2, p. 85) provides further comparisons of the

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[1] The daily tidal range is the difference between daily maximum and daily minimum water surface heights. A daily tidal range in flows is similarly defined as the difference in the daily maximum (ebb) and daily minimum (flood) flows

daily forebay inflows and outflows and shows they are significantly different on a daily time scale, although they tend to collapse to closer values as the data are averaged over 14 days. Unfortunately, the instantaneous inflows to the forebay are not directly measured; they are estimated,[2] so there is some uncertainty regarding the accuracy of the estimates.

During periods of reasonably steady San Joaquin River inflows to the Delta, it is likely that variations in inflows to Clifton Court Forebay may explain much of the observed short-term variability in net OMR flows not explained by exports. The tidal spring-neap cycle and meteorological factors are often implicated as causing significant variability in observed OMR flows, but these factors may be more indirect than direct causes of variability. They are indirect causes because they affect the CCFB inflows, which in turn affect the OMR flows. Daily inflows to the forebay depend on the difference in water surface elevations outside and inside the forebay during the periods of each day when the gates are in the open position. As can be seen in Figure 1 (see, in particular, the month of December), the tidal spring-neap cycle causes a 14-day rise-and-fall in mean Delta water surface heights. The water surface heights tend to rise during the more energetic spring tides and fall during the neap tides. This can lead to a tendency toward greater inflows to the forebay on spring tides and lesser inflows on neap tides depending on how the opening and closing times for the forebay gates are adjusted to account for these effects. The project operators are aware of the spring-neap tidal cycle and do try to account for it.

During storm events in winter and spring, changes in atmospheric pressure and wind also can lead to significant fluctuations in water surface heights in the Delta that can affect diversions into the forebay. Figure 3 illustrates the more than one foot rise in tidally averaged water surface height on Middle River that resulted from the large storm and low-pressure system that occurred over northern California during the week of January 18, 2010. This particular storm led to the “first flush” event of the winter that caused daily flows on the Sacramento River at Freeport to reach 55,000 cfs by Jan 24. It is typical for this type of low-pressure event observed in previous years to correspond with a significant oscillation in OMR flows as also occurred in 2010 (see Figure 3, second graph from bottom). OMR flows first become more strongly negative as the estuary water levels rise, and then become less negative as project operations adjust, high pressure returns, and Delta water levels fall.

The time series for daily, 5-day, and 14-day averages of the OMR flows measured during the winter of WY2010 are graphed in Figure 4. During the period from January 20 through the end of March a combination of the NMFS and USFWS RPA actions required a flow objective that was mostly -5,000 cfs[3].

[2] Inflows to Clifton Court Forebay are indirectly estimated by the DWR Delta Field Division using a mass balance approach (Le, 2004) or by gate equations developed by Hills (1988).
[3] For a short period from February 10-18, 2010 the OMR flow objective was lowered temporarily to -4,000 cfs.

The average flows that occurred were slightly lower than this objective (approximately -4,500 cfs). The 5-day averages were also maintained at levels that were no more negative than the required 25 percent of the targeted flow objective for the 14-day average. Overall, the project operators did an excellent job with the difficult task of closely meeting the flow objectives during 2010, but without exceeding them. However, because there were only a few transitions in the flow objectives during 2010, the task was easier that what might happen in future years.

Panel response to proposal I.A (part 1): We have no strong objections to this proposal. It most likely will not introduce any significant increased variability in OMR flow that could affect entrainment of delta smelt or outmigrating juvenile salmonids. Of course, if a goal of the proposal is to increase exports slightly, allowing the 14-day average of OMR flows to fluctuate a specified amount more negative than the objective flow might be a solution also. Larger negative fluctuations in the 5-day averages could also be allowed to improve flexibility for the operators. A goal could be to relax requirements enough so that the operators could use a predictive equation of their choice to set export levels and yet remain in compliance with the OMR action. In any case, we suggest to USFWS and NMFS that they further explore whether much of the troublesome short-term variability in OMR flows that is not explained by exports is explained simply by the variability in the actual south Delta diversions from the estuary. If diversions explain much of the variability, it might be wise to seek improved and real-time measurements of CCFB inflows for use in managing diversions. Accurate real-time measurements would conceivably allow setting more precise closing times for the CCFB gates once a diversion objective has been met. If a goal of USFWS and NMFS is to reduce any relatively large, project-related short-term variability in OMR flows, then the prediction equation used in the adjusted action could be applied for setting an objective on forebay inflows (diversions) rather than for exports. This approach may not be as favorable to the SWP operators because it would again present more logistical difficulties than managing exports, but it would reduce short-term variability in OMR flows if that becomes a concern.

Issue #2: *In situations when the required OMR flow drops several times in quick succession, project operators have expressed a concern that the protective standard has been set in a way that can be very difficult to meet [see example in the October 2010 Delta Operations for Salmonids and Sturgeon (DOSS) annual report, page 20].*

***NMFS Proposal I.A (part 2) for Adjusting OMR Actions**:*

- *To provide flexibility in operations, when a fish density trigger is met, the export reduction floor shall be 1,500 cfs (i.e., the project operators would not* *be required to go below 1,500 cfs in order to meet OMR) until the required OMR limit (e.g., no more negative than -3,500 cfs) is met.*

- *As long as the operators make all "good faith efforts," we could consider that compliance, even if the specific OMR limit is not met.*
- *There may be more flexibility in the OMR, and therefore, exports, later in the averaging period.*

Panel response to proposal I.A (part 2): This proposal makes sense. We understand that it is necessary to keep at least one pump operating at the Jones Pumping Plant to provide water to locations where no other source is available. This requires setting a floor of about 1,500 cfs on exports. The overall issue, however, of how to deal with transitions in OMR flow objectives is a challenging one, especially if changes in flow objectives occur in rather rapid succession and also considering that long-duration (14-day) moving averages are used to define the flow objectives in the RPA actions. NMFS has provided fairly complicated transition language in their Biological Opinion (p. 649). An alternative solution to transitions may be to base compliance on the use of an equation that defines exports or diversions based on the OMR flow objective as considered in the part 1 proposal above. During the first 7 days[4] after and (if necessary) before the flow objective is changed either up or down, the equation would be used in place of the OMR objective. On the 8th day the 14-day average would again apply. The MWD equation (Hutton, 2008) is the most accurate equation right now. The equation proposed by the Contra Costa Water District, which is to define total exports for a given OMR flow objective by

$$\text{Exports} = -1*(\text{OMR flow objective}) + 0.5*(\text{SJR flow})$$

might be adequate, but is probably simpler than warranted considering that better equations are available and they are all easy to apply. According to information provided by NMFS and USFWS, DWR has drafted a proposal for new transition language. We will wait to hear what their proposal is.

Proposal I.B **– Calendar-based OMR Trigger** (for NMFS RPA Action IV.2.3, Biological Opinion p. 648)

Issue: *DWR asked that the Panel carefully consider whether the calendar-based OMR trigger is an appropriate action upon which to regulate the operations of the export facilities. DWR believes that NMFS, in order to support their hypothesis that exports draw salmonids off their normal migratory route, improperly relied upon a Particle Tracking Model.*

[4] 7 days represents one-half the time period of a 14-day moving average

NMFS Proposal I.B for Adjusting Calendar-based OMR Trigger: *Nothing new is proposed for this component of the RPA. Calendar-based trigger is necessary, as there is significant Sacramento winter-run Chinook salmon (winter-run) present in the Delta as of January 1st of each year. In addition, Central Valley (CV) spring-run Chinook salmon (spring-run) and CV steelhead from the San Joaquin River Basin continue their outmigration well into June. This action is necessary to keep the salmonids away from the zone of influence of the export facilities.*

Panel response to proposal I.B: The Panel is reluctant to endorse the calendar-based OMR trigger used in NMFS RPA Action IV.2.3 without studying the monitoring data more carefully. We are unsure whether juvenile winter-run Chinook or juvenile steelhead are present in the Delta during January of all years and in sufficient numbers to justify the curtailing of exports through an OMR action. A preliminary look through the 2009/2010 data report by Llaban (2010) that was provided to the Panel to review appears to show no winter-run caught in the Sacramento Trawl during January and none observed in the salvage until just after the time of the first flush on the Sacramento River in late-January. Also, it seems as if few or none were caught in the central Delta, south Delta, or San Joaquin River beach seines until late-January or thereafter. If our interpretations of these data are correct (and they might not be) it would seem that in 2010 a Jan 1st trigger date for an OMR Action might have been earlier than needed. Could it be that juvenile winter-run do not enter into the Delta in significant numbers until the first-flush event on the Sacramento River? If so, perhaps triggering the action before the first flush is not warranted. There are years such as 2000, 2001, 2007, and 2009 where the first flush did not occur until February. It would seem worthwhile to review the monitoring and salvage data for these years to identify whether juvenile winter-run were in the Delta during January.

Regarding Action IV.2.3 in general, the Panel feels additional acoustic tagging studies in the north Delta would be valuable to better understand the importance of exports and negative OMR flow levels in affecting survival through the Delta for Sacramento River juvenile Chinook salmon. The Panel understands that earlier coded-wire-tagged release-recovery studies in the north Delta (Delta Action 8 Experiments, etc.) have been somewhat inconclusive regarding export effects on survival. The use of acoustic tags and in-river receivers, however, is a promising alternative to CWT data that can provide valuable information regarding fish survival through individual reaches and their route selection. Key questions that could be answered are: What are the percent routing and survival of Sacramento River fish through the major migration routes (Sacramento River, Sutter/Steamboat Sloughs, Delta Cross Channel and Georgiana Slough)? Of the fish departing from Georgiana Slough and entering the central Delta, what percentage is lost through direct or indirect effects of exports? An ongoing research program to answer these questions is needed so that the debate over Action IV.2.3 does not have to continue.

Regarding the issue of particle tracking raised by DWR, the Panel agrees with DWR that particle-tracking modeling studies using neutrally buoyant particles are ***not*** a good surrogate for the fine-scale migratory behavior of salmon smolts or for estimating the transit time of smolts through the Delta. What little that is known about the migratory progress of smolts in estuaries is that their movements are in steps, characterized by swimming in the direction of the current followed by periods of holding in areas of low current velocity. These are not behaviors described by neutrally buoyant particles. On the other hand, in the process of migrating to the sea, smolts are thought to cue almost entirely on downstream flow direction. Because neutrally buoyant, particle-tracking modeling gives clear indications of flow directions, it can be a useful tool in helping to forecast how movements of smolts through the Delta may be influenced by flow.

Proposal I.C – 2nd Trigger to Reduce OMR to no more negative than -3,500 cfs (for NMFS RPA Action IV.2.3, Biological Opinion p. 649)

Issue: *The 2nd trigger, as written in RPA table, is not workable in its current form (see NMFS' March 12, 2010, Determination based on the DOSS advice from March 11, 2010 at http://swr.nmfs.noaa.gov/ocap/2010-03-12_NMFS_determination.pdf). A subgroup of DOSS convened several meetings to recreate the second trigger. The proposed second trigger has not been vetted through the DOSS group, and therefore, DOSS has not provided advice to the Water Operations Management Team (WOMT) and NMFS (per process provided in Opinion pages 582-583) regarding the corrected second trigger.*

NMFS Proposal I.C for Adjusting 2nd Trigger to reduce OMR to no more negative than -3,500 cfs: *Based on NMFS participation on the DOSS subgroup, NMFS believes the first stage of the second trigger is as follows:*

- *First stage: daily loss > 8 fish/thousand acre feet (TAF) exported multiplied by exports (in TAF); and*
- *Second stage: daily loss > 12 fish/TAF multiplied by exports (in TAF).*

Panel response to proposal I.C: The panel chooses, without bias, not to comment on adjusting of the 2nd trigger because insufficient information was provided.

***<u>Proposal II</u>* – San Joaquin Inflow-to-Export Ratio Action** (NMFS RPA Action IV.2.1, Biological Opinion p. 641)

Issue: *While this action restricts total exports (normally to low levels) during April and May based on the inflow-to-export ratio, it does not specify whether exports occur from the CVP or SWP. Because high predation mortality occurs in the Clifton Court Forebay (CCFB), and the louver efficiency at the Skinner Fish Facility is lower when pumping is low, it may be wise to consider keeping the CCFB gates closed during this action so as to reduce salvage and loss.*

NMFS Proposal II: for Adjusting the San Joaquin Inflow-to-Export Ratio Action:

- *Keep the CCFB closed, and pump the water from south of the louvers at the Tracy (Federal) facility to the CCFB to provide water for the Byron-Bethany Irrigation District and for the State to pump.*
- *This conceptual proposal will need engineering/feasibility review.*
- *With the intertie likely to be operational starting in 2012, there will be more flexibility to export water from the Tracy facility, especially during April and May.*

<u>Panel response to proposal II</u>: The panel understands the thinking behind this proposal, but is unsure how effective it will be based on information that has been learned from the coded-wire tag (CWT) and acoustic-tag (AT) experiments done since 2000 as part of the Vernalis Adaptive Management Plan (VAMP). If an effective fish barrier[5] is deployed at the head of Old River (HOR), and exports are kept at the low level (typically 1,500 cfs) that is necessary to satisfy the inflow-to-outflow ratio for this Action (Action IV.2.1), it is unlikely that enough outmigrating San Joaquin River salmonids will become entrained into the CCFB during April and May to justify a need to close off the forebay entirely. Between 2000 and 2004, the data from the VAMP CWT experiments done with a physical HOR barrier in place and low exports (approximately 1,500 cfs – 2,250 cfs) show that expanded salvage estimates from the combined projects' fish facilities were no more than a few hundred of the tagged experimental fish. In the experiments during 2001 and 2003, it was less than 50 fish. These experiments were done with release sample sizes of from 50,000 to 100,000 tagged juvenile salmon (from the Merced River Hatchery) released on the San Joaquin River at either Durham Ferry or Mossdale. A table summarizing the numbers from these experiments can be found in Newman (2008, Table 5). In 2009, an AT experiment for VAMP was done that included periods when the bubble barrier at the HOR was not turned on. Vogel (2010, Table 13) detected only three (estimated) live acoustic-tagged smolts in the forebay at a monitoring station located immediately inside (west) of the CCFB entrance gates. These three fish were from a sample size of 173

[5] The 2010 Delta Science Program review of the VAMP program (see Hankin and others, 2010) made convincing arguments for employing an operable physical barrier at the head of Old River.

(estimated) live acoustic-tagged smolts that entered Old River and were detected at the Old River at Middle River flow split. A total of 77 (estimated) live acoustic-tagged fish were detected just outside (east of) the entrance to the forebay gates, so tagged fish were in the vicinity of the entrance. What appeared to happen is that at the very low SWP export levels during VAMP, the CCFB gates were opened only periodically, typically at night, for such short periods that only a few fish became entrained. This experiment suggests that even when fish enter Old River, if SWP exports are very low, entrainment into the forebay may also be low. Because Action IV.2.1 will generally require higher San Joaquin River inflows at Vernalis during April and May than the previous VAMP pulse flows, we should expect even lower entrainment rates into the forebay. Overall, because entrainment levels into the forebay during April and May are expected to be so low, and considering that DWR has concerns about meeting their minimum levels of demand for the SWP during this action if the entrance gates are kept closed for two full months, we feel that it is not necessary to implement this action at this time. If new AT experiments indicate that significant numbers of fish released on the San Joaquin River are entrained at the CCFB, then this proposal could be reconsidered.

Regarding Action IV.2.1 and the above proposal, the Panel was provided a lot of additional information by DWR regarding their feeling that a negative statistical relationship does not exist between project exports and survival of San Joaquin River salmonids through the Delta. DWR did a thorough job of summarizing the literature on this subject through March, 2010. Regarding the Action itself, DWR noted that they “strenuously objected to its inclusion” in the RPA for the NMFS Biological Opinion. However, evaluating the scientific basis or conceptual validity of the process underlying the development of any RPA Action was specifically not in the charge to this panel, although we could propose or consider adjustments to Actions in light of information learned from the prior year’s operations or research. The Delta Science Program did provide the Panel as part of our supplemental reading material the most recent review of the VAMP study by Hankin and others (May, 2010). That report does provide some new insights into the issue of exports and San Joaquin salmon survival through the Delta. We feel that additional acoustic-tagging studies on the San Joaquin River and in the south Delta hold promise for better quantifying whether levels of exports (or OMR flows) play a role in affecting the percentage of salmonids that leave their normal migratory route or are delayed in their migration through the Delta.

Proposal III **– Shasta Reservoir February Forecast using a 90% Exceedance Forecast** (NMFS RPA Action I.2.3, Biological Opinion p. 597)

Issue: *Reclamation’s 90% exceedance forecast, as required in the RPA, is conservative for the benefit of fish, but is frustrating to agriculture as they* *cannot accurately plan and project their crops and water allocation. For example, Reclamation's initial water allocation for water year 2010 was 5%, and they eventually increased it to 40%.*

***NMFS Proposal III for Adjusting Shasta Reservoir February Forecast**:*

- *Improve 90% exceedance forecast.*
- *NOAA's National Weather Service (NWS), through its Climate Prediction Center (CPC), has a new tool that can predict climate over the next 90 days.*
- *Reclamation should initiate an effort to hindcast its 90% exceedance forecasts in previous years, and compare them to the NWS's 90-day climate prediction.*
- *During a 5-year trial period, have Reclamation continue to conduct February forecasts using the 90% exceedance forecast, and also use the NWS' 90-day climate prediction, for informational purposes only to see how the NWS' 90-day forecast tracks. If the NWS' 90-day forecast is fairly accurate, consider the adaptive management change to forecasts using that tool as the best available science.*
- *NMFS will work with NWS to issue a 90-day climate/weather prediction.*

Panel response to proposal III: The panel agrees that more accurate long-range forecasts would be beneficial to all project stakeholders and encourages monitoring of developments in climate prediction and rigorous testing of models. The National Weather Service Climate Prediction Center's long-lead forecast tool appears especially promising for air temperatures, but we note that precipitation is predicted with "marginal skill" except in cases of strong El Niño or La Niña conditions (http://www.cpc.noaa.gov/products/predictions/90day/tools.html; accessed 11/27/10). In addition to working with the National Weather Service to improve exceedance forecasting, it seems reasonable to take advantage of existing collaborations between NMFS, NASA and academic climate scientists (discussed by Eric Danner during this workshop in terms of short-time step stream temperature modeling) to develop larger/longer scale forecasts based on advanced coupled ocean-atmosphere global circulation models.

Proposal IV – Stanislaus Operations

***Issue**: Implementation of the spring pulse flow on the Stanislaus River resulted in an inverted pulse at Vernalis.*

NMFS Proposal IV for Adjusting Stanislaus Operations

- *The Stanislaus Operations Group (SOG), the San Joaquin River Group, and NMFS need to communicate to determine the flexibility within the RPA and to maximize the multipurpose use of water.*

• *Add text to RPA Action III.1.1 (Opinion page 620) that provides SOG with the flexibility needed to make minor refinements, as necessary, in conjunction with VAMP flows.*

Panel response to proposal IV: The panel encourages additional cooperation to improve flexibility and maximize multipurpose water use within the San Joaquin River watershed. The Stanislaus Operations Group as defined in RPA action III.1.1 was formed to explore “real-time operational flexibility” and already makes minor refinements in prescribed actions (e.g. altering the timing of the January pulse to coincide with precipitation).

Proposal V **– Immediate and Near-Term Significant Improvements to Increase Survival or Reduce Predation of Listed Species**

Issue: The most direct benefit to listed species is to increase their survival, or reduce their predation, as they migrate through the Delta.

NMFS Proposal V for Adjusting Actions Related to Increasing Survival or Reducing Predation of Listed Species in the Delta:

1. *Consider opportunities for a more successful barrier at the Head of Old River. This proposal is consistent with the engineering solutions prescribed in RPA Action IV.1.3 (Opinion page 640).*
2. *Consider opportunities to significantly reduce predation rates at the pumping facilities themselves, immediately, or in the near term. For example, screening predators from entering the CCF to assist in the implementation of RPA Action IV.4.2(2) (Opinion page 656).*
3. *Accelerate the timing for implementation of RPA Actions IV.4.1-IV.4.3.*

Panel response to proposal V: The Panel strongly encourages development of barriers that divert fish from low-quality (sink) habitats created as an unintended consequence of water operations. However, the Panel has insufficient information on the opportunities noted in Proposal V.1 for improving the success of engineering solutions in RPA Action IV.1.3. The “consideration of opportunities” is a vague proposed action and assessing the effectiveness of such an action would be a subjective exercise. It is difficult to determine how the proposed adjustment differs substantively from the portion of the original Action IV.1.3 that was intended to reduce entrainment risk for Central Valley steelhead migrating through the Delta from the San Joaquin River. The Panel sees major challenges in developing effective diversion barriers that require careful consideration of ecological and behavioral factors as well as engineering factors. As outlined in Table 3 note L, the Panel believes that insufficient attention is currently given to these behavioral issues and encourages expanding the team to include the needed expertise. For example, the U.S Army Corps of Engineers has demonstrated expertise in applying cognitive ecology principles to fish diversion (e.g. Goodwin et al. 2006).

Proposed adjustment V.2 shares with V.1 a similar vague objective to "consider opportunities" for reducing predation at the pumping facilities. Without knowing the details of the opportunities, the Panel finds it difficult to encourage this adjustment to Action IV.4.2 (2). Also, any attempt to screen predators from entering Clifton Court Forebay would likely be costly and may bear a low likelihood of success. The Panel considers preventing listed species from entering Old River and the south Delta in the first place a potentially more productive course of action that minimizes not only predation but other negative effects of pumping (e.g., disruption of migratory patterns and mortality/morbidity associated with physical contact with screens etc.) Reducing the currently reliable prey stream for predators created by the pumping facilities, would ultimately reduce predator abundance near the facilities.

The Panel is concerned that the adjusted alternative proposed in V.3, which accelerates the timing for implementation of Action IV. 4.2(2a), may be unrealistic, in which case it would be neither reasonable nor prudent as a short-term goal. At the least, the Panel suggests consultation with DWR prior to revising the schedule for this action.

RECOMMENDATION FOR FORMAT OF REPORTS PRESENTED TO FUTURE REVIEW PANELS

The panel noticed a great deal of variability in the quantity and format of data and interpretations thereof, both in the presentations at the OCAP annual review workshop and in the written reports provided by the technical working groups prior to the workshop. Panelists were provided >400 pages of technical reports as primary review documents less than two weeks before the workshop, as well as several hundred pages of background reading. A standardized report format, clearer identification of the indicators to be considered in assessing the effectiveness of RPA actions, and better integration of abiotic and biotic data would be extremely helpful for future review panels. Clarity and inclusive data presentation are paramount, as independent review panelists should not be expected to have insider knowledge of the myriad agency monitoring programs and their results.

For the written technical reports, the general format of the Stanislaus Operations Group and Delta Operations for Salmonids and Sturgeon Group reports (i.e. list of acronyms, detailed table of contents, explicit listings of successes, issues, and clarifications) could serve as a template for all future technical reports. This panel would like to see, however, the addition of a chapter elucidating the impacts or potential impacts of operations on the species. For example, to what extent do areas influenced by salmonid spawning season temperature controls overlap with suitable gravels and/or actual use by salmonids during the water year? From discussions at the end of the workshop, it became apparent that in some cases at least those data exist, but were not always clearly presented. Summary graphs are very helpful (more so than long tables), but working groups should take care to make sure that all graph axes are labeled, which was not always the case in reports for this year.

In oral workshop presentations, it would be useful to the panel for presenters to avoid a chronological narrative of the year's activities, which in most cases was provided in the written technical report, and instead focus on a succinct analysis of metrics of success and issues that arose for each applicable action. Again, integration of abiotic targets (e.g. temperature at a specific control point, pulse flows at a particular time) with biologically pertinent information would facilitate judgment on whether a given RPA action is meeting its objective with respect to avoiding jeopardy to a listed ESU or DPS.

REFERENCES

Anderson, J.J. 1988. Diverting migrating fish past turbines. The Northwest Environmental Journal 4:109-128.

Anderson, J.J. 1991. Fish Bypass System Mathematical Models. WATERPOWER 91, Proceedings of the International Conference on Hydropower. Denver, Colorado. July 24-26, 1991.

Goodwin, R. A., J. M. Nestler, J. J. Anderson, L. J. Weber, and D. P. Loucks, (2006) Forecasting 3-D fish movement behavior using a Eulerian–Lagrangian–agent method (ELAM), Ecological Modelling. 192:197-223.

Goodwin, R. A., J. M. Nestler, J. J. Anderson, L. J. Weber (2007) A New Tool to Forecast Fish Movement and Passage. Hydro Review 27(4):58-71.

Hankin, D., Dauble, D., Pizzimenti, J.J., and Smith, P.E., 2010, The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel, Delta Science Program, May 13, 2010, 45 p., (Accessed December 7, 2010 at URL http://www.deltacouncil.ca.gov/delta_science_program/pdf/review_vamp_panel_report_final_051110.pdf)

Hills, E., 1988, New flow equations for Clifton Court Gates: Technical Memorandum, California Department of Water Resources, State Water Project Division of Operations and Maintenance, May 9, 1988, Sacramento, CA.

Hutton, P., 2008, A model to estimate combined Old & Middle River flows: Report for the Metropolitan Water District of Southern California, April 2008, 90 p.

Kemp, P. S., M. H. Gessel, B. P. Sandford, and J. G. Williams. 2006. The behaviour of Pacific salmonid smolts during passage over two experimental weirs under light and dark conditions. River Research and Applications 22(4):429-440.

Kozlowski, J. 1993. Measuring fitness in life history studies. Trends in Ecology and Evolution 7:155-174.

Llaban, A., 2010, 2009/2010 Salmonids and Green Sturgeon incidental take and monitoring program annual data report: Department of Water Resources (Draft report provided to the OCAP Review Panel), October 2010, 31 p. (Accessed December 5, 2010 at URL http://www.deltacouncil.ca.gov/delta_science_program/pdf/workshops/OCAP_2010/tech_teams/DOSS%20Annual%20report%20of%20activities_October%202010.pdf)

Le, K., 2004, Calculating Clifton Court Forebay inflow, *in* Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, Twenty-fifth annual progress report: California Department of Water Resources, Chapter 12, 13 p. (Accessed December 4, 2010 at URL http://modeling.water.ca.gov/delta/reports/annrpt/2004/2004Ch12.pdf

Nestler, J. M., Goodwin, R. A., Smith, D. L., Anderson, J. J., and S. Li (2008). Optimum Fish Passage and Guidance Designs are Based in the Hydrogeomorphology of Natural Rivers. River Research and Applications 24: 148–168.

Newman, K.B., 2008, An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies, Report for Delta Science Program Project # Sci-06-G06-299, 135 p.

U.S. Bureau of Reclamation. 2008. Increasing juvenile fish capture efficiency at the Tracy Fish Collection Facility: an analysis of increased bypass ratios during low primary velocities. Tracy Fish Collection Facility Studies, California. Volume 35. Mid Pacific Region and Denver Technical Service Center. August 2008. vi + 30 pages

Vogel, D., 2010, Evaluation of acoustic-tagged juvenile Chinook salmon movements in the Sacramento-San Joaquin Delta during the 2009 Vernalis Adaptive Management Program. February 2010 Draft. Natural Resource Scientists, Inc. Red Bluff, CA.

FIGURES

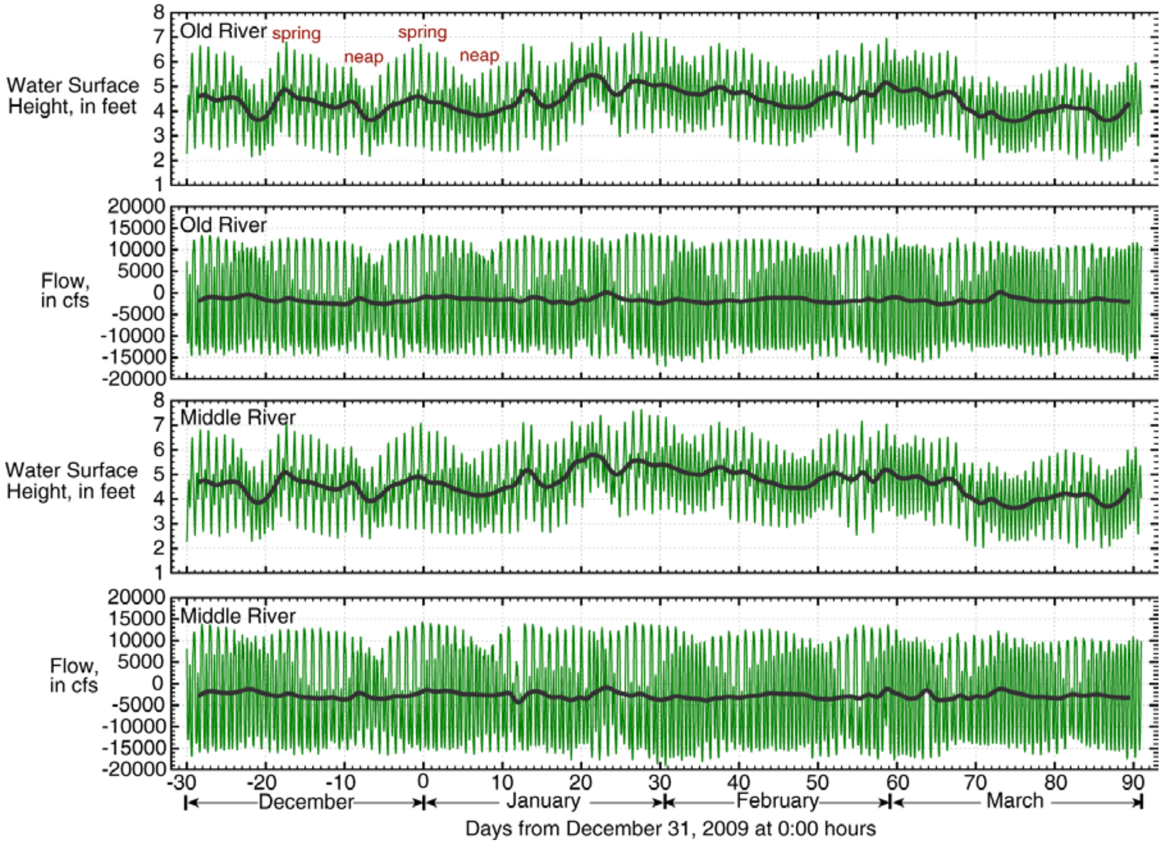

Figure 1 -- Graphs showing measured time series of 15-minute tidal water surface heights and flows (in green) from the USGS gaging stations on Old River and Middle River adjacent to Bacon Island. The data were downloaded from the California Data Exchange Center (CDEC). By convention, ebb (outgoing) flows are assigned positive values and flood (incoming) flows are assigned negative values. The time period plotted is winter (Dec - Mar) of water year 2010. Tidally averaged water surface heights and flows calculated using the standard USGS tidal (Godin) filter are shown by the thick black curves. The tides of maximum range are called spring tides and the tides of minimum range are called neap tides. The spring-neap cycle repeats itself once every 14 days, but varies in magnitude through the year. The greatest spring tides occur during late-December and late-June of each year.

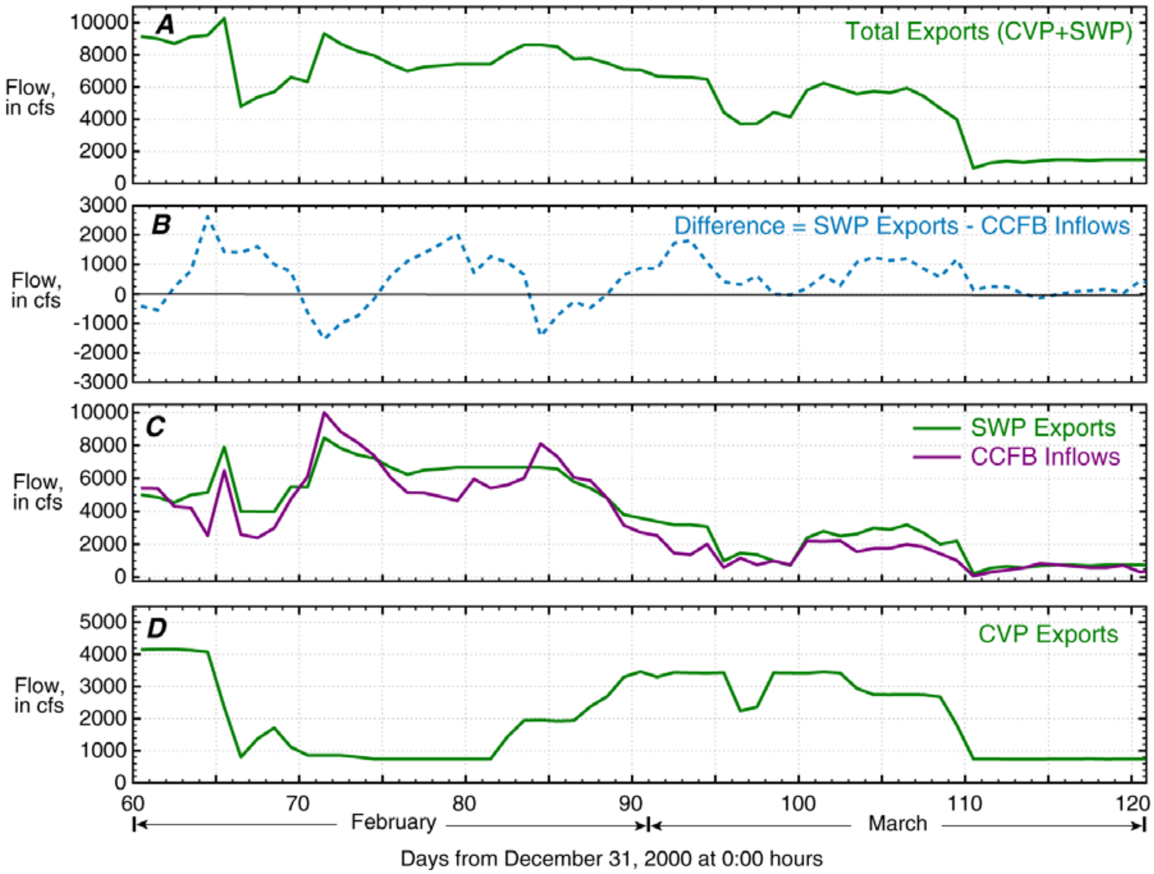

Figure 2 -- Graphs showing time series of daily values during Feb-Mar of 2001 for ***A*)** total exports (CVP+SWP), ***B*)** the difference in SWP exports from the Clifton Court Forebay (CCFB) and inflows to the forebay, ***C*)** SWP exports from the CCFB and inflows to the forebay, and ***D*)** CVP exports. Export data were taken from DAYFLOW. The CCFB inflows were calculated by Kate Le (DWR) using a DWR spreadsheet based on the Hills (1988) equations.

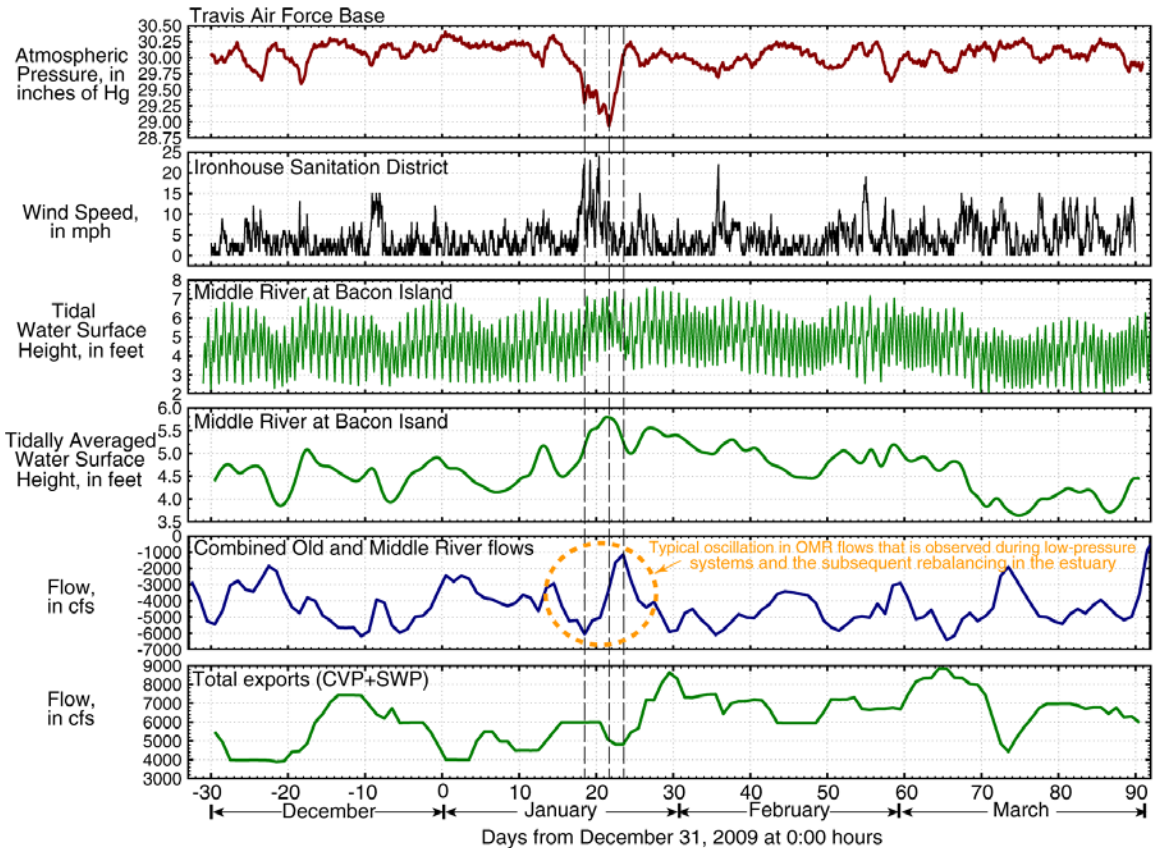

Figure 3 -- Graphs showing effects from a low-pressure system during January of 2010 on water surface heights in Middle River and on combined flows in Old and Middle Rivers. The exports data were taken from the table provided to the panel in the draft DOSS Technical Team Report (dated October 2010). The daily data for combined Old and Middle River flows came from the USGS National Water Information System (NWIS) data base. (The data for Old River and Middle River were retrieved individually and then added together.) All other data came from CDEC.

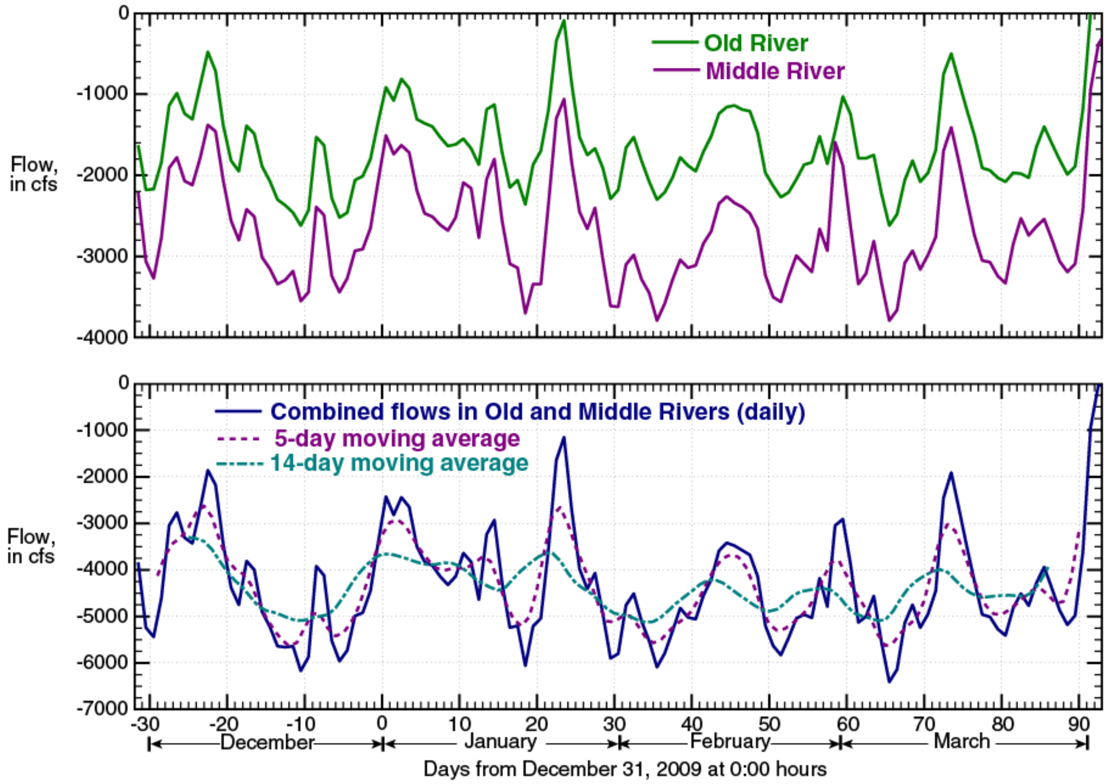

Figure 4 -- Graphs showing time series of the measured daily flows during the winter (Dec-Mar) of water year 2010 in Old River and Middle River (top) and the combined flows in Old and Middle Rivers (bottom). The combined flows in Old and Middle Rivers are plotted as daily values, 5-day moving averages, and 14-day moving averages. The data are from the Old River and Middle River gaging stations operated by USGS adjacent to Bacon Island. The data were taken from the USGS NWIS data base. The 5-day and 14-day moving averages were computed by the panel.

APPENDIX 1

Review Materials Available to the 2010 OCAP Independent Review Panel

I. The following documents were provided in electronic format as required reading by the panel prior to the 2-day workshop in Sacramento, CA on 8-9 November 2010:

- Clear Creek Technical Working Group (CCTWG) Annual Review Report
- Annual Report of Activities: Interagency Fish Passage Steering Committee
- OCAP Biological Opinion Review (DRAFT June 2009 – September 2010): Fish Actions Implemented Pursuant to the NOAA Biological Opinion on the Sacramento River
- Sacramento River Temperature Task Group
- Red Bluff Diversion Dam Technical Team 2010 Report to the Independent Review Panel
- Annual Review of American River Operations as They Relate to Implementation of the Reasonable and Prudent Alternative for the Central Valley Project and State Water Project Operations Criteria and Plan
    - ARG Attachment 1 - USFWS Draft Summary of Lower American River Fish Actions 10-7-2010
    - ARG Attachment 2-1 - Meeting Notes Jun 09-Nov 09
    - ARG Attachment 2-2 - Meeting Notes Jan 10-Sep 10
    - ARG Attachment 3 - Chapter 1 – Background
    - ARG Attachment 4 - Chapter 3 - Water Operations Summary Jun 09-Sep 10
- Annual Report of Activities (June 5, 2009 to September 30, 2010): Stanislaus Operations Group (SOG)
- Delta Operations for Salmonids and Sturgeon Group – 2010 Annual Report – October 2010
- Smelt Working Group Report to the Independent Review Panel - Water Year 2010
    - Attachment 1 - Delta Smelt Risk Assessment Matrix
    - Attachment 2 - Final Smelt Working Group Notes
    - Tools for Delta Smelt Management Workshop Summary

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

- NMFS OCAP Opinion, section 11.2.1.2, pages 583-671
- USFWS Biological Opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project (pages 279-285 and 324-381)
- RPA Summary Matrix of the NMFS and USFWS OCAP Opinion RPAs
- National Academy of Science's March 19, 2010 report
- VAMP peer review report
- State Water Board's Delta Flows Recommendations Report
- Task 3: Green Sturgeon Research

III. Additional written materials provided to the panel after the 8-9 November 2010 workshop (there was no implicit or explicit obligation on the part of the panel to consider these materials in its review):

- A CD containing a cover letter from Terry Erlewine (General Manager, State Water Contractors) to Cliff Dahm (Lead Scientist, Delta Science Program) and additional materials, including **71 documents representing declarations and determinations from legal proceedings relating to the NMFS and USFWS OCAP Biological Opinions and RPAs**. The cover letter, dated 4 November 2010, requested that the current panel charge be amended to require consideration of these additional documents. The Panel Charge was not amended.

- A **133 page pdf document** forwarded to the panel by Sam Harader (Delta Science Program) **representing post hoc comments from the state's Department of Water Resources on conceptual proposals for adjustments to NMFS OCAP RPA actions** presented to the panel at the public workshop in Sacramento on 8 November 2010.

APPENDIX 2

Verbatim questions as presented in the panel charge defining the scope of this review (from Exhibit A, Attachment 1 of the Charge to the Delta Science Program Independent Review Panel for the OCAP Integrated Annual Review):

1) (a) How effective was the implementation of each RPA Action (in some cases a Suite of Actions) in meeting its objective (NMFS' OCAP 11.2.2, pages 587-671 and USFWS' OCAP Attachment B, pages 324-381)?

   (b) How effective was the process for coordinating real-time operations with the technical teams' analyses and input as presented in the OCAP Opinions? [NMFS' OCAP Opinion (pages 582-583) and USFWS' OCAP Opinion (page 280)]?

2) (a) Were the scientific study designs, methods, and implementation procedures used appropriate for evaluating the effectiveness of the RPA Actions?

   (b) What scientific study designs, methods, and implementation procedures might be more appropriate for evaluating the effectiveness of the RPA Actions?

   (c) How could the scientific indicators used for measuring the effectiveness of the RPA Actions be improved?

3) How can each RPA Action be improved to more effectively meet the objective of the RPA Action (or in some cases a Suite of Actions)?

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IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

THE CONSOLIDATED SALMON CASES	1:09-cv-1053 OWW-DLB 1:09-cv-1090 OWW-DLB 1:09-cv-1378 OWW-DLB 1:09-cv-1520 OWW-SMS 1:09-cv-1580 OWW-DLB 1:09-cv-1625 OWW-SMS
SAN LUIS & DELTA-MENDOTA WATER AUTHORITY; WESTLANDS WATER DISTRICT v. GARY F. LOCKE, as Secretary of the United States Department of Commerce; et al.	
STOCKTON EAST WATER DISTRICT, et al. v. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, et al.	**DECLARATION OF BRADLEY CAVALLO IN SUPPORT OF PLAINTIFF-INTERVENOR CALIFORNIA DEPARTMENT OF WATER RESOURCES MOTION FOR SUMMARY JUDGMENT**
STATE WATER CONTRACTORS v. GARY F. LOCKE, Secretary, etc., et al.	Date: November 18-19, 2010 Time: 9:00 a.m. Dept: 3 Judge: The Honorable Oliver W. Wanger
KERN COUNTY WATER AGENCY, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.	
OAKDALE IRRIGATION DISTRICT, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.	
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA v. NATIONAL MARINE FISHERIES SERVICE, et al.	

I, Bradley Cavallo, declare as follows:

1. I have 12 years of experience working with anadromous fishery issues in Central California. I am currently a Senior Scientist and President of Cramer Fish Sciences in Auburn, California, where I have worked since 2006. Prior to this position, I was employed from 2003 until 2006 as a Senior Environmental Scientist and from 1999 to 2003 as an Environmental Scientist at the California Department of Water Resources in Sacramento, California. Prior to these positions, I was employed as a Fisheries Biologist at the California Department of Fish and Game in Stockton, California. In 1997, I earned a Master of Science degree in Aquatic Ecology from the University of Montana at Missoula. In 1994, I earned a Bachelor of Science in Wildlife and Fisheries Biology from University of California at Davis. I have authored numerous fishery reports, published papers and made many scientific presentations in the field of fisheries science. In the course of my professional career and education, I have attained expert knowledge of regulated rivers and estuaries, particularly related to the ecology of Chinook salmon and other anadromous fishes.

I. ACTION IV.2.1

2. The ostensible purpose of reasonable and prudent alternative (RPA) Action IV.2.1 is to provide flows in the lower San Joaquin River (SJR) to benefit survival of emigrating Central Valley steelhead (*Oncorhynchus mykiss*) originating from the SJR. In addition to its focus on SJR-origin steelhead, NMFS also indicated Action IV.2.1 would enhance the survival of Sacramento River salmonids. (BiOp 644-645, AR 00106724-00106725.)

3. The apparent importance of SJR flows to survival of juvenile salmonid emigrants of the San Joaquin Basin is very well supported by available science and is undisputed. However, my review of Action IV.2.1 finds the action is flawed in two key respects. First, NMFS rationale for the action misrepresents several studies, and incorrectly conflates river flow and export effects on juvenile salmonid survival. Second, while Action IV.2.1 purports to manage both flows and exports for the benefit of juvenile salmonids, in fact it only restricts exports. There is no evidence available to suggest that the Action IV.2.1 will result in increased SJR flows. Thus, the poor design and faulty scientific underpinnings of the action will largely ineffective in achieving the

stated objective of increased SJR flows, and ultimately also ineffective in improving the survival juvenile salmonids originating from the SJR.

A. Flows, Not Exports, Significantly Correlated with Salmon Survival

1. Introduction

4. The effect of exports and SJR flows on the survival of juvenile salmonids has been the subject of intense study and more than 25 years of focused experiments (VAMP and pre-VAMP studies). I am aware of no single fishery issue in the Central Valley which has been the subject of a longer or more intensive experimental investigation.

5. Without exception, quantitative analyses from mark-recapture experiments and correlative analysis of spawning escapements have found no evidence for statistically or biologically significant adverse effects on the survival of juvenile salmonids related to south Delta exports rates. (Baker and Morhardt (2001), AR 00108384; DFG (2005), AR 00212410; SJRGA (2007), AR 00134496; Mesick et al. (2007), AR 00125497; Newman (2008) (VAMP), AR 00127144.) In contrast, these same studies, as well as others which did not quantitatively evaluate export effects (e.g., Kjelson et al. (1982), Kjelson and Brandes (1989)), have consistently found evidence for a positive effect of SJR flows on survival of juvenile salmonids.

2. No Evidence for Adverse Export Effects

6. In the BiOp, NMFS attributes the lack of evidence for adverse export effects for SJR salmonids to inadequate sample size (BiOp 371), environmental noise (Appendix 5, page 9, paragraph 3, line 14), and incomplete execution of the VAMP experimental design (BiOp 425; Appendix 5, p. 8, AR 00105948). However, the rationale for Action IV.2.1 does not consider, as a reasonable biologist would, that adverse export effects for SJR salmonids have not been observed <u>because adverse effects do not exist or are simply too small</u> to substantially effect the population.

7. In contrast, the absence of significant adverse effects from exports would be and has been the reasonable conclusion for other biologists who have examined this issue. For example, Mesick et al. (2007) analyzed Tuolumne River fall-run Chinook data and found exports to have little or no explanatory value while SJR flows alone explained 92% of variation in adult salmon

abundance. (AR 00125508.) This result is consistent with virtually every statistical analysis that has assessed the relationship of project export levels and SJR salmonid survival.

8. A review of the statistical analyses contained in the administrative record for the Salmon BiOp discloses that none of the studies could demonstrate a negative statistical relationship between SJR salmonid survival and project export levels, alone. Either no relationship could be established or a positive relationship was shown:

a. Kjelson, Loudermilk, Hood, and Brandes, "The Influence of San Joaquin River Inflow, Central Valley and State Water Project Exports and Migration Route on Fall-Run Chinook Smolt Survival in the Southern Delta During the Spring of 1989" (AR 00122343)

> Survival of tagged smolts released under low export conditions was not greater than for those released under high export conditions (Table 4). This was an unexpected result as we believed conditions for survival should have improved when exports were lowered, since direct losses at the Project facilities were decreased, flow in the mainstem San Joaquin was increased and reverse flows in the Delta were eliminated.

(AR 00122358-00122359.)

b. Brandes and McLain, "Juvenile Chinook Salmon Abundance, Distribution, and Survival in the San Sacramento-San Joaquin Estuary," Fish Bulletin 179, Vol. 2 (2001) (AR 00109555.)

> To determine if exports influenced the survival of smolts in the San Joaquin Delta, experiments were conducted in 1989, 1990 and 1991 at medium/high and low export levels. Results were mixed showing in 1989 and 1990 that survival estimates between Dos Reis and Jersey point were higher with higher exports whereas in 1991 between Stockton and the mouth of the Mokelumne River (Tables 11 and 12) survival was shown to be lower (0.008 compared to 0.15) when exports were higher...In addition, results in 1989 and 1990 also showed that survival indices of the upper Old River groups relative to the Jersey point groups were also higher during the higher export period, but overall still about half that of the survival of smolts released at Dos Reis (Table 11).

(AR 00109602 - 00109604.)

c. San Joaquin River Group Authority, "2005 Annual Technical Report" (AR 00134226.)

> Regression of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, but both relationships indicated survival increased as exports increased.

(AR 00134289 - 00134290.)

d. California Department of Fish and Game, "Final Draft 11-28-05 San Joaquin River Fall-run Chinook Salmon Population Model" (AR 00212310.)

> There is no correlation between exports and adult salmon escapement in the Tuolumne River two and one-half years later (Figure 24).

(AR 00212424, 00212477.)

e. Mesick, McLain, Marston and Heyne, "Draft Limiting Factor Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River" (February 27, 2007) (AR 00125497.)

> [P]reliminary correlation analyses suggest that the combined State and Federal export rates during the smolt outmigration period (April 1 to June 15) have relatively little effect on the production of adult recruits in the Tuolumne River compared to the effect of winter and spring flows. Furthermore, reducing export rates from an average of 264% of Vernalis flows between 1980 and 1995 to an average of 43% of Vernalis flows and installing the head of Old River Barrier between 1996 and 2002 during the mid-April to mid-May VAMP period did not result in an increase in Tuolumne River adult recruitment (Figures 3 and 17).

(AR 00125522.)

f. Ken B. Newman, "An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies" (March 31, 2008) (AR 00127144.)

> The Bayesian hierarchical model analyzed the multiple release and recovery data, including Antioch, Chipps Island, and ocean recoveries, simultaneously....There was little evidence for any association between exports and survival, and what evidence there was pointed towards a somewhat surprising positive association with exports.

(AR 00127219 - 00127220.)

9. Brandes and McLain, in a published 2001 paper, summarized the results of the export/salmon survival research by observing that "[t]here is no empirical correlation at all between survival in Lower San Joaquin River and the rate of CVP-SWP export." (AR 00108400.) Based upon their review, Brandes and McLain conclude that "no relationship between export rate and smolt mortality, suitable for setting day-to-day operating levels, has been found." (AR 00108402.)

3. Evidence for Significant Correlation Between River Flows and Salmon Survival

10. Appendix 5 of the BiOp cites and describes a number of studies to support the formulation of Action IV.2.1. However, a careful review shows that most of these studies support

only the importance of SJR flows, but not for the export restrictions which are the substance of Action IV.2.1 .

11. For example, Appendix 5 of the BiOp presents Figures 8 and 9 (Exhibit 1, attached to this declaration) to illustrate the positive effect of SJR flows on salmon smolt survival. (AR 00107165.) Figures 10 and 11 (Exhibit 2) are then presented to illustrate the positive relationship between the ratio of SJR flows to exports. (AR 00107167.) However, the inclusion of exports in the relationship between salmon survival and SJR flows is strongly contradicted by evidence (as described in section I.A.2 above).

12. Indeed, inspection of the degree of scatter in the figures of Exhibit 2 relative to the degree of scatter in the figures of Exhibit 1 suggests SJR inflow to export ratio provides a poorer fit to observed data than does SJR inflow alone. For example, the model describing smolt survival in relation to SJR flows alone (Exhibit 1, bottom) has an r^2 value of 0.73 while the comparable model with the ratio of SJR flows to exports has an r^2 value of only 0.26 (Exhibit 2, bottom).

13. An r^2 value closer to 1 signifies that salmon survival is better explained by SJR flows (r^2 =0.73) than by the ratio of SJR flows to exports (r^2 = 0.26).

14. Thus, the model with SJR flows alone explains a larger proportion of the observed variation in smolt survival than does a model with both SJR flows and exports. This finding is consistent with statistical analyses reported by Newman (2008, VAMP) and summarized in Section I.A.2 (above) showing that SJR flows, not exports, are significant drivers of juvenile salmonid survival.

15. To further illustrate the importance of SJR flows over exports, DFG (2005) provides statistical analysis and figures depicting how export volume alone (without SJR flows) relates to survival of salmon smolts. Though DFG (2005) was cited in the BiOp, figures from DFG (2005) which conflict with the rationale for restricted exports in Action IV.2.1 are conspicuously absent in Appendix 5 or elsewhere in the BiOp.

16. Exhibit 3 to this declaration contrasts Figure 21 from DFG (2005) (AR 00212476) with its analog, Figure 9 from Appendix 5 of the BiOp (AR 00107165). The top figure in Exhibit

3 (again, Figure 9 from Appendix 5 of the BiOp) (AR 00107165), shows a positive relationship between smolt survival and SJR inflows. The bottom figure in Exhibit 3 comes from DFG (2005) (AR 00212476) and shows smolt survival in relation to exports.

17. The top figure in Exhibit 3 shows a positive relationship between SJR flow and survival, while the bottom figure shows, not an adverse relationship, but a positive relationship between exports and salmon smolt survival; indicating that, if anything, increased exports are associated with increased survival of salmon smolts.

18. This pattern is also apparent for adult salmon abundance. Exhibit 4, attached to this declaration, contrasts Figure 24 from DFG (2005) (AR 00212477) with its analog, Figure 8 from Appendix 5 of the BiOp (AR 00107165). The top figure in Exhibit 4 (again, Figure 8 from Appendix 5 of the BiOp) shows a positive relationship between SJR flows and adult salmon escapement 2.5 years earlier. In contrast, the bottom figure in Exhibit 4 (from DFG 2005) shows that there is no relationship between Tuolumne River adult salmon escapement and export volumes 2.5 years earlier.

B. Sacramento River Studies are Improperly Used to Support San Joaquin River RPA Action

19. Another significant error in the development and rationale for Action IV.2.1 is the use of Sacramento River basin salmon survival studies to support SJR basin flow and export standards. The most common example is the repeated reference to Newman (2008) as providing support for the significance of export effects on juvenile salmonids.

20. It is extremely important to note that the Newman (2008) includes analysis of two entirely separate studies. One, the Delta Action 8 (DA8) focused specifically and exclusively on testing for export effects on juvenile salmonids originating from the Sacramento River (SR). (AR 00127219-00127220.) The other, VAMP, focused specifically and exclusively on SJR flow and export effects on SJR-origin juvenile salmonids. (AR 00127220-00127221.)

21. It is incorrect and inappropriate to reference DA8 results or other SR basin salmon survival studies as rationale for Action IV.2.1 because the objective of the action is specifically focused on SJR origin salmonids. However, despite the geographic disconnect between the

Sacramento River basin and San Joaquin River, flow-export requirements specified in Action IV.2.1 incorrectly cite Newman (2008) as supporting Action IV.2.1:

> Delta Action 8 studies found a statistically significant negative association between survival of fish moving through the Delta interior and export volumes. There was a 98 percent probability that as exports increased, relative survival (interior Delta compared to Sacramento River release) decreased. There is a positive relationship between the level of exports and the amount of fish released in Georgiana Slough that are eventually salvaged.

(Appendix 5, page 9, AR 00107155.)

22. Not only is the DA8 component of Newman (2008) irrelevant to Action IV.2.1, but the BiOp seriously misrepresents the findings of Dr. Newman. Newman did not use the word "significant" in his description of results of the DA8 study because Dr. Newman did not test the explanatory power of effects other than exports, and even so found that the "DIC value [a measure of model fit] for a model without exports was not much higher than the corresponding model with exports." (Newman (2008), page 59, AR 00127203.)

23. Further emphasizing the non-significance of export effects from the DA8 study, in a follow up to the DA8 analysis of Newman (2008), Newman and Brandes (2009) concluded that "the relationship between exports and the relative survival of Georgiana Slough releases seems relatively weak." Based upon their review of the DA 8 data, Newman and Brandes stated, "what we cannot conclude is that exports are the cause of this lower relative survival." (AR 00127347.)

24. As described previously, the VAMP portion of Newman (2008) which bears directly on the rationale and effectiveness of Action IV.2.1 does not provide any support for adverse effect of exports on SJR salmonids.

25. In addition to citing the Newman (2008) DA8 analysis to support SJR Action IV.2.1, the BiOp also cites Newman and Rice (2002) (AR 00127363) and Newman (2003) (AR 00127122). . Like the DA8 component of Newman (2008), these studies focus specifically on Sacramento River fall run Chinook and are thus not applicable to SJR focused Action IV.2.1

C. RPA Prescriptions Arbitrary, Unlikely to Increase San Joaquin River Flows

26. As described in above sections I.A. and I.B., there is no reasonable biological justification for Action IV.2.1 to specify a ratio of SJR inflow to exports rather than specifying

SJR flows alone. Action IV.2.1 calls for exports between April 1st through May 31st to be constrained by an inflow to export ratio, where exports could exceed 1,500 cfs (cubic feet per second) only when SJR flows exceed 6,000 cfs. Yet, as SJR flows rise above 6,000 cfs the proportion of SJR flow available for exports remains flat at 4:1. No evidence is provided to support that inflow to export ratios such as those required by Action IV.2.1 will result in increased SJR flows.

27. Given the absence of adverse export effects, an RPA seeking to effectively increase SJR flows to benefit juvenile salmonids might instead allow proportionally <u>greater</u> volume of exports as SJR flows increase.

II. ACTION IV.2.3

28. Action IV.2.3 specifies a number of actions intended to reduce adverse export effects on Sacramento River (SR) and SJR origin salmonids. NMFS relied on three sources to support their development of specific Old and Middle River (OMR) flow restrictions of Action IV.2.3: 1) particle tracking model (PTM) simulations, 2) relationships between OMR flows and fish salvage, and 3) studies evaluating export effects on Delta salmonids. I conducted a thorough review of the substance and rationale for Action IV.2.3 and found that NMFS failed to properly utilize best available science in each of these three areas.

A. Particle Tracking Model Improperly Applied for Juvenile Salmonids

1. Introduction

29. The applicability of PTM results to juvenile salmonids was discussed at length in the preliminary injunction proceedings. Based on the presented evidence, the court concluded that the PTM, "provides a very rough approximation of salmonid behavior" (Findings of Fact, Document 347, p.119), but acknowledged NMFS use of PTM was "highly disputed" (Findings of Fact, Document 347, p.123).

30. Information already in the record, but not discussed in the preliminary injunction proceedings, shows that NMFS use of the PTM was unreasonable and conflicted directly with the best available science. Furthermore, in response to criticism of its PTM use, NMFS offered

apparently new rationalizations and gave the misleading impression that the original analysis had covered ground that it had not.

2. Limitations of the PTM

31. PTM is a tool designed to estimate the fate of neutrally buoyant particles over relatively long time periods; typically for time horizons ranging from 30 to 90 days. Regarding the accuracy of PTM for evaluating export and river inflow effects, Kimmerer and Nobriga (2008) indicated the model was reliable if, "allowed to run long enough to resolve particles' ultimate fate." (AR 00122246.)

32. Given this characteristic of the PTM, Kimmerer and Nobriga (2008) focused on the ultimate fate of the particles and not on the short term movement of particles over hours or days. Kimmerer and Nobriga (2008) further indicate that "model accuracy varies depending on the length of the simulation." (AR 00122250.) I have reviewed the PTM memorandum, dated June 3, 2009, and that memorandum does not indicate that NMFS has considered the length of simulation and its affect on the reliability of PTM results.

33. Calibration is a term used to described a rigorous process by which all relevant model functions are tested against field observations, and modified (if necessary) to make model predictions consistent with field observations. Kimmerer and Nobriga (2008) notes that the PTM has "not been calibrated," and that the lack of calibration may be especially problematic for how particle behavior has been modeled at Delta junctions. (AR00122262). This very cautious description of the PTM's reliability and poor calibration status, directly contradicts NMFS characterization from the BiOp which stated, "The model [PTM] has been calibrated with data from monitoring stations throughout the Delta." (AR 00106021.)

34. Further highlighting the contradiction, Kimmerer and Nobriga (2008) states, "The comparisons with field data described above <u>do not constitute a sufficient calibration</u> of PTM… Furthermore, the basic formulation of the PTM has <u>not been subject to peer review</u>." (AR 00122250, emphasis added.)

35. Thus, NMFS did not accurately describe or consider the limitations of the PTM in using it to shape Action IV.2.3.

3. Improper Length of Simulations

36. According to the BiOp (AR 00106022), NMFS' principal objective in applying the PTM was to gain insights on the behavior and fate of particles at five junctions on the mainstem San Joaquin River in response to exports and river flows.

37. Given the rapid and directed movements of salmonid smolts, it is both inappropriate and inaccurate to use the fate of particles integrated over weeks or months to even roughly assess salmonid smolt effects.

38. Recent telemetry studies show that salmon smolts spend minutes or hours at channel junctions (Burau et al. 2007, AR 00109732) and only days migrating through longer Delta reaches (Vogel 2004, AR 00217955). Thus, relatively short time periods should be examined if PTM or other flow simulations methods are to be used to assess salmon movement in response to possible tidal, river flow, and export effects.

39. However, since PTM does not yield reliable results over periods this short (as discussed above). It is likely inappropriate to use PTM to assess possible tidal, river flow, and export effects on salmonids at channel junctions because the PTM does not accurately represent particle behavior at channel junctions, and does not yield reliable results on the short (i.e. 2 to 5 days) time horizon appropriate to assess juvenile salmonid behavior at those junctions.

4. Post-decision Rationalization

40. Despite the obvious importance of the time horizon issue, I could not find any evidence that NMFS was cognizant of the problem or made any meaningful effort to address it.

41. The BiOp does not provide an assessment of particles over the first five days, or any other similarly short time interval.

42. The NMFS PTM memo states, "Particle fate was modeled (tracked) starting with the day after injection, and then every 5-days for the first 31 days. A final measurement was made at 60 days post injection." (AR 00106022.) This sentence provides the only instance in the PTM memo or the BiOp where PTM results at 5-days intervals are discussed or even mentioned.

43. Though several PTM memo figures depict the fate of particles at five day increments, the only instance where the memo specifically mentions PTM results over a short time horizon

occurs in the following sentence on page 3: "the typical pattern following injection at station 912 was a period of several days with little or no entrainment." (AR 00106023.) Thus, in the one instance where a time horizon of only several days was discussed, the results indicated no net movement of particles and thus no evidence for an OMR-mediated entrainment effect.

44. Furthermore, as was discussed above, even if NMFS did conduct PTM simulations over 5-day or "several day" intervals, the results would not be accurate or meaningful in assessing juvenile salmonid behavior because the PTM itself is not reliable for short durations.

5. Alternative Methods for Evaluating Export-related Hydrodynamics Changes Experienced by Salmonids

45. The substance of Action IV.2.3 is predicated upon the hypothesis that more negative OMR flows draw an increasingly significant proportion of salmonids off of their normal migratory route and towards the south Delta export facilities. Since this effect is not supported by available record evidence, NMFS relied upon PTM to support their use of this hypothesis in developing Action IV.2.3. (NMFS PTM Memo. AR 00106021- 48.)

46. As indicated in previous sections, PTM is not an appropriate methodology for assessing negative OMR flows on juvenile salmonids. An example of an alternative method for assessing negative OMR flows on juvenile salmonids available to NMFS would be to use DSM2 HYDRO simulation results to assess how location-specific flows are affected by OMR flows.

47. DSM2 HYDRO provides the basis for particle tracking simulations, but unlike PTM, DSM2 HYDRO has been validated through extensive field testing (Kimmerer and Nobriga 2008). Regarding DSM2 HYDRO, Kimmerer and Nobriga state:

> DSM2 HYDRO was calibrated to empirical flow and stage data (May 1988, April 1997, April 1998, September–October 1998; CDWR 2001). The model's friction parameters for each of ~50 regions were adjusted until simulated values best matched observed daily average and instantaneous flow and stage data. The model calibration was validated by comparing simulated flow and stage with field data from 1990–1999. Results of this calibration and validation are available in the form of maps with selectable nodes that link to graphical displays of model results and data…

(AR 00122248- 00122250.)

48. In contrast, Kimmerer and Nobriga say of PTM:

> However, we have not evaluated the extent to which the PTM reliably records the movement of particles. The comparisons with field data described above do not

> constitute a sufficient calibration of PTM. This shortfall could be addressed indirectly through a comparison of particle releases in PTM with tracer releases in QUAL, but that is beyond our scope. Furthermore, the basic formulation of the PTM has not been subjected to peer review.

(AR 00122250.) Thus, DSM2 HYDRO provides a more reliable and calibrated measure of location-specific flow conditions in response to OMR flows and other factors.

49. By analyzing 15-minute interval flow data provided by DSM2 HYDRO, NMFS could have assessed flow changes along the primary salmonid migration corridor in relation to negative OMR flows, tides and river inflows to tides inflow. Specifically, NMFS could have used DSM2 HYDRO data to calculate the average change in instantaneous flow (at 15-minute intervals) with contrasting levels of negative OMR flows.

50. For example, flows at Ch. 172 (Turner Cut) could be assessed as OMR flows decreased from -1,500 cfs to -3,500 cfs. Small changes in instantaneous flows would suggest small potential impacts to salmonids, large flows would suggest large potential impact to salmonids. Though there is uncertainty regarding how instantaneous flows influence juvenile salmonid migration behavior, this uncertainty is considerably less than that associated with interpreting PTM results for juvenile salmonid migration behavior.

51. Instantaneous flow estimates provided by DSM2 HYDRO are consistent with the scale of time in which migrating salmonids are known to react to flows and select migration routes as suggested by recent acoustic tagging studies. (e.g. Burau et al. (2007), p. 34) The same is not true for PTM results integrated over one to three months.

6. Best Available Science Does Not Support Use of PTM for Salmonids

52. Kimmerer and Nobriga (2008) described PTM results, but were careful not to suggest that the fate of particles could be equated with the fate of fish with complex swimming behavior. For example, Kimmerer and Nobriga (2008) emphasized the limitations of the PTM for late larval stage delta smelt, stating:

> We are, furthermore, not inclined to define a "zone of influence" of the pumps on the basis of our results, since the probability of entrainment depends on time horizon which, in many cases, is too long to be useful for analyzing the movements of larval fish. By the end of the modeled time period, the fish would already have metamorphosed, and their behavior would have become more complex.

(AR 00122263.)

53. Given that salmonid smolts are large fish with more complex swimming behavior than delta smelt, it is implied that the time horizon is likewise too long to be useful for salmonids.

54. Others researchers have more specifically evaluated the applicability of PTM results to salmonid smolts. Baker and Morhardt (2001) (AR 00109394) were very critical of neutrally buoyant particles as an indicator of salmonid smolt behavior, for example:

> San Joaquin smolts pass through the Delta in a median time of 11 days, some arriving at Chipps Island as early as five days after release at the point where the San Joaquin River joins the Delta, and some taking as long as 26 days…This is considerably shorter than the transit time for neutrally-buoyant tracer particles.

(AR 00108394, emphasis added.) In describing the rapid migration of smolts relative to neutrally buoyant particles, they state, "This is in accordance with the striking difference between the passage time of smolts and passive particles; smolts actively swim toward the ocean." (AR 00108396, emphasis added.) Regarding whether or not salmonid smolt behavior follows the movement of water in tidally driven portions of the Delta, they state, "the most straightforward model, that the movement of smolts mirrors the movement of water, has been shown to be **incorrect**. Smolts and water travel through the Delta at very different rates and end up at very different places." (AR 00108394, emphasis added.) "If smolts simply traveled at a fixed speed relative to the water they were in, one would expect 60% or more of them to go to the pumps as well." (AR 00108398.)

55. The Department of Water Resources (DWR) also conducted analysis comparing observed CWT recoveries with predicted recovery timing and location as predicted by PTM, they conclude:

> The result of the comparison of timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island shows that there is no correlation. This is shown in the last two figures in this attachment. There are factors other than hydrodynamics affecting juvenile Chinook emigration through the south Delta not accounted for in the PTM. Based on the 24 experiments graphed in this evaluation, the PTM results are an adequate surrogate for "timing" of salmonid emigration in only very high flow years like 1995, 1998 and 2006. But for the rest of the years, intermediate and low flow years, the PTM results would result in significant project regulation 3 to 6 weeks beyond emigration timing.

(AR 00105430.)

56. Similarly, Blake and Horn (2004) state, "model results using tracers as surrogates for juvenile salmon showed the majority did not become entrained as the model would have suggested." (AR00120633.) In their application of the PTM for developing Action IV.2.3, NMFS clearly overlooked the contrary recommendations provided by these studies and provided no new data analysis to refute theses criticisms of particle tracking simulations for evaluating the fate of salmonid smolts.

7. NMFS Misrepresents Salmonid Tracking to Support PTM Use

57. The NMFS PTM memorandum provides a lengthy narrative description of juvenile salmonid swimming and migration behavior in relation to flow fields and channel junctions. For example, consider the following excerpt:

> Assuming that salmonids use flow direction and velocity to help navigate during their downstream migration, then perturbations in the normal flow fields (i.e., natural conditions) would be seen as a potential obstacles [sic] to normal migration behavior. As seen in numerous acoustic tracking studies (Horn and Blake 2004, Vogel 2004 and 2008, San Joaquin River Group Authority 2007 and 2008, Burau et al. 2007, Perry and Skalski 2008) salmonids passing a junction point in a river channel can be advected into a given channel under the influence of the flow pattern in the channel. In fact, the proportion of fish can be influenced by the velocity profile in the channel which can position fish nearer to the mouth of a channel bifurcation and place them at a higher risk of entrainment into that channel at levels higher than would have been anticipated by the actual flow split (Horn and Blake 2004, Burau et al. 2007).

(AR00106025.)

58. This paragraph appears persuasive because it includes numerous citations to many excellent studies of salmonid migration behavior. However, the actual substance of these studies in no way supports NMFS' use of PTM for evaluating flow effects on juvenile salmonids. If any conclusion is to be drawn from the studies cited in this section of the PTM memorandum, it is that salmonid smolt migration behavior is extremely sensitive to complex flow fields (in three dimensions) which change dynamically over very short periods of time (hours).

59. However, as described previously in Sections II.A.1, 2, and 3, these are precisely the types of flow complexities and fish behaviors that are NOT reliably represented by the PTM. Reiterating the key points from earlier: 1) PTM is only effective at modeling the fate of particles over longer time periods (Kimmerer and Nobriga 2008), 2) Juvenile salmonids exhibit rapid and directed movement and thus the time horizon for assessing flow effects on salmonid migration

must also be brief, 3) NMFS did not use salmonid-appropriate time horizons for their PTM analysis, 4) NMFS did not use available DSM2-hydro flow data to assess the potential for more negative OMR flows to influence route selection for migrating juvenile salmonids.

B. Fish Salvage Data Does Not Support Adverse Population Effects from More Negative OMR Flow

60. In presenting their rationale for Action IV.2.3, NMFS states bluntly that, "Salvage rates increase with increasing exports." (AR 00106026.) If salvage rate is defined as the number of individuals salvaged per unit of time, then we would indeed expect this pattern to be true. However, such a definition of salvage rate is not helpful for evaluating NMFS' key conclusion supporting Action IV.2.3:

> …that as OMR reverse flows increase, risk of entrainment in to the channels of the South Delta is increased. Conversely, the risk of entrainment into the channels of the South Delta is reduced when exports are lower and the net flow in the OMR channels is more positive—that is, in the direction of the natural flow toward the ocean.

(AR 00106031.)

70. In order to test for such an export effect based upon salvage data, it is necessary to report not just the number of fish salvaged, but the rate of salvage per volume of water exported and per number of fish potentially exposed to entrainment. Though several appropriate data sources and analyses were available, NMFS did not conduct or present them in the BiOp.

71. One example of such an analysis was provided by Hanson (2008), who calculated "salvage percentage" as the expanded number of coded wire tagged (CWT) salmon recovered at salvage facilities divided by the total number of CWTed fish released (and therefore, potentially vulnerable to entrainment). (AR 00120048-00120052.) Dr. Hanson analyzed data from 118 Sacramento River basin CWT releases representing more than 14 million juvenile salmon; releases which should be very representative for export effects experienced by salmonid smolts migrating volitionally down the Sacramento River. Though we expect there to be considerable variation in observed salvage proportion as a function of factors like river flow, release location, and fish size, Dr. Hanson also analyzed some these factors and found his method had sufficient statistical power to detect a significant effects of fish size and SR flow, while no such relationship was observed for exports (Hanson 2008).

72. If NMFS' hypothesis that more negative OMR flows entrain a greater proportion of juvenile salmonids into the central Delta were correct, we would expect "salvage proportion" for CWTed fish to increase clearly and substantially with increasing exports. However, as shown in Exhibit 5 and Exhibit 6, Dr. Hanson found no pattern of increased "salvage proportion" with increased exports. The biological opinion notes that "Hanson (2008) did not find any significant relationship between exports and survival," but discounts the Hanson analysis on the grounds that Newman 2008 allegedly "found increasing trends for fish in Georgiana Slough to be entrained with increases in exports (Delta Action 8 Studies)." (AR 00106453.) However, Newman (2008, DA8) did not provide a detailed assessment of the relationship between export volume and <u>salvage rate</u>. Rather Newman's analysis was focused on modeling <u>salmon survival</u> as a function of exports; his assessment of salvage rate was seemingly incidental and Dr. Newman did not implicate any statistical or biological significance to the observed relationship.

73. Dr. Hanson's analysis does not support NMFS hypothesis that negative OMR flows draw greater proportion of the population into the interior Delta. The Newman (2008) analysis yielded inconclusive results regarding the significance of larger exports on salvage rate. A reasonable biologist would have not have rejected the analysis provided by Hanson (2008) in favor of the cursory analysis of salvage rates and exports provided by Newman (2008). No sufficient analysis of exports and salvage rates is provided to support the specific OMR flow criteria specified in Action IV.2.3.

C. Adverse Effects from Negative OMR Flows Not Supported by Best Available Science

74. Since Action IV.2.3 is purported to substantially benefit both SJR and SR origin salmonids, it is relevant to consider studies from both river basins. As described previously in Section I.A, long-term and intensive salmon survival experiments on the SJR illustrate unequivocally that increased South Delta exports are NOT associated with adverse effects on juvenile salmonid survival, and also are NOT associated with decreased adult salmon escapement.

75. Also, as described previously, the use of the inflow to export ratio for statistical analysis or RPA development is inappropriate and misleading because SJR inflows alone provide a better and more parsimonious explanation of observed changes in juvenile salmonid survival and adult escapement. Including exports or negative OMR flows in these analyses is statically nonsensical and acts to obfuscate rather than clarify management actions which may benefit ESA listed salmonids.

76. The effect of exports on SR basin salmonids is less clear. The strongest support for an adverse export effect comes from analysis of the DA8 experiments. (Newman (2008) – DA8, AR 00127218-00127219; Newman and Brandes (2008), AR 00127347-00127349.)

77. However, the implications of DA8 results for management of negative OMR flows (exports) are unclear for two reasons. First, unlike VAMP, DA8 experiments were conducted ONLY to test for export effects, and therefore did not evaluate the statistical fit of export effects relative to factors like flow, turbidity, water temperature or Delta Cross Channel position. It was presumably for this reason that Newman and Brandes concluded that they could not determine if the observed decrease in survival was due to export or some other untested factor (AR 00127347).

78. Furthermore, Newman and Brandes concluded that the model WITHOUT exports was just as good a predictor of relative survival as the model WITH exports; "thus apparently scant evidence for a relationship between Θ [relative survival] and exports." (Newman and Brandes (2008) at 20; AR 00127346.)

79. Second, even if we accept that the negative export effect is real (i.e. not a spurious statistical relationship resulting from poor design of the DA8 study), the predicted decrease in relative survival is only 2.5% for each 1,000 cfs exported.

80. Furthermore, consistent with the findings of Perry and Skalski (2008) (AR 00132798-00132820), only a fraction of SR basin origin Chinook are expected to pass through Georgiana Slough where they might be exposed to reduced survival.

81. Collectively, these facts suggest that a reasonable biologist would not predicate OMR flow restrictions upon expected benefits to SR juvenile salmonids. It is very unlikely that that

OMR flow restrictions described in Action IV.2.3 will yield any substantial benefits to SJR or SR juvenile salmonids. In fact, to the extent that the OMR restrictions of Action IV.2.3 and SJR inflow/export ratios of Action IV.2.1 cause water managers to reduce conveyance flows through the San Joaquin and Sacramento Rivers, these actions may result in net harm to ESA listed salmonids.

III. Review and Summary

A. Misapplication of Inconclusive Studies

1. Introduction

82. NMFS mis-construes cited studies throughout the BiOp, sometimes by extrapolating beyond study conclusions, sometimes by including only phrases or conclusions that supported their premise and excluding phrases or conclusions that didn't support their premise, and sometimes by completely misapplying studies inappropriate to the discussion.

2. Misuse of Newman (2008)

83. NMFS cited Newman (2008) as concluding there was a statistically significant negative correlation between exports and salmon survival. (AR 00107155.) Newman (2008) did not use the words statistically significant to describe his findings. Rather, Newman concluded from his Bayesian method analysis there was very little difference between the model with exports and the model without exports. Newman (2008) actually wrote:

> The preferred model based on DIC is the multinomial with log transformed [theta] and uniform priors for the [variances] (Table 11), but <u>all the multinomial models yielded quite similar results.</u> The DIC for this model, 427.0, however, was <u>only slightly less than the DIC for the models without exports</u> (the "Interior" models where minimum DIC was 427.7).

(AR 00127203, emphasis added.)

84. NMFS also inappropriately cited Newman 2008, Delta Action 8 experiments to support the RPA action IV.2.1 – the San Joaquin River flow-to-exports ratio. The Delta Action 8 experiments are specific to juvenile Chinook emigrating from the Sacramento River, whereas the VAMP experiments are specific to juvenile Chinook emigrating from the San Joaquin River.

3. Extrapolation of Perry and Skalski (2008)

85. NMFS inappropriately cited Perry and Skalski (2008) in support of the adverse effect of exports on survival of juvenile Chinook emigrating from the Sacramento River. Referring to the results of Perry and Skalski (2008), NMFS wrote, "The probability of ending up at the Delta export facilities or remaining in the interior delta waterways increases with increased export pumping, particularly for those fish in the San Joaquin River system." (BiOp 383, AR 00106463.) There is no mention of exports in the Results or Discussion sections of Perry and Skalski (2008). (AR 00132815-00132824.)

4. Misstatement of Vogel (2004) Conclusions

86. NMFS misrepresented Vogel (2004) as concluding more juvenile Chinook moved towards the CVP and SWP pumps as exports increased. Referring to the results of Vogel (2004), NMFS wrote:

> Fish released in the mainstem San Joaquin River near Fourteenmile Slough in the spring of 2002 and 2003 showed distinct movement patterns based on the level of export pumping and tides. When the combined exports created negative flows in the channels feeding into the South Delta, (i.e., Turner and Columbia Cuts), a significant proportion of the released fish moved into those channels and were followed in a southerly direction towards the pumps. Conversely, when the VAMP experiment reduced export levels and increased flows in the San Joaquin River, more fish stayed in the main channel of the San Joaquin River and headed downstream with the net flow towards San Francisco Bay.

(BiOp 383, AR 00106460.)

Vogel's actual conclusion was:

> These experiments could not explain why some fish moved off the mainstem San Joaquin River into south Delta channels. Due to the wide variation in hydrologic conditions during the two central Delta studies, it was difficult to determine the principal factors affecting fish migration. Based on limited data from these studies, it may be that a combination of a neap tide, reduced exports, and increased San Joaquin River flows is beneficial for outmigrating smolts, but more research is necessary.

(Vogel (2004), p. 37, AR 00217996.)

5. Selective use of Kimmerer and Nobriga (2008)

87. NMFS misrepresented the Kimmerer and Nobriga (2008) study by selectively excluding cautionary conclusions. Kimmerer and Nobriga (2008) twice express caution with regard to using the PTM to describe fish movement:

> A consequence of this is that simple questions (e.g., what proportion of particles are entrained under a given set of conditions) have no clear answer. Instead, the answer depends on the time horizon, which in turn depends on the overall flow conditions and the site of the release. We are, furthermore, not inclined to define a "zone of influence" of the pumps on the basis of our results, since the probability of entrainment depends on time horizon which, in many cases, is too long to be useful for analyzing the movements of larval fish. By the end of the modeled time period, the fish would already have meta-morphosed, and their behavior would have become more complex.

(AR 00122263;) and:

> We do not claim that the specific results presented here represent actual movements of salmon; rather, these results indicate what factors may or may not be important in determining how salmon smolts may move through the Delta.

(AR 00122263.)

88. However, this caution is not evident in the NMFS BiOp depiction of the Kimmerer and Nobriga (2008) results. On pages 361 and 380 of the BiOp, NMFS uses the results of PTM to describe how Old and Middle River flow affects salmon movement in the Delta. On page 380 of the BiOp, NMFS quotes Kimmerer and Nobriga as follows: "'despite all these differences, the PTM results suggests that river flow may be an important variable in determining which way the salmon go and their probability of survival, and should be included in the design and analysis of future studies.' (Kimmerer and Nobriga (2008) p. 19)." (AR 00106461, emphasis added.)

B. Failure to Consider Contrary Data and Conclusions within Cited Studies

1. Introduction

89. NMFS failed to incorporate some data and conclusions within studies they cite which were contrary to their premise. When studies conflict with NMFS' conclusions, NMFS should explain and justify their decision by citing supporting literature or providing original analysis which directly justify and support their conclusion. As the examples below illustrate, the conclusions of the studies cited in the BiOp were sometimes in direct conflict with Action IV.2.1 and/or Action IV.2.3.

2. Baker and Morhardt (2001) Criticism of the PTM Ignored

90. NMFS cited Baker and Morhardt (2001) in their support for the San Joaquin River flow-to-export ratio, using the relationship between San Joaquin Flow and adult escapement. As discussed previously, NMFS inappropriately extrapolated Baker and Morhardt (2001) to support

the San Joaquin River flow-to-exports ratio when Baker and Morhardt illustrated San Joaquin River flow and adult escapement.

91. In addition, NMFS neglected to consider or even acknowledge Baker and Morhardt's criticism of the PTM in the BiOp. Baker and Morhardt write:

> Figure 7 (top) shows that Delta inflow has little if any effect on smolt travel time, probably because the large tidal flows swamp any passive effect of the incoming flows from the San Joaquin River, as suggested by the particle tracking results. On the other hand, Figure 7 (bottom) shows that the larger the smolts at the time of release, the shorter the travel time. This is in accordance with the striking difference between the passage time of smolts and passive particles: smolts actively swim toward the ocean, and the bigger they are the faster they do it.

(AR 00108396.)

92. NMFS also neglected to acknowledge Baker and Morhardt's conclusion regarding the effect of exports on survival in the south Delta in Old River. Baker and Morhardt wrote:

> Results so far on survival in Old River have been even more unsatisfactory. Taken at face value, multiple regression of survival vs. flow in Old River and CVP-SWP export leads to the conclusion that increased exports would improve smolt survival along this route (presumably an artifact of the strong contribution of export to Old River flow). As with the Lower San Joaquin River, the problem is that the degree of scatter, and lack of good controls, makes interpretation difficult.

(AR 00108400.)

3. Evidence for No Export Effect on Salmon Ignored

93. Each of the following are excerpts from studies cited in the BiOp, where conclusions of the study were not reflected nor refuted in the substance or rationale for Action IV.2.1 or Action IV.2.3

94. From the San Joaquin River Group Authority, "2005 Annual Technical Report," "Regression of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, but both relationships indicated survival increased as exports increased." (AR 00134289 - 00134290.)

95. From the California Department of Fish and Game, "Final Draft 11-28-05 San Joaquin River Fall-run Chinook Salmon Population Model," "There is no correlation between exports and adult salmon escapement in the Tuolumne River two and one-half years later (Figure 24)." (AR 00212424, 00212477.)

96. From the Mesick, McLain, Marston and Heyne, "Draft Limiting Factor Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River" (February 27, 2007):

> [P]reliminary correlation analyses suggest that the combined State and Federal export rates during the smolt outmigration period (April 1 to June 15) have relatively little effect on the production of adult recruits in the Tuolumne River compared to the effect of winter and spring flows. Furthermore, reducing export rates from an average of 264% of Vernalis flows between 1980 and 1995 to an average of 43% of Vernalis flows and installing the head of Old River Barrier between 1996 and 2002 during the mid-April to mid-May VAMP period did not result in an increase in Tuolumne River adult recruitment (Figures 3 and 17).

(AR 00125522.)

97. Also, Brandes and McLain, in a published 2001 paper, summarized the results of the export/salmon survival research by observing that "[t]here is no empirical correlation at all between survival in Lower San Joaquin River and the rate of CVP-SWP export." (AR 00108400.) Based upon their review, Brandes and McLain conclude that "no relationship between export rate and smolt mortality, suitable for setting day-to-day operating levels, has been found." (AR 00108402.)

98. Despite the absence of a demonstrated relationship between exports and salmonid survival in cited studies or by original analyses provided by NMFS, the BiOp goes on to specify date-specific restrictions on exports in Action IV.2.1 and Action IV.2.3.

I declare under penalty of perjury under the laws of the State of California and the United States that the foregoing is true and correct. Executed this 6th day of August 2010 at Auburn, California.

BRADLEY CAVALLO

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20323154.doc

EXHIBIT 1

Figure 8:

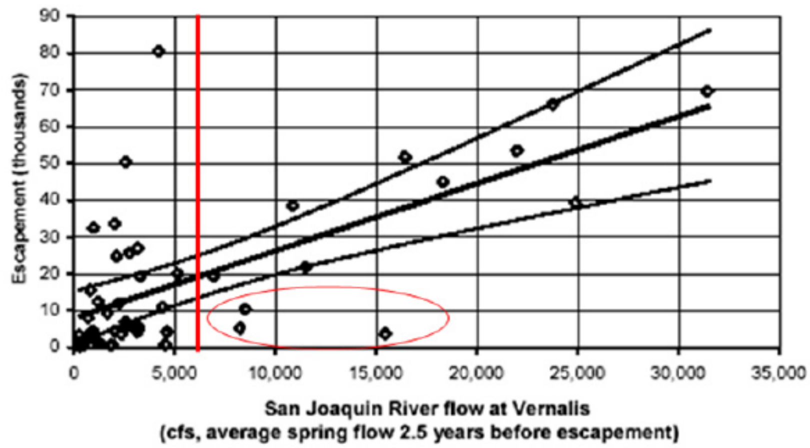


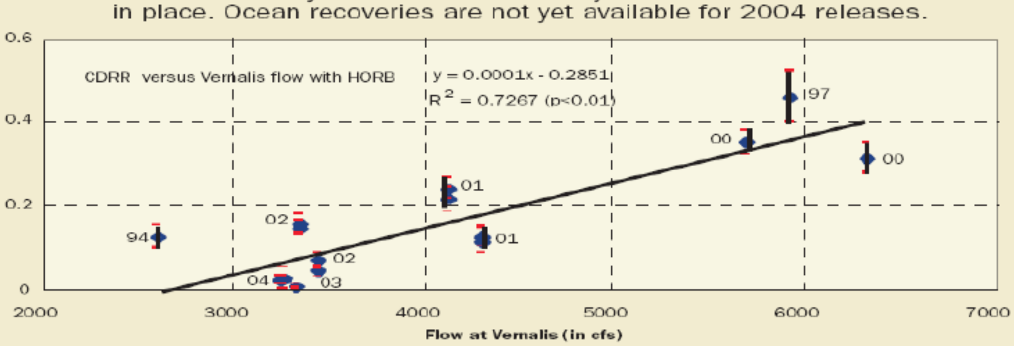
Figure 11 Total escapement to San Joaquin tributaries, 1951 through 1996, and spring flow in the San Joaquin River at Vernalis 2.5 years earlier. Fitted regression line and envelope of 95% confidence region for fitted line are shown.

Copied from Baker and Morhardt 2001.

Figure 9:

Figure 5-11

CDRR (point estimates of survival) plus and minus 2 standard errors using Chipps Island, Antioch and ocean recoveries, for groups released at Mossdale or Durham Ferry and Jersey Point in 1994, 1997, 2000-2004 and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with HORB in place. Ocean recoveries are not yet available for 2004 releases.

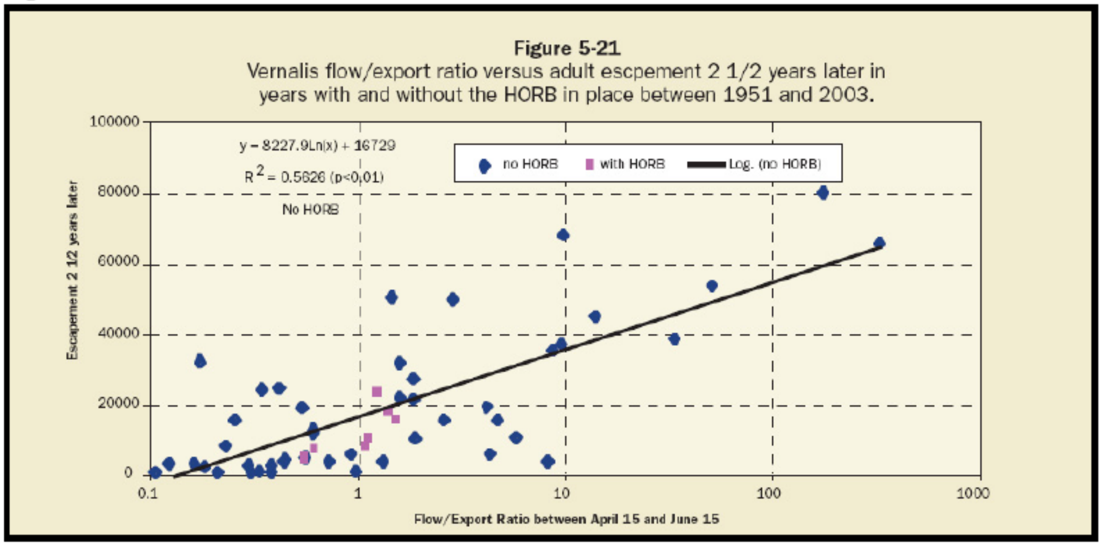


Copied from the 2006 Annual Technical Report, Vernalis Adaptive Management Plan

EXHIBIT 1: Figures illustrating positive relationship between 1) adult salmon abundance and SJR flows (top) and 2) survival of CWTed salmon smolts and SJR flows (bottom). Both figures come from Appendix 5 of the BiOp.

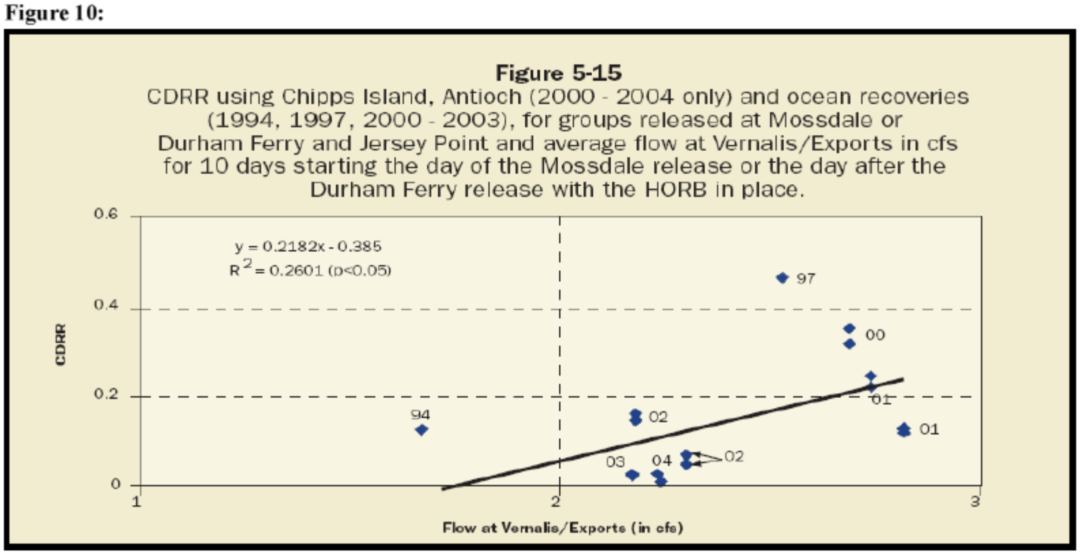
EXHIBIT 2

Figure 11



Copied from the 2006 Annual Technical Report, Vernalis Adaptive Management Plan

Figure 10:

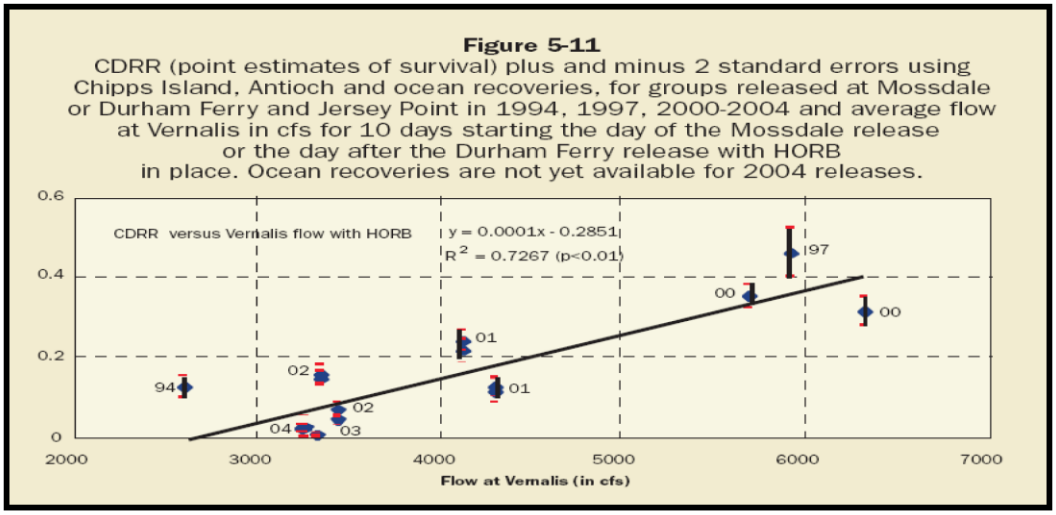


Copied from the 2006 Annual Technical Report, Vernalis Adaptive Management Plan

EXHIBIT 2: Figures illustrating the relationship between 1) adult salmon abundance and the ratio SJR flows to exports (top) and 2) survival of CWTed salmon smolts and the ratio SJR flows to exports (bottom). Though the relationship is positive, the fit between the ratio between SJR flows and exports is weaker than the relationship with SJR flows alone (see EXHIBIT 1). Both figures come from Appendix 5 of the BiOp.

EXHIBIT 3

Figure 9:



Copied from the 2006 Annual Technical Report, Vernalis Adaptive Management Plan

Figure 21. Delta Smolt Survival with Delta Export and Delta Inflow (HORB)

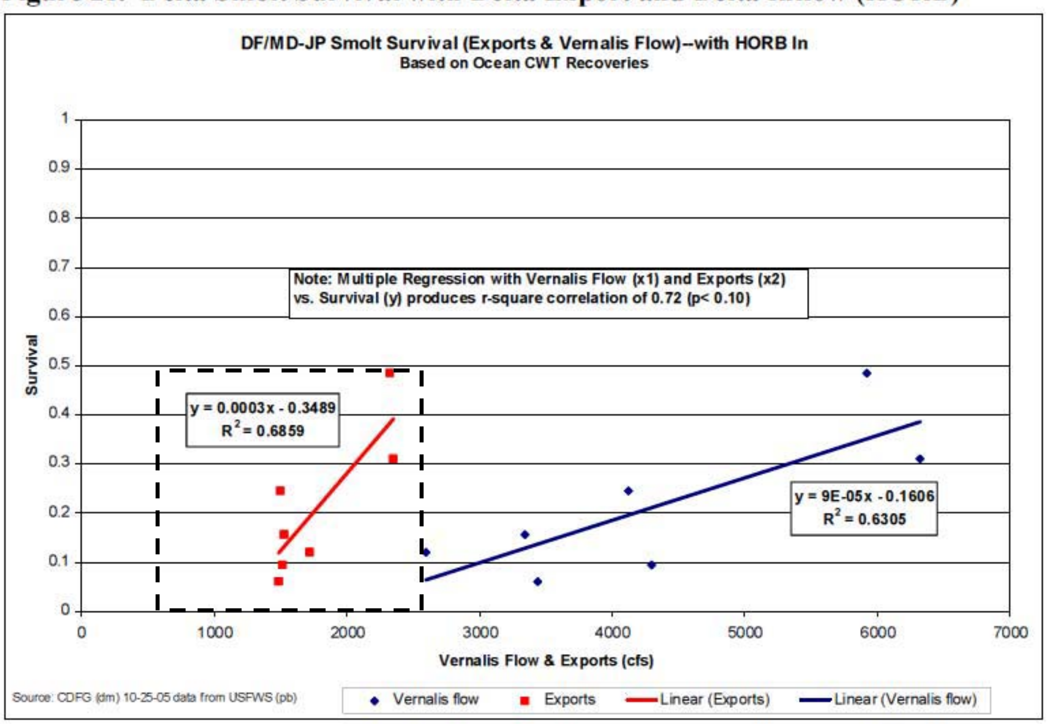


EXHIBIT 3: Figures showing positive relationship between: 1) survival of CWTed salmon smolts and SJR flows (top), and 2) survival of CWTed salmon smolts and exports (bottom figure within dash-lined box). In contrast to the rationale for Action IV.2.1, exports have been positively associated with salmon survival. The top figure come from Appendix 5 of the BiOp, the bottom figure comes from DFG (2005).

EXHIBIT 4

Figure 8:

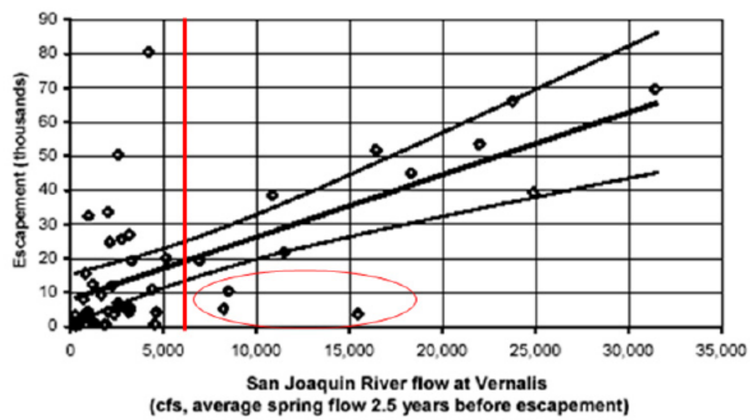


Figure 11 Total escapement to San Joaquin tributaries, 1951 through 1996, and spring flow in the San Joaquin River at Vernalis 2.5 years earlier. Fitted regression line and envelope of 95% confidence region for fitted line are shown.

Copied from Baker and Morhardt 2001.

Figure 24. Delta Export and Tuolumne River Escapement.

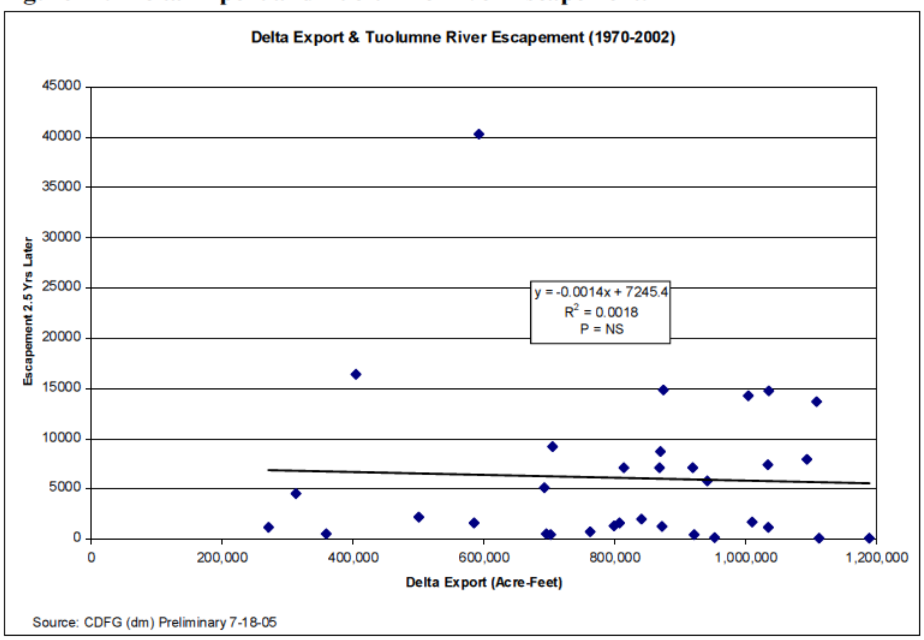


EXHIBIT 4: Figures contrasting relationship between: 1) adult salmon abundance and SJR flows (top), and 2) adult salmon abundance and exports. In contrast to the rationale for Action IV.2.1, evidence does not support exports as having an adverse effect on adult Chinook salmon abundance. The top figure come from Appendix 5 of the BiOp, the bottom figure comes from Baker and Morhardt (2001).

EXHIBIT 5

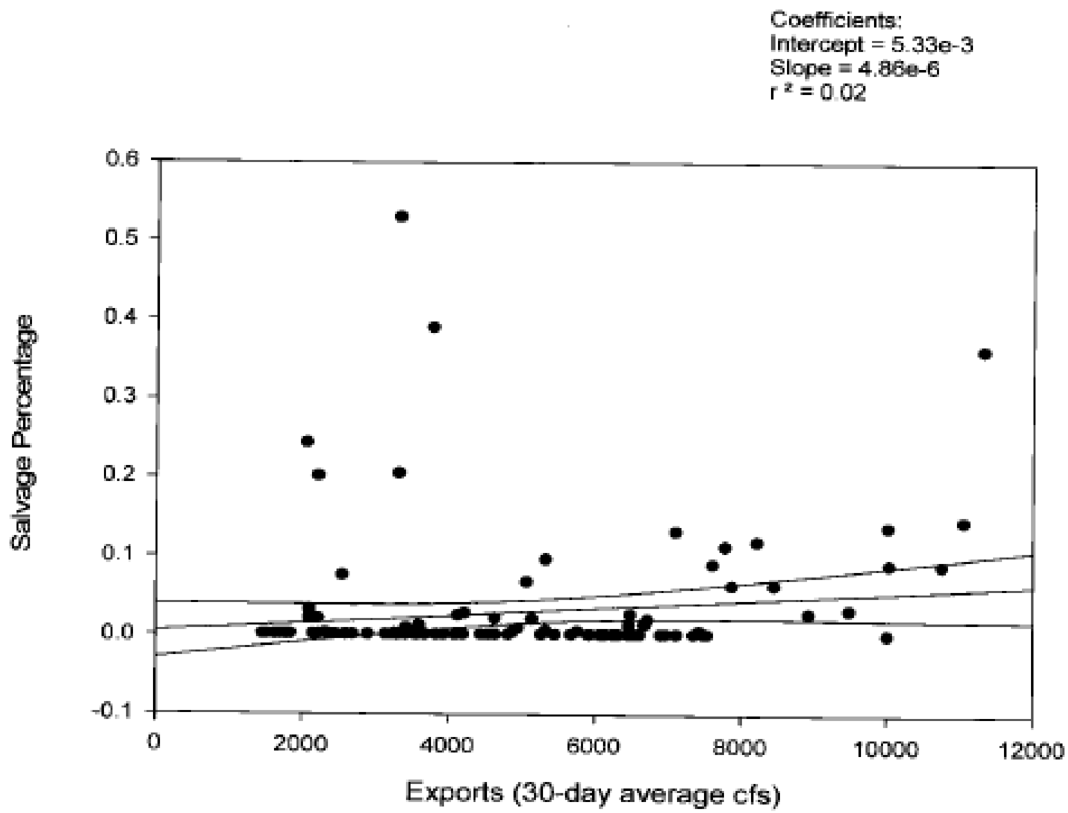


Exhibit 4. Relationship between SWP and CVP exports (30-day average) and percentage salvage.

EXHIBIT 5: Figure showing "salvage percentage" (the proportion CWTed salmon lost at export facilities) relative to average total exports for 30 days after CWTed fish were vulnerable to entrainment. Action IV.2.3 presumes that more negative OMR flows result in greater numbers of fish entrained toward the pumps. This analysis shows instead that there is no relationship between "salvage percentage" and export volume.

EXHIBIT 6

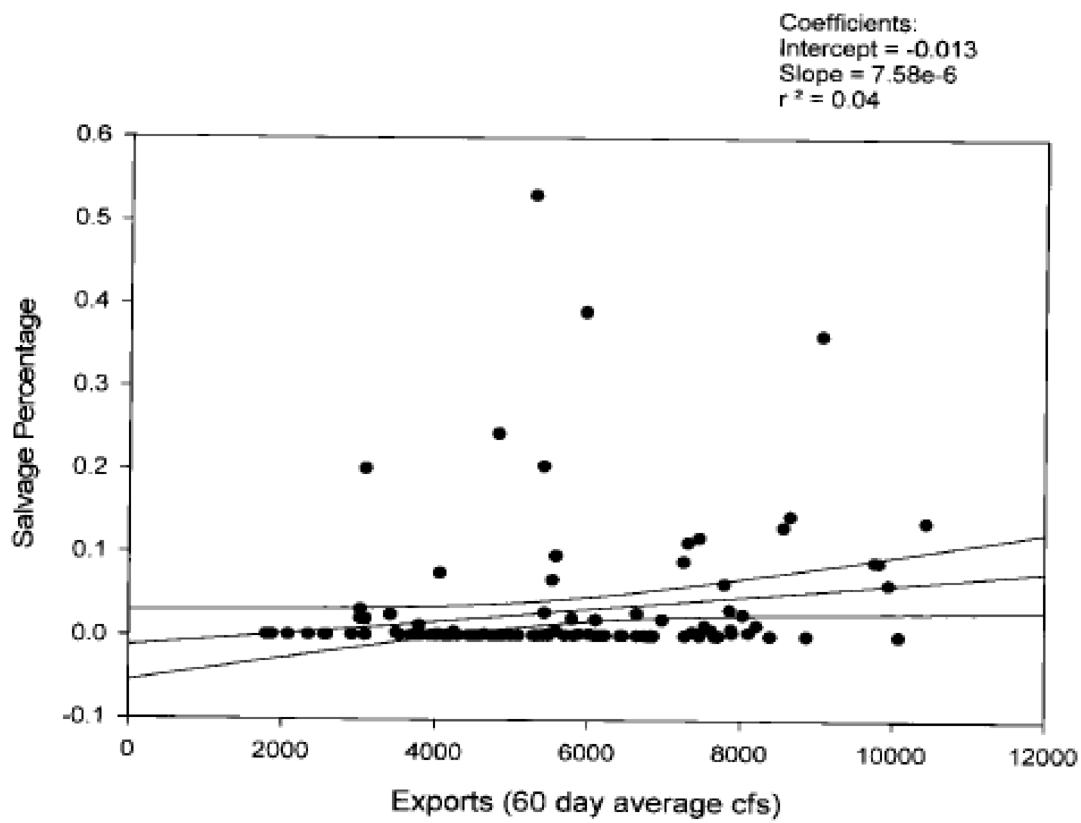


Exhibit 5. Relationship between SWP and CVP exports (60-day average) and percentage salvage.

EXHIBIT 6: Figure showing "salvage percentage" (the proportion CWTed salmon lost at export facilities) relative to average total exports for 60 days after CWTed fish were vulnerable to entrainment. Action IV.2.3 presumes that more negative OMR flows result in greater numbers of fish entrained toward the pumps. This analysis shows instead that there is no relationship between "salvage percentage" and export volume.

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IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

THE CONSOLIDATED SALMONID CASES	1:09-cv-1053 OWW-DLB 1:09-cv-1090 OWW-DLB 1:09-cv-1378 OWW-DLB 1:09-cv-1520 OWW-SMS 1:09-cv-1580 OWW-DLB 1:09-cv-1625 OWW-SMS
SAN LUIS & DELTA-MENDOTA WATER AUTHORITY; WESTLANDS WATER DISTRICT v. GARY F. LOCKE, as Secretary of the United States Department of Commerce; et al.	
STOCKTON EAST WATER DISTRICT, et al. v. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, et al.	**DECLARATION OF BRADLEY CAVALLO IN SUPPORT OF PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION**
STATE WATER CONTRACTORS v. GARY F. LOCKE, Secretary, et al.	Date: March 8, 2011 Time: 9:00 a.m. Ctrm: 3 Judge: The Honorable Oliver W. Wanger
KERN COUNTY WATER AGENCY, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.	
OAKDALE IRRIGATION DISTRICT, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.	
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA v. NATIONAL MARINE FISHERIES SERVICE, et al.	

I, Bradley Cavallo, declare as follows:

1. I have 13 years of experience working with anadromous fishery issues in Central California. I am currently a Senior Scientist and President of Cramer Fish Sciences in Auburn, California, where I have worked since 2006. Prior to this position, I was employed from 2003 until 2006 as a Senior Environmental Scientist and from 1999 to 2003 as an Environmental Scientist at the California Department of Water Resources in Sacramento, California. Prior to these positions, I was employed as a Fisheries Biologist at the California Department of Fish and Game in Stockton, California. In 1997, I earned a Master of Science degree in Aquatic Ecology from the University of Montana at Missoula. In 1994, I earned a Bachelor of Science in Wildlife and Fisheries Biology from University of California at Davis. I have authored numerous fishery reports, published papers and made many scientific presentations in the field of fisheries science. In the course of my professional career and education, I have attained expert knowledge of regulated rivers and estuaries, particularly related to the ecology of Chinook salmon and other anadromous fishes.

2. In my previous declarations I have shown, through extensive review of quantitative evidence, that reasonable and prudent alternative (RPA) Actions IV.2.1 and IV.2.3 are not supported by best available science

3. Rather than reiterating these arguments, this declaration addresses NMFS principle rationale for RPA Actions IV.2.1 and IV.2.3. Specifically, I critically evaluate NMFS contention that exports profoundly influence net flows in the Delta, and the related conclusion by NMFS that resulting flow changes cause harm to juvenile salmon. As an alternative to the PTM results and qualitative assessments relied on by NMFS, I provide results from DSM2 HYDRO and the Delta Passage Models. These models provide a robust, direct quantitative assessment of flows in the Delta, and thus make it possible to properly assess export-related flow effects on salmon, and to evaluate the related effectiveness of RPA Actions IV.2.1 and IV.2.3.

I. THE RPA INTENDS TO MANAGE NET FLOWS IN THE DELTA

4. The stated purpose of RPA Action IV.2.1 is to provide flows in the lower San Joaquin River (SJR) to increase survival of emigrating Central Valley steelhead (*Onchorynchus mykiss*)

originating from the SJR, as well as to enhance the survival of Sacramento River (SR) salmonids (BiOp 644-645, AR 106724-106725). Similarly, the stated purpose of RPA Action IV.2.3 is to reduce adverse export effects on SR and SJR origin salmonids. To achieve this objective, Action IV.2.3 prescribes minimum flows in Old and Middle River (OMR).

5. In support of these prescriptions, NMFS relied heavily on particle tracking model (PTM) simulations to represent changes in what they describe as *net* Delta flows. For example, the BiOp states, "the risk of entrainment into the channels of the south Delta is reduced when exports are lower and the *net flow* in the OMR channels is more positive – that is, in the direction of the natural flow toward the ocean." (BiOp 652, AR 00106732, emphasis added.) This point is made again in Mr. Stuart's memo detailing the results of the PTM simulations, where he states, "*Net flows* leading south toward the pumps will provide flow cues to the fish that are incorrect and contrary to the direction the fish needs to move to successfully exit the delta" and that fish may follow these cues and "be entrained into the salvage operations." (PTM Memo at.6, AR 00106026, emphasis added.)

6. In describing the rationale for the San Joaquin River I:E ratio of Action RPA IV.2.1, the BiOp states that increased flows within the San Joaquin River portion of the Delta will also benefit Sacramento River salmonids due to "increased *net flow* toward the ocean" resulting from increased SJR inflows and reduced exports (BiOp. 645, Appendix 5 at 74, AR 00106014, emphasis added.) In describing the rationale for the minimum OMR flows prescribed by RPA IV.2.3, the BiOp states that:

> The data output for the PTM simulation of particles injected at the confluence of the Mokelumne River and the San Joaquin River (Station 815) indicate that as *net OMR flow* increases southwards from -2,500 to -3,500 cfs, the risk of particle entrainment nearly doubles from 10 percent to 20 percent, and quadruples to 40 percent at -5,000 cfs. At flows more negative than -5,000 cfs, the risk of entrainment increases at an even greater rate, reaching approximately 90 percent at -7,000 cfs. Even if salmonids do not behave exactly as neutrally buoyant particles, the risk of entrainment escalates considerably with increasing exports, as represented by the net *OMR flows*. The logical conclusion is that as OMR reverse flows increase, risk of entrainment into the channels of the South Delta is increased.

(BiOp 652, AR 00106732, emphasis added.) It is therefore apparent that the ostensible purpose of both Action IV.2.1 and Action IV.2.3, is to reduce net negative flows in the Delta. The BiOp does not define net flows, nor does it describe the appropriate time interval for which net flows should be evaluated to determine the potential for adverse effects on juvenile salmonids. Instead, the BiOp relies upon PTM simulations to establish the effect of exports and to represent net flows in the Delta.

II. An Alternative Method for Assessing Flow Effects on Juvenile Salmon

7. I previously have identified DSM2 HYDRO as a readily available tool which provides channel specific flow data at 15-minute time intervals. Unlike PTM results which must be compiled over 30 to 90 days (Cavallo Dec. in Supp. of DWR Mot. For Summ. J. at 10. (Doc. 452)), DSM2 HYDRO results may be evaluated at 15-minute, hourly or daily time increments. The migratory process of salmon smolts in estuaries is thought to occur in steps, "characterized by swimming in the direction of the current followed by periods of holding in areas of low current velocity." (2010 Independent Review Panel Report at 25.) And recent Delta telemetry tagging studies shows that salmon smolts spend minutes or hours at channel junctions (Burau et al., 2007, AR00109732) and only days migrating through longer Delta reaches (Vogel 2004, AR00217955). Thus, a relatively short time interval (e.g. 1 day) is an appropriate scale at which to examine the potential for adverse hydrodynamic effects on juvenile salmon. Analyses of net flows calculated over weeks or months (as with PTM) are inappropriate because migrating juvenile salmon do not stay in one place long enough to be subjected to such gradual effects.

8. Similarly, much of the Delta is heavily influenced by tides, and in such reaches simple measures of net flow (whether averaged over days or weeks) are misleading because the magnitude of tidal flux far exceeds the subtle influence of net flows. As an example of this point, I have plotted DSM2 HYDRO based estimates of channel flows at 15-minute increments for a location in the western Delta (RSAN014) and provided it as Exhibit 1. (RSAN014 represents reach SJ3 in the Delta Passage Model (DPM); Both DSM2 HYDRO and the DPM are described in greater detail in later paragraphs). Exhibit 1 illustrates that the magnitude of tidal flux can be very large (in excess of 100,000 cfs in this example) and as such the influence of exports is very small. Yet, a simple calculation of net flows from the same data plotted in Exhibit 1 would indicate average flow values of -220, -2,263, and -4,337 at exports of 2,000, 6,000 and 10,000

respectively. In reaches with large tidal flux, and given the directed movement and strong swimming behavior of juvenile salmonids, it is very likely that these changes in average or net flow are nearly imperceptible.

9. I have used DSM2 HYDRO and completed an evaluation of export and river inflow effects on Delta flow conditions. I used DSM2 HYDRO results from Kimmerer and Nobriga (2008) (AR 00122248-00122252) representing three levels of exports and three levels of river inflows. Exhibit 2 provides a summary of the river inflow and export conditions modeled. Further details on the assumptions of the DSM2 HYDRO simulations are provided in Kimmerer and Nobriga (2008).

10. DSM2 HYDRO estimates flow every 15 minutes at 517 separate channels within the Delta. Following Kimmerer and Nobriga (2008) I used estimated flows every 15-minutes over a single 24-hour period of simulation (including tidal oscillations but where inflows and exports were constant). I summarized this very large data set by calculating the percentage increase in negative flow occurrence resulting from exports increasing from 2,000 to 6,000 cubic feet per second (cfs) and from 6,000 to 10,000 cfs. Thus, if half (50%) of all flow observations at a specific channel were negative at 2,000 cfs, we would report the percentage increase in those negative flows resulting from exports at 6,000 cfs. Channel locations solely influenced by river flows would always have positive flows. Conversely, channel locations very close to export facilities would always have negative flows. In both of these instances, no change in the occurrence of negative flows would be expected as exports increased. However, these extremes are not typical for most Delta channel. In a channel only influenced by tides, we would expect flows to be negative about 50% of the time and positive for the remaining 50%. That is, flows would be positive on ebb (outgoing) tides and negative on flood (incoming) tides (as depicted in Exhibit 1). My analysis sought to illustrate the spatial extent of increased negative flows in the Delta and to depict how the incidence of flows changes as a function of exports and inflows.

11. Exhibit 3, Exhibit 4, and Exhibit 5 depict the percentage increase in the occurrence of negative flows during low river inflow conditions with three contrasting levels of exports. As exports change from 2,000 cfs to 6,000 cfs (upper panels) and from 6,000 cfs to 10,000 cfs (lower

panels) the colors of Delta channels change in relation to the incidence of negative flow. OMR flows also change, and values are indicated on each panel of these Exhibits. Channels in which negative flows change very little (<1%) are indicated in grey. Channels in which negative flows increases from 1 to 2% are indicated as yellow and orange. Channels in which negative flows increased by greater amounts are depicted as red (3-4%) and purple (5-30%).

12. Closely examining Exhibit 3 reveals two significant observations. First, large changes (>5%) in the occurrence of negative flows are confined to channels in close proximity to the south Delta export facilities. Second, channel junctions along the San Joaquin River which were identified by NMFS as primary areas of concern for juvenile salmonid migration (AR 00106022) are relatively insensitive to increasing exports. The incidence of negative flows at these locations only increased by at most 1% to 2% as OMR values decreased from -2298 to -5400 and from -5400 to -8503 (Exhibit 3).

13. Exhibit 4 and Exhibit 5 depict the same increase in exports as shown in Exhibit 3, but with greater river inflows (total inflow of 21,000 cfs for Exhibit 4 and 38,000 cfs for Exhibit 5). Patterns in the increase of negative flows were generally similar regardless of river inflow levels.

14. DSM2 HYDRO analysis results differ starkly from comparable PTM analyses. For example, NMFS conducted PTM analysis and released particles at Station 815 (the approximate location of Station 815 is labeled as Mokelumne River on Exhibits 3 to 5) , and reported a 3900% increase in particles entrained at the export facilities (from 0.6% to 23.5%) as OMR values decreased -1250 to -3500. (PTM Memo, p. 3, AR 00106023.) As shown in Exhibits 3, 4 and 5 such an increase in exports (or decrease in OMR) produces only slight (if any) changes in the incidence of negative flows within a 24-hour period; nothing like the dramatic increase in negative flows which is implied by the PTM-based assessment at this same location.

15. Similarly, Kimmerer and Nobriga (2008) (AR 00122249) assessed particle entrainment at locations “Med” and “Sto” on the San Joaquin River. These two locations correspond to the areas labeled as Columbia Cut and Turner Cut on Exhibits 3, 4 and 5. Kimmerer and Nobriga reported that 58% and 48% of particles were entrained for particles released at these two locations under low inflows (12,000 cfs) and low exports (2,000 cfs). (AR

00122255.) Again, DSM2 HYDRO simulations show that the actual changes in the incidence of negative flows at these locations over a 24-hour period is very small.

16. Collectively these results confirm previous my previous observation that, "given the rapid and directed movements of salmonid smolts, it is both inappropriate and inaccurate to use the fate of particles integrated over weeks or months to even roughly assess salmonid smolt effects." (Cavallo Dec. in Supp. of DWR Mot. For Summ. J. p. 11 (Doc. 452).) The long time period over which PTM integrates the fate of particles greatly exaggerates the perception of export impacts on juvenile salmonids. Indeed, recent telemetry studies shows that salmon smolts spend minutes or hours at channel junctions (Burau et al. 2007, AR00109732) and only days migrating through longer Delta reaches (Vogel 2004, AR00217955). Given the fractional changes in negative flows which occur along the primary migration route of the San Joaquin River there is little reason to expect an adverse impact such has been hypothesized by NMFS to support Actions IV.2.1 and IV.2.3.

17. The results of the DSM2 HYDRO analysis presented here are entirely consistent with and help to explain the difficulty nearly all investigations have had in finding evidence of adverse export effects on the survival and route selection for San Joaquin River juvenile salmonids. The very small changes in negative flows which occur along the mainstem San Joaquin River as exports increase may be an all but undetectable effect on migrating juvenile salmonids. Given these results, it is perhaps not surprising that Vogel (2004) (AR 00217996), Newman (2008) (AR 00127219-00127220) and others have been unable to observe evidence for an adverse export effect.

III. DELTA PASSAGE MODEL MORE ACCURATELY ESTIMATES THROUGH-DELTA SURVIVAL

18. The Delta Passage Model (DPM) is a simulation tool which allows us to specifically track the routing and survival of salmonid smolts as they migrate through the Delta. The DPM incorporates the results of best available scientific information regarding race-specific arrival timing, route selection, behavior and mortality of juvenile salmon. The DPM includes results of the Delta Action 8 study (including variability in predicted response to exports) as described by

Newman and Brandes (2009) (AR 00089863) and applies estimated export-related mortality to the sub-set of fish which pass through Georgiana Slough. Positive relationships between survival and river flow, as shown by Newman (2008) (AR 00127219) and others, are also included in the Delta Passage Model. This integration of factors influencing through-Delta survival provided by the Delta Passage Model provides an example of the quantitative approach recommended to NMFS by the CALFED Independent Science Panel. (Anderson et al. 2009, 5-6, 9-10, 13, 19-22, 28-29; AR 00108163 et passim.)

19. The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions in the Delta. The DPM is composed of 10 reaches and four junctions (Exhibit 5A) selected to represent primary salmonid migration corridors where high quality fish and hydrodynamic data were available. For simplification, Sutter Slough and Steamboat Slough are combined as the reach SS and the forks of the Mokelumne River and Georgiana Slough are combined as Geo/DCC. The Geo/DCC reach is accessed by Sacramento runs through the combined junction of Georgiana Slough and Delta Cross Channel (Junction C). Different areas of the Interior Delta reach can be entered from three different pathways: 1) Geo/DCC, 2) SJ2, or 3) Old River Junction (Junction D). The four distributary junctions depicted in the DPM are: A) Sacramento River at Freemont Weir (head of Yolo Bypass), B) Sacramento River at head of Sutter and Steamboat Sloughs, C) Sacramento River at the combined junction with Georgiana Slough and Delta Cross Channel, and D) San Joaquin River at the head of Old River (Exhibit 5A).

20. Though NMFS was provided with preliminary results of a DPM-based assessment of their proposed RPA Actions IV.2.1 and IV.2.3 on April 24, 2009 (AR 00105439-00105451), we have now completed a more thorough analysis using CALSIM data provided by DWR and using the most current version of the DPM. The version of the DPM used for this analysis has undergone extensive review and revisions in collaboration with resource agency scientists as part of the Bay Delta Conservation Plan (BDCP) process. The version of the DPM used for the analysis is fully documented and available in Appendix E10 of the BDCP effects analysis expected to be released in February 2011. CALSIM data used for this analysis is based upon 81

years of hydrologic conditions (i.e. precipitation history) ranging from 1922 to 2003 with two contrasting scenarios of required water project operations: "BiOp" and "Pre-BiOp". The "BiOp" scenario represents water project operations as expected to occur under the provisions of the 2009 OCAP Biological Opinions (both NMFS and USFWS). In contrast, the "Pre-BiOp" scenario represents water project operations as would be expected to occur without the 2009 OCAP Biological Opinion. Thus, in the "Pre-BiOp" Delta water project operations were primarily determined by the D-1641 agreement and conditions of earlier BiOps.

21. In a previous declaration, I observed that, "while Action IV.2.1 purports to manage both flows and exports for the benefit of juvenile salmonids, in fact it only restricts exports. There is no evidence available to suggest that the Action IV.2.1 will result in increased SJR flows." (Cavallo Dec. in Supp. of DWR Mot. For Summ. J. at 3 (Doc. 452).) Results provided by the CALSIM analysis now confirm this observation. Exhibit 6 plots the difference in monthly average flows between the "BiOp" and "Pre-BiOp" scenarios. Exhibit 6 clearly shows that the 2009 BiOp does not increase San Joaquin River flows entering the Delta.

22. Estimates of winter run Chinook through-Delta survival using the DPM show an average survival improvement of 1.3% with the "BiOp" relative to the "Pre-BiOp" (Exhibit 7). The upper panel of Exhibit 7 illustrates that there is considerable year-to-year variation in winter-run Chinook survival through the Delta. This variation is due to changes in water years types which have a very strong influence on river inflows to the Delta. To better explain the relative importance of export effects addressed by Action IV.2.1 and IV.2.3, I plotted the through-Delta mortality for winter run Chinook which is attributable to exports relative to other stressors which are not addressed by RPA Actions IV.2.1 and IV.2.3 (Exhibit 7A). Exhibit 7A clearly illustrates that the effect of exports is very small relative to non-project stressors. Non-project stressors include factors such as water year type, predation, degraded habitat, temperature, turbidity, and river inflow management.

23. Estimates of spring run Chinook through-Delta survival using the DPM show an average survival improvement of 0.2% with the "BiOp" relative to the "Pre-BiOp." (Exhibit 8.) The upper panel of Exhibit 8 illustrates that there is considerable year-to-year variation spring run

Chinook survival through the Delta. This variation is due to changes in water years types which have a very strong influence on river inflows to the Delta.

24. Estimates of San Joaquin River (SJR) fall run Chinook through-Delta survival using the DPM show an average survival decrease of 1.1% with the “BiOp” relative to the “Pre-BiOp.” (Exhibit 9.) Survival through the Delta from the SJR appears to be extremely low and improves with greater SJR inflows to the Delta. However, as described in paragraph 18, “BiOp” operations (including Actions IV.2.1 and IV.2.3) do not appear to increase SJR river inflows to the Delta. The small observed decrease in SJR survival with the “BiOp” is due to the reduction in exports associated with Actions IV.2.1 and IV.2.3. This occurs because recent acoustic tagging studies and analysis of CWT data show that survival through the Old River route is higher with greater exports because greater exports increase flows through Old River. The mechanism by which these export benefits occur, if they occur at all, is highly uncertain and debatable. I conservatively interpret the results of the DPM for SJR Chinook salmon to indicate there is no difference in through-Delta survival with “BiOp” conditions relative to “pre-BiOp” conditions.

IV. Best Available Science Demonstrates No Appreciable Benefit from the RPA

25. Results presented in my analysis of the DSM2 HYDRO model with varying levels of exports (and OMR flows) clearly show that the potential for exports to adversely impact migration of juvenile salmonids is relatively small, and that PTM analyses relied upon by NMFS in developing Actions IV.2.1 and IV.2.3 greatly exaggerates the potential hydrodynamic impact of exports on juvenile salmonids. As I have described previously and at length (Cavallo Dec. in Supp. of DWR Mot. For Summ. J. at 9-15 (Doc. 452)) the PTM is an inappropriate tool to assess flow effects on juvenile salmonids in tidally-driven portions of the Delta. Its use for this purpose is entirely without scientific basis or precedent, and experts have uniformly reported the failure of PTM to comport with the observed fates and behavior fish. In contrast, DSM2 HYDRO results appear to be very consistent with observations of fish behavior and entrainment risk. Collectively, Newman (2008) (AR 00127219-00127220), Vogel (2004) (AR 00217996) and others were unable to find an export effect on survival or migration route for fish on the San

Joaquin River. (VAMP Review Panel Report (2010) at 5.) DSM2 HYDRO results reported here comport with these findings and illustrate that the export-influenced hydrodynamic effect hypothesized to exist for juvenile salmonids is either absent, or simply too small to be reliably detected.

26. Analysis of the DPM revealed small (1.3% on average) survival benefits for winter run Chinook from operations under the "BiOp" scenario. However, most winter run Chinook will have already migrated out of the Delta by March 15th, and thus the benefits observed are attributable to RPA actions implemented earlier in the year and are not substantially attributable to the disputed portions of Actions IV.2.1 and IV.2.3. Thus, in my professional opinion enjoining RPA Actions IV.2.1 and IV.2.3 will not appreciably harm Sacramento winter-run Chinook.

27. Sacramento River spring run Chinook and the San Joaquin River component of the Central Valley steelhead will be actively emigrating during the period of time affected by RPA Actions IV.2.1 and IV.2.3. However, DSM2 HYDRO and DPM analysis presented here clearly show that potential adverse impact to these species and to their critical habitat would not appreciably occur if RPA Actions IV.2.1 and IV.2.3 were enjoined.

28. Based upon the analysis contained in this declaration, it is my opinion that enjoining the calendar based Old and Middle River component of Action IV.2.3 and the inflow-export ratio component of Action IV.2.1 through this water year will not reduce appreciably the likelihood of survival or recovery or appreciably diminish the value of the critical habitat of the listed salmonids in the BiOp.

I declare under penalty of perjury under the laws of the State of California and the United States that the foregoing is true and correct. Executed this 3rd day of February 2011 at Auburn, California.

BRADLEY CAVALLO

REFERENCE LIST

James J. Anderson et al., Independent Review of a Draft Version of the 2009 NMFS OCAP Biological Opinion (CALFED Science Program 2009) (AR 00108158)

James J. Anderson et al., 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 (2010)

Jon Burau et al., Sacramento/San Joaquin River Delta Regional Salmon Outmigration Study Plan: Developing Understanding for Management and Restoration (2007) (AR 00109732)

Committee on Sustainable Water and Environmental Management in the California Bay–Delta, National Academy of Sciences National Research Council, A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay Delta (National Academies Press 2010)

Dennis Dauble et al., The Vernales Adaptive Management Program (VAMP): Report of the 2010 Review Panel, Prepared for the Delta Science Program (2010)

Wim J. Kimmerer et al., Investigating Particle Transport and Fate in the Sacramento – San Joaquin Delta Using a Particle Tracking Model, San Francisco Estuary & Watershed Science, February 2008 (AR00122246)

Ken B. Newman, An Evaluation of Four Sacramento – San Joaquin River Delta Juvenile Salmon Survival Studies (2008) (AR 00127144)

Ken B. Newman et al., Hierarchial Modeling of Juvenile Chinook Salmon Survival as a Function of Sacramento – San Joaquin Delta Water Exports (2009) (AR 00089863)

San Joaquin River Technical Committee, Summary Report of the Vernalis Adaptive Management Plan (VAMP) for 2000 – 2008, Prepared for the Advisory Panel Review Conducted by the Delta Science Program (2008)

Jeffrey Stuart, Particle Tracking Model Results for Old and Middle River Flow Manipulation, Unpublished Memorandum (National Marine Fisheries Service 2009) (AR 00106021)

David A. Vogel, Juvenile Chinook Salmon Radio-Telemetry Studies in the Northern and Central Sacramento – San Joaquin Delta 2002 – 2003 (National Fish and Wildlife Foundation 2004) (AR 00217955)

Exhibit 1. Tidal flux vs. “net flows

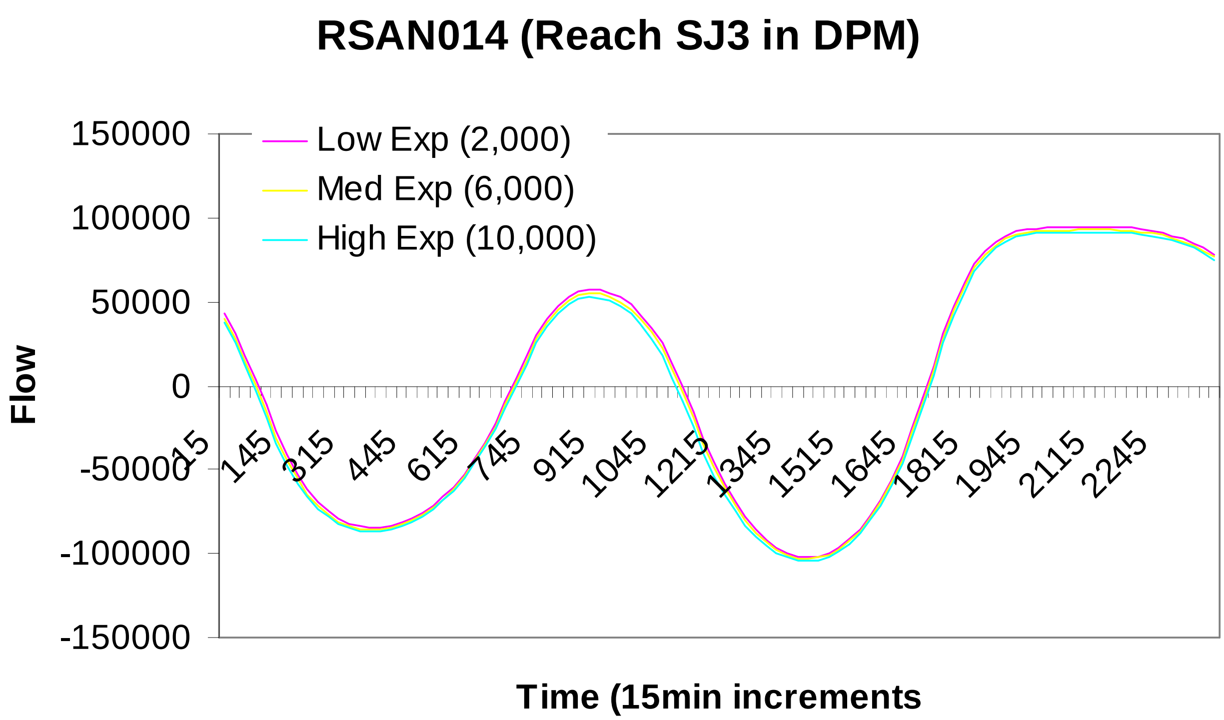


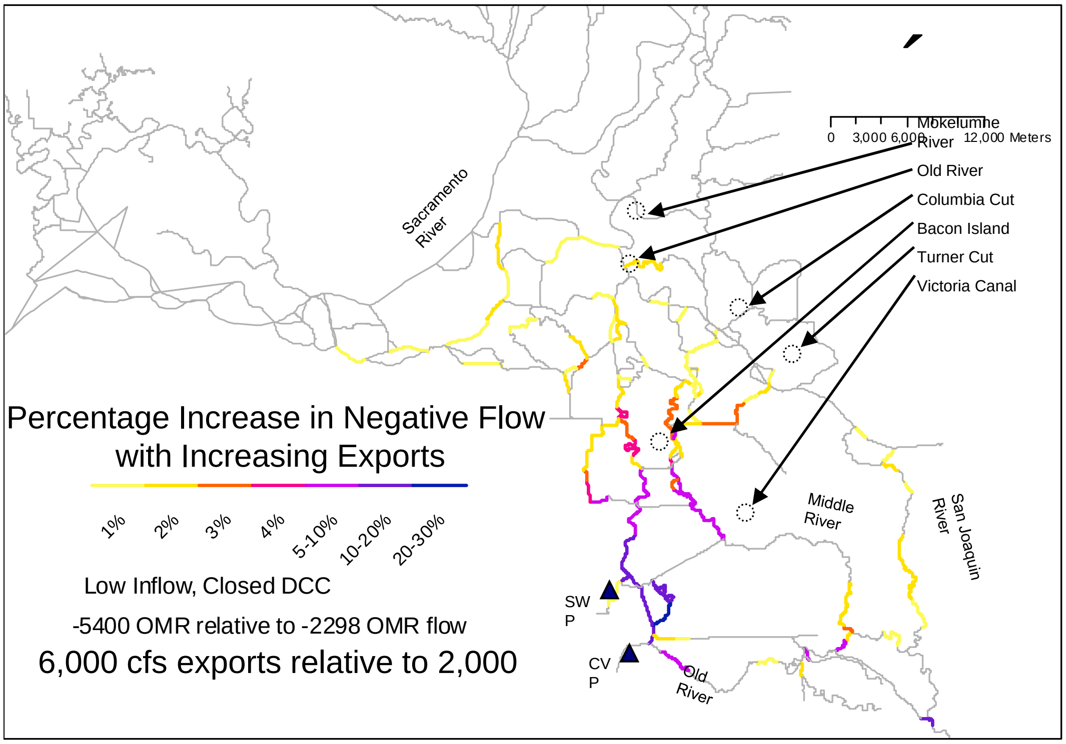
Exhibit 1. DSM2 HYDRO estimated flows in 15-minute increments for a channel in the western Delta for three levels of south Delta exports. Tidal flux approaches 100,000 cfs, but increasing exports have very little influence on observed flow oscillations. Yet, average (or net) flows calculated from this data are -220, -2,263, and -4,337 respectively. Without consideration for the tidal flux, these negative net flows might be interpreted as harmful to juvenile salmon.

Exhibit 2. Scenarios for DSM2 HYDRO

Total Inflow	Inflow Sacramento	San Joaquin	DCC Gate Position	Total Exports	OMR
Low (12,000 cfs)	Low (10,595 cfs)	Low (1,405 cfs)	Closed	Low (2000 cfs)	-2298
Low (12,000 cfs)	Low (10,595 cfs)	Low (1,405 cfs)	Closed	Med (6,000 cfs)	-5400
Low (12,000 cfs)	Low (10,595 cfs)	Low (1,405 cfs)	Closed	High (10,000 cfs)	-8503
Med (21,000 cfs)	Med (18,264 cfs)	Med (2,736 cfs)	Closed	Low (2000 cfs)	-1511
Med (21,000 cfs)	Med (18,264 cfs)	Med (2,736 cfs)	Closed	Med (6,000 cfs)	-4614
Med (21,000 cfs)	Med (18,264 cfs)	Med (2,736 cfs)	Closed	High (10,000 cfs)	-7717
High (38,000 cfs)	High (32,288 cfs)	High (5,712 cfs)	Closed	Low (2000 cfs)	246
High (38,000 cfs)	High (32,288 cfs)	High (5,712 cfs)	Closed	Med (6,000 cfs)	-2856
High (38,000 cfs)	High (32,288 cfs)	High (5,712 cfs)	Closed	High (10,000 cfs)	-5959

Exhibit 2. River inflows, south Delta exports, Delta Cross Channel (DCC) position, and OMR flows conditions assesses by Kimmerer and Nobriga (2008). Kimmerer and Nobriga (2008) reported particle tracking model results from these (and other) scenarios. DSM@ HYDRO results for these nine scenarios are depicted in Exhibit 2, Exhibit 3, and Exhibit 4.

Exhibit 3. DSM2 HYDRO, Low Inflows



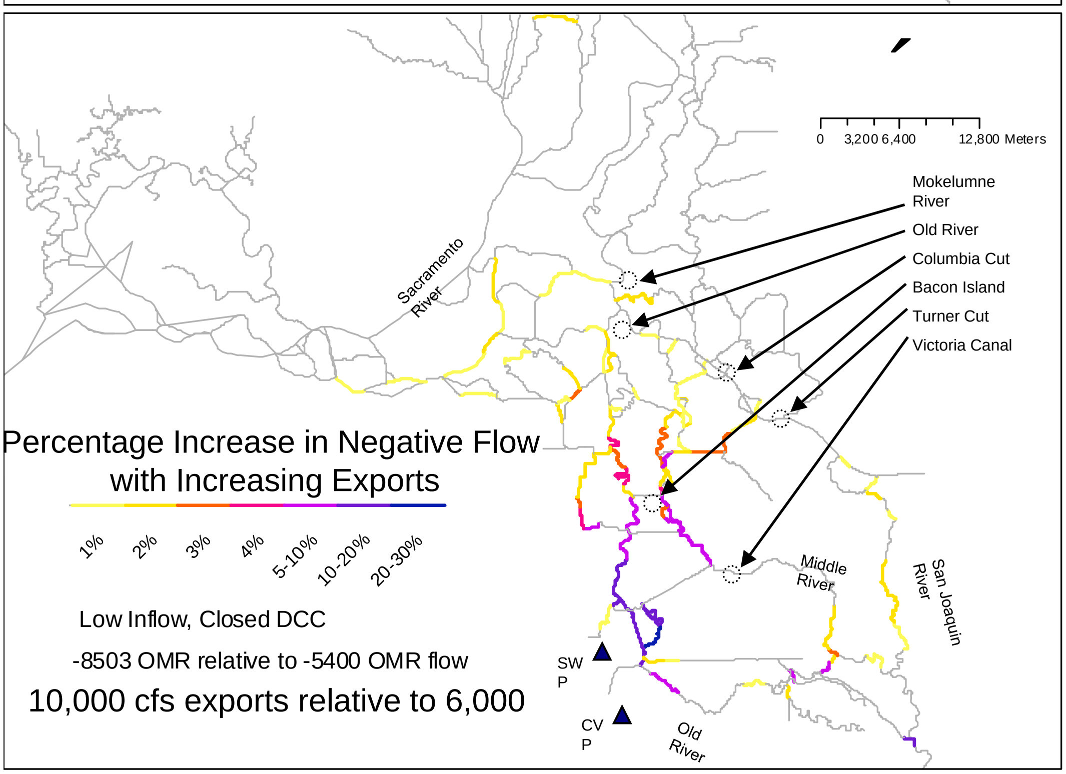
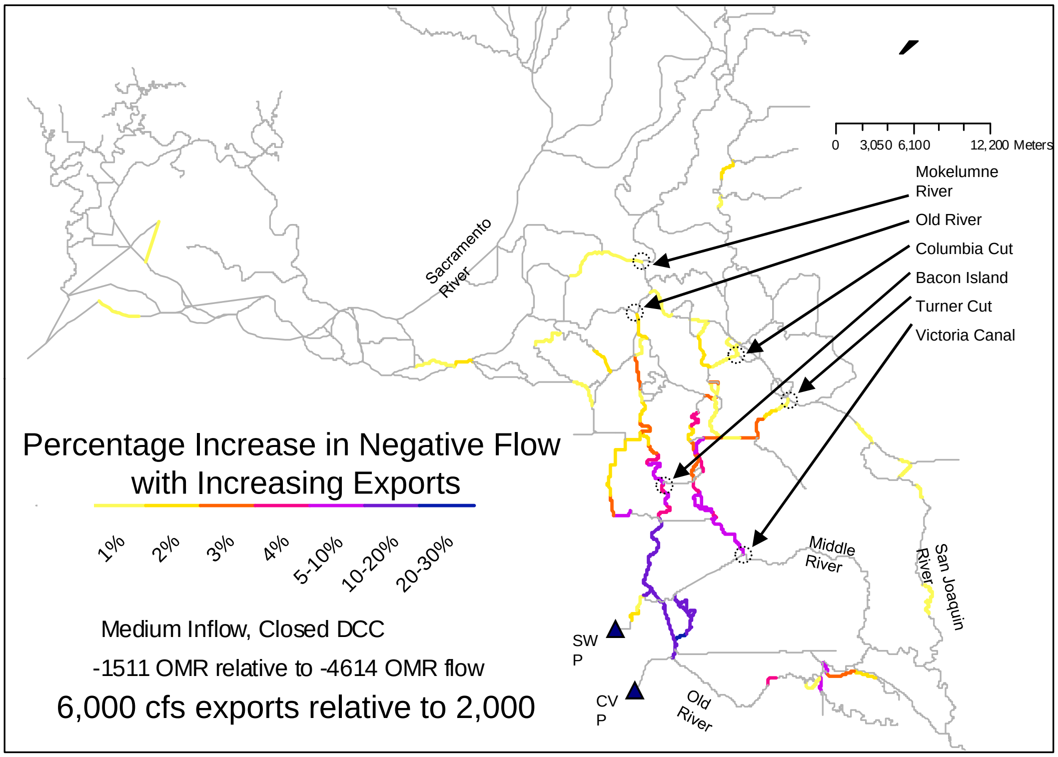


Exhibit 3. Percentage increase in the occurrence of negative flows during low river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no change. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

Exhibit 4. DSM2 HYDRO, Medium Inflows



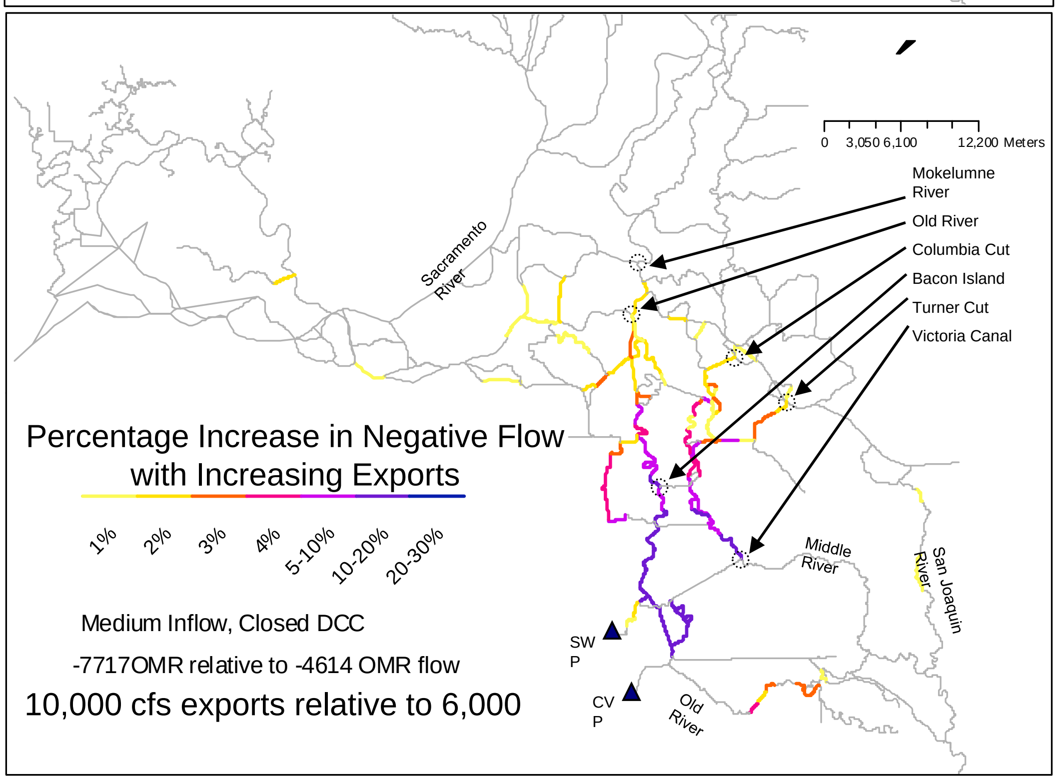
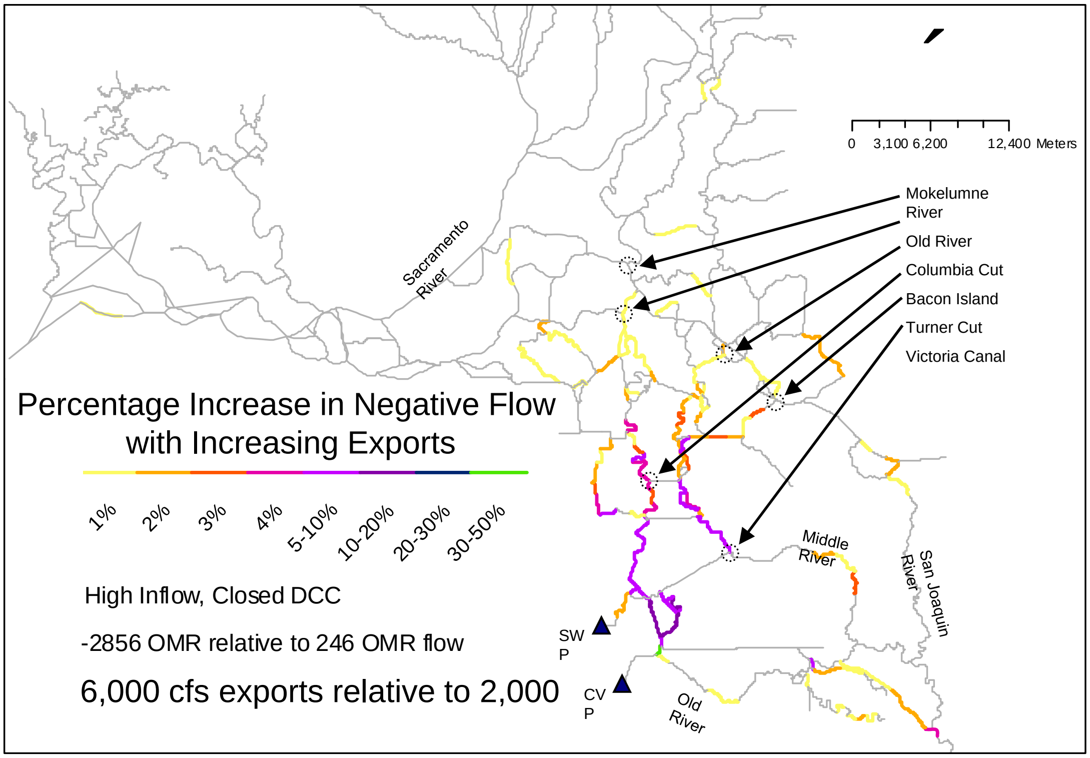


Exhibit 4. Percentage increase in the occurrence of negative flows during medium river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no change. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

Exhibit 5. DSM2 HYDRO, High Inflows



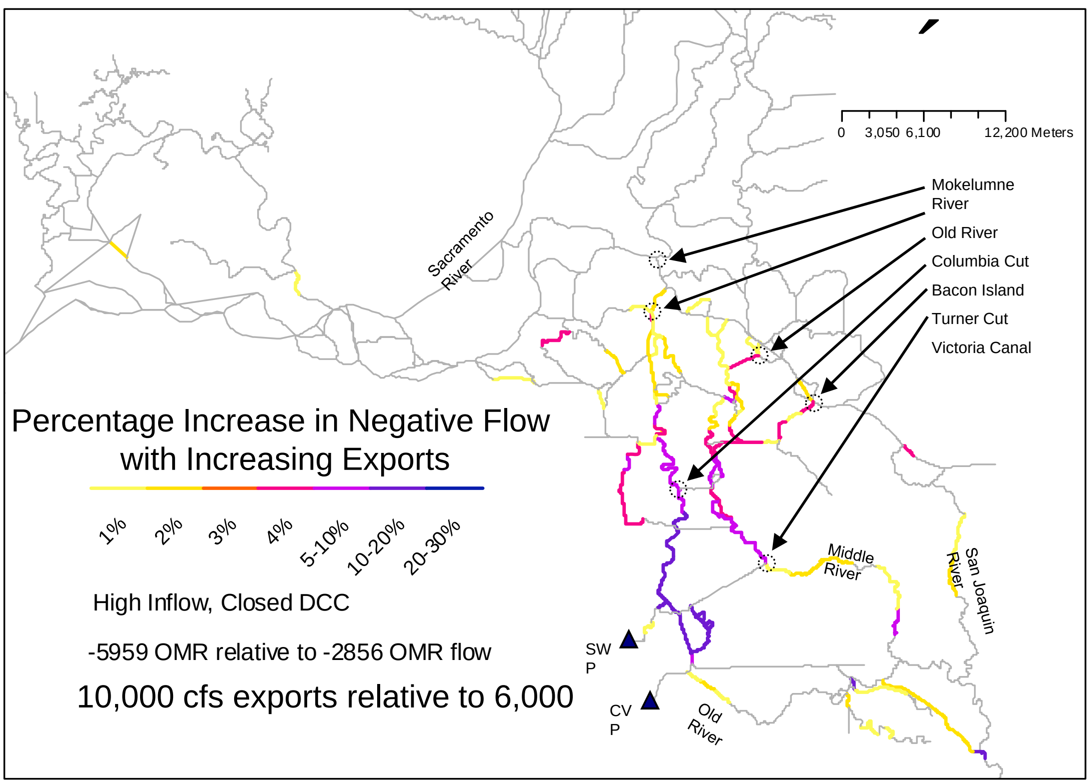


Exhibit 5. Percentage increase in the occurrence of negative flows during high river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no change. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

Exhibit 5A. Delta as represented in the DPM

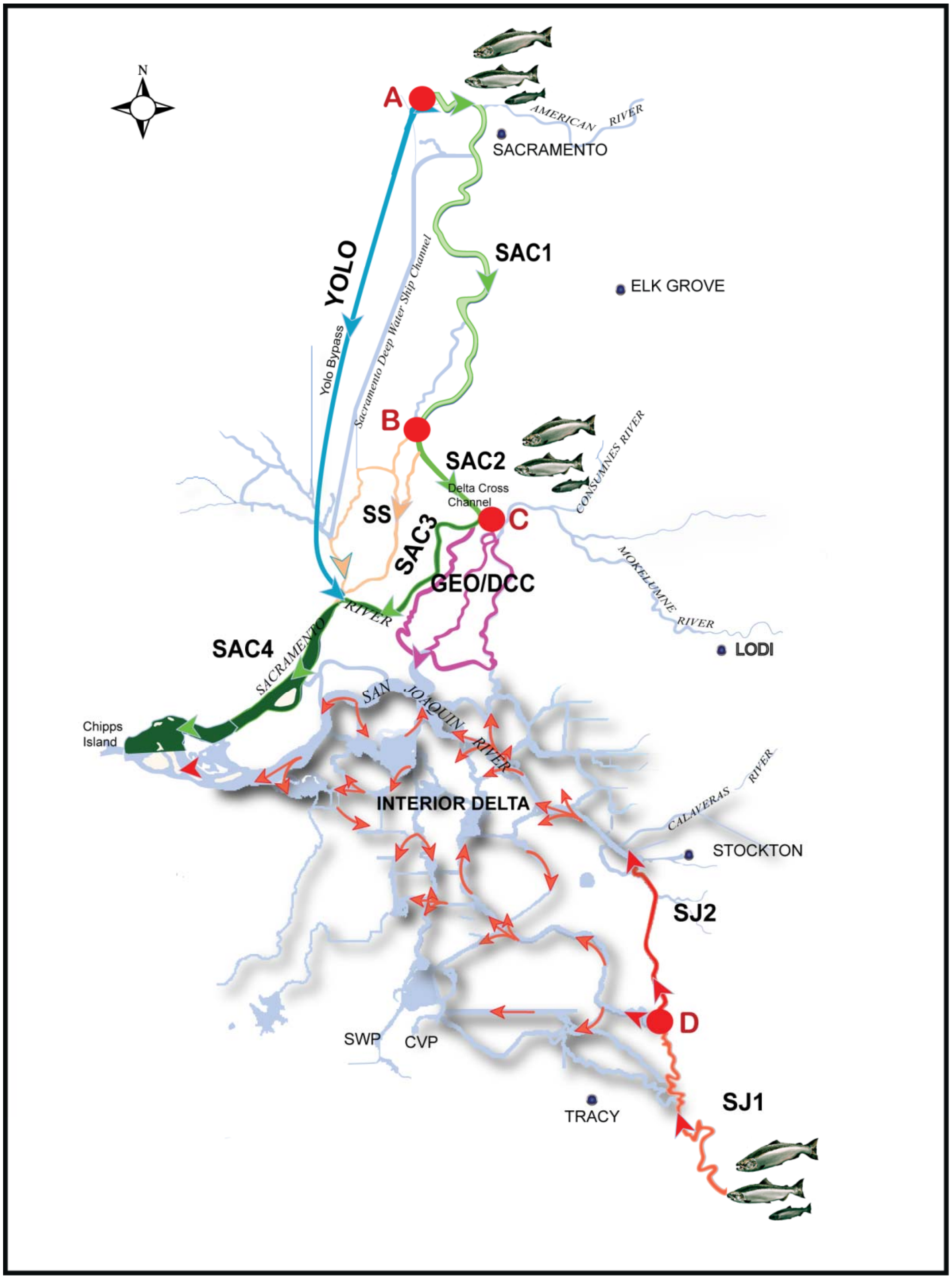


Exhibit 5A. Map of the Sacramento-San Joaquin Delta showing the modeled reaches and junctions represented in the Delta Passage Model (DPM). Colored river channels are modeled reaches and red circles are junctions. Salmonid icons indicate locations where juvenile salmonids can be introduced into the model

Exhibit 6. San Joaquin River flows (at Vernalis)

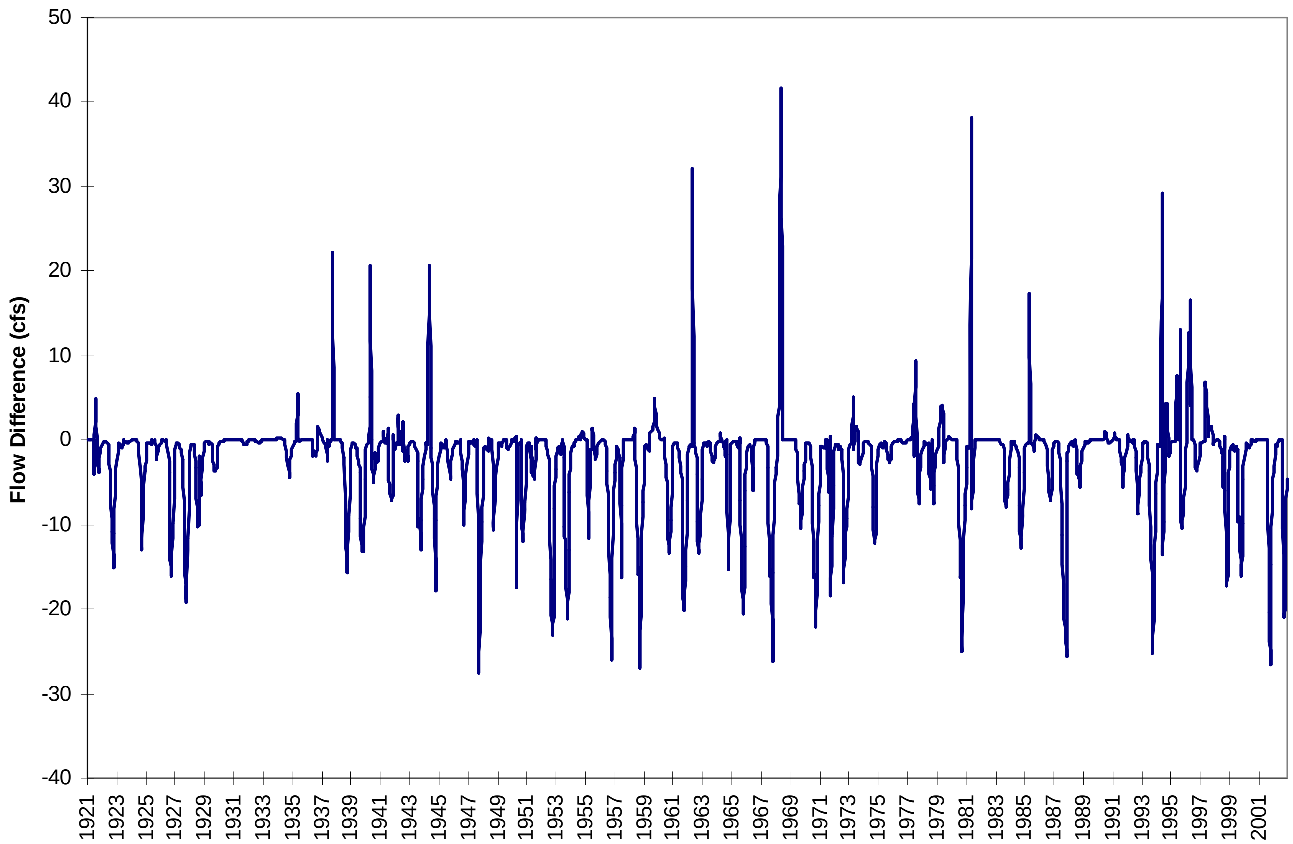


Exhibit 6. Difference in San Joaquin River flows (at Vernalis) with 2009 BiOp requirements relative to "pre-BiOp" requirements. Values less than zero indicate months when flows with the 2009 BiOp were less than flows under pre-BiOp conditions. On average, flows with the "BiOp" were no different from flows with "pre-BiOp".

Exhibit 7. Winter Run Chinook DPM Results

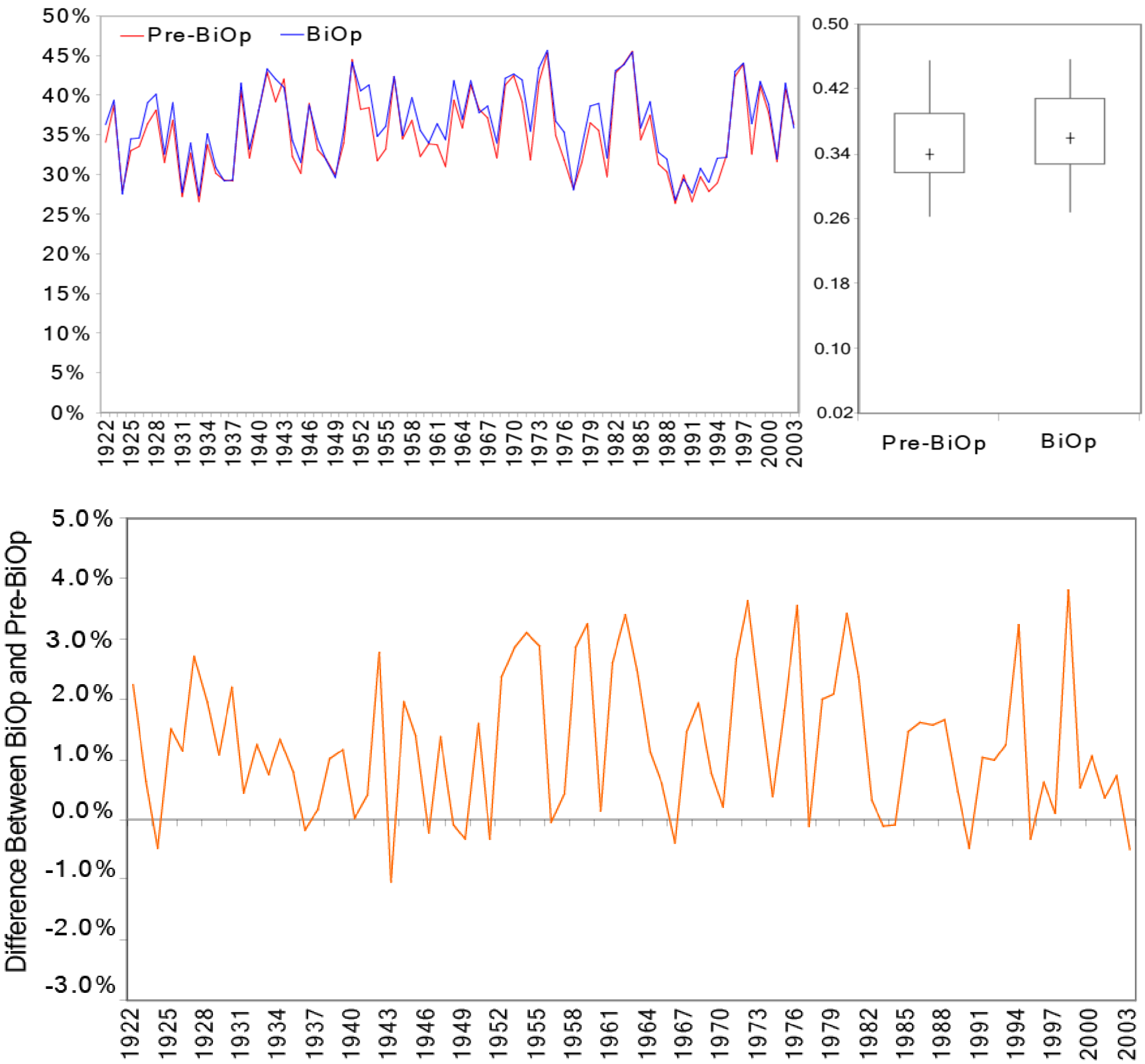


Exhibit 7. Juvenile winter run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps (“BiOp”) and under “pre-BiOp” requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between “BiOp” and “Pre-BiOp”. On average, winter run Chinook survival was 1.3% higher with the “BiOp” condition relative to the “Pre-BiOp”.

Exhibit 7A. Relative Contribution of Exports to Winter Run Chinook Through-Delta Mortality

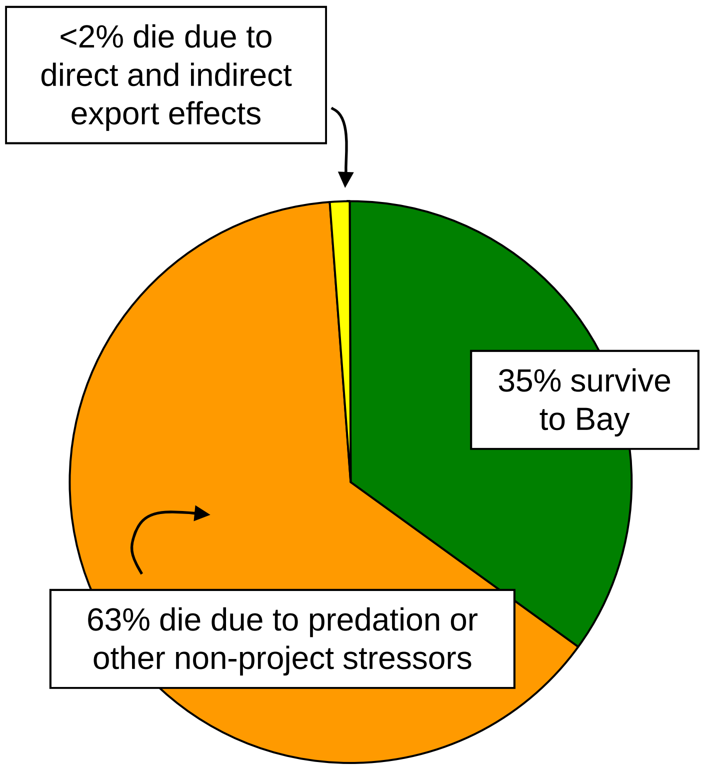


Exhibit 7A. Sources of through-Delta mortality for juvenile winter run Chinook as indicated by the Delta Passage Model and the studies upon which the DPM is based. Accounting for fish routing, river flows and other factors shows that export effects (both direct and indirect) exhibit a relatively small influence on through-Delta salmon survival. Through-Delta survival is poor, but most of losses are unrelated to effects addressed by RPA Actions IV.2.1 and IV.2.3.

Exhibit 8. Spring Run Chinook DPM Results

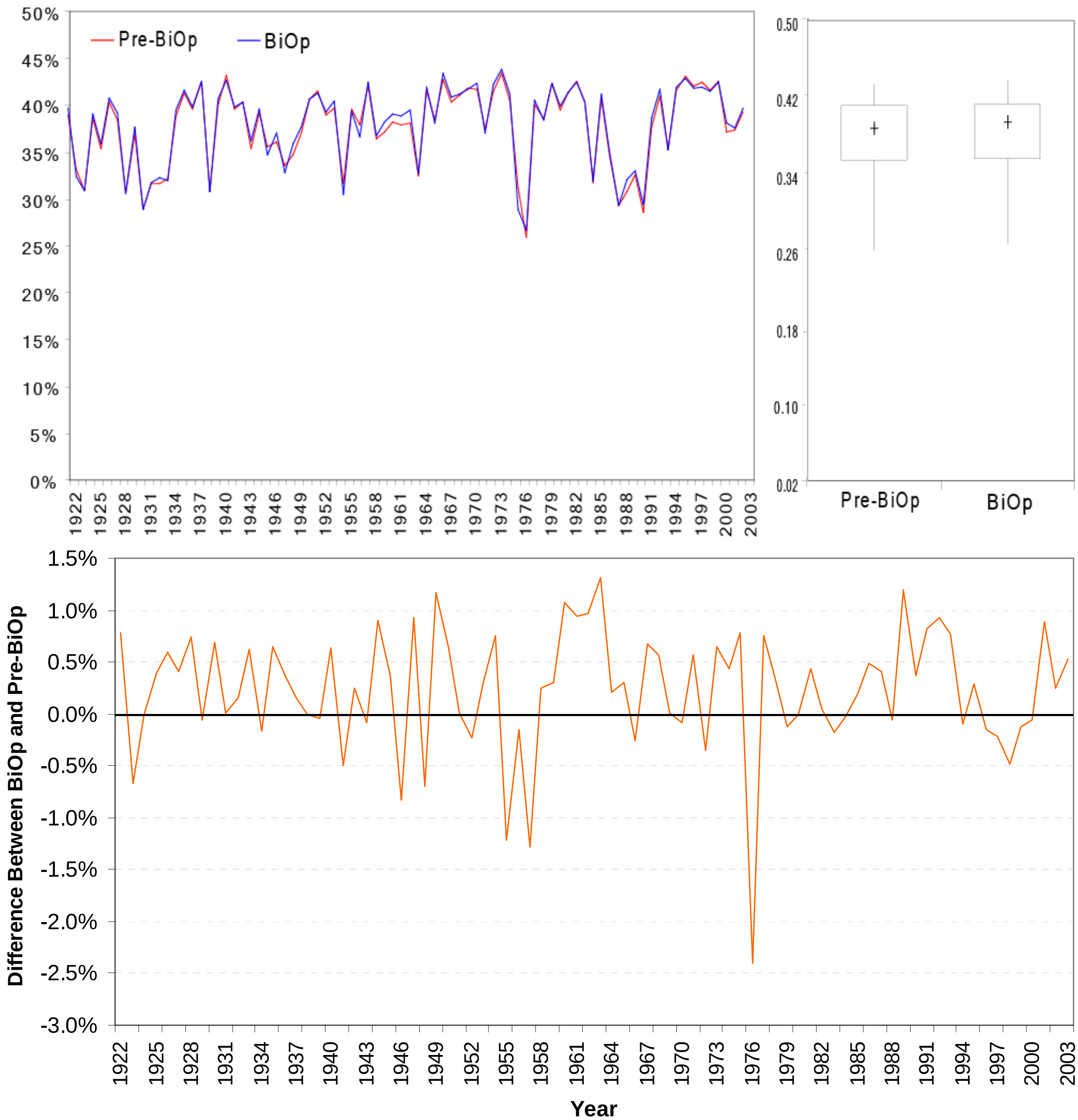


Exhibit 8. Juvenile spring run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps ("BiOp") and under "pre-BiOp" requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between "BiOp" and "Pre-BiOp". On average, spring run Chinook survival was 0.2% higher with the "BiOp" condition relative to the "Pre-BiOp".

Exhibit 9. SJR Fall Run Chinook DPM Results

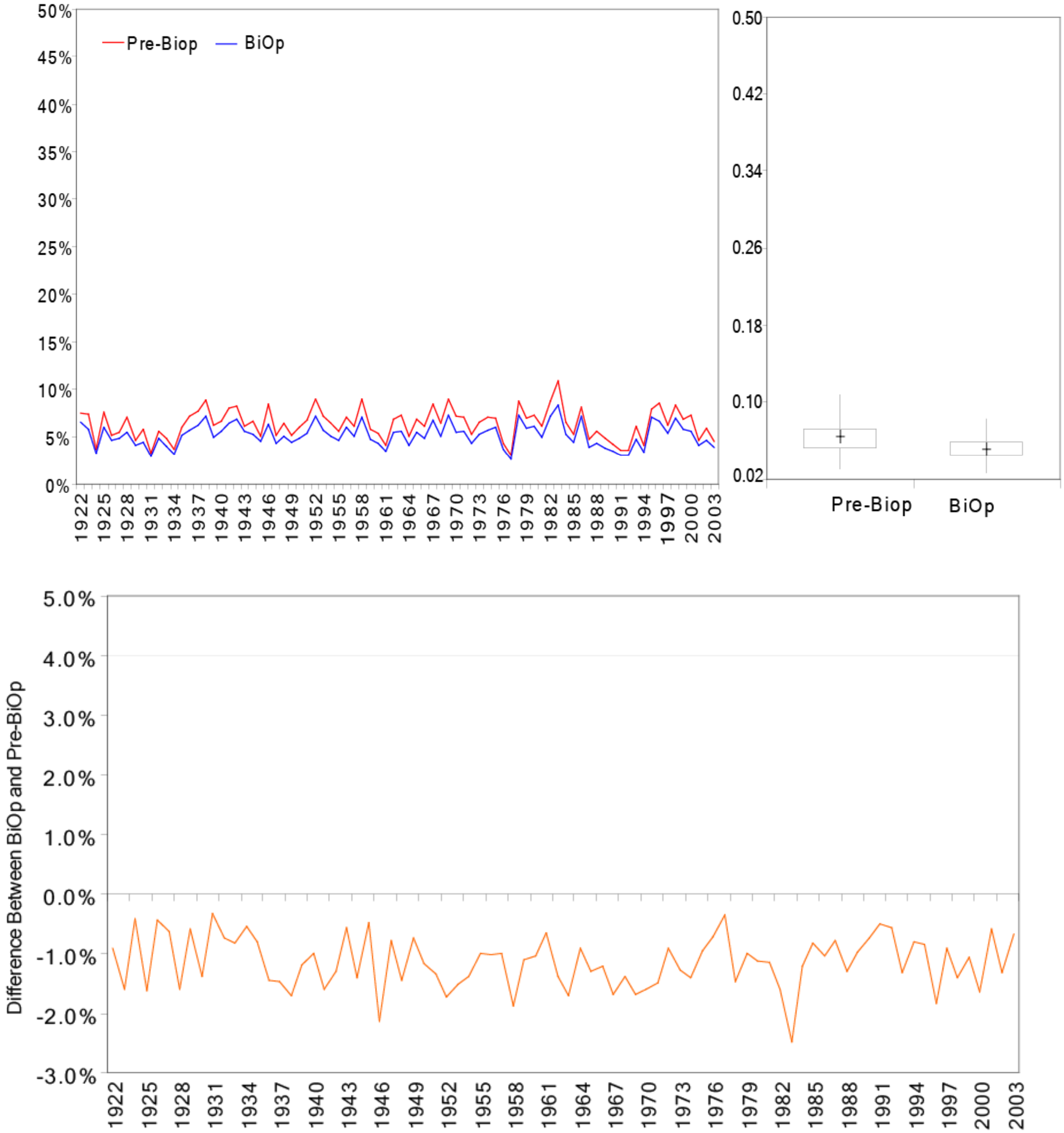


Exhibit 9. San Joaquin River juvenile fall run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps ("BiOp") and under "pre-BiOp" requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between "BiOp" and "Pre-BiOp". On average, SJR fall run Chinook survival was 1.1% lower with the "BiOp" condition relative to the "Pre-BiOp".

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IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

THE CONSOLIDATED SALMONID CASES

SAN LUIS & DELTA-MENDOTA WATER AUTHORITY; WESTLANDS WATER DISTRICT v. GARY F. LOCKE, as Secretary of the United States Department of Commerce; et al.

STOCKTON EAST WATER DISTRICT, et al. v. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, et al.

STATE WATER CONTRACTORS v. GARY F. LOCKE, Secretary, et al.

KERN COUNTY WATER AGENCY, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.

OAKDALE IRRIGATION DISTRICT, et al. v. UNITED STATES DEPARTMENT OF COMMERCE, et al.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA v. NATIONAL MARINE FISHERIES SERVICE, et al.

1:09-cv-1053 OWW-DLB
1:09-cv-1090 OWW-DLB
1:09-cv-1378 OWW-DLB
1:09-cv-1520 OWW-SMS
1:09-cv-1580 OWW-DLB
1:09-cv-1625 OWW-SMS

SECOND DECLARATION OF BRADLEY CAVALLO IN SUPPORT OF PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION

Date: March 8, 2011
Time: 1:30 p.m.
Ctrm: 3
Judge: The Honorable Oliver W. Wanger

I, Bradley Cavallo, declare as follows:

1. I have 13 years of experience working with anadromous fishery issues in Central California. I am currently a Senior Scientist and President of Cramer Fish Sciences in Auburn, California, where I have worked since 2006. Prior to this position, I was employed from 2003 until 2006 as a Senior Environmental Scientist and from 1999 to 2003 as an Environmental Scientist at the California Department of Water Resources in Sacramento, California. Prior to these positions, I was employed as a Fisheries Biologist at the California Department of Fish and Game in Stockton, California. In 1997, I earned a Master of Science degree in Aquatic Ecology from the University of Montana at Missoula. In 1994, I earned a Bachelor of Science in Wildlife and Fisheries Biology from University of California at Davis. I have authored numerous fishery reports, published papers and made many scientific presentations in the field of fisheries science. In the course of my professional career and education, I have attained expert knowledge of regulated rivers and estuaries, particularly related to the ecology of Chinook salmon and other anadromous fishes.

2. I have read the Sixth Declaration of Jeffrey Stuart in Support of Federal Defendants' Opposition to Plaintiff's Motion for Preliminary Injunction (Doc. 571).

I. EXPORT EFFECTS ON DELTA HYDRODYNAMICS

3. In paragraph 40 of the Sixth Stuart Declaration, Mr. Stuart agrees with my observation that the particle tracking model (PTM) is based upon DSM2 HYDRO model results. (Corrected Sixth Decl. of Jeffrey Stuart in Supp. of Fed. Defs.' Opp'n to Pls.' Mot. for Prelim. Inj. (Sixth Stuart Decl.) (Doc. 571) at ¶ 40.) Mr. Stuart suggests that this alleged consideration of the shorter time period by NMFS justifies NMFS use of the PTM to explain salmon behavior. Mr. Stuart then concludes this dependence demonstrates that the PTM represents the shorter time intervals which I have repeatedly suggested are most appropriate for assessing juvenile salmonid movements. (Sixth Stuart Decl. at ¶ 40; Cavallo Decl. in Supp. of Pl.-Intervenor Department of Water Resources Mot. for Summ. J. (Cavallo Decl. in Supp. of DWR Mot. Summ. J.) (Doc. 452) at ¶¶ 36-38.) However, the fact that the PTM calculates particle movements every 15 minutes

does not justify its use in the Salmon Biological Opinion (BiOp). The relevant question is the time-scale at which PTM results are reported and used for crafting management decisions. As Kimmerer and Nobriga (2008) indicated, PTM results are reliable only if "allowed to run long enough to resolve the particles' ultimate fate," which typically takes from 30 to 90 days. (AR 00122246.) Even so, NMFS has never provided any evidence showing how PTM results for periods less than 30 days were used to develop or support RPA Action IV.2.1 or Action IV.2.3.

4. In paragraph 42, Mr. Stuart cites a number of acoustic tagging studies for his view that the "gradual effects of negative flows" influence salmon behavior. (Sixth Stuart Decl. at ¶ 42.) The findings from these studies are entirely consistent with my descriptions of salmonid movements in the Delta, and with my conclusions regarding the minimal opportunity for adverse export effects. For example, Stuart reports the median travel time from Durham Ferry to Chipps Island was 8.5 days (based upon Holbrook et al. 2009). (*Id.*) Approximately seventy-two river miles separate Durham Ferry and Chipps Island, and thus acoustically tagged smolts covering this distance in 8.5 days are moving at a very rapid pace; <u>8.5 miles per day on average</u>. At the conclusion of paragraph 42, Mr. Stuart opines that such movement rates provide "ample time [for fish] to be influenced by several tidal cycles and the effects of export pumping[.]" This statement is not supported by the referenced acoustic tagging studies and is entirely speculative; Mr. Stuart provides neither hydrodynamic data nor fish studies to support this assertion.

5. Perhaps most importantly, none of the observations from acoustic tagging studies described by Mr. Stuart affirm PTM as a useful representation of salmonid movements. In contrast, these studies further highlight the substantial discrepancies between PTM predictions and fish behavior. While Holbrook et al. estimated an average travel time of 8.5 days from Durham Ferry to Chipps Island, Kimmerer and Nobriga's (2008) found that particles traveling from Mossdale (downstream of Durham Ferry) took 35 to 70 days for just half of the particles ultimately arriving at Chipps Island to get there. (Kimmerer and Nobriga 2008, Figure 6.) These differences between acoustically tagged Chinook and PTM predictions only add to the discrepancies between PTM and fish behavior which I have described at length previously. (Cavallo Decl. in Supp. of DWR Mot. Summ. J. ¶¶ 52-56).

6. Action IV.2.3 and IV.2.1 are largely predicated upon NMFS' hypothesis that more negative OMR flows (i.e. greater exports) draw a substantial proportion of salmonids off of their normal migratory routes and towards the south Delta export facilities. (BiOp p. 652, AR 00106732.). Thus the behavior of juvenile salmonids at channel junctions (properly be viewed as "forks in the road") in response to tides, river flows and exports is critical to evaluating these RPA Actions.

7. In paragraph 43, Mr. Stuart asserts "net change in the tidally influenced hydrodynamics…still influences the behavior of fish." (Sixth Stuart Decl. at ¶ 43.) However, this is only Mr. Stuart's speculation. Mr. Stuart does not provide or discuss hydrodynamic data which supports his hypothesis regarding export effects at channel junctions. Neither Moser et al (1991), nor Hankin et al (2010) provides such data. (discussed further in paragraph 26 below.) As such, Mr. Stuart has no factual basis for specifying a hydrodynamic mechanism by which exports would alter route selection at channel junctions. Lastly, Mr. Stuart fails to cite any fish studies which support his hypothesis for adverse hydrodynamic effects. Later in his declaration Mr. Stuart does cite to Vogel (2004) stating "net negative flows were identified as a potential reason for the observed distribution of tagged fish." (Sixth Stuart Decl. at ¶ 47.) As has been discussed before, this is a misrepresentation of Vogel's findings; Vogel does not attribute his observations to export-induced "net negative flows" as Mr. Stuart implies. (Cavallo Decl. in Supp. of DWR Mot. Summ. J. ¶ 86.)

8. In contrast, I have conducted a detailed assessment of how exports influence Delta hydrodynamics (using DSM2 HYDRO) which was presented in my previous declaration. For the sake of clarity, I include those exhibits again here (with some cosmetic revisions) as Exhibits A1, A2 and A3. Though other types of analysis are certainly possible, I chose to calculate and present changes in occurrence of negative flows for all available DSM2 HYDRO channels. This choice was based upon the analysis and findings described by Perry (2010). In brief, Perry showed that fish arriving at the junction of Georgiana Slough were more likely to leave the main river channel if they arrived at a time when flows in the main stem Sacramento River were negative. (Perry 2010, at p. 171-172.)

9. More specifically, Perry determined that the probability of fish entering Georgiana Slough (from the Sacramento River) was a function of just three variables: *U* (the occurrence of negative flows at the time fish arrived), *Qs* (Sacramento River flows at the time fish arrived) and *Qg* (Georgiana Slough flows at the time fish arrived). However, junctions of the San Joaquin River hypothesized to be important by NMFS are only partially analogous to the Georgiana Slough junction analyzed by Perry (2010). The primary difference is that Georgiana Slough is influenced by river flow and tides, where junctions of San Joaquin River (except at the Head of Old River) are only affected by tides.

10. Perry observed that increased Sacramento River flows at the Georgiana Slough junction dampened tidal forces, and effectively decreased the period of time during which negative flows occurred. In contrast, my analysis of DSM2 HYDRO data indicates tidal forces dominate all of the San Joaquin River junctions identified by NMFS. (Exhibit B.)

11. Unfortunately, no analysis comparable to Perry's has been conducted for predominantly tidal junctions on the San Joaquin River. However, given Perry's findings at Georgiana Slough, and because river flow effects are absent, it is reasonable to conclude that *U* (the occurrence of negative flows at the time fish arrived) would be a primary determinant of fish route selection at junctions of the San Joaquin River. Mr. Stuart's contention that my analysis of the San Joaquin River is incomplete is inconsistent with Perry 2010 and the above described differences between junctions on the lower San Joaquin River basin and Georgiana Slough on the Sacramento River.

12. Mr. Stuart's opinion regarding the factors influencing route selection is described in his paragraph 48 where he states, "the ultimate path would be <u>strongly dictated by</u> the relative magnitude of the <u>net flows</u> into the different channels when fish are present." (Sixth Stuart Decl. at ¶ 48 (emphasis added).) To support this claim, Mr. Stuart cites the findings of Holbrook et al. (2009) and states, "fish entering the Old River channel from the main river channel of the San Joaquin, at the head of Old River, correlated with the fraction of river discharge entering the Old River channel." (*Id.*) However, Mr. Stuart has confused the magnitude of the net flows, which Holbrook did not use, with the proportion of flows present at the time a fish arrives at the

junction. Analogous to Perry (2010), Holbrook found a correlation with the proportion of flow at the exact time fish arrived at the junction not with the "magnitude of net flows" as Mr. Stuart claims. Net flows are, by definition, averaged over some time period, usually 24-hours.

13. Like the Georgiana Slough junction, the Head of Old River junction is influenced both by tides and river flows, and thus both are imperfect analogies to downstream junctions on the main stem San Joaquin River which are influenced only by tides. However, in simplest terms, the observations from Perry (2010) and Holbrook et al. (2009) show route selection is strongly influenced by the direction of flow at the time fish arrive at junction. My analysis (Exhibits A1, A2, and A3) shows that at junctions of the San Joaquin River, exports have very little influence on the duration of negative flows. Thus, there is no mechanism consistent with findings of Perry and Holbrook et al. by which exports could substantially alter route selection at junctions of the San Joaquin River. Mr. Stuart's contention that route selection at tidal junctions is determined by flows averaged over 24 hours (i.e. net flow) is not supported by any studies, and is in direct conflict with the mechanisms of route selection described by Perry (2010) and Holbrook et al. (2009).

14. In Exhibit 1 of my previous declaration, I presented flow data for Delta location RSAN014 to illustrate how large the magnitude of tidal flux can be relative to very subtle changes in "net negative flows" which can result from South Delta exports. (Decl. of Bradley Cavallo in Supp. of Pls.' Mot. for Prelim. Inj. (Cavallo Decl. in Supp. Prelim. Inj.) Exhibit 1 (Doc. 552-1).) This exhibit was clearly provided as an illustrative example, not representative for the Delta as a whole. However, Mr. Stuart still objected to the location I selected. Mr. Stuart suggested, "picking a point farther upstream near the confluence of the Mokelumne River with the main stem of the San Joaquin River would give a more useful set of information since this is where fish from the Sacramento River enter the region influenced by the exports." (Sixth Stuart Decl. at ¶ 44.)

15. I have taken Mr. Stuart at his word and have prepared an exhibit and presented detailed data depicting flows over 24-hours at DSM2 HYDRO Channel 44 which is located, precisely as suggested by Mr. Stuart, on the main stem San Joaquin River immediately upstream

of its confluence with the Mokelumne River. The data source and methods for generating this data are described in my previous declaration. (Cavallo Decl. in Supp. Prelim. Inj.) (Doc. 552) at ¶¶9, 10.)

16. For clarity, I present DSM2 HYDRO data in identical formats for both RSAN014 and Channel 44. Data generated by DSM2 HYDRO for RSAN014 is listed in Exhibit C1 attached to this declaration. Data generated by DSM2 HYDRO for Channel 44 is listed in Exhibit C2 attached to this declaration. Flows at 15-minute increments at RSAN014 and at Channel 44 are plotted in Exhibit D attached to this declaration. Tabular summary results of flows at both locations are listed Exhibit E attached to this declaration.

17. Flows at Channel 44 were generally very similar to flows at RSAN014. Tidal flux at both locations was very large; the difference between peak flood and peak ebb tides was roughly 194,000 cfs at Channel 44 and 197,000 cfs RSAN0114. At Channel 44, peak positive flows were as high as 90,000 cfs and peak negative flows were as low as -107,000 cfs. (Exhibit E). At RSAN014, peak positive flows were as high as 94,000 cfs and peak negative flows were as low as -104,000 cfs. (Exhibit E.) If tidal flux is ignored and average (or net) flows are calculated, the observed flow values at Channel 44 were -4,241, -7,006, and -9,818 cfs at exports of 2,000, 6,000 and 10,000 cfs, respectively. Average (or net) flows at RSAN0114 were -220, -2,263 and -4,337 cfs at exports of 2,000, 6,000 and 10,000 cfs, respectively.

18. In my previous declaration I produced a series of maps (resubmitted here as Exhibits A1, A2 and A3) showing how the occurrence of negative flows changed with increasing exports. As I indicated previously, those maps were based on data from 517 DSM2 HYDRO channels. The tables shown in Exhibit E provide the same results depicted in Exhibit A for RSAN014 and Channel 44 in a tabular form. The percent change in the occurrence of negative flows at Channel 44 was less than 1% as export increase from 2,000 to 6,000 cfs, and 1% as exports increase from 6,000 to 10,000 cfs. At RSAN014, the percentage change in the occurrence of negatives flows was less than 1% as export increase from 2,000 to 6,000 cfs, and 2.1% as exports increase from 6,000 to 10,000 cfs.

19. In paragraph 45, Mr. Stuart states that my analysis of negative flow occurrences is incomplete, and claims that, "increasing exports increases the magnitude of negative flows, and decreases the magnitude of positive flows." (Sixth Stuart Decl. at ¶ 45.) Mr. Stuart cites no original evidence to support this assertion, but points only to his visual inspection of Exhibit 1 of my Declaration in Support of Plaintiffs' Motion for Preliminary Injunction. Regardless of what Mr. Stuart may see in the exhibits, the numbers are clear, the data does not support Mr. Stuart's conclusion.

20. At RSAN014, as exports increase from 2,000 to 6,000 cfs the magnitude of peak positive flows decreases from 94,858 to 92,886 cfs; a change of just 2.1%. As exports increase from 6,000 to 10,000 cfs the magnitude of peak positive flows decreases from 92,886 to 91,554 cfs; a change of just 1.4%. (Exhibit E).

21. At Channel 44, as exports increase from 2,000 to 6,000 cfs the magnitude of peak positive flows decrease from 90,004 cfs to 87,065 cfs; a change of 3.3%. As exports increase from 6,000 to 10,000 cfs the magnitude of peak positive flows decreased from 87,065 to 84,534 cfs: a change of 2.9%. (Exhibit E.)

22. At RSAN014, as exports increase from 2,000 to 6,000 cfs the magnitude of peak negative flows decreased from -102,356 to -103,231 cfs; a change of 0.9%. As exports increase from 6,000 to 10,000 cfs the magnitude of peak negative flows decreased from -103,231 to -104,576 cfs: a change of 1.3%. (Exhibit E.)

23. At Channel 44, again the location specifically requested by Mr. Stuart, the export effect is again similar to that observed at RSAN014. As exports increase from 2,000 to 6,000 cfs the magnitude of peak negative flows decreased from -104,977 to -106,068 cfs; a change of 1.0%. As export increase from 6,000 to 10,000 cfs the magnitude of peak negative flows decreased from -106,068 to -107,527 cfs: a change of 1.4%. (Exhibit E.)

II. DELTA SCIENCE PROGRAM VAMP REVIEW

24. Mr. Stuart provides numerous citations to the Delta Science Program review of the VAMP studies (Hankin et al. 2010). I have reviewed this report and find that it provides no

evidence which affirms the rationale or likely effectiveness of RPA Actions IV.2.1 and IV.2.3. However, in multiple instances Mr. Stuart appears to misrepresent findings from Hankin et al. (2010).

25. At his paragraph 43, Mr. Stuart states that salinity gradient may be a factor used as a navigation guide by juvenile salmonids migrating through the Delta and Mr. Stuart cites Hankin et al. (2010) to support this claim. (Sixth Stuart Decl. at ¶ 43.) However, in contrast to Mr. Stuart's usage, the VAMP review dismissed the importance of salinity gradient stating, "while salinity would seem like an obvious cue for migration, there is little evidence of that (Williams, 2006)." (Hankin et al (2010) at p. 13.) Hankin et al. went on to conclude, "it seems likely that successful navigation must depend to some degree on factors other than the direction of the net current alone." (*Id.*) The review panel indicated that sun position or cues from the Earth's magnetic field were the cues most likely relied upon in tidal habitats (i.e. areas with turbidity and weak river flow signals). (*Id.*)

26. Also regarding juvenile salmonid navigation, Mr. Stuart states, "Other factors may be physical, such as orienting to the <u>ambient flow fields</u> in the river channel and moving in the direction of <u>net flow fields</u> (emphasis added) (Moser *et al.* 1991 as cited in Hankin *et al.* 2010)." (Sixth Stuart Decl. at ¶ 43.) Mr. Stuart's use of the words "ambient flow fields" and "net flow fields" creates the impression that Hankin et al. agrees with and supports Stuart's notion that net negative flows in tidally influenced portions of the Delta could substantially alter juvenile salmonid navigation. However, the results of Moser et al. (as described by Hankin et al.) say nothing of the influence from "net flow fields." Rather, Hankin et al. attribute to Moser et al. (1991) the following, "coho salmon smolts were displaced rapidly downstream by swift, <u>unidirectional river currents</u> but were retained in the estuary by relatively <u>low-velocity, reversing tidal currents</u>." (Hankin et al. (2010) at p. 13 (emphasis added).) Hankin et al. does not support Mr. Stuart's notion of "net flow fields" disrupting the migratory behavior of juvenile salmonids, because Hankin et al. and Moser et al. address the impact of unidirectional river current and reverse tidal current, and do not address "net flow fields."

27. Hankin et al. (2010) discusses reverse flows and the potential for adverse effect on juvenile salmonids, and Mr. Stuart quotes the VAMP review panel report as stating, it is "biologically untenable to imagine that downstream-migrating salmon can easily navigate to the main stem Sacramento River by migrating in a direction that would appear, based on net flow direction as upstream to them." (Sixth Stuart Decl. at ¶ 57, citing Hankin et al. 2010 at p. 8.) Though Mr. Stuart represents this quote as a general conclusion of the VAMP review panel and therefore generally supportive of his rationale for Action IV.2.3, it clearly is not. Rather, the quote comes from a section of the VAMP review which discussed likely effectiveness of a fish barrier located at the Head of Old River. The discussion preceding this quote makes clear only Old and Middle River (just north of the South Delta export facilities) is being discussed; <u>not net negatives flows in the Delta generally.</u> (Hankin et al. 2010 at pp. 6-7.) Thus, this quote does not support NMFS contention that Actions IV.2.3 and IV.2.1 will improve juvenile salmonid survival by reducing movements into the interior Delta from junctions along the San Joaquin River.

28. The VAMP review report mentions export-induced reverse flows and related salmonid effects in several other instances, but the discussion is always linked to Old and Middle River of the interior Delta. Regarding export effects for fish migrating down the main stem San Joaquin River, the panel stated only that effects could, "conceivably occur...if exports are sufficiently high." (Hankin et al. 2010 at p. 19.) However, Hankin et al. (2010) does not indicate what this export level might be, nor does it provide fish or hydrodynamic data to support or test this potentiality.

29. The VAMP report reviews all available studies which have attempted to quantify indirect export effects on San Joaquin River origin juvenile salmonids. Its conclusion is the same as my own: studies provide no evidence for an adverse export effect on San Joaquin River salmonids. Significantly, the VAMP review report does not consider the Delta Action 8 studies of Newman and Brandes (2010). This omission is consistent with my previously stated position that Delta Action 8 studies should not be used to identify or support management strategies for San Joaquin River origin juvenile salmonids. (Cavallo Decl. in Supp. of DWR Mot. Summ. J. ¶ 21.)

30. Mr. Stuart claims I have concluded there is no export effect and thus am in conflict with the conclusions of the VAMP review panel. (Sixth Stuart Decl. at ¶ 57.) This statement misrepresents my clearly stated opinion from my summary judgment declaration:

> The fact that decades of research have failed to show the hypothesized adverse export effect leads a reasonable biologist to conclude that an effect either does not exist, or that the effect may exist but is small, difficult to detect and therefore likely not biologically significant relative to other factors influencing salmon survival in the Delta.

(Second Decl. of Bradley Cavallo in Supp. of Pl.-Intervenor DWR Mot. Summ. J. (Doc. 497) ¶ 5, citing Cavallo Decl. in Supp. of DWR Mot. Summ. J. ¶ 6:22-23.)

31. Second, contrary to Mr. Stuart's implication, the VAMP review panel did not find or present evidence for a biologically significant export effect. The VAMP review panel recommended no specific export restrictions. The VAMP review panel concluded only that, under some hypothetical and unspecified conditions, exports might have something other than "no effect." (Hankin et al. (2010) at p. 5.) However, exports do not operate under hypothetical, unbounded conditions. Rather exports are already constrained by conditions of Water Rights Decision 1641 and by "take" restrictions. While I agree that some export effect (likely small) does exist, this conclusion and the conclusions of the VAMP review panel in no way justify or support the calendar-based OMR restrictions of Action IV.2.3.

32. Mr. Stuart takes further liberties interpreting the conclusions of the VAMP review panel. In his paragraph 113, he states, "Hankin et al. (2010) considered the south Delta to be a 'confusion zone' and <u>anything that could be done</u> to assist salmonids in staying in the San Joaquin River main channel and quickly exiting the delta to the estuary <u>would be of great benefit to their survival</u>." (Sixth Stuart Decl. at ¶ 113, (emphasis added).) <u>The VAMP review panel report does not make this recommendation</u>. Hankin et al. (2010) mentions a "confusion zone," but this is attributed only to the portion of the Delta near the export facilities and is mentioned only in the context of the value likely to result from placing a barrier at the Head of Old River. (Hankin et al. (2010) at p. 31.)

33. In reality, the VAMP review panel was highly circumspect, regarding management actions to benefit juvenile salmon, they concluded:

> Panel members are in agreement that simply meeting certain flow objectives at Vernalis is unlikely to achieve consistent rates of smolt survival through the Delta over time. The complexities of Delta hydraulics in a strongly tidal environment, and high and likely highly variable impacts of predation, appear to affect survival rates more than the river flow, by itself, and greatly complicate the assessment of effects of flow on survival rates of smolts. And overlaying these complexities is an apparent strong trend toward reduced survival rates at all flows over the past ten years in the Delta. Nevertheless, the evidence supports a conclusion that increased flows generally have a positive effect on survival and that it is desirable, to the extent feasible, to reduce or eliminate downstream passage through the Old River channel.

(Hankin et al. 2010, p. 3 (emphasis added).) Thus, the review panel recommended increased San Joaquin River flows and implementing measures to reduce fish entering Old River. As will be described below, RPA Action IV.2.1 is ineffective in increasing San Joaquin River flows. The desirability of actions to reduce fish movement into Old River is undisputed.

34. In contrast to its judgment regarding flows, the VAMP review panel's report makes no specific recommendations regarding exports, stating only, "it makes sense during VAMP to continue limiting exports to some fraction of San Joaquin River flow…so that the entire flow of the San Joaquin River is not diverted." (Hankin et al. (2010) at p. 9). This recommendation would support an inflow to export ratio of 1:1, but does not support the 4:1 ratio required by Action IV.2.1 at inflows greater than 6,000 cfs.

III. RIVER INFLOWS WITH THE BIOP

35. Mr. Stuart describes the intent of RPA Action IV.2.1 is "to provide flows in the lower San Joaquin River system of sufficient duration and magnitude" to improve juvenile salmonid survival. (Fourth Decl. of Jeffrey Stuart in Supp. of Federal Defs.' Mot. for Summ. J. and Opp'n to All Pls.' Mot. for Summ. J. (Doc. 485) at ¶ 22.) On this point I have previously stated, "There is no evidence available to suggest that the Action IV.2.1 will result in increased SJR flows . . . . [T]he poor design and faulty scientific underpinnings of the action will [be] largely ineffective in achieving the stated objective of increased SJR flows, and ultimately also ineffective in improving the survival juvenile salmonids originating from the SJR." (Cavallo Decl. in Supp. of DWR Mot. Summ. J. at ¶ 3.)

36. In my previous declaration I provided Exhibit 6 and showed that, consistent with my earlier prediction, Action IV.2.1 was not successful in increasing San Joaquin River flows. (Cavallo Decl. in Supp. Prelim. Inj., Exhibit 6.) Mr. Stuart, in his paragraph 51, points to CALSIM modeling from November 2009 and suggests that DWR has failed to include Vernalis flow requirements for April and May. (Sixth Stuart Decl. at ¶ 51.) I have discussed this matter with DWR modelers, and they have indicated CALSIM model output provided to me are correct and are consistent with 2009 OCAP BiOp requirements to the extent that compliance is feasible. (Exhibit F attached hereto.)

37. The apparent importance of river flows to survival of juvenile salmonid emigrants of the San Joaquin and Sacramento Rivers is well supported by available science and is largely undisputed. Though NMFS seems to recognize the importance of river inflows to juvenile salmonids, NMFS failed to anticipate that CVP deliveries alone might be inadequate to achieve San Joaquin River flows objectives described by Action IV.2.1. (See Exhibit F.) To better illustrate this unintended consequence of NMFS' export constraints, I have plotted changes in monthly average Sacramento River and San Joaquin River flows with BiOp and pre-BiOp conditions. As before, this CALSIM data was provided to me by DWR modelers.

38. In order to make the assessment of river inflows effects as relevant as possible to this proceeding, I acquired current water year predictions for the San Joaquin and Sacramento basins from http://cdec.water.ca.gov/cgi-progs/iodir/WSI. Water year index data indicated that for the Sacramento River basin 2011 was most likely to be either "Dry", "Below Normal", "Above Normal" or "Wet" (definitely not "Critically Dry"). Water year index data indicate that for the San Joaquin River basin 2011 is most likely to be either "Below Normal," "Above Normal," or "Wet." Based on these classifications, I calculated average monthly flows under each of these water year types and compared flows between BiOp and pre-BiOp conditions.

39. Exhibit G, attached hereto, shows average monthly San Joaquin River flows (at Vernalis) under the BiOp, relative to the pre-BiOp. During spring months affected by Actions IV.2.1 and IV.2.3, San Joaquin River flows changed very little (<10 cfs) with the BiOp, relative to the pre-BiOp.

40. Exhibit H, attached hereto, shows average monthly Sacramento River flows (at Hood) under the BiOp and relative to the pre-BiOp. Sacramento River flows in March decreased somewhat (<1,000 cfs) for all four water year types considered. Flows in April and May were largely unchanged, except for a less than 1,000 cfs decrease during "Wet" water year types. Sacramento River flows decreased substantially (between 2,000 and 4,000 cfs) in June for all water year types except "Wet."

41. Flow changes on the San Joaquin River for the Water Year types likely to occur in 2011 show that Action IV.2.1 is not effective in increasing San Joaquin River flows. Thus, we would not anticipate the action would provide any substantial benefit to outmigrating juvenile steelhead.

42. Flow changes on the Sacramento River for the Water Year types likely to occur in 2011 show that export restrictions associated with Action IV.2.1 and IV.2.3 seem to actually <u>decrease flows into the Delta from the Sacramento River in March, May and June</u>. When these reduced flows occur coincident with emigrating juvenile salmonids (including winter run, spring run Chinook, and Central Valley steelhead) reduced survival is likely to result (for example, see Perry 2010).

IV. THROUGH-DELTA SURVIVAL: THE DELTA PASSAGE MODEL

43. In my previous declaration, I provided results from the Delta Passage Model (DPM) to assess the effectiveness of RPA Actions IV.2.1 and IV.2.3. We began development of the Delta Passage Model three years ago, and have been working regularly with resources agency scientists to revise and improve the model. The most thorough review and revisions to the DPM were completed in the latter half of 2010 as part of the Bay Delta Conservation Planning (BDCP) process. Application of the Delta Passage Model for the BDCP included one all day workshop (August 24th, 2010), one half-day workshop (November 15th, 2010) and semi-weekly "Anadromous Theme Team" meetings in August, September and October. Scientific staff from NMFS as well as other resource agency scientists were present at these workshops and meetings. Though comments and revisions were suggested (and acted upon), the DPM was well received

and at no point did any participating federal or state agency scientist indicate the model was unfit to assess salmonid survival.

44. In his paragraph 51, Mr. Stuart provides some of his thoughts on deficiencies of the Delta Passage Model. (Sixth Stuart Decl. at ¶ 51.) Other than revisions which have already been made through BDCP, none of Mr. Stuart's comments are actionable; he speaks only of the need for more studies and the need to better account for predation in tag detection data. To the extent the problems identified by Mr. Stuart are valid, they are problems with telemetry studies themselves, not with how those studies were applied in the DPM. Most scientists recognize that models are always built with imperfect information. Scientists working on the application of DPM to the BDCP did not share Mr. Stuart's concerns regarding ostensible deficiencies of the model.

45. Mr. Stuart takes issue with how the DPM accounts for indirect mortality. (Sixth Stuart Decl. at ¶ 53.) Again, these criticism were not shared by NMFS and other resource agency staff participating in the DPM application for the BDCP project. In any case, Mr. Stuart continues to be confused regarding what sources of mortality can reasonably be attributed to exports and which cannot. In his paragraph 75, for example, Mr. Stuart attributes observations of "indirect mortality in the Delta" to the "research results from Perry and Skalski (2008), Vogel (2008) and Burau et al. (2007)." (Sixth Stuart Decl. at ¶ 75.) Mr. Stuart has been corrected on this error before, but he persists in repeating the misrepresentation. These studies provide only an assessment of mortality generally. They make no determination regarding the relative contribution of project operations to indirect mortality.

46. There are in fact studies which have quantified indirect mortality in the Delta. They are VAMP and pre-VAMP experiments analyzed by Newman (2008), and Delta Action 8 experiments analyzed by Newman and Brandes (2010). The findings from these studies were used to account for the indirect mortality in the Delta. Mr. Stuart may wish for a different accounting, but these are the only studies available which have evaluated salmon survival with varying levels of exports. Though mechanisms of indirect mortality can not be determined with

these studies, the experimental design and analyses used were expected to be effective in quantifying overall survival impacts from increased exports.

47. In discussing San Joaquin River fall-run Chinook DPM results in my previous declaration, I incorrectly attributed decreased survival with the BiOp to increased flows through Old River. Mr. Stuart was right to correct me. (Sixth Stuart Decl. at ¶ 56.) In fact, consistent with Mr. Stuart's correction, the DPM does represent reduced survival through Old River relative to the San Joaquin River route.

48. Contrary to my original explanation, the small difference in survival observed between the BiOp and pre-BiOp conditions for San Joaquin River fall-run Chinook is due primarily to the assumed presence of a physical barrier at the Head of Old River during April and May in the pre-BiOp condition. (Exhibit I, attached hereto.) However, pre-BiOp results without the Head of Old River barrier would be approximately equivalent to the results for the BiOp condition. We know this to be the case because CALSIM data shows that the BiOp does not appreciably change San Joaquin River inflows. (Exhibit G, attached hereto.) Export restrictions resulting from Action IV.2.1 and IV.2.3 would have no effect on DPM estimated survival because, consistent with the findings of Newman (2008) and others, there is no estimable adverse survival effect resulting from exports on San Joaquin River juvenile Chinook salmon.

49. In my previous declaration, I used the DPM to estimate and compare winter run and spring run Chinook survival with the BiOp and with pre-BiOp operations. (Cavallo Decl. in Supp. Prelim. Inj. at ¶ 22, 23.) However, my prior analysis did not account for the fact that many winter run Chinook salmon and spring run Chinook salmon smolts will have already passed through the Delta by March 11th, 2011 and thus would not be effected by RPA Actions IV.2.1 and IV.2.3. (See Sixth Stuart Decl. at ¶ 104 and 105.) Therefore, I adjusted the Delta Passage Model so that it only reflects flow and export differences which occur after February each year. Revised estimates for winter run Chinook are reported in Exhibit J to this Declaration. With this adjustment, winter run Chinook survival with the BiOp is <0.01% improved over the pre-BiOp condition. Revised estimates for spring run Chinook are reported in Exhibit K. With this

adjustment, spring run Chinook survival with the BiOp is 0.08% improved over the pre-BiOp condition.

V. Why juvenile Salmonids Occur in the South Delta

50. At a number of points in his declaration, Mr. Stuart makes clear that he believes that a primary reason juvenile salmonids occur in the South Delta is because of the hydrodynamic impacts of South Delta exports. For example, in paragraph 46 Mr. Stuart states:

> Mr. Cavallo concludes that exports do not affect salmonid movement because they do not significantly affect the amount of time that the flows are negatives. This conclusion is flawed because it fails to explain the very real observation that salmonids from the Sacramento River basin, as well as study fish released in waterways some distance from the export facilities are nonetheless still drawn towards the export facilities and recovered in salvage. If Mr. Cavallo's premise were correct, one would never expect to see fish from the Sacramento River Basin in the salvage, yet they are obviously present.

(Sixth Stuart Decl. at ¶ 46.) Thus, Mr. Stuart seems to believe that in the absence of exports, very few juvenile salmonids, and especially no Sacramento River origin salmonids, would occur in the South Delta in the vicinity of the export facilities. Mr. Stuart's logic seems to confuse the effect (juvenile salmonids presence in the South Delta) with the presumed cause. <u>In reality, it is perfectly reasonably that some proportion of juvenile salmonids would occur in the South Delta entirely independent of export levels.</u> Mr. Stuart does not seem to have considered this possibility.

51. In fact, analysis of coded wire tagging recoveries strongly suggests that presence of Sacramento River origin juvenile salmonids at the export facilities is not an indicator of adverse effects, but rather an indicator of high salmon abundance and improved through Delta survival generally. As part of my work with Cramer Fish Sciences, we recently conducted an analysis examining 92 juvenile Chinook salmon release groups made just upstream the Delta on the Sacramento River. The report describing the analysis is entitled "Assessment of Chinook salmon through-Delta survival with coded wire tagged hatchery releases, 1993-2005" and is attached as Exhibit L. Using ocean recoveries of coded wire tagged juvenile Chinook salmon, we modeled survival and tested hypotheses regarding how release-specific characteristics (release location, temperature at release, mean fish size), and outmigration conditions (river inflow, exports, water

quality) influenced apparent through-Delta survival. (Exhibit L, Table 1, attached hereto.) Ocean conditions were also included as a covariate to account for year-to-year survival variation occurring after Delta passage. Because salmon survival is thought to be adversely affected by exports and salvage loss, we hypothesized *a priori* that salvage loss of coded wire tagged individuals would be associated with decreased ocean recoveries. (Exhibit L, Table 2.) In fact, the contrary appears to be the case.

52. Model selection for our analysis indicated that the "best" model included predictors related to release-specific characteristics, flow, and water quality. Model averaging revealed that the proportion of fish salvaged was the only predictor of survival that was well supported by the data. (Exhibit L, Table 6.) Contrary to our expectations, greater salvage loss was associated with greater ocean recoveries, and thus better survival. We would not interpret this result to mean that salvage loss causes improved survival. Rather, the results suggest salvage loss is a much better indicator of positive through-Delta salmon survival, than it is an indicator of adverse export effects.

53. We are not aware of any other analysis which has tested for an association between salvage loss and relative salmon survival in the Delta. For example, Newman (2003) and Newman (2008) did not include salvage recoveries as a candidate explanatory variable for estimated relative survival; though they certainly could have.

54. Though common intuition would suggest salvage loss would, if anything, be an indicator of significant adverse export effects, this is not necessarily the case. If fish enter the South Delta with or without exports (as they almost certainly would), then higher exports would tend to "sample" a larger fraction of those fish which had already entered the southern Delta near export pumping. Fish lost directly or indirectly because of export pumping might not show up in studies of through-Delta survival (e.g. Newman 2008; VAMP) because: 1) the proportion of fish adversely effected by exports is relatively small, and/or 2) survival through the South Delta is already very poor, such that many fish not lost to exports, do not survive anyway, but are instead lost to non-export related mortality.

55. The results of our CWT analysis (described fully in Exhibit L) comport with other studies which have found little evidence for a strong adverse export effect and are also consistent with the subtle hydrodynamic effect exports exert through much of the Delta. (Exhibits A1, A2, A3, D, and E, attached hereto.) Mr. Stuart has constructed RPA Actions IV.2.1 and IV.2.3 with the presumption that it is primarily exports which move juvenile salmonids off their natural migration corridors and toward export facilities where they experience substantial direct and indirect mortality. Mr. Stuart's hypothesis is not supported by the salvage loss and ocean recovery results described above, or by the conclusions of tagged salmon survival analyses described in my previous declarations.

VI. NEW INFORMATION RELATED TO DELTA ACTION 8 EXPORT-SURVIVAL RELATIONSHIP

56. Newman and Brandes (2010) completed an analysis of coded wire tag experimental releases and found some evidence for decreased survival for fish released into Georgiana Slough as exports increased. Newman and Brandes described that further research should: 1) account for the proportion of Sacramento River fish which volitionally enter the interior Delta through Georgiana Slough/DCC, and 2) conduct comparable experiments using acoustically tagged Chinook salmon smolts. The first item has already been accomplished by our application of the Delta Passage Model. The second item was recently accomplished (at least in part) through an analysis by Perry (2010).

57. Perry (2010) analyzed eleven groups of acoustically tagged Chinook salmon released in the Sacramento River between December 2006 and January 2009. The analysis examined 932 acoustically tagged salmon smolts, including 287 which entered the interior Delta as they moved from the Mokelumne River into the mainstem San Joaquin River adjacent to DSM2 Hydro Channel 44 (e.g. flows depicted in Exhibit D). Perry modeled survival to Chipps Island for these acoustically tagged fish and examined release group, year, and route and also tested for covariates related to flows and exports experienced by individual tagged fish. Perry found Sacramento River flow was positively associated with survival for fish migrating through the Sacramento

River and Sutter-Steamboat Slough routes. In fact, this positive flow relationship is included in the DPM. Regarding export effects, Perry found that including exports in the model did not significantly improve model fit. Perry (2010) went on to explain that the inability to detect an export effect could be attributed to the relatively small sample size and to the environmental complexity of the interior Delta. However, this result combined with the already tenuous export-survival relationship identified by Newman and Brandes (2010) suggests there is ample cause to question the reliability of the Delta Action 8 export-survival relationship as a foundation for water operations management.

CONCLUSIONS

58. Based on the findings presented here and in my previous declaration, it is my opinion that enjoining the inflow export ratio component of RPA Action IV.2.1 and the calendar based Old and Middle River flow component of IV.2.3 through this water year will not appreciably reduce the likelihood of survival or recovery or appreciably diminish the critical habitat of the listed salmonids in the BiOp.

I declare under penalty of perjury under the laws of the State of California and the United States that the foregoing is true and correct. Executed this 28th day of February 2011 at Auburn, California.

BRADLEY CAVALLO

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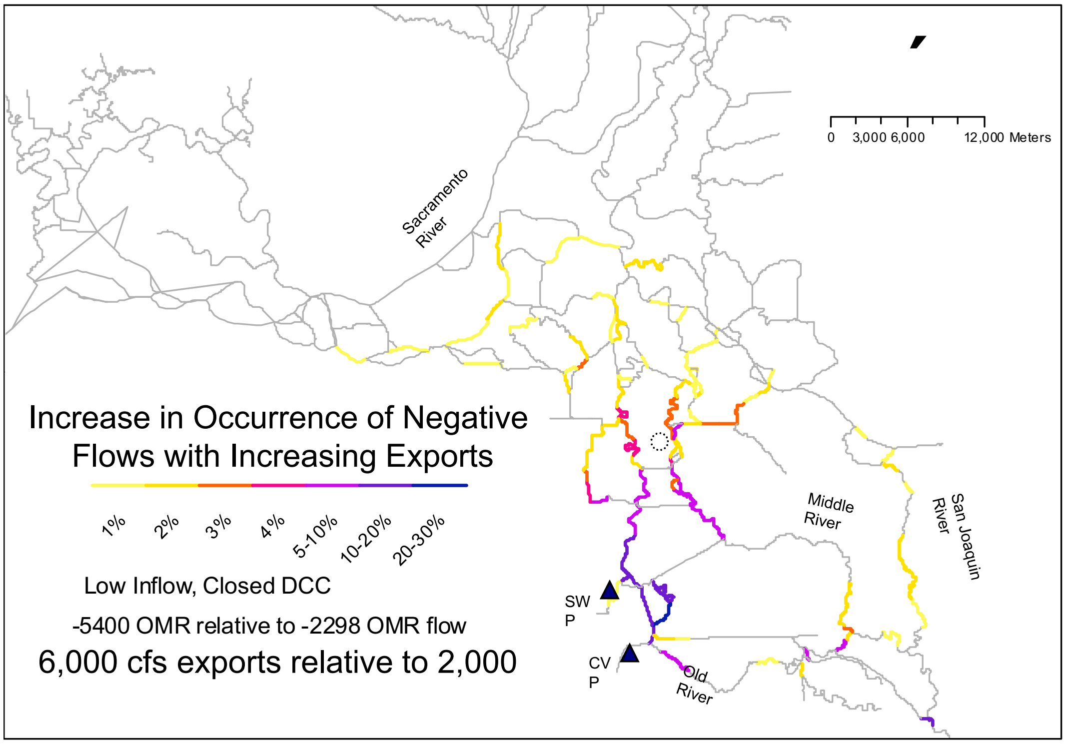
Exhibit A1. DSM2 HYDRO, Low Inflows



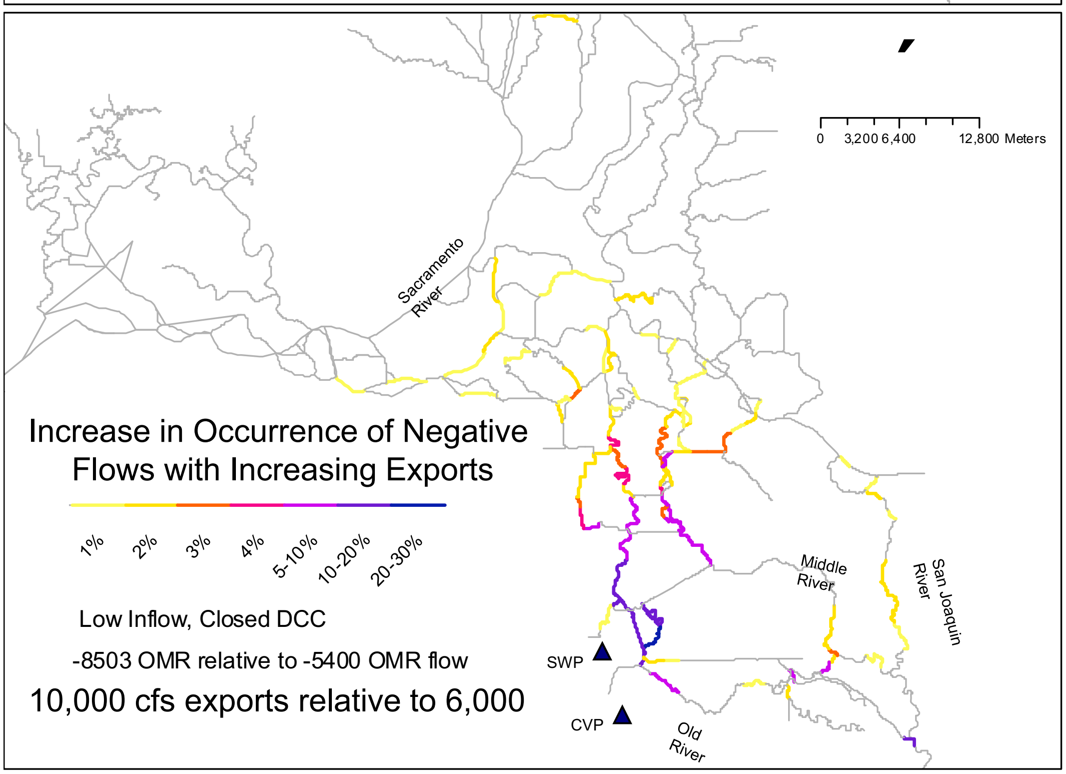
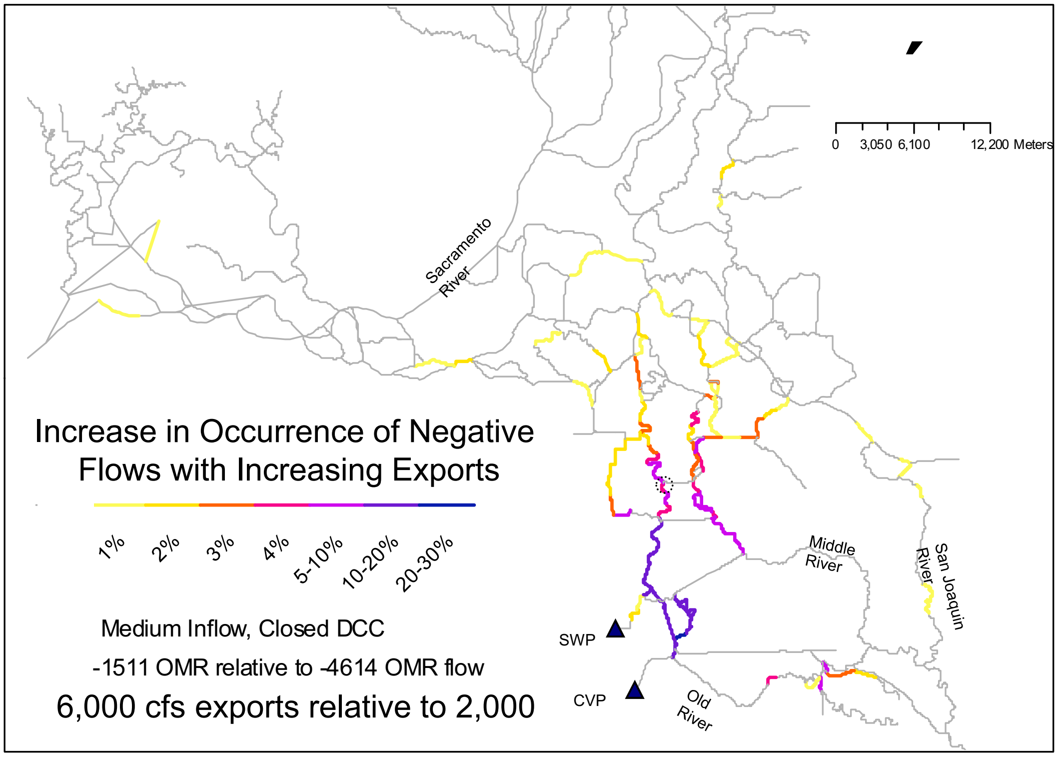


Exhibit A1. Percentage increase in the occurrence of negative flows during low river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no negative change. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

Exhibit A2. DSM2 HYDRO, Medium Inflows



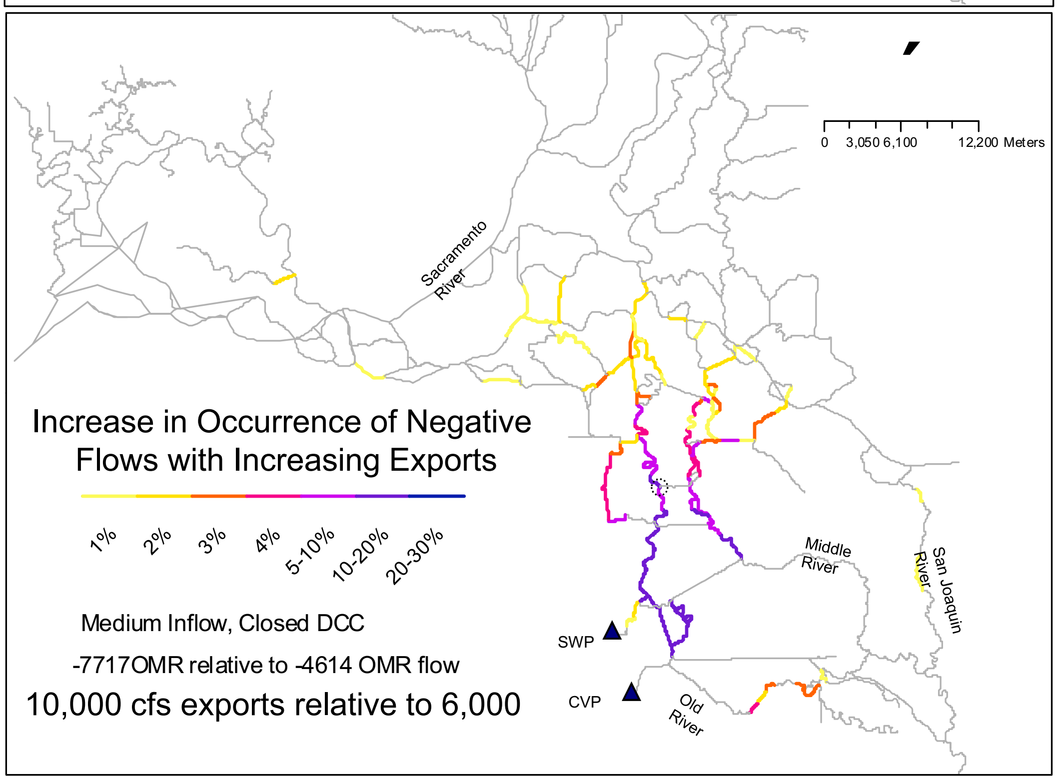
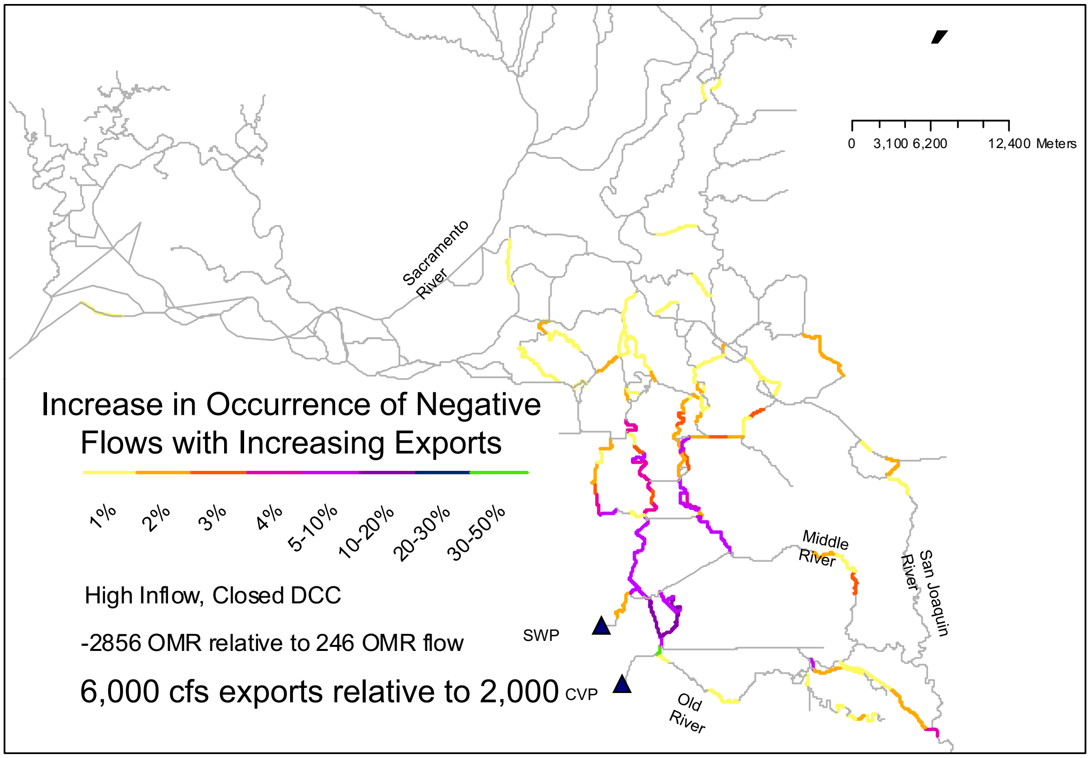


Exhibit A2. Percentage increase in the occurrence of negative flows during medium river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no change in negative flows. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

Exhibit 4. DSM2 HYDRO, High Inflows



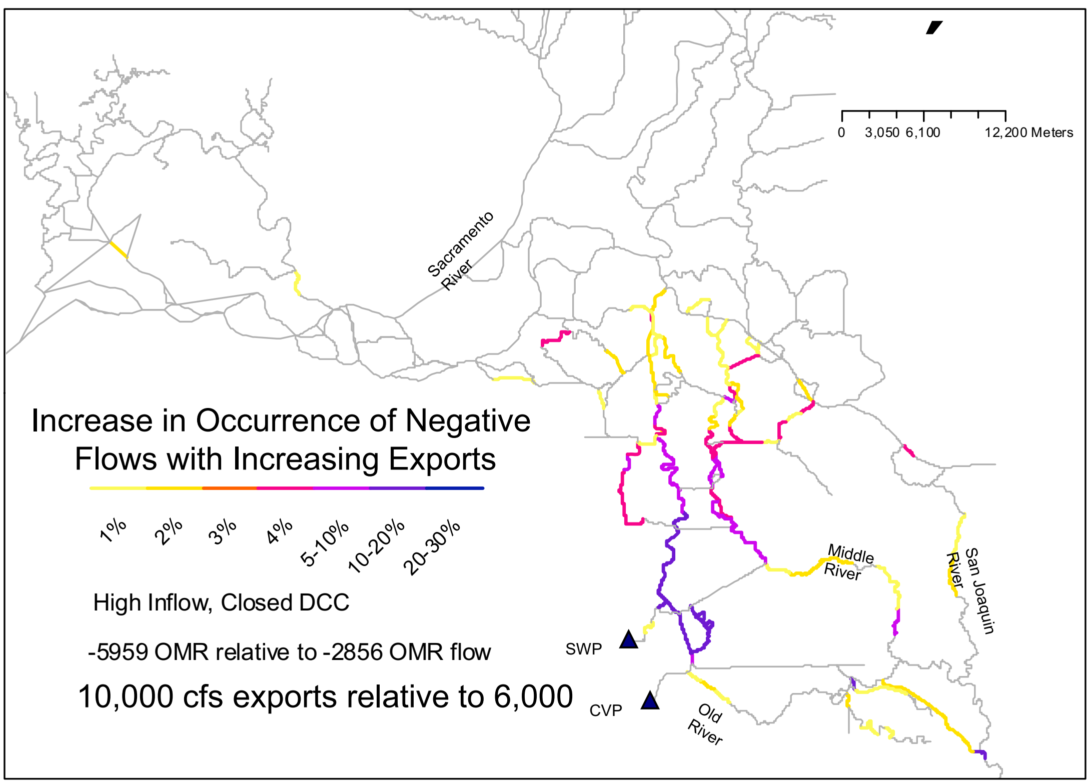


Exhibit A3. Percentage increase in the occurrence of negative flows during high river inflow conditions as exports change from 2,000 cfs to 6,000 cfs (upper panel) and from 6,000 cfs to 10,000 cfs (lower panel). Grey color indicates no change in negative flows. Yellow, orange, and red indicate 1 to 4% increase in negative flows. Purple and blue indicates negative flow increases from 5 to 30%.

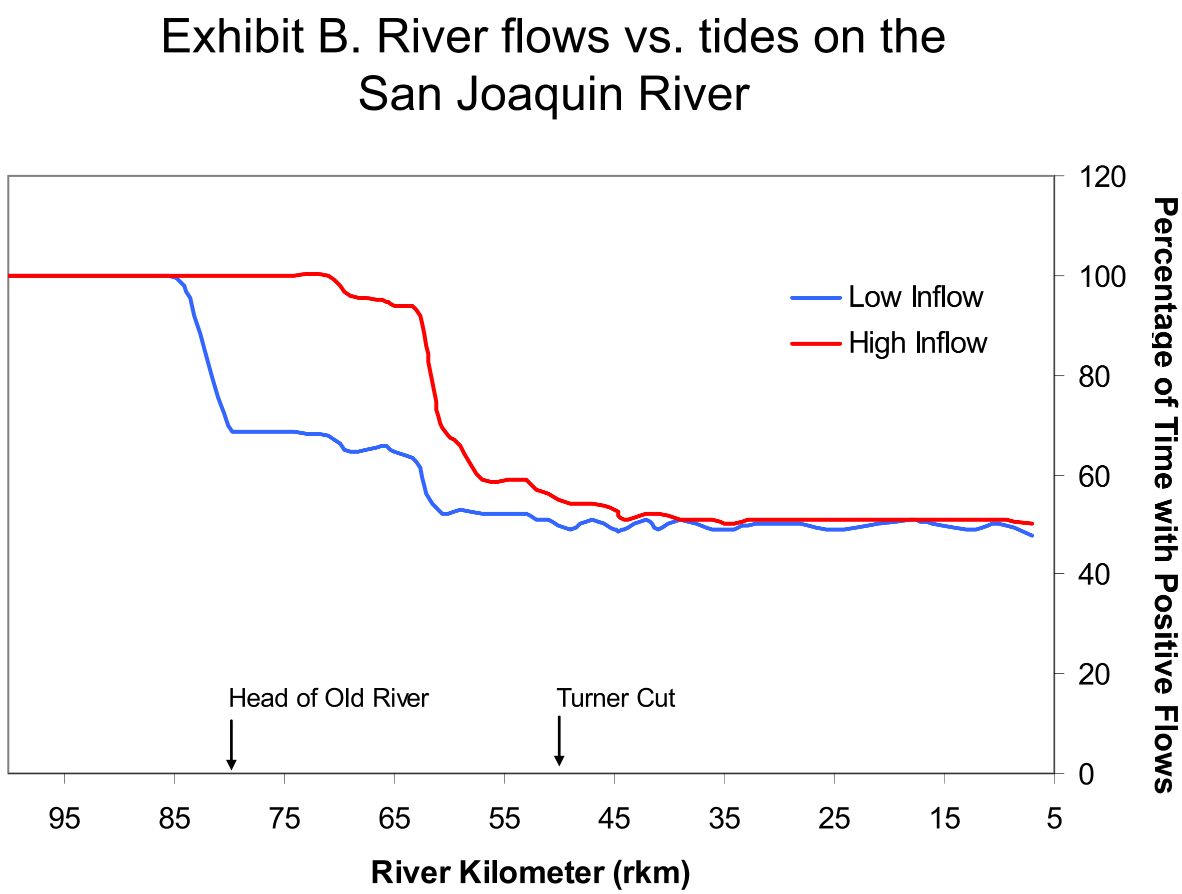


Exhibit B. Percentage of time with positive flows by river kilometer. Vaues near 50% indicate tidal forces dominate. Values near 100% indicate river forces dominate. Data derived from DSM2 HYDRO simulations described by Kimmerer and Nobriga (2008)

Exhibit C1. RSAN014 Flow Data

Channel RSAN014 DSM2 HYDRO output: Medium Inflow, DCC Closed

Minutes	Low Exp (2,000 cfs)	Med Exp (6,000 cfs)	High Exp (10,000 cfs)	Minutes	Low Exp (2,000 cfs)	Med Exp (6,000 cfs)	High Exp (10,000 cfs)
15	42755	40050	37792	**1215**	-58299	-60880	-65201
30	31272	28247	25697	**1230**	-69220	-71293	-74993
45	18494	15030	12074	**1245**	-78360	-80036	-83138
100	4153	167	-3165	**1300**	-85900	-87281	-89840
115	-11406	-15649	-19083	**1315**	-91973	-93149	-95269
130	-26812	-30902	-34127	**1330**	-96672	-97711	-99502
145	-40757	-44420	-47212	**1345**	-99979	-100930	-102494
200	-52491	-55630	-57943	**1400**	-101869	-102746	-104165
215	-61910	-64562	-66491	**1415**	-102356	-103231	-104576
230	-69334	-71594	-73223	**1430**	-101597	-102436	-103776
245	-75060	-77013	-78386	**1445**	-99553	-100438	-101822
300	-79254	-80962	-82171	**1500**	-96166	-97108	-98566
315	-82203	-83738	-84752	**1515**	-91439	-92419	-93977
330	-83986	-85402	-86330	**1530**	-85290	-86292	-87978
345	-84666	-85992	-86851	**1545**	-77460	-78580	-80371
400	-84351	-85624	-86416	**1600**	-67753	-69039	-71024
415	-83172	-84426	-85219	**1615**	-56101	-57489	-59663
430	-81288	-82554	-83369	**1630**	-42274	-43832	-46206
445	-78727	-80012	-80851	**1645**	-26023	-27899	-30618
500	-75418	-76769	-77638	**1700**	-7622	-9855	-12726
515	-71324	-72718	-73617	**1715**	11862	9440	6463
530	-66321	-67758	-68691	**1730**	30743	28184	25283
545	-60222	-61724	-62698	**1745**	47525	44935	42268
600	-52854	-54429	-55433	**1800**	61424	58927	56561
615	-44073	-45743	-46852	**1815**	72217	69864	67838
630	-33887	-35693	-36919	**1830**	80160	77952	76227
645	-22310	-24295	-25672	**1845**	85733	83646	82160
700	-9505	-11714	-13329	**1900**	89401	87432	86118
715	4112	1711	-188	**1915**	91674	89792	88595
730	17678	15199	13037	**1930**	92972	91134	90012
745	29948	27528	25185	**1945**	93696	91891	90792
800	40041	37777	35356	**2000**	94111	92286	91171
815	47657	45556	43112	**2015**	94346	92513	91362
830	52885	50893	48422	**2030**	94552	92675	91464
845	56020	54047	51533	**2045**	94726	92796	91481
900	57335	55305	52751	**2100**	94800	92845	91554
915	57074	54938	52329	**2115**	94858	92886	91551
930	55429	53164	50472	**2130**	94767	92800	91412
945	52456	50060	47258	**2145**	94481	92575	91155
1000	48084	45549	42596	**2200**	94007	92186	90711
1015	42186	39488	36317	**2215**	93295	91546	90020
1030	34617	31700	28206	**2230**	92310	90655	89084
1045	25159	21941	17966	**2245**	91031	89471	87877
1100	13582	9983	5351	**2300**	89425	87905	86291
1115	-168	-4076	-9280	**2315**	87406	85883	84366
1130	-15403	-19342	-24751	**2330**	85010	83460	81974
1145	-30871	-34513	-39828	**2345**	82067	80466	78992
1200	-45429	-48588	-53506	**0**	78408	76730	75266

Exhibit C1. Flow data for channel RSAN014 in 15-minute increments provided by DSM2 HYDRO. Data derived from DSM2 HYDRO simulations described by Kimmerer and Nobriga (2008)

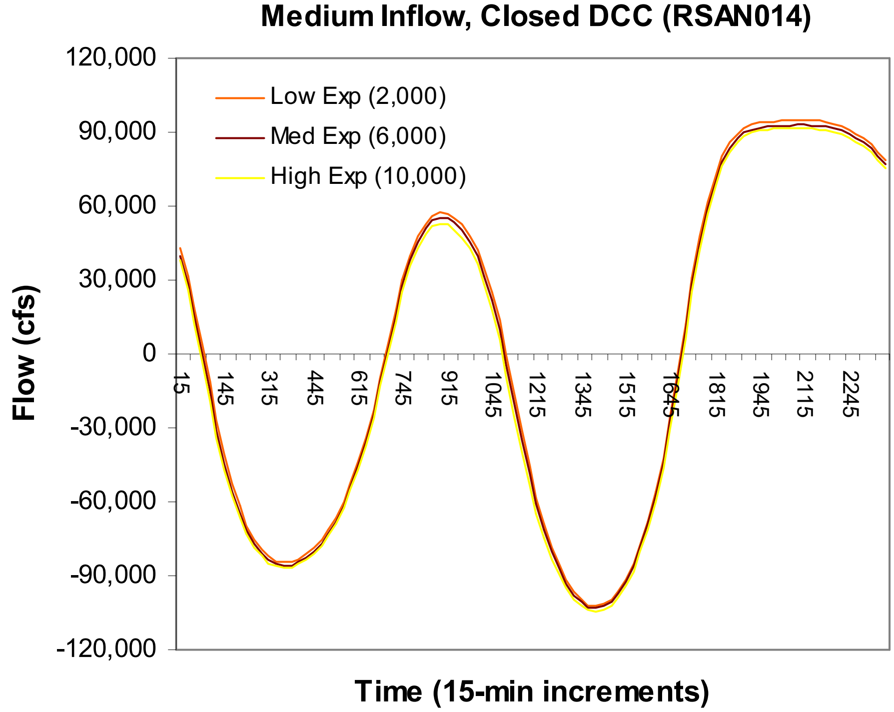
Exhibit C2. Channel 44 Flow Data

Channel 44 DSM2 HYDRO output: Medium Inflow, DCC Closed

Minutes	Low Exp (2,000 cfs)	Med Exp (6,000 cfs)	High Exp (10,000 cfs)	Minutes	Low Exp (2,000 cfs)	Med Exp (6,000 cfs)	High Exp (10,000 cfs)
15	48041	45153	42909	**1215**	-56757	-59709	-65435
30	37534	34228	31628	**1230**	-68635	-70970	-75444
45	24817	20967	17891	**1245**	-77993	-79871	-83217
100	9744	5227	1614	**1300**	-85320	-86886	-89340
115	-7378	-12390	-16332	**1315**	-91119	-92464	-94311
130	-25016	-30030	-33868	**1330**	-95777	-96986	-98448
145	-41023	-45588	-48962	**1345**	-99514	-100655	-101931
200	-54110	-58005	-60779	**1400**	-102379	-103485	-104744
215	-64083	-67290	-69487	**1415**	-104254	-105352	-106681
230	-71265	-73915	-75652	**1430**	-104977	-106068	-107527
245	-76317	-78576	-80004	**1445**	-104506	-105597	-107232
300	-79868	-81876	-83103	**1500**	-102657	-103793	-105635
315	-82397	-84226	-85312	**1515**	-99409	-100639	-102683
330	-84224	-85918	-86904	**1530**	-94755	-96163	-98396
345	-85488	-87082	-88003	**1545**	-88529	-90179	-92609
400	-86183	-87703	-88599	**1600**	-80607	-82504	-85114
415	-86184	-87656	-88552	**1615**	-70709	-72927	-75684
430	-85410	-86867	-87768	**1630**	-58579	-61247	-64185
445	-83854	-85316	-86239	**1645**	-44113	-47272	-50447
500	-81509	-83027	-83989	**1700**	-27097	-30749	-34235
515	-78352	-79935	-80947	**1715**	-7311	-11500	-15389
530	-74279	-75927	-77007	**1730**	14260	9670	5556
545	-69117	-70848	-72023	**1745**	34888	30266	26352
600	-62637	-64489	-65801	**1800**	51865	47493	44060
615	-54639	-56637	-58155	**1815**	64242	60195	57339
630	-45003	-47183	-48994	**1830**	72647	68923	66434
645	-33652	-36083	-38292	**1845**	77949	74517	72319
700	-20538	-23293	-26022	**1900**	81141	77904	75974
715	-5776	-8883	-12205	**1915**	83138	80011	78168
730	9814	6483	2643	**1930**	84485	81397	79535
745	24515	21182	17034	**1945**	85571	82468	80525
800	36681	33446	29171	**2000**	86606	83451	81410
815	45627	42431	38150	**2015**	87586	84349	82223
830	51520	48275	44071	**2030**	88426	85123	82921
845	54851	51477	47363	**2045**	89106	85789	83517
900	56123	52620	48565	**2100**	89631	86337	83996
915	55840	52233	48204	**2115**	89941	86762	84354
930	54381	50701	46687	**2130**	90004	87015	84534
945	51984	48276	44221	**2145**	89773	87066	84501
1000	48733	45000	40804	**2200**	89252	86863	84226
1015	44439	40676	36222	**2215**	88468	86338	83697
1030	38732	34934	30068	**2230**	87446	85484	82967
1045	31166	27294	21826	**2245**	86251	84356	81980
1100	21214	17193	10878	**2300**	84815	82927	80763
1115	8316	4047	-3244	**2315**	83131	81244	79336
1130	-7587	-12007	-19938	**2330**	81214	79302	77569
1145	-25167	-29364	-37169	**2345**	78936	76980	75382
1200	-42113	-45747	-52701	**0**	76207	74201	72657

Exhibit C2. Flow data for channel Chanel 44 in 15-minute increments provided by DSM2 HYDRO. Data derived from DSM2 HYDRO simulations described by Kimmerer and Nobriga (2008)

Exhibit D. RSAN014 and Channel 44 Flow Data



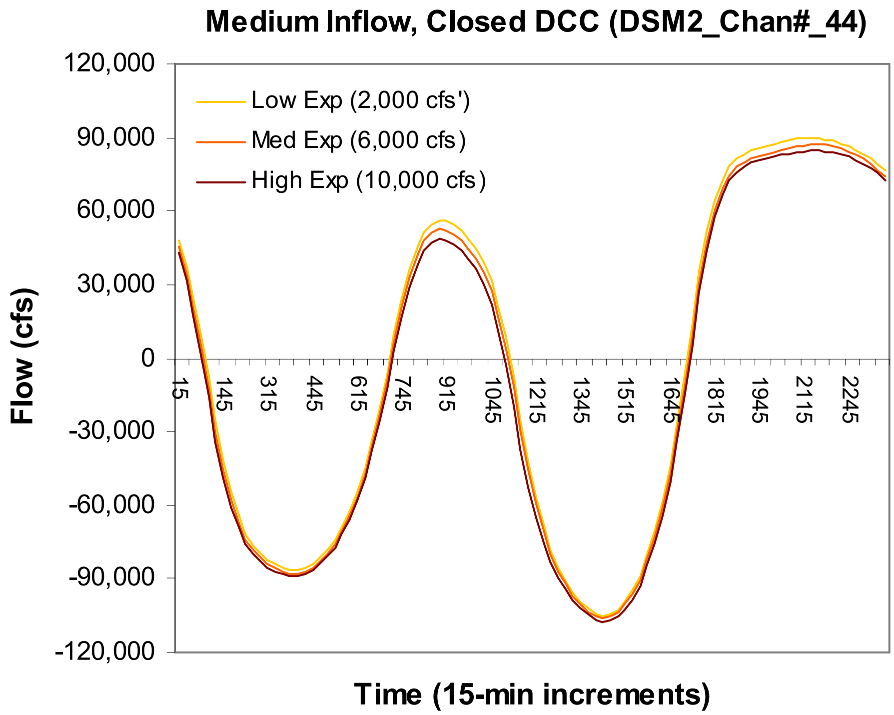


Exhibit D. DSM2 HYDRO estimated flows in 15-minute increments for a RSAN014 and Channel 44 at three levels of south Delta exports. Effect of exports is very subtle relative to tidal effects

.

Exhibit E. Summary of RSAN014 and Channel 44 flow conditions

RSAN014 DSM2 HYDRO output: Medium Inflow, DCC Closed

	Max Flux	Max Flow	Min Flow	Average (net) flow	% Change in Max	% Change in Min Flow	% Change in Time of Negative Flow
Low Exp (2,000 cfs)	197214	94858	-102356	-220	-	-	-
Med Exp (6,000 cfs)	196117	92886	-103231	-2263	-2.1%	0.9%	<1.0%
High Exp (10,000	196130	91554	-104576	-4337	-1.4%	1.3%	2.1%

Channel 44 DSM2 HYDRO output: Medium Inflow, DCC Closed

	Max Flux	Max Flow	Min Flow	Average (net) flow	% Change in Max	% Change in Min Flow	% Change in Time of Negative Flow
Low Exp (2,000 cfs)	194981	90004	-104977	-4241	-	-	-
Med Exp (6,000 cfs)	193133	87066	-106068	-7006	-3.3%	1.0%	<1.0%
High Exp (10,000	192061	84534	-107527	-9818	-2.9%	1.4%	1.0%

Exhibit E. Summary of DSM2 HYDRO estimated flows in 15-minute increments fora RSAN014 and Channel 44 at three levels of south Delta exports.

.

Exhibit F. Communication with DWR modelers regarding handling of OCAP requirements for CALSIM "BiOp" conditions

From: Reyes, Erik
To: Kerckhoff, Laurence H.
Cc: Chung, Francis
Sent: Fri Feb 18 15:57:15 2011
Subject: Description of NMFS BO Action IV.2.1 and Summary of Jones Pumping, Mendota Pool Flows and Westside Returns

Larry,

Following are some explanations as to why the SJR flow at Vernalis in a BiOps environment is very similar to or sometimes lower than SJR flow at Vernalis in a Pre-BiOps environment.

NMFS Action IV.2.1 (excerpted from the BDCP Baseline Documentation)
NMFS Action IV.2.1 states that: From April 1 through May 31, 1) Reclamation shall continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action 3.1.3 and Appendix 2-E of the NMFS BO); and 2) Combined CVP and SWP exports shall be restricted to the ratio depicted in table 6 below based on the applicable San Joaquin River Index, but will be no less than 1,500 cfs (consistent with the health and safety provision governing this action.)

In CalSim the flows at Vernalis are regulated by item 1) of Action IV.2.1 described above. Item 1) of this action was implemented the following way:

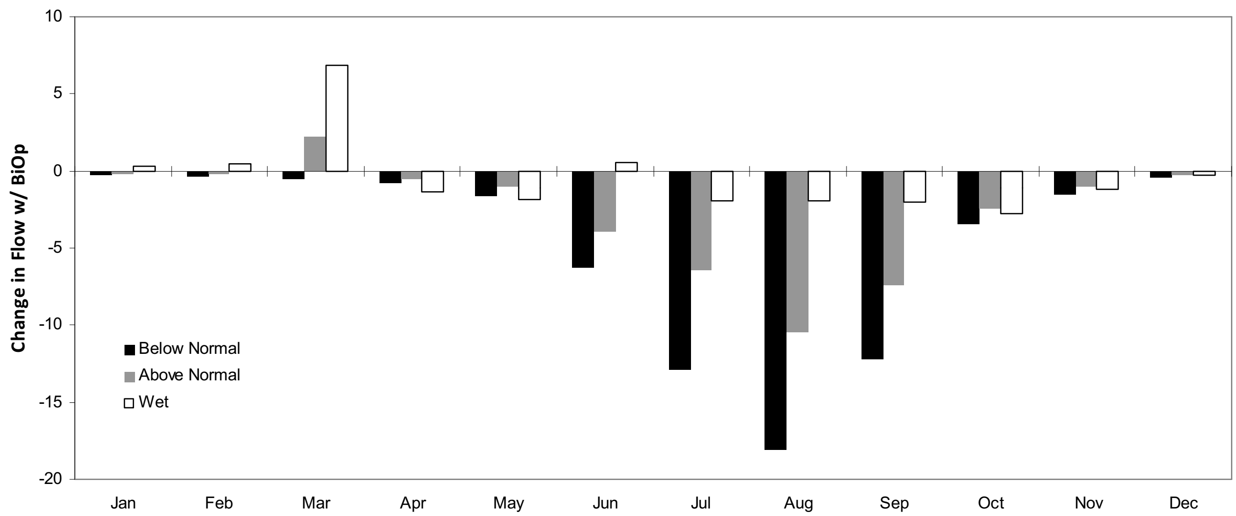
Action: Flows at Vernalis during April and May will be based on the Stanislaus River flow prescribed in Action 3.1.3 and the flow contributions from the rest of the San Joaquin River basin consistent with the representation of VAMP contained in the Biological Assessment (BA) modeling. In many years this flow may be less than the minimum Vernalis flow identified in the NOAA BO.

Rationale: Although the described model representation does not produce the full Vernalis flow objective outlined in the NOAA BO, it does include the elements that are within the control of the CVP and SWP, and that are reasonably certain to occur for the purpose of the EIS/EIR modeling.

A simpler way of stating the above is that the CVP (USBR) realizes that the BiOps call for greater flows at Vernalis but only supplies the amount under the CVP's control. The amount under the CVP's control is equal to the amount provided originally under VAMP. So although the NMFS BiOps Action IV.2.1 is active and being modeled, the criteria is "shorted" and the resulting flow is about the same level as under VAMP which is the Pre-BiOps standard.

Summary of Delta Mendota Canal (DMC) flows
With the BiOps regulating exports to lower levels than Pre-BiOps/D1641 levels, Jones PP pumps approximately 300 TAF less annually. This lower level of flow is maintained from the Upper DMC all the way down to the lower DMC and the Mendota Pool. The flow from the DMC to the Mendota Pool is 8 TAF less annually under the BiOps than under the Pre-BiOps. The lower DMC flows also mean lower deliveries to the CVP contractors who have return flows that flow into the San Joaquin river. Lower deliveries can also mean lower return flows. The Westside returns are 3 TAF less annually under the BiOps than under the Pre-BiOps.

Exhibit G. San Joaquin River flows with BiOp vs. pre-BiOp



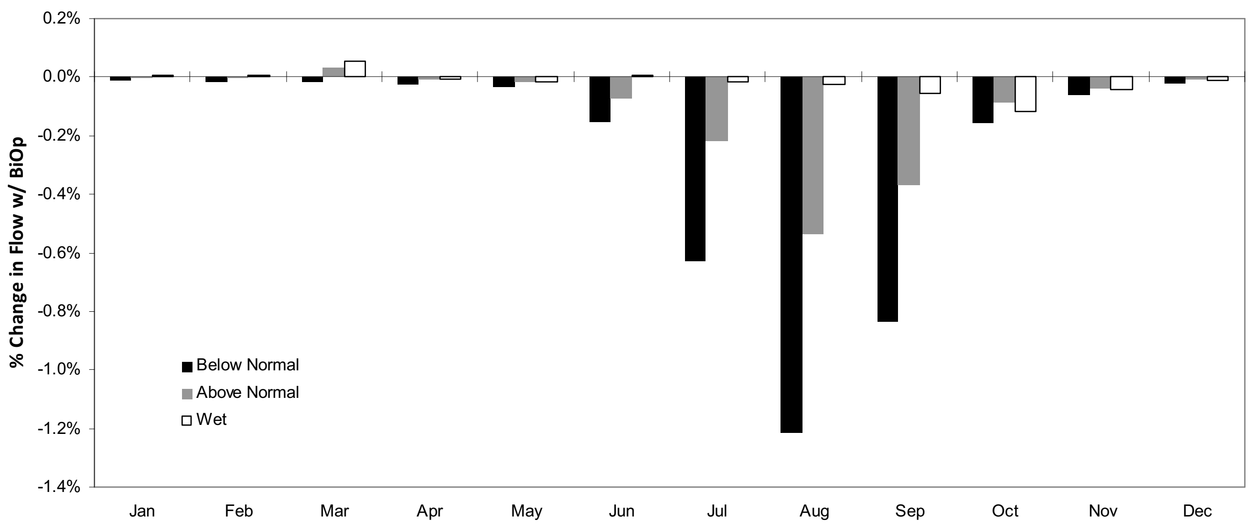


Exhibit G. Change in San Joaquin River flows (at Vernalis) with the BiOp relative to the pre-BiOp. Tog graph depicts change in cfs. Bottom graph depicts percentage change relative to average monthly BiOp flow.

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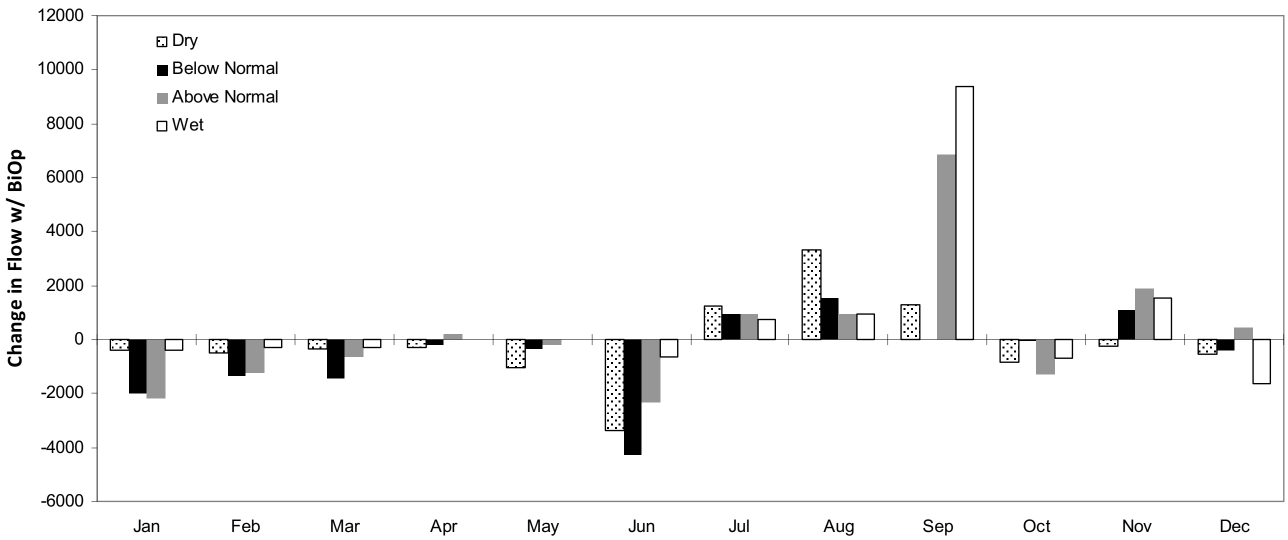
Exhibit H. Sacramento River flows with BiOp vs. pre-BiOp



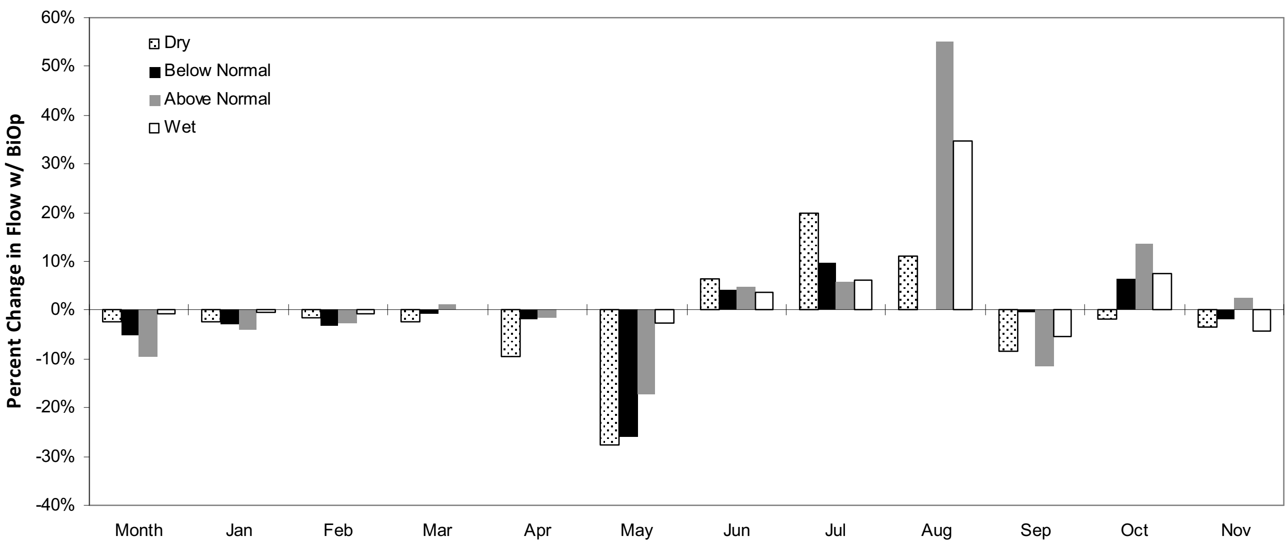


Exhibit H. Change in Sacramento River flows (at Hood) with the BiOp relative to the pre-BiOp. Tog graph depicts change in cfs. Bottom graph depicts percentage change relative to average monthly BiOp flow.

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Exhibit I. SJR Fall Run Chinook DPM Results

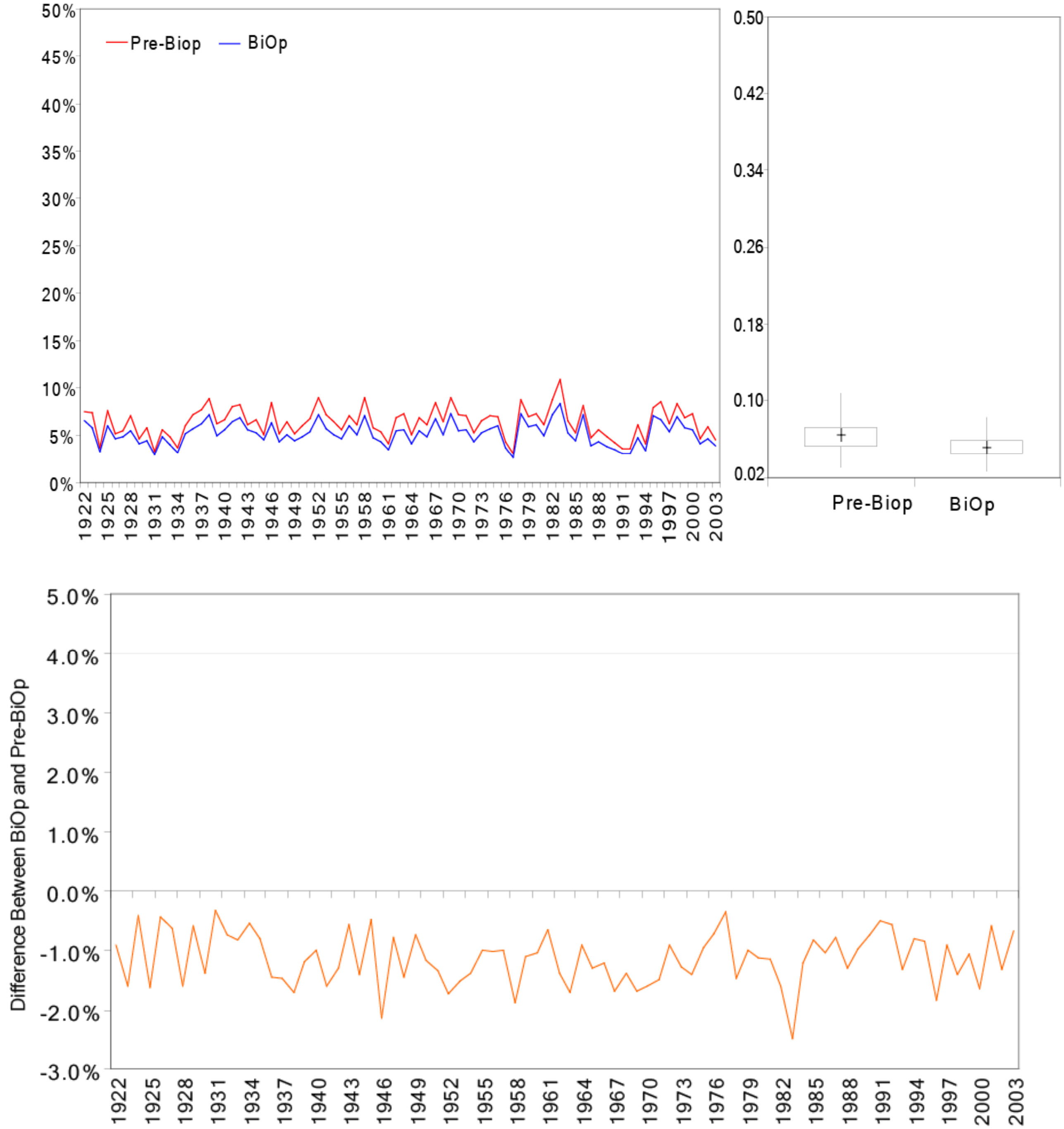
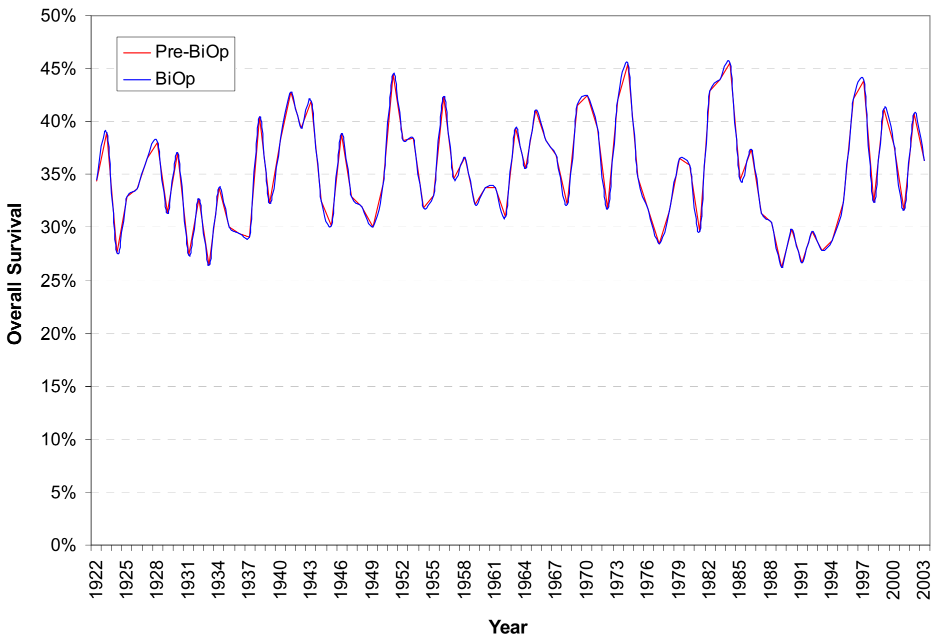
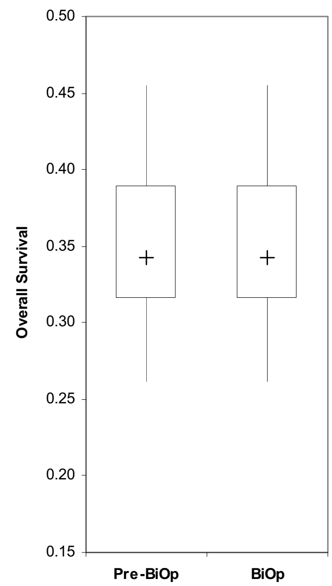


Exhibit I. San Joaquin River juvenile fall run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps ("BiOp") and under "pre-BiOp" requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between "BiOp" and "Pre-BiOp". On average, SJR fall run Chinook survival was 1.1% lower with the "BiOp" condition relative to the "Pre-BiOp".

Exhibit J. Revised Winter Run Chinook DPM Results





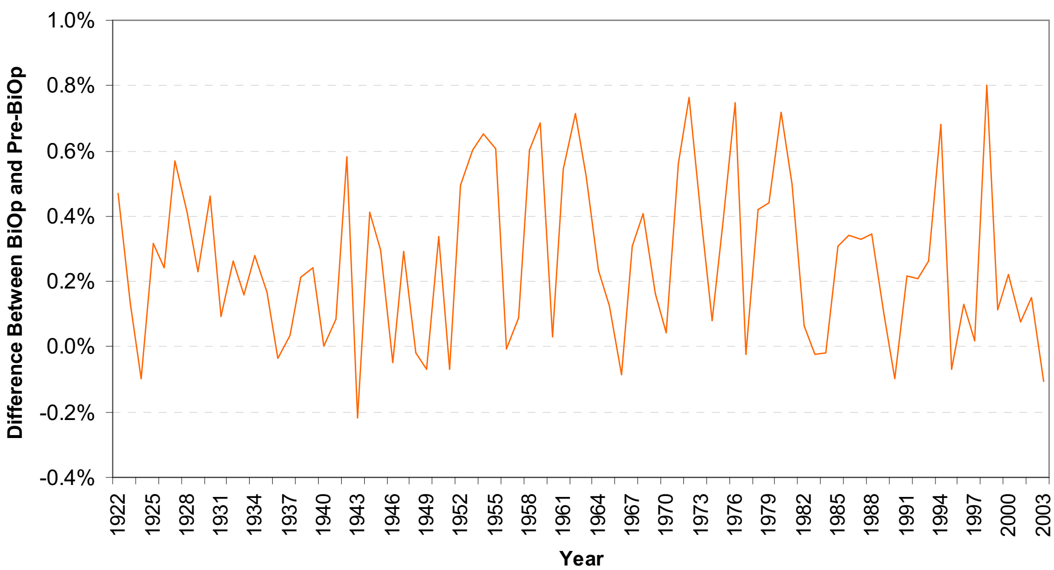


Exhibit J. Sacramento River juvenile winter run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps ("BiOp") and under "pre-BiOp" requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between "BiOp" and "Pre-BiOp". After accounting for just the component of winter run Chinook expected to pass through the Delta after March 11, winter run Chinook survival was <0.01% higher with the "BiOp" condition relative to the "Pre-BiOp".

Exhibit K. Revised Spring Run Chinook DPM Results

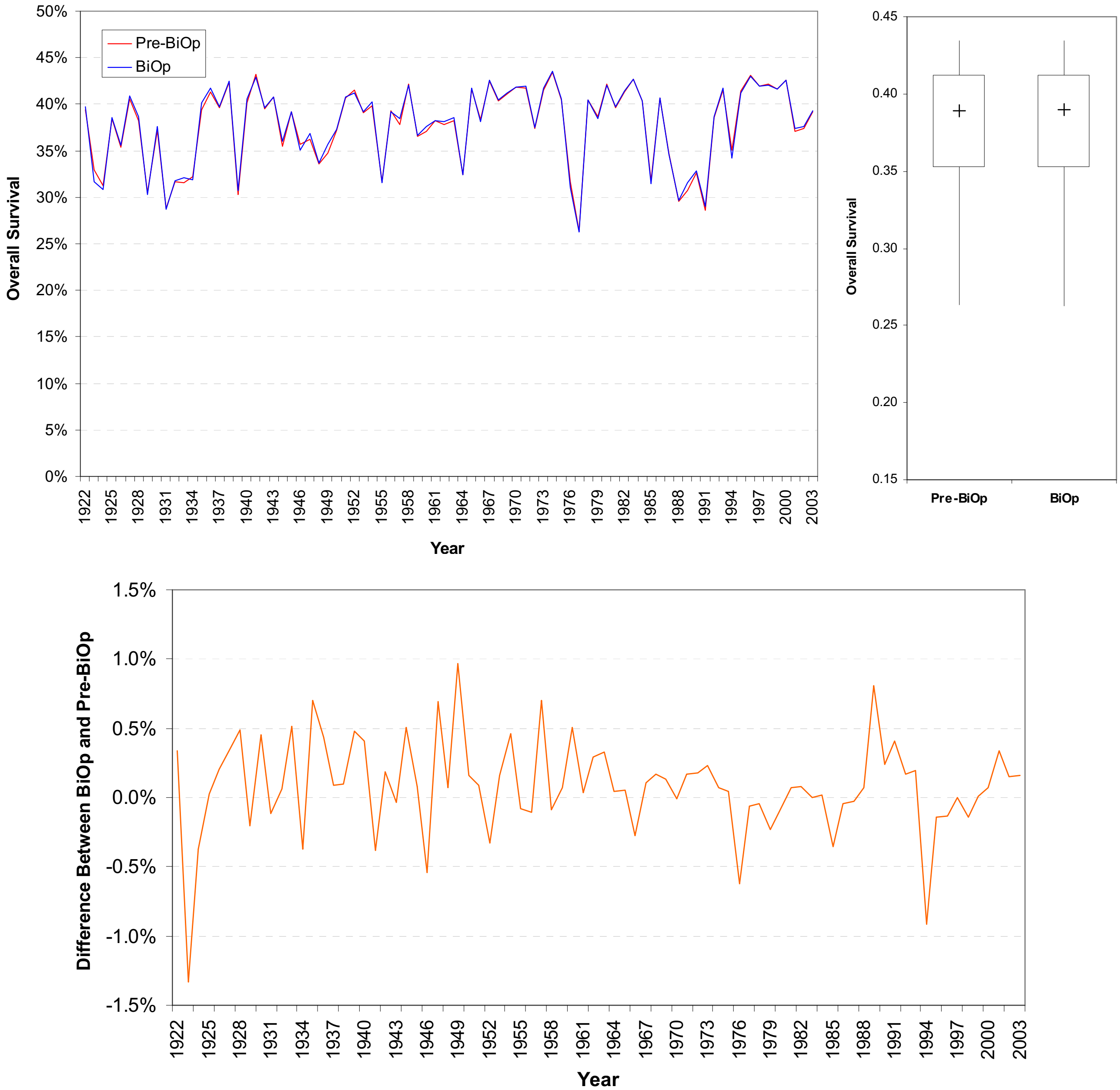


Exhibit K. Sacramento River juvenile spring run Chinook through-Delta survival as estimated by the Delta Passage Model (DPM) using CALSIM estimated flow and exports with 2009 BiOps (“BiOp”) and under “pre-BiOp” requirements. Upper panels show distribution of observed survival estimates, lower panel plots observed difference between “BiOp” and “Pre-BiOp”. After accounting for the component of spring run Chinook expected to pass through the Delta after March 11, spring run Chinook survival was 0.08% higher with the “BiOp” condition relative to the “Pre-BiOp”.

EXHIBIT L

Assessment of Chinook Salmon Through-Delta Survival With Coded Wire Tagged Hatchery Releases, 1993-2005

Prepared by:

Steven Zeug and Brad Cavallo

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EXECUTIVE SUMMARY

Through-Delta survival of juvenile salmon was examined with release and recovery data of coded wire tagged releases made between 1993 and 2005. Recovery data were provided by ocean harvest sampling. Two analyses were conducted to test hypotheses regarding how release-specific characteristics (release location, temperature at release, mean fish size), and outmigration conditions (river inflow, exports, water quality) influence through-Delta survival. Ocean conditions were also included as a covariate to account for year-to-year survival variation occurring after Delta passage. The first analysis modeled survival of releases made just above the Delta in the Sacramento and San Joaquin Rivers. In the Sacramento, the best model of survival included predictors related to release-specific characteristics, flow and water quality, however, model averaging indicated that the proportion of fish salvaged was the only predictor with good support in the data and this relationship was positive. In the San Joaquin, the best model contained predictors related to release-specific characteristics, flow, water quality and ocean conditions. Predictors with good support in the data included positive associations with temperature, fish size and ocean productivity. The second analysis modeled predictors of salvage at south Delta export facilities for Sacramento River releases. The best model included predictors related to release-specific characteristics, and flow. Well supported predictors included positive associations with fish length, flow in the Sacramento and exports. Though higher exports were associated with greater salvage, there was not a well supported relationship between through-Delta survival and exports. Though exports may have an adverse effect on salmon survival that is small, uncertain and otherwise difficult to detect; this analyses suggest salvage at the South Delta export facilities is better viewed as indicator of salmon abundance and positive-through Delta survival, and not a measure of adverse effects.

INTRODUCTION

The survival of juvenile Chinook salmon migrating through the Delta is the subject of considerable management interest. Mortality of migrating juveniles associated with degraded Delta habitat and water project operations (principally exports) are thought to be at least partly responsible for the decline of Chinook salmon populations (Kjelson and Brandes 1989; Lindley and Mohr 2003). Several studies have assessed factors influencing through-Delta survival for juvenile Chinook (e.g. Baker et al. 1995, Newman and Rice 2002, Newman 2003, Newman 2008, Newman and Brandes 2010), however, there are a large number of tagged hatchery releases that have not been used in previous analyses because they were not within the scope of the specific questions those studies attempted to address. Additionally, previous analyses have not directly integrated measures of ocean conditions on salmon survival. Variation in ocean productivity has been shown to significantly affect the growth and maturation of Chinook (Wells et al. 2007) and has been implicated as a major factor influencing the number of returning spawners. This variability has the potential to strongly influence the subsequent ocean recovery of tagged releases that are used in analyses of through-Delta survival. Recoveries in the ocean are considerably higher than inland recoveries of migrating juveniles (Newman 2008) and thus exert a strong influence on estimates of survival through the Delta.

Survival and capture probabilities of tagged Chinook salmon in the ocean fishery provide a means to assess factors influencing survival through the Delta while simultaneously accounting for ocean conditions. For example, in years where Delta conditions were favorable but ocean conditions were poor we would expect ocean recoveries of in-river releases (Sac and SJ) to be lower than would be predicted by Delta conditions alone. Though Newman (2003) and Newman (2008) both utilized ocean recoveries in their analysis, our method is advantageous because: 1) measures of ocean productivity are directly integrated into the analysis, 2) more and larger release groups are used, and 3) recoveries in the Chipps Island trawl were not required.

Mortality of juvenile salmon associated with water exports at facilities in the south Delta has been hypothesized to influence through-Delta survival. Although, analyses have been conducted on count data from these facilities and limited coded wire tagged releases, there has not been an attempt to integrate the large number of tagged releases available. These releases span a wide range of fish size, races, rearing types, release locations, export levels and environmental conditions. Modeling of these data has the potential to reveal relationships between salmon characteristics, environmental conditions and water operations that are critical to the effective management of Chinook salmon in the Central Valley.

METHODS

A. Sacramento and San Joaquin River releases

Data on coded wire tagged releases in the Sacramento and San Joaquin Rivers and ocean recoveries were obtained from the Regional Mark Processing Center database. Predictor variables were grouped into four broad categories that have the potential to affect survival (Table 1). The first category represented release-specific characteristics that could affect survival including: river temperature at the time of release, mean fork length of the fish being released, and release location. River temperature at the time of release and mean fork length was obtained from the US Fish and Wildlife Service's Chipps Island Survival Table. On certain release dates for the Sacramento River, no information on river temperature was provided. When this occurred, temperature measurements on the day of release were taken from USGS gauge 11447650 located on the Sacramento River at Freeport. Release locations in both rivers varied within and between years (Figure 1). To account for this, release location was included as an indicator variable with sites numbered from downstream to upstream. The second category represented flow conditions in the Delta and included: flow in the river where salmon were released (calculated as the average flow for 7 days following the release), average exports for 7 days after release, and the proportion of the release group salvaged at the export facilities. Flow, data was obtained from USGS gauges at Freeport and Vernalis for the Sacramento and San Joaquin Rivers respectively. The third category represented water quality in the Delta. Predictors in this category included ammonium concentration (NH_4), the ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorous (DIN:DIP), and Secchi depth. These data were monthly averages provided by the Metropolitan Water District. Ammonium and DIN:DIP were chosen to represent Delta water quality because these have been implicated in the decline of other pelagic species in the Delta (Gilbert 2010). The final category represented ocean conditions and was composed of an index of ocean productivity developed by Wells et al. (2007) and hereafter referred to as Wells' index. This index has been shown to have a significant effect on the growth and maturation of salmon, especially in their second year at sea (Wells et al. 2007). Thus, values for the year of entry into the ocean and the second year at sea were included in this category. Prior to model construction, predictor variables were transformed to z-scores by subtracting each observation from the mean and dividing by the standard deviation. This transformation was performed to scale these variables into units of standard deviations rather than to account for non-linear relationships with the response variable. The indicator variable "location" was not transformed.

Generalized linear mixed models were constructed *apriori* to evaluate hypotheses regarding how predictors influence the survival of juveniles as they migrate through the Delta prior to being captured in the ocean fishery (Table 2). Models utilized a binomial error distribution with a logit link function. To account for variation in the size of release groups we modeled the recovery data directly by using the cbind function in R. The response variable was bound together as the number of recoveries and the number of fish unaccounted for. Sacramento and San Joaquin releases were modeled separately as it is unlikely that the same set of predictors apply to each river. The year of release was included as a random effect in each model and an observation level random effect was included to address over dispersion in the data. Combinations of release-specific, flow, water quality and ocean conditions were included as fixed effects. A total of 15 candidate models were evaluated for their fit to the data using an information theoretic approach (Table 3). Akaike's information criterion corrected for small sample size (AIC_c) was calculated for each model. Model weights ($AIC_c w$) were then calculated using the difference in AIC_c values between the "best model" and other candidate models. Model weights range from 0-1 and are interpreted as the probability that the model under consideration is the best given the data. To gain additional information about predictors, model averaged coefficients and unconditional confidence intervals were calculated using model weights. In this way, information from all models was used to determine which predictors were well supported by the data. When zero was not included in the unconditional confidence interval, the variable was considered to have good support in data as a predictor of survival. All statistical modeling was performed with the R statistical software package (R Development Core Team, 2010).

B. Salvage

To obtain data on salvage of coded wire tagged releases, the Regional Mark Processing Center database was queried to obtain tag codes and release data for all releases made in the Sacramento River and its tributaries from 1993-2007 (Figures 2a and 2b). Tag codes were then used to obtain numbers of fish salvaged from each release from the US Fish and Wildlife Service's Chipps Island Survival Table. A suite of 10 variables were selected to predict salvage of salmon releases (Table 3). Although water exports are expected to be an important predictor of salvage, this variable was strongly correlated with Old-Middle River flow therefore we decided to exclude Old-Middle River flow and include exports in the analysis. With the exception of indicator and dummy variables, predictors were transformed to z-scores prior to analysis. A generalized linear mixed model with a binomial error structure was chosen for the analysis as in the previous analyses. Year was a random effect and an observation-level random variable was included to account for over dispersion in the data. Models were constructed based on hypothesized relationships between salvage and predictors (Table 4). Model selection and averaging proceeded as described above.

RESULTS

A. Sacramento and San Joaquin River releases

A total of 92 release groups were identified from the Sacramento River and 107 from the San Joaquin River. Model selection for Sacramento releases indicated that there were two competing models with AIC_c weights of 0.456 and 0.413 respectively (Table 5). No other candidate model had an AIC_cw greater than 0.077. The "best" model had an AIC_cw of 0.456 and included predictors related to release-specific characteristics, flow, and water quality. The competing model included predictors associated with flow and water quality. Model averaging revealed that the proportion of fish salvaged was the only predictor of survival that was well supported by the data and this relationship was positive (Table 6). Unconditional confidence intervals calculated for all other predictors included zero that indicated a low level of support in data. None of the hypothesized relationships between survival and predictors were supported by data for releases in the Sacramento River (Table 7).

Two competing models of survival were selected for releases in the San Joaquin River (Table 8). The first model had an $AIC_c w$ of 0.730 and included all of the examined predictors (full model). The second model ($AIC_c w$ = 0.270) included predictors associated with water quality, ocean conditions, and release-specific characteristics. Thus, the major difference in these two models was the exclusion of predictors related to flow in the reduced model. Model averaging revealed temperature, mean fork length, exports, Secchi depth and Wells' index during the second year at sea were well supported by the data as predictors of survival (Table 6). Three of the hypothesized relationships between survival and predictor variables were well supported by the data (Table 7). Survival was positively associated with mean length at release and Wells' index during the second year at sea whereas, survival was negatively associated with temperature.

B. Salvage

A total of 1317 release groups were identified from the Sacramento River and tributaries. The model with the best fit to the data had an $AIC_c w$ of 0.736 and included predictors associated with release-specific characteristics and flow (Table 9). The full model had marginal support in data ($AIC_c w$ = 0.264). All other models were poorly supported ($AIC_c w$ < 0.001). Three hypothesized relationships were well supported by the data as indicated by model averaging (Table 10). Salvage was positively associated with rearing type where hatchery fish were salvaged at a greater rate. Positive associations were also found with DCC position (greater salvage when the DCC was open) and exports. Mean fork length and inflow also were well supported, however, counter to what was predicted, the associations with salvage were positive.

DISCUSSION

A. Sacramento and San Joaquin releases

The level of support in data for predictors of survival varied considerably between the Sacramento and San Joaquin. In the Sacramento, none of the hypothesized relationships between survival and predictors were supported by the data. The positive relationship between survival and the proportion of fish salvaged was unexpected as more frequent encounters with salvage facilities was hypothesized to increase mortality within release groups. Additionally, there was not a well supported relationship between survival and exports despite a previous study that found a significant relationship between these variables (Newman and Brandes 2010). The study by Newman and Brandes (2010) utilized releases made directly into the main stem Sacramento and interior delta but did not account for the proportion of fish migrating down the Sacramento that enter each route. If large proportions of each release remained in the main stem, exports may have had little effect on their survival. The relationship between survival and the proportion of fish salvaged was not well supported in the San Joaquin River and the relationship with exports was positive. These results suggest that associations between survival, exports and salvage are different than hypothesized or are more complex than could be elucidated from the coded wire tagged releases. However, variation between rivers in response to exports may be expected given the spatial location of export facilities, channel network morphology and flow regime. Fish migrating down the Sacramento may enter the interior Delta where they are more susceptible to salvage, or they may continue down the main stem Sacramento. The proportion of fish entering the interior Delta is a complex relationship between flow, tides, position of the DCC, and timing of fish arrival at the Delta (Perry 2010). In the San Joaquin, all migration routes pass through the interior Delta although the proportion of fish salvaged and the relationship with exports was not clear from this analysis. Clearly, additional studies are required to elucidate the relationship between entrainment into the interior delta, exports, salvage and survival.

Hypothesized relationships between survival, fish size, temperature, and ocean conditions were well supported for releases in the San Joaquin River. Larger size may reduce mortality from gape-limited predators in the Delta such as striped bass. Additionally, larger fish are stronger swimmers and may have a greater ability to avoid entrainment into water diversions or sub-optimal routes through the Delta. The relationship between survival and temperature suggests that release at lower temperatures increases survival. Temperatures closer to the optimum for juvenile salmon may increase the success of acclimation and reduce mortality form temperature shock (the difference between temperature in the hatchery and temperature at the release site). Survival was greater for San Joaquin releases when ocean productivity was high in the second year at sea. A similar relationship between ocean conditions and growth of Chinook was found by Wells et al (2007) that may suggest a relationship between growth and survival of Chinook in the ocean.

The current analysis utilized eleven years of data with multiple releases in each year yet many of the hypothesized relationships between survival and predictors were not well supported by the data. The use of coded wire tags may be a partial explanation for some of the weak relationships. Multiple routes through the Delta can be used by fish released in both rivers. Mortality rates would be expected to vary between routes in conjunction with environmental conditions; however, the proportion of fish migrating through each route could not be estimated from the available data. Thousands of fish have the same tag code and the fate of individual fish cannot be elucidated. Regardless of the limitations of the data, it is clear that there is not a direct relationship between survival, exports and salvage. Future studies would benefit greatly by using tagging methods that allow for the estimation of survival through specific migration routes.

B. Salvage

Several relationships between salvage and predictors that were well supported by the data were unexpected given our hypotheses. Flow was positively associated with salvage yet high flows are thought to reduce salvage by moving fish quickly through the Delta and keeping them in the main channel and away from routes through the interior Delta. However, high flows may increase survival into the Delta (Perry 2010). Thus, more fish would be present in the Delta to be salvaged. The positive relationship between length and salvage also was unexpected. Larger fish may survive at a higher rate and greater salvage could simply indicate that larger fish survive in the interior Delta long enough to be salvaged. Length was a significant predictor of survival in the San Joaquin analysis above and in the Sacramento; although the relationship was not well supported, the coefficient for length was positive.

Hypotheses related to exports, DCC position and rearing type were well supported by the data. When the DCC is open, a greater proportion of Sacramento flow enters the interior Delta and there is a greater probability that salmon will be entrained into routes leading to export facilities (Perry 2010). The relationship between exports and salvage was predictable because as more water is extracted, the probability of salvage goes up (Figure 3). Wild fish were salvaged at a lower rate than hatchery fish however, similar to the analysis of survival, the large number of hatchery fish released and the greater release group size may influence this relationship.

Relationships between survival and salvage were not well supported by the data. Many studies have hypothesized that exports have an adverse effect on juvenile salmon outmigration (Newman 2008) and regulators have long assumed salvage losses are an indicator of this adverse impact (e.g NMFS 2009). In contrast, this analysis indicates salvage loss is not associated with reduced survival; coefficients of survival were more positive with greater exports, though these positive relationships would not properly be interpreted as significant. Salvaged fish are trucked from export facilities to the western Delta and released, thus salvage may not have an effect on survival because once salmon are captured, they can avoid having to migrate through the interior delta where other sources of mortality (e.g. predation) may have a strong influence on survival.

The current analysis reveals that salvage increases proportionally with exports yet survival does not decrease with salvage. This result suggests that restricting exports may be effective at decreasing salvage but may not be effective at increasing survival of juvenile salmon. However, our salvage analysis only focused on the direct effect of exports by measuring the number of salmon that encounter the export facilities. Indirect effects of exports such as changes in hydrology were evaluated in the analyses of through-Delta survival of releases in the Sacramento River and San Joaquin Rivers. Theses analyses found that the hypothesized negative effect of exports on survival was not well supported. For Sacramento Releases the effect of exports was not supported by the data, though the coefficient was negative, whereas in The San Joaquin, exports had a positive and well supported effect on survival. Though coded wire tagging is a suitable method for evaluating gross changes in survival associated with indirect (and direct) export effects, its is poorly suited to identify mechanism underlying observed effects. For example, changes in hydrodynamics driven by exports may influence the number of fish entering the interior Delta and their residence time. Yet the proportion of fish entering this region and the time of occupancy cannot be estimated from the CWT data. Once in the interior Delta, there are many potential routes that salmon may use and each varies in the influence of exports on hydrodynamics. A study that accounts for the fate of individual fish through specific migration routes would be needed to quantify mechanisms for any indirect effects of exports on survival. Regardless, these data provide strong evidence that there is unlikely to be a strong or large magnitude relationship among salvage, exports and through-Delta survival. Additional studies would be most beneficial in quantifying the effect (at whatever level it occurs) and by providing specific information to managers on how to correct locations or mechanisms of adverse effect where they occur.

D. Comparison with previous studies

Several other studies have investigated the survival of juvenile salmon released in the Sacramento River as they migrate through the Delta. Newman and Rice (2002) modeled a smaller set of earlier coded wire tagged releases into the Sacramento River (1979-1995). Similar to our analysis, Newman and Rice did not find a significant relationship between exports and survival. However, Newman and Rice found strong positive effects of flow and salinity and strong negative effects of tide and release temperature. Our study found a positive relationship with flow but model averaging indicated there was little support in data for this relationship. Temperature also had little support in data whereas Newman and Rice found a significant negative relationship. A partial explanation for these differences is the type of data used in the modeling exercise as well as the temporal extent of the data. Newman and Rice utilized a combination of in-river recoveries and ocean recoveries whereas we chose only to use ocean recoveries to avoid bias resulting from the timing and effort of the mid-water trawl used to recover salmon in-river. Additionally, the modeling techniques varied between the two studies. Newman and Rice chose the use of a ridge parameter to stabilize estimates of coefficients whereas we chose a generalized linear mixed model and then model averaging to determine the level of support in data for the coefficients. The data sets used by Newman and Rice and in the current study overlapped by only two years. Thus, our study can be viewed as a test of the relationships found by Newman and Rice with an independent data set. However, there is a possibility that management actions and environmental conditions in the years of our study were different from those in the years of analyzed by Newman and Rice. For example, Newman and Rice included the position of the Delta Cross Channel as a variable in their analysis. In the data set analyzed here, the DCC was never open during the period when salmon were released. Additionally, actions may have been taken to avoid releasing fish when temperatures are unfavorable, however, we have no evidence that these actions were taken.

Newman (2003) modeled the survival of salmon through the Delta with paired releases in the Sacramento River and downstream of the Chipps Island trawl between 1979 and 1995. This effort utilized several types of models to analyze the data and the strength and sign of many coefficients were sensitive to the type of model used. However, the hierarchical model favored by Newman found significant effects of 9 of the 11 variables they examined including positive associations between survival, flow, temperature, size and turbidity. Additionally, Newman found a negative association between survival, release temperature and exports. Our study did not find any of these relationships to be well supported by the data. We used a multi-level model that accounted for over dispersion which is similar to that recommended by Newman (2003). Thus, it is possible that variables that were not included by Newman or in the current study have a large impact on survival (e.g. predation, ocean harvest rates). Alternatively, the strength of different coefficients may be change between years making it difficult to elucidate patterns through time.

Our analyses of San Joaquin releases found a well supported positive association between larger exports and improved survival. A similar relationship was found by Newman (2008) in an analysis of San Joaquin releases. Many of the other relationships that we found to be well supported were positive associations with fish size and negative associations with temperature. These relationships were found to be significant in studies of Sacramento releases (Newman and Rice 2002; Newman 2003). There appears to be several relationships that are consistent among the current analysis and previous analyses including the positive effect of size and the negative effect of temperature. Other relationships appear to depend on the data set analyzed and the type of model used. It is clear from the current analyses and previous analyses that there is not a strong relationship between exports, salvage and survival. Additional research is needed on this topic before management actions can be taken with confidence that they will increase survival of outmigrating salmon.

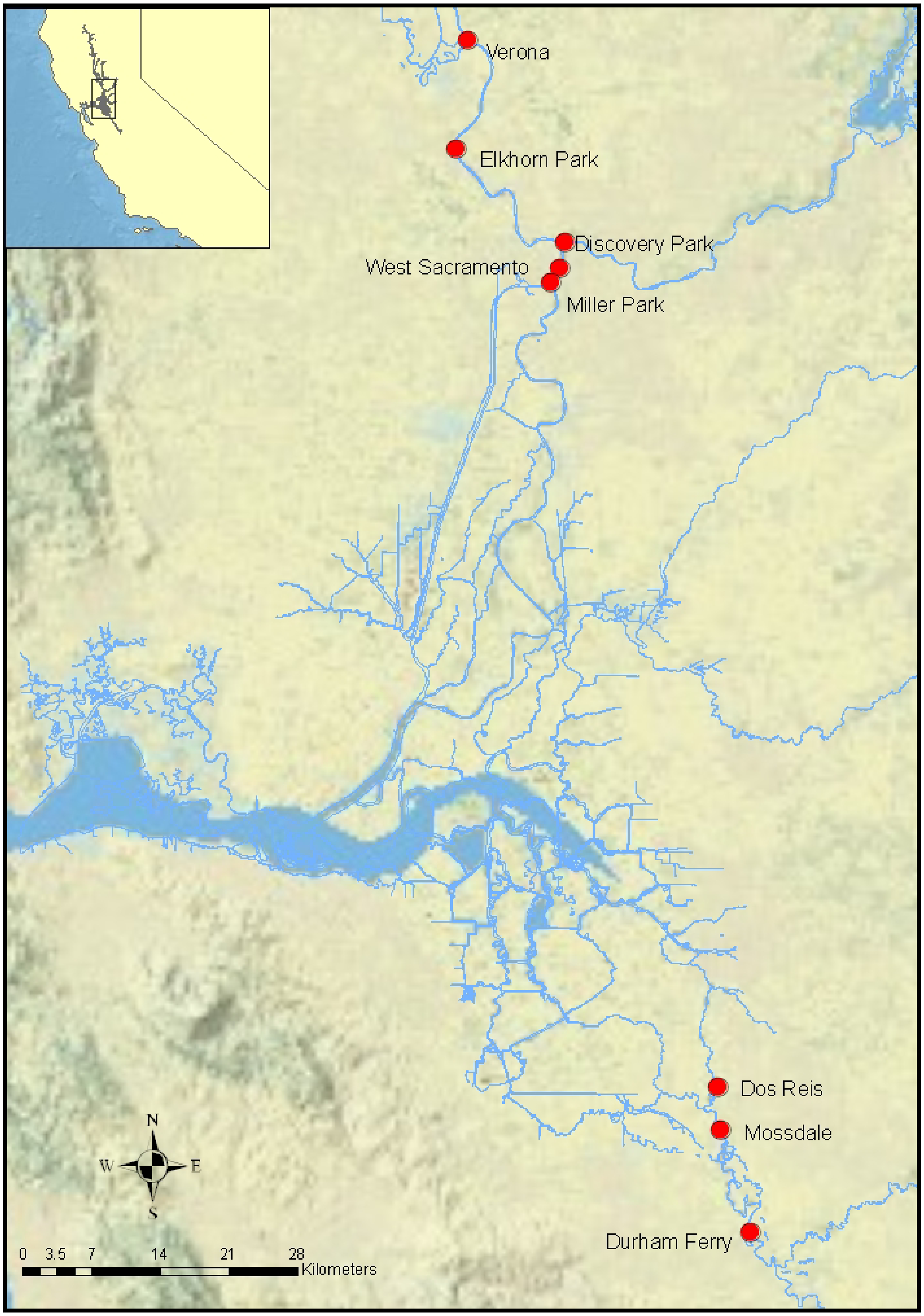

Figure 1. Map of release locations of coded wire tagged salmon in the Sacramento and San Joaquin Rivers.

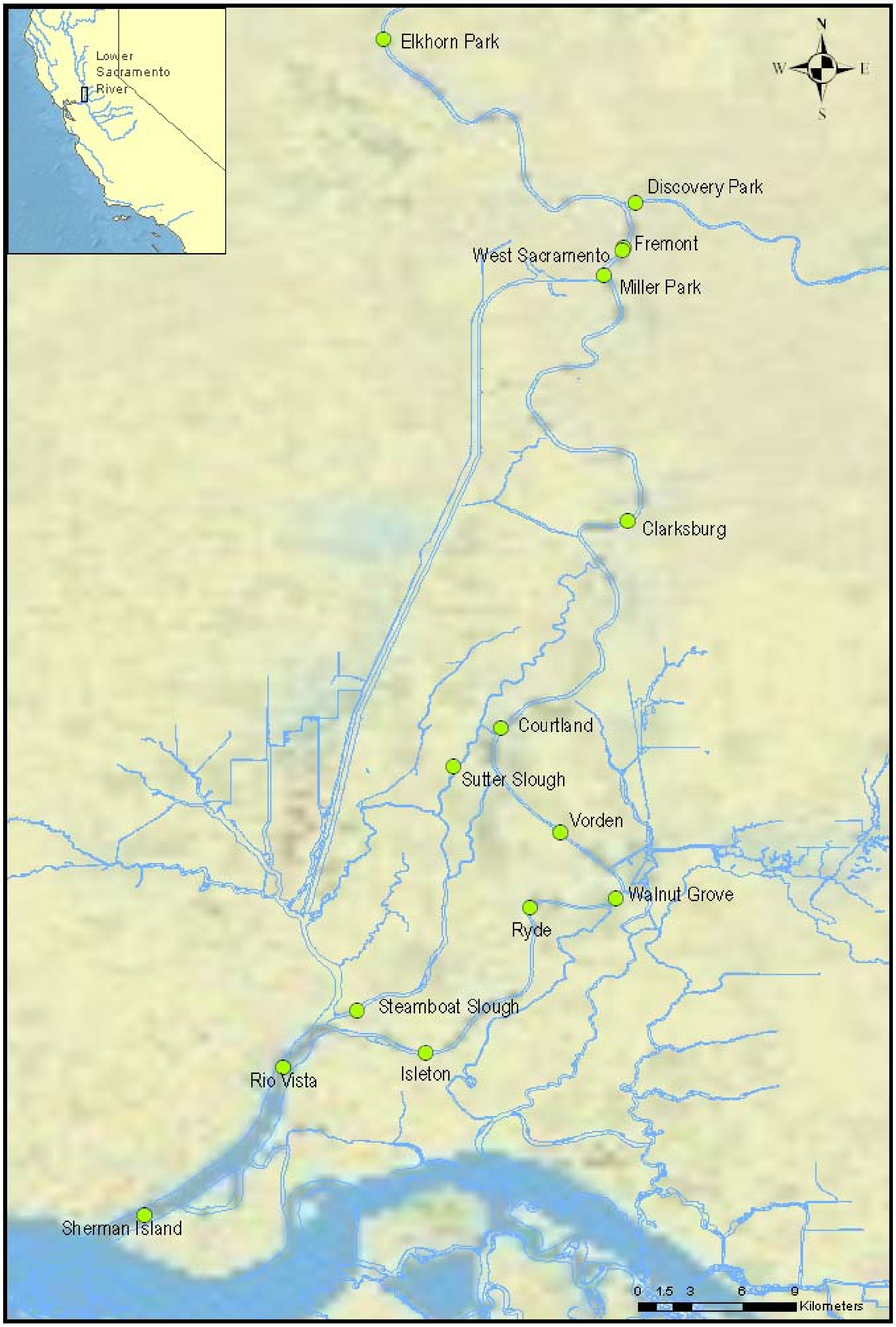

Figure 2a. Release locations of coded wire tagged salmon in the lower Sacramento River used in the analysis of salvage.

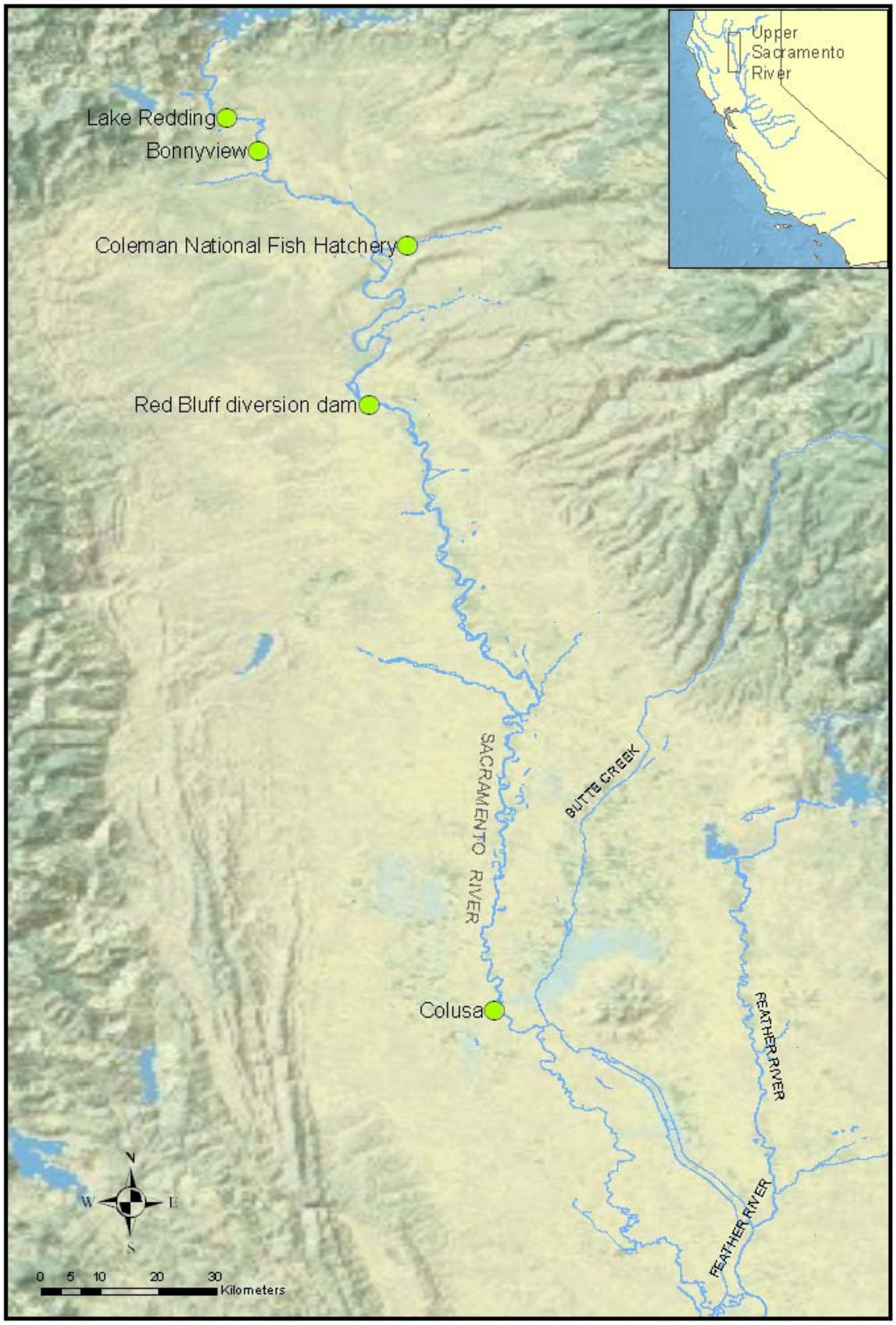

Figure 2b. Release locations of coded wire tagged salmon in the upper Sacramento River used in the analysis of salvage.

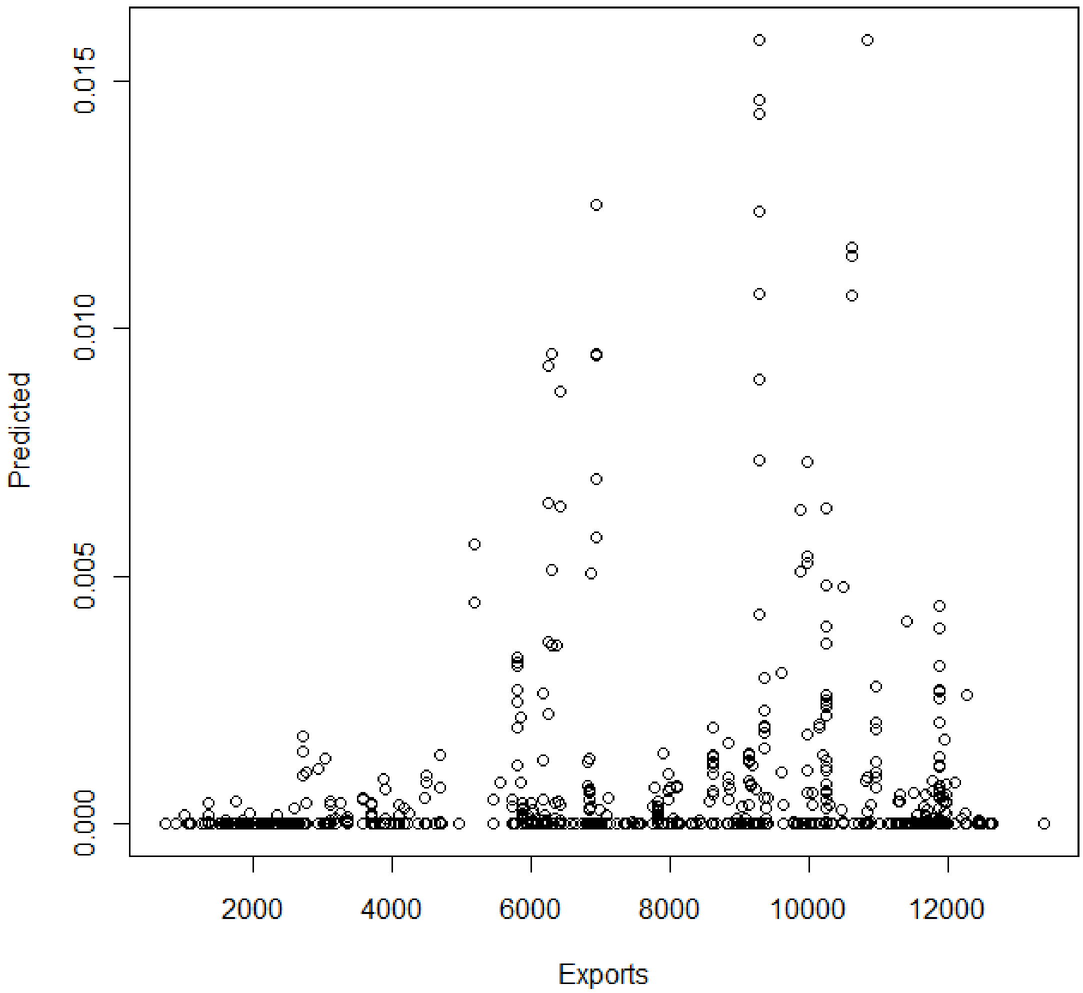

Figure 3. Plot of export volume and predicted salvage probabilities for Sacramento River releases from 1993 to 2007

Tables

Table1. Predictor variables used to model survival of coded wire tagged salmon released in the Sacramento and San Joaquin River.

Category	Predictor	Definition
Release-specific	location	An indicator variable that represents the location where juvenile salmon were released; numbered from downstream to upstream.
	temp	Water temperature at the time of release.*
	length	Average fork length of salmon in the release group.
Flow	inflow	Average flow in the Sacramento or San Joaquin River for 7 days following the release.
	exports	Average exports in the 7 days following the release.
	% salvaged	Proportion of each release group collected at export facilities.
Water Quality	NH_4	Concentration of NH_4+ in the Sacramento or San Joaquin River in the month of the release.
	DIN:DIP	Ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorous in the Sacramento or San Joaquin River in the month of the release.
	Secchi	Average Secchi depth in the month of the release.
Ocean conditions	Wells'	Wells' index of ocean productivity in the year that juvenile salmon enter the ocean.
	Wells'_{t+1}	Wells' index of ocean productivity during the release group's second year at sea.

* Temperature data for certain Sacramento releases were missing and replaced with temperature measurements from a USGS gauging station on the Sacramento River at Freeport.

Table 2. Hypothesized relationships between predictor variables and salmon survival.

Category	Predictor	Hypothesized relationship with survival
Release-specific	location	Negative: releases made farther upstream are exposed to sources of mortality for a longer time period than releases made farther downstream.
	temp	Negative: higher temperatures in the river channel reduce successful acclimation and increase mortality through temperature shock.
	length	Positive: larger fish are less susceptible to predation.
Flow	inflow	Positive: high flows move fish through the Delta quickly and there is less chance of entrainment into the interior Delta.
	exports	Negative: higher exports cause direct mortality at export facilities or indirect mortality through entrainment in the interior Delta.
	% salvaged	Negative: as salvage increases, the probability of capture in the ocean decreases.
Water quality	NH_4	Negative: high concentrations of NH_4 alter food webs so they are unfavorable to salmon (Gilbert In press).
	DIN:DIP	Negative: high concentrations of DIN relative to DIP alter food webs so they are unfavorable to salmon (Gilbert In press).
	Secchi	Negative: low visibility decreases susceptibility to predation.
Ocean conditions	Wells' t	Positive: productive ocean conditions when salmon enter the ocean increase the probability of survival.
	Wells' t+1	Positive: productive ocean conditions increase salmon growth, increasing the probability of survival (Wells et al. 2007).

Table 3. Definition of predictors used to model salvage of coded wire tagged salmon releases.

Predictor	Definition
location	An indicator variable that represents the location where juvenile salmon were released; numbered from downstream to upstream.
month	An indicator variable that represents the month that juvenile salmon were released numbered from earliest to latest.
length	Mean fork length of salmon in each release group.
rearing	A dummy variable representing rearing type where 1 = hatchery and 0 = wild.
year	Year of release.
DCC	A dummy variable representing the position of the Delta Cross Channel where 1 = open and 0 = closed.
inflow	Average flow in the Sacramento River for 7 days following each release.
exp	Average exports for 7 days following each release.
CI rate	Recovery rate of salmon from each release group in the Chipps Island trawl.
o rate	Recovery rate of salmon from each release in the ocean fishery.

Table 4. Hypothesized relationships between predictors and salvage of salmon releases.

Category	Predictor	Hypothesized relationship with salvage
Release-specific	location	Negative: fish released closer to routes into the interior Delta may be entrained at a greater rate due to disorientation.
	month	Negative: the DCC is open more frequently during early releases.
	length	Negative: larger fish have a greater swimming ability and may be able to avoid sub-optimal migration routes.
	rearing	Positive: wild fish are better adapted to natural habitats.
Flow	DCC	Positive: When the DCC is open, more fish are entrained in the interior Delta where the export facilities are located.
	inflow	Negative: high flows reduce entrainment into the interior Delta.
	exports	Positive: salvage increases as the volume of water exported increases.
Survival	CI rate	Negative: greater salvage reduces the probability of capture in the Chipps Isalnd trawl.
	ocean rate	Negative: greater salvage reduces the probability of capture in the ocean fishery.

Table 5. Candidate models of survival for Sacramento River coded wire tagged releases. Models are arranged from the most to least likely according to AIC_c values.

Release-specific	Flow	Water quality	Ocean conditions	AIC_c	ΔAIC_c	AIC weight
X	X	X		432.050	0.000	0.456
	X	X		432.250	0.200	0.413
X	X	X	X	435.600	3.548	0.077
	X	X	X	436.385	4.333	0.052
X		X		447.250	15.198	< 0.001
		X		449.012	16.960	< 0.001
X		X	X	451.385	19.333	< 0.001
		X	X	452.735	20.683	< 0.001
X				457.988	25.936	< 0.001
	X			459.988	27.936	< 0.001
X	X			460.195	28.143	< 0.001
X			X	461.735	29.683	< 0.001
	X		X	463.735	31.683	< 0.001
X	X		X	464.300	32.248	< 0.001
			X	486.698	54.646	< 0.001

Table 6. Model averaged coefficients and unconditional confidence intervals for predictors used to model the survival of coded wire tagged salmon released in the Sacramento and San Joaquin Rivers. Asterisks indicate that the predictor had good support in data (zero was not included in the confidence interval).

Predictor	Sacramento River	San Joaquin River
Release location	0.445 (-0.127 - 1.017)	-0.07 (-0.324 - 0.183)
River temperature (°F)	0.727 (-0.024 - 1.478)	-0.601* (-0.782 - -0.419)
Fork length (mm)	0.619 (-0.380 - 1.618)	0.568* (0.266 - 0.869)
River flow ($ft^3 s^{-1}$)	0.171 (-0.076 - 0.418)	-0.281 (-0.902 - 0.340)
Exports ($ft^3 s^{-1}$)	-0.053 (-0.303 - 0.197)	0.359* (0.129 - 0.590)
% salvaged	0.21* (0.127 - 0.293)	-0.078 (-0.242 - 0.087)
NH_4 ($mg\ l^{-1}$)	0.056 (-0.220 - 0.331)	-1.039 (-2.300 - 0.222)
DIN:DIP	0.034 (-0.191 - 0.259)	-0.256 (-0.816 - 0.305)
Secchi (cm)	0.321 (-0.032 - 0.674)	1.219* (0.727 - 1.710)
$Wells'_t$	0.448 (-0.178 - 1.075)	0.964 (-0.565 - 0.765)
$Wells'_{t+1}$	-0.016 (-0.657 - 0.625)	1.963* (0.531 - 3.396)

Table 7. Support for hypothesized relationships between survival of Sacramento and San Joaquin releases and predictor variables following model selection.

Category	Predictor	Hypothesized relationship	Support in data	
			Sacramento	**San Joaquin**
Release-specific	location	negative	no	no
	temp	negative	no	yes
	length	positive	no	yes
Flow	inflow	positive	no	no
	exports	negative	no	no
	% salvaged	negative	no	no
Water quality	NH_4	negative	no	no
	DIN:DIP	negative	no	no
	Secchi	negative	no	no
Ocean conditions	Wells' t	positive	no	no
	Wells' t+1	positive	no	yes

Table 8. Candidate models of survival for San Joaquin River coded wire tagged releases. Models are arranged from the most to least likely according to AIC_c values.

Release-specific	Flow	Water quality	Ocean conditions	AIC_c	ΔAIC_c	AIC_c weight
X	X	X	X	402.250	0.000	0.614
X		X	X	404.181	1.931	0.234
X		X		406.118	3.868	0.089
X	X	X		406.805	4.555	0.063
		X	X	429.674	27.424	<0.001
	X	X	X	430.181	27.931	<0.001
		X		433.955	31.705	<0.001
	X	X		436.118	33.868	<0.001
X				456.840	54.590	<0.001
X			X	457.469	55.219	<0.001
X	X		X	460.779	58.529	<0.001
X	X			461.856	59.606	<0.001
	X		X	476.469	74.219	<0.001
	X			477.840	75.590	<0.001
			X	479.594	77.344	<0.001

Table 9. Candidate models of salvage of coded wire tagged salmon releases in the Sacramento River. Models are arranged from most to least likely based on AIC_c values.

Model	Release-specific	Flow	Survival	AIC_c	ΔAIC_c	AIC_c weight
F2	X	X		2415.933	0.000	0.736
S4	X	X	X	2417.987	2.054	0.264
P1	X			2480.756	64.823	<0.001
S2	X		X	2484.516	68.583	<0.001
S3		X	X	2619.363	203.430	<0.001
F1		X		2633.956	218.023	<0.001
S1			X	2716.829	300.896	<0.001

Table 10. Model averaged coefficients and unconditional confidence intervals for predictors included in salvage models. Asterisks indicate that the predictor was well supported by the data (zero was not included in the confidence interval).

Category	Parameter	Estimate
Release-specific	location	-0.03 (-0.092 - 0.033)
	month	-0.144 (-0.407 - 0.119)
	length	2.215* (1.852 - 2.577)
	rearing	1.679* (0.028 - 3.078)
Flow	DCC	1.611* (0.576 - 2.645)
	inflow	0.34* (0.032 - 0.649)
	exports	1.355* (0.985 - 1.726)
Survival	CI rate	0.158 (-0.157 - 0.472)
	ocean rate	0.109 (-0.229 - 0.447)

REFERENCES

Baker, P. F., Speed, T. P. & Ligon, F. K. 1995. Estimating the influence of temperature on the survival of Chinook salmon smolts migrating through the Sacramento-San Joaquin River Delta of California. Canadian Journal of Fisheries and Aquatic Sciences 52:855-863.

Gilbert, P.M. 2010. Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California. Reviews in Fisheries Science 18:211-232.

Kjelson, M. and P. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento San-Joaquin Rivers, California. In Levings C. et al., editors. Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105, pages 100-115.

Lindley, ST, Mohr, MS. 2003. Modeling the effect of striped bass (Morone saxatilis) on the population viability of Sacramento River winter-run Chinook salmon (Oncorhyncus tschawytscha). U.S. Fishery Bulletin 101:321-331.

Newman, K. B. and J. Rice. 2002. Modeling the survival of Chinook salmon smolts outmigrating through the lower Sacramento River system. Journal of the American Statistical Association 97:983-993.

Newman, K. B. 2003. Modeling paired release-recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. Statistical Modeling 3:157-177.

Newman, K. B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. Project number SCI-06-G06-299. U.S. Fish and Wildlife Service, Stockton, CA. http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS
_salmon_studies_final_033108.pdf (November 2008)

Newman, K. B. and P.L. Brandes. 2010. Hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports. North American Journal of Fisheries Management 30:157-169.

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

Wells, B.K, Grimes, C.B. and Waldvogel, J.B. 2007. Quantifying the effects of wind, upwelling, curl, sea surface temperature and sea level height on growth and maturation of a California Chinook salmon (*Oncorhynchus tshawytscha*) population. Fisheries Oceanography 16:363-382.

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