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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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MEMORANDUM FOR: ARN 151422SWR2004SA9116 (TN 2008/09022)

FROM: Jeffrey Stuart, Fishery Biologist, Southwest Region JS

REVIEWED BY: Maria Rea, Supervisor, Sacramento Area Office

SUBJECT: Technical memorandum regarding the San Joaquin River "4:1Flow to Export ratio" Reasonable and Prudent Alternative (RPA) for the formal section 7 consultation regarding the Long-Term Operations of the Central Valley Project and State Water Project

Purpose of Reasonable and Prudent Alternative:

The purpose of this reasonable and prudent alternative (RPA) is to provide flows in the lower San Joaquin River, as measured at the Vernalis monitoring gage, of sufficient duration and magnitude to increase the survival of emigrating Central Valley steelhead (*Oncorhynchus mykiss*) originating in the east side tributaries of the San Joaquin River basin through the lower San Joaquin River and into the delta in such a manner as to avoid jeopardy to this component of the Central Valley Steelhead distinct Population Segment (DPS). The effects analysis of the proposed operations on the Southern Sierra Diversity group of Central Valley steelhead contained in the biological opinion describes the effects of flow on the behavior and biology of steelhead in the San Joaquin basin. This document focuses on the relationship of flow to fish outmigration survival and adult returns, as well as the process used in the development of the RPA.

Background:

The 2008 Biological Assessment (BA) for the Long Term Operations of the Central Valley Project and State Water Project hereafter referred to as the Operations and Criteria Plan (OCAP) had as a part of its project description, a commitment to carry on actions that were similar to the actions carried out under the Vernalis Adaptive Management Plan (VAMP) experiments. The VAMP experiments were an integral part of the San Joaquin River Agreement (SJRA) commitment to implement the State Water Resources Control Board (SWRCB) 1995 Water

Quality Control Plan (WQCP). VAMP, officially initiated in 2000 as part of SWRCB Decision 1641 (D-1641), is a large scale, long term (12 year) experiment/management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientific experiment designed to test hypotheses concerning the effects of river flow and exports on juvenile salmon survival rates in the San Joaquin River and Delta in response to the presence of the Head of Old River Barrier (HORB). The funding of VAMP, through Reclamation and DWR is set to expire in December 2009. The SJRA is set to expire in 2012. The BA is however, vague in the details of the "VAMP-like" actions to be taken after the conclusion of the current VAMP agreement. The project description in the BA did not describe which actions would continue and to what level any actions that did continue would be implemented. This lack of clarity in the project description was of great concern to NMFS. Ongoing consultations with Reclamation and DWR following issuance of the BA failed to develop these post-VAMP actions beyond general concepts. Reclamation and DWR indicated during these meetings that "VAMP-like" flows would be met at Vernalis (current point of flow compliance), but specificity as to the magnitude, points of origin, and duration of flows were not elaborated on. For the purposes of the Central Valley Project (CVP) and State Water Project (SWP) operations forecasts, the VAMP target flows are simply assumed to exist at the confluence of the Stanislaus and San Joaquin Rivers. The BA indicated that flow increases to achieve the VAMP-like targets could be provided using Central Valley Project Improvement Act (CVPIA) authorities under sections 3406 (b)(1), (b)(2), and (b)(3).

In addition to flows, the VAMP experiment included export reductions during the 31-day experimental period. Export rates are to be limited to 1,500 cubic feet per second (cfs) for VAMP target flows of 2,000 cfs, 3,200 cfs, 4450 cfs, or 7,000 cfs. At target flows of 5,700 cfs, an export rate of 2,250 cfs is allowed. An additional export rate of 3,000 cfs can also be implemented at the target flow of 7,000 cfs. Pumping reductions for the CVP which cannot be recovered through reoperations of the project are considered to be WQCP expenses covered by (b)(2) assets. Pumping reductions for the SWP are limited to the amount that can be recovered through operations adjustments and exports of up to 48 thousand acre feet (taf) of transferred water made available through the Yuba Accord. The Yuba Accord provides up to 60 taf annually for Environmental Water Account (EWA) purposes from the lower Yuba River, and may increase this amount in drier years. It is anticipated that of the 60 taf transferred from the Yuba River, 48 taf will be available for export in the Delta. DWR has indicated that export curtailments will be limited to the 48 taf of Yuba Accord water during the "VAMP-like" actions. Exports will increase once this supply of water is exhausted.

Currently, supplemental volumes of water needed to reach the annual target flow are released on each of the three east side tributaries, *i.e.* the Stanislaus River, the Tuolumne River, and the Merced River, in a coordinated fashion to provide pulse flows down each river channel while maintaining the target flow at the Vernalis gage. These pulse flows are believed to stimulate outmigration of fall-run Chinook salmon (the target species for the VAMP experiments) downstream towards the Delta. However, it also is acknowledged that other species of fish, including the CV steelhead, benefit from these pulses (see San Joaquin River Group Authority 2006, 2007). NMFS finds that these pulse flows are critical cues for the listed steelhead in these tributaries to initiate their downstream emigration to the ocean. As described in the effects analysis of the biological opinion, loss of the flow stimulus to initiate emigration downstream to the ocean will have behavioral and physical effects on fish remaining instream. These effects include competition with conspecifics as well as with fall-run Chinook salmon residing in the same stream reaches, increased fish density within the stream reaches used by over summering steelhead, and reductions in the quality and quantity of identified critical habitat in the basin (*i.e.*, rearing and migratory corridor habitat) used by the steelhead.

Reclamation and DWR did not provide further resolution of their future operations other than to provide VAMP-like flows at Vernalis. The lack of specificity concerning future flows on the Tuolumne and Merced Rivers is concerning. NMFS has considerable interest in how the flows in the two other tributaries, besides the Stanislaus River, will be affected by the future CVP/SWP operations. As mentioned above, the Tuolumne River and Merced River release a portion of the total supplemental water required to meet the targeted flows required under the VAMP experiment each year. These flows are integral to stimulating outmigration of both the threatened CV steelhead, and fall-run, a species of concern under the Endangered Species Act, from the Tuolumne River and Merced River. Furthermore, decreases in the pulse flows on these two rivers would be an adverse modification of critical habitat designated for CV steelhead. Flow related decreases would affect rearing area suitability and create physical and flow related obstructions in the migration corridors from the rearing areas below the dams, downstream to Vernalis on the San Joaquin River where the Stanislaus River enters.

The lack of specificity in the project description as to future project actions to safeguard the ability of Central Valley steelhead to persist in the San Joaquin River basin and the apparent abandonment of the purchase of water on the Tuolumne and Merced Rivers at current levels (as required in the SJRA) places the remaining population in the basin at a greater risk of extirpation in the future. As proposed, the project reduces the likelihood that San Joaquin River basin steelhead will have the same level of protection as currently seen and in fact may lose ground on the Tuolumne and Merced Rivers.

In light of this risk, NMFS evaluated potential alternative actions to enhance the conditions in the San Joaquin River basin. While alternative actions were primarily focused on the lower valley floor reach of the San Joaquin River from its confluences with the east side tributaries through the Delta, NMFS anticipates that actions that increase flows in the lower river reaches (*i.e.,* at the Vernalis compliance point) will create beneficial conditions in upstream reaches of the tributaries from the first dam downstream to the confluence with the San Joaquin River that will benefit steelhead (as well as fall-run Chinook salmon). The following discussion explains NMFS' reasoning in selecting the conditions for the San Joaquin River 4:1 flow to export RPA.

As part of the foundation for developing an RPA for the lower San Joaquin River and Delta, NMFS first reviewed reports and studies concerning the status of anadromous fish and salmonids in the San Joaquin River basin. Although not an exhaustive review of all literature available, the reports and papers spanned several decades. Skinner (1958) reported that Central Valley populations of Chinook salmon exhibited wide fluctuations in abundance from 1870 onward by examining landings of Chinook salmon in California. The overall trend in abundance was negative, but every thirty years or so, particularly large landings occurred. Skinner opined that the declines in the Chinook salmon fisheries appear to be chronologically associated with water development projects in California, and the increase in the ocean troll fishery. Skinner describes the effects of the construction of Friant Dam on the upper San Joaquin River on the former spring-run Chinook salmon population in that watershed. "Friant Dam on the San Joaquin River has had multiple effects on the spring fishery. In the first place the dam has cut off a third or more of the spawning area. Secondly, flows below the dam were inadequate during normal migration periods to assure passage of the fish either up or down the river. Only enough water is permitted to flow down the river to fulfill irrigation commitments. The released water flows to the delta Mendota Pool and a small amount reaches the "Sack Dam" at Temple Slough where it is diverted for agricultural purposes. Below this point, the river goes dry except for small amounts of water received from its downstream tributaries. Because of these conditions, salmon obviously cannot ascend to the spawning area in the vicinity of Friant Dam." Skinner also makes the observation that with the extirpation of the San Joaquin River spring run population that the commercial catches of spring run Chinook salmon plummeted from 2,290,000 pounds in the 1946 season to 14,900 pounds in 1953. Functional extirpation of the San Joaquin River spring run Chinook salmon population occurred following the completion of the Madera Canal in 1944, and the completion of the Friant-Kern canal in 1949, allowing full use of the distributional system under the Bureau of Reclamation's operational plan. Skinner concluded that the last successful spawn of spring run Chinook salmon in the San Joaquin River has not occurred "since the spring of 1946."

A paper by Kjelson *et al.* (1981) described the effects of freshwater inflow on survival, abundance, migration, and rearing of Chinook salmon in the upstream (Delta) portions of the Sacramento-San Joaquin Estuary. Kjelson *et al.* pointed out that additional inflows of freshwater at the appropriate time during the winter and spring will increase the numbers of fry and juvenile salmon utilizing the estuary and the survival of juveniles in the estuary. Flow related concerns for salmon in the estuary stem from water development activities in the Central Valley that have altered the distribution of flow resulting in impacts on juvenile and adult salmon migrations, as well as the lack of comprehensive flow standards on the tributaries and main stem river reaches that are protective of salmon. The authors further explain that water development projects have caused major changes in the flow patterns within the estuary and the amount of flow entering the ocean from upstream sources. The San Joaquin River system has been particularly altered as most of the upstream inflow to the basin has been captured and utilized in regions upstream of the Delta. Typical export rates substantially exceed the flow of the San Joaquin River; hence most of the San Joaquin River flow goes to the pumps rather than to the ocean. The authors concluded that the distribution and flow of water through the Delta waterways are heavily influenced by the design and operation of the state and federal water projects. The paper reports that analysis of data gathered between 1957 and 1973 indicates that the numbers of adult Chinook salmon spawners returning to the San Joaquin River system are influenced by flows 2.5 years earlier during their rearing and downstream emigration life history phases. In general, higher flows resulted in greater numbers of adults returning to spawn. Kjelson *et al.* also implicates the potential adverse effects of the pumps in the reduced survival of fish emigrating through the Delta, indicating that as export rates are increased, more downstream migrating salmon are drawn to the fish screens. Kjelson *et al.* estimates that the number of fish observed at the fish screens is probably only 5 percent of the total downstream migration in the system, but that a "much larger fraction probably is drawn out of their normal migration path" by the effects of the pumps on water flow in the Delta's channels. Kjelson *et al*. states that the "alteration in flow distribution caused by drafting increased volumes of water across the Delta to the pumps apparently increases the mortality of salmon that do not ever reach the fish screens." In support of this statement, Kjelson *et al*. points out those mark-recapture studies in which fish that migrate downstream in waterways that are far removed from the effects of the pumps had higher relative survival rates than those released in waterways under the influence of the pumps.

In a second paper by Kjelson *et al.* (1982), they reiterate the reduced survival of salmon in the delta due to influences of natural and anthropogenic sources. They found that Chinook salmon smolt survival decreased as flow rates decreased and water temperatures increased, particularly in the later portions of the outmigration period. Furthermore, they restated their belief that the influence of the state and federal exports negatively impacted the survival of emigrating smolts through the Delta.

In a study assessing the influence of San Joaquin River inflows, state and federal exports and migration routes, Kjelson *et al.* (1990) released experimental fish (coded wire tagged hatchery Chinook salmon) during the spring of 1989 at Dos Reis on the San Joaquin River below the head of Old River, and in Old River itself downstream of the head under conditions with low San Joaquin River flow (≈ 2,000 cfs) and high/low export conditions (10,000 cfs and 1,800 cfs). The results of the study were unexpected as the rate of survival was not greater for the low export conditions compared to the higher export conditions. Upon further examination of the data, Kjelson *et al*. found that survival was comparatively lower for all upstream release groups that year compared to other studies conducted in previous years. In addition, Kjelson *et al.* surmised that the short period of reduced exports (7 days) was not long enough to allow fish to exit the system and move beyond the influence of the exports when higher pumping resumed. Based on the times to recovery at Chipps Island, it was concluded that a sizeable proportion of the released fish were still in the Delta when the higher export levels resumed. This conclusion is further reinforced by the salvage of fish released at Jersey Point, indicating that fish were drawn upstream into the interior of the Delta and towards the pumps. The study, although having several significant flaws, did conclude that survival was higher in the main stem San Joaquin River compared to Old River and that survival in the Delta interior was lower compared to the western Delta (*i.e.,* Jersey Point releases). The authors cautioned about drawing conclusions about export rates and survival from the data due to its obvious flaws.

A paper by Kjelson and Brandes (1989) reports on the results of ongoing mark-recapture studies conducted in the Sacramento-San Joaquin Delta and the effects of river flows, percent diversion of Sacramento River water through the Delta Cross Channel, and river temperatures. The findings of this paper also conclude that elevated flows, as measured at Rio Vista on the Sacramento River, increase survival of Chinook salmon smolts from the Sacramento River basin through the Delta as measured by both ocean recoveries of adults and recaptures of tagged smolts at Chipps Island in the mid-water trawls. Similarly, adult escapement in the San Joaquin River basin also increases with spring time flows at Vernalis 2.5 years earlier. Increasing water temperature was also shown to decrease smolt survival through the Delta during the critical April through June outmigration period of fall-run Chinook salmon.

In a more recent report, Mesick *et al.* (2007) assessed the limiting factors affecting populations of fall run Chinook salmon and steelhead in the Tuolumne River. The paper describes potential limiting factors which may affect the abundance of fall-run Chinook salmon and both resident and anadromous (steelhead) forms of rainbow trout in the Tuolumne River. This information was then synthesized into conceptual models to help guide management decisions in regards to these two salmonid species. In general, Mesick *et al.* found that river flows were the limiting factor with the greatest influence on the salmonid populations in the Tuolumne River. As found in previous studies, there is a strong relationship between adult escapement and spring river flows during the juvenile/smolt outmigration stage. Flows measured over the period between March 1 and June 15 explains over 90 percent of the variation in the escapement data. However, Mesick *et al*. identified two critical flow periods for salmon smolts on the Tuolumne River: winter flows which affect fry survival to smolt stage, and spring flows which affect the survival of smolts migrating from the river through the delta. Based on results from ongoing VAMP studies, Mesick *et al*. also noted that increased flows at Vernalis also increased survival of smolts emigrating through the Delta. Water temperature in the river was also identified as a potential limiting actor for salmonid survival within the emigration time period. Flows have a substantial role in maintaining suitable water temperatures within the river system, with higher flows prolonging and extending the cool water migratory corridor downstream than low flow conditions. Mesick *et al.* found that for Tuolumne River fall-run Chinook salmon escapement data, that exports had little effect on adult production compared to winter and spring flows. Flows were the primary factor, beyond all other factors, in determining adult production from smolts.

NMFS also reviewed the restoration reports for the Central Valley Project Improvement Act, including the three volumes of "Working Paper on Restoration Needs" for the Anadromous Fish Restoration Program (AFRP) (USFWS 1995) and the Final Restoration Plan for the Anadromous Fish Restoration Program (USFWS 2001). The plan identified the Delta as the highest priority for restoration actions (page 17, Final Restoration Plan), given that it was highly degraded, due in part to CVP (and SWP) operations, and that all anadromous fish must pass through the delta as juveniles and adults. In addition, the San Joaquin River main stem and its tributaries below Mendota Pool were assigned a high priority (but lower than the Delta) due to its highly degraded habitat and substantially reduced production of fall-run Chinook salmon. Specific actions in each watershed and the delta were identified to address the limiting factors present in those areas and were prioritized as to their ability to implement the "doubling goal" for affected fish populations. In general, actions scored a high priority if they promote natural channel and riparian habitat values and natural processes, such as those affecting stream flow, water temperature, water quality, and riparian areas. Actions are assigned medium priority if the affect emigration or access to streams, such as sites of entrainment into diversions and migration barriers. Like the previous reports, the AFRP Restoration Plan recommended increasing flows within the tributaries and main stem San Joaquin River as a high priority action to increase salmonid production. Within the Delta, actions which would provide protection to juvenile salmonids migrating through the Delta from November 1 through June 30, equivalent to the protection provided by restricting exports to minimal levels, were given high priority. The specific increases in flow were developed to achieve the targeted doubling of fish populations as required under the CVPIA, and are not necessarily the flows needed to sustain or protect populations from further decline or achieve population stability. Targeted flows are typically much greater than the average or median flows observed in the rivers under current conditions. In addition to flows, maintaining appropriate water temperatures in the tributaries for salmonid life history stages was given a high priority. The AFRP restoration plan recommended that actions be implemented "to maintain suitable water temperatures or minimize length of exposure to unsuitable water temperatures for all life stages of Chinook salmon in the San Joaquin River and Delta." Targeted water temperatures are 56^{o}F between October 15 and February 15 and 65^{o}F between April 1 and May31 for Chinook salmon in the main stem San Joaquin River. Furthermore, the construction and operation of a barrier at the head of Old River to improve conditions for Chinook salmon migration and survival was given a high priority so long as its operation had minimal adverse effects on other delta fish species.

An additional reference used by NMFS during the development and assessment of this RPA is the California Department Fish and Game's "Final Draft 11-28-05 San Joaquin River Fall-run Chinook salmon Population Model" which evaluated various parameters that have been identified as influencing abundance of escapement of fall-run Chinook salmon into the San Joaquin River. These parameters included such variables as ocean harvest, Delta exports and survival, abundance of spawners, and spring flow magnitude, duration, and frequency. The model was developed in response to the SWRCB call for comments and recommendations to the 1995 WQCP San Joaquin River spring Vernalis flow objectives in 2005. CDFG determined that the Vernalis spring flow objectives were not adequate for the long-term protection of fall-run Chinook salmon beneficial uses in the San Joaquin River basin because: 1) the San Joaquin River salmon population trend continues to be below the 1967 - 1991 historic average upon which the narrative Doubling Goal was established (CVPIA Restoration Plan goals); 2) salmon smolts are not afforded the level of protection as envisioned by the 1995 WQCP; 3) the VAMP experiment is not working because it has not been implemented as designed; and 4) spring outflow is the primary factor controlling fall-run Chinook salmon population in the San Joaquin River basin. CDFG summarized the shortfalls of the 1995 WQCP Vernalis flow objectives as being due to: 1) the diminished magnitude of the Vernalis flow objective; 2) the narrowness of the pulse flow protection window; 3) the infrequent occurrence of elevated flow objective levels; and 4) the frequent occurrence of reduced flow objective levels. CDFG found in the development of their spreadsheet model that non-flow parameters had little or no relationship to fall-run Chinook salmon population abundance and that spring-time flow magnitude, duration, and frequency were the dominant factors influencing Chinook salmon abundance in the basin. In their analysis of the influence of exports and flow on salmon production, CDFG could not find a statistically significant role for exports compared to the influence of the spring time flows. The role of flow always dominated the interaction of exports and flow on salmon abundance. However, it should be noted that exports typically increase when San Joaquin River flows increase, thereby making exact relationships difficult to determine and that only a narrow range of river flows and exports were tested in the VAMP experiments to date. CDFG summarized the relationship between export, flow, and salmon production to be that when the ratio of exports to Vernalis flow decreases both escapement and cohort production increases. The relationships that suggest flow is the dominant factor influencing salmon production, rather than exports, are: 1) when the ratio of spring exports to spring Vernalis flows decreases, Vernalis flow greatly increases and San Joaquin River basin production greatly increases; 2) when the ratio of spring exports to spring Vernalis flows increases, Vernalis flow greatly decreases and San Joaquin River basin salmon production substantially decreases; 3) juvenile salmon survival increases when spring Vernalis flows increase; 4) spring export to spring Vernalis flow ratio has little influence upon juvenile salmon survival; and 5) as the difference between spring Vernalis flow level and spring export flow level increases, escapement increases. Nevertheless, CDFG recognized that the influence of delta exports upon San Joaquin River salmon production was not totally clear but that its influence was not as negative, at least compared to flows, as it had previously been thought to be. Their analysis indicated that comparatively, flows were the much more influential variable in determining production levels in the basin compared to exports.

The model results indicated that in all scenarios tested, increasing the magnitude of spring outflow resulted in increased salmon production for all water year types. Likewise, in all scenarios tested, expanding the window of protection resulted in increased salmon production. The greatest increment in salmon production associated with increasing the window of protection was from 30 days to 60 days. Further increases in the window of protection beyond 60 days produced smaller incremental gains in salmon production. The 60 day period roughly encompasses the majority of the salmon outmigration window. When both flow magnitude and the window of protection are increased together, the salmon production in the basin increases substantially. Based on the model results, CDFG concluded that the optimal mix of flows and window of protection was: 1) wet years=20,000 cfs for 90 days; 2) above normal years=15,000 cfs and a 75 day window; 3) below normal years = 10,000 cfs for 60 days; 4) dry years = 7,000 cfs for 45 days; and 5) critical years = 5,000 cfs for 30 days. The model suggests that these flow objectives at Vernalis would accomplish the Doubling Goals of the CVPIA-AFRP, improve the fall-run Chinook salmon replacement ratio, and would, as compared to other possible flow objective windows simulated with the model which met the Doubling Goals; result in the lowest water demand. This mixture of flows and protective windows, however, still used approximately 1 million additional acre feet of water from the reservoirs, on average, to meet its needs.

Analyses of the relationship between exports and survival of fall-run Chinook salmon (Kjelson et al. 1981, Brandes and McLain 2001, Newman and Rice 2002, Newman 2003, and Newman 2008) have suggested that survival is negatively associated with exports. Newman’s (2008) analysis of the 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. The analysis of the VAMP data was less clear regarding exports. A statistically significant relationship between exports and survival could not be found. Any relationship between exports and survival probabilities were weak to negligible. Newman however pointed out that this may have been due to the correlation of export rates and flow levels in the VAMP experiments. In addition, the relative range of combinations between exports (1500 – 3000 cfs) and Vernalis flows (less than 7,000 cfs) is very narrow. Newman indicated that the high level of environmental noise likely swamped the signal from the export effects on survival. Newman recommended that alternative experimental procedure (*e.g.* acoustic tagged fish) be used to reduce the noise to signal ratio in the experimental data collected in any future studies. Newman and Brandes (2009, in review) reassessed data from the interior Delta studies, using only studies utilizing late fall Chinook salmon with temporally paired releases. They confirmed that fish released in the interior of the Delta had substantially lower survival rates than fish released in the Sacramento River. The ratio of recovery fractions were consistently much less than 1.0 and the posterior means and the maximum likelihood estimates of θ_t were at most 0.8. The median of θ_t was 0.35 (survival ratio of interior Delta to Sacramento releases). Newman and Brandes (2009 in review) also stated that the relationship between the relative survival and export levels produced estimates of export effects that were consistently negative, and for Bayesian Hierarchical Models, the probability that the effects are negative was 86 to 92 percent. However, the signal-to-noise ratio is low enough that that DIC values and posterior model probabilities indicate that the predictive ability of models without exports is equivalent to models which include exports. Environmental variation is large enough that a failure to find a stronger association could be a function of sample size. In order to find a significant relationship, Newman (2008) estimated that 100 paired releases were needed to yield a coefficient of variation of 20 percent. Newman and Brandes (2009 in review) also recommended that studies to assess the effects of exports on salvage deliberately fix the level of exports at varying levels of flow to determine whether it is the absolute level or the relative level of export that affects the fraction of Georgiana releases that are salvaged at the fish facilities. This same approach is applicable to understanding the role of exports to flow in the San Joaquin River system.

<u>Development of the RPA:</u>

San Joaquin River Basin Steelhead

Assessing the current status of the Central Valley steelhead population indicated that the current populations are severely depressed within the east side tributaries. Monitoring of fish exiting the San Joaquin River system is done by Kodiak trawling in the San Joaquin River between Mossdale and the Head of Old River. Trawls are typically conducted three days per a week by the USFWS from approximately July 1 to March 30. Sampling is increased to five days per a week (10 tows per day at 20 minutes per tow) from April 1 through June 30 during the VAMP experimental period and spring Chinook salmon emigration period. CDFG conducts these spring time monitoring trawls. All trawls are conducted during daylight hours. All species of fish captured are identified to species and enumerated. All Chinook salmon and steelhead captured in the trawls are measured and checked for clipped adipose fins. Typically, few steelhead are recovered by the Mossdale trawl. Recoveries were frequently less than 10 fish for an entire season (see figure 1) with most fish being captured during the April-May period. In support of the VSP criteria for the Central Valley steelhead DPS, all remaining populations must be protected, and geographic and genetic diversity should be maintained. The San Joaquin River tributary populations represent the Southern Sierra diversity group.

Data from the rotary screw traps located on the Stanislaus River at Oakdale (upstream) and at Caswell Park (downstream) indicate that several dozen smolts/larger juvenile *Oncorhynchus* *mykiss* are recovered annually during the winter and spring emigration season starting in December and extending into June (see figure 2). The median date of capture for these fish is March 1. The trap data from the Stanislaus River serves as a useful tool to estimate when downstream migration of San Joaquin River basin steelhead occurs, and can be used to estimate when fish from other tributaries in the basin would be moving downstream too. This assumes that fish behave in a relatively consistent manner throughout the basin and that individual tributaries in the basin do not exhibit unique traits in their migratory behavior.

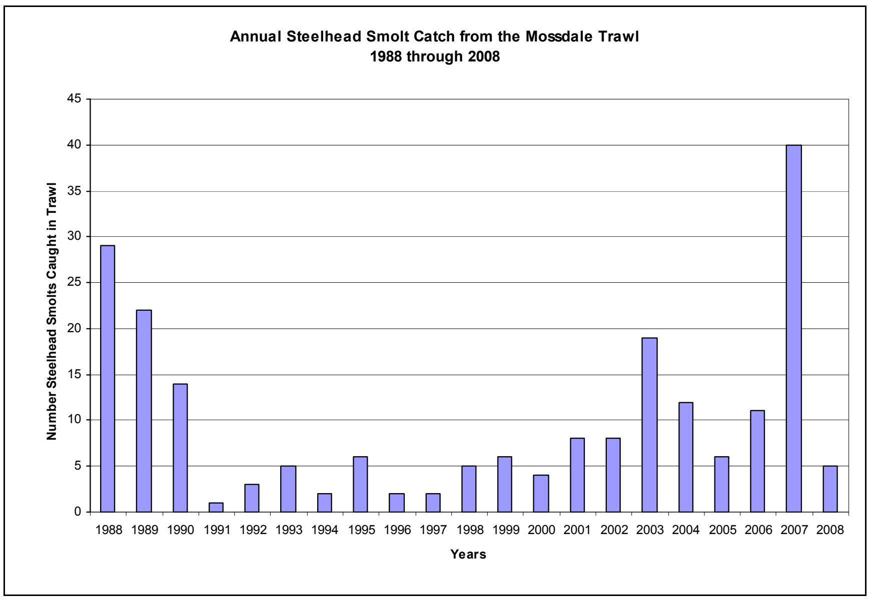


Figure 1: Catches of steelhead in the Mossdale Trawls from 1988 through 2008

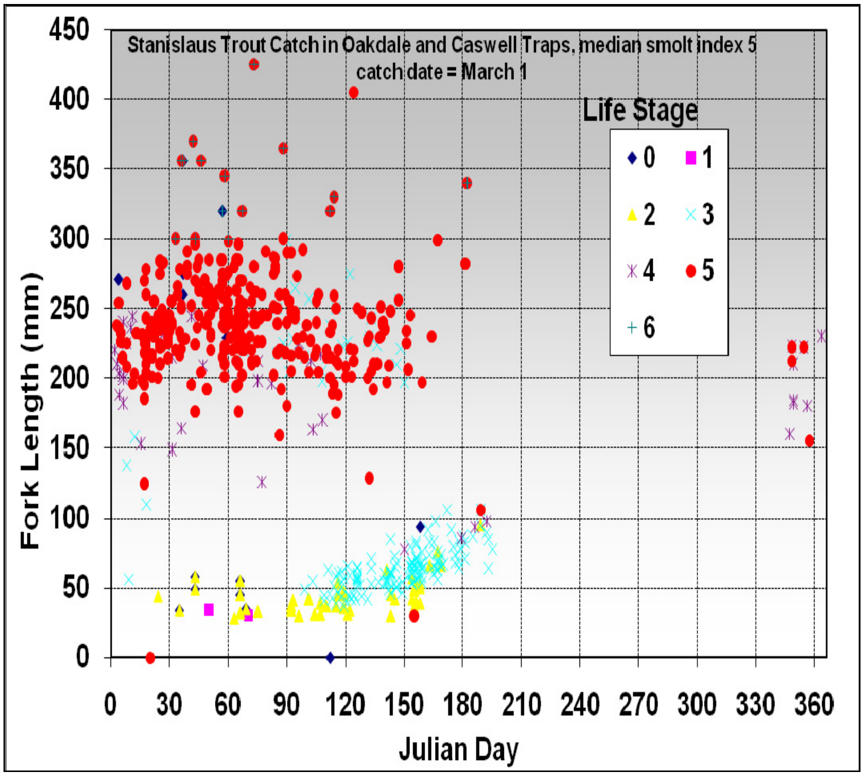


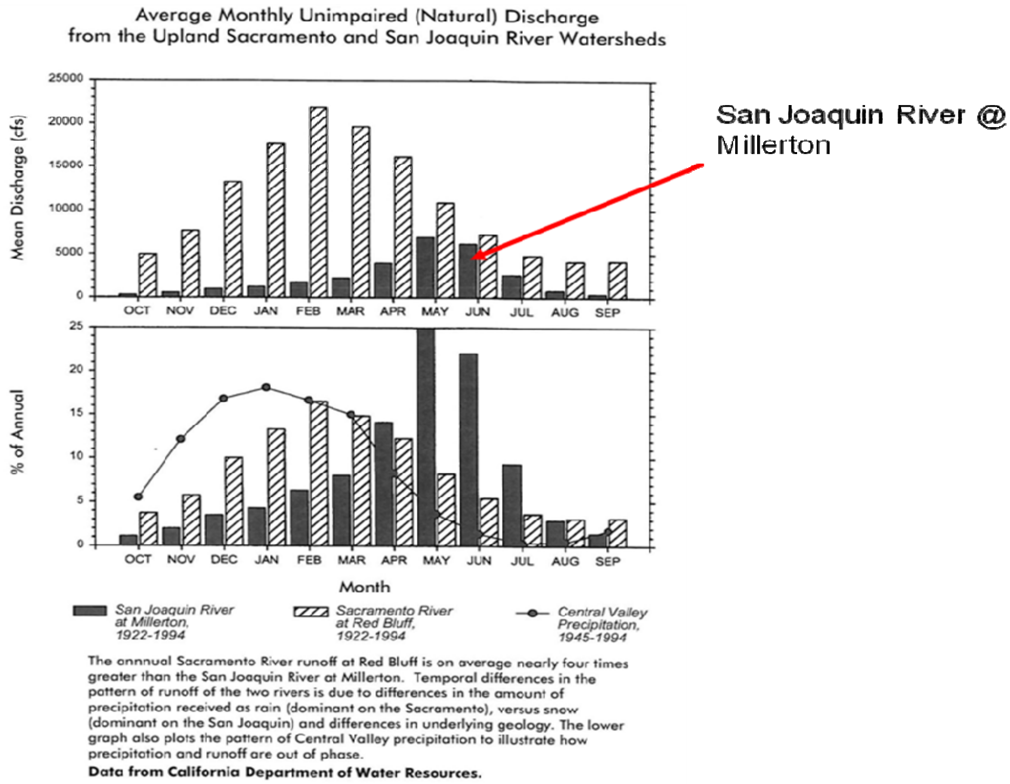
Figure 2: Captures of Rainbow Trout in the Rotary Screw Traps on the Stanislaus River (Oakdale and Caswell traps) 1995 to 2009. Life Stages: 1 egg, 2 yolk sac fry, 3 fry, 4 silvery parr, 5 smolt and 6 adult.

Due to the paucity of data for San Joaquin River basin steelhead, NMFS has decided to use fall-run Chinook salmon populations in the San Joaquin River basin as a surrogate species in developing the RPA. Fall-run Chinook salmon co-occur in the three basin tributaries alongside steelhead. Both species have similar environmental needs for cool water, river flows, and migratory corridors. NMFS makes the assumption that conditions that are favorable to fall-run Chinook salmon will provide similar benefits to co-occurring steelhead populations in the same watershed. Therefore, using fall-run Chinook salmon populations in the basin as an indicator species, conditions that improve the abundance of fall-run should improve the abundance of steelhead.

Flows and Export levels

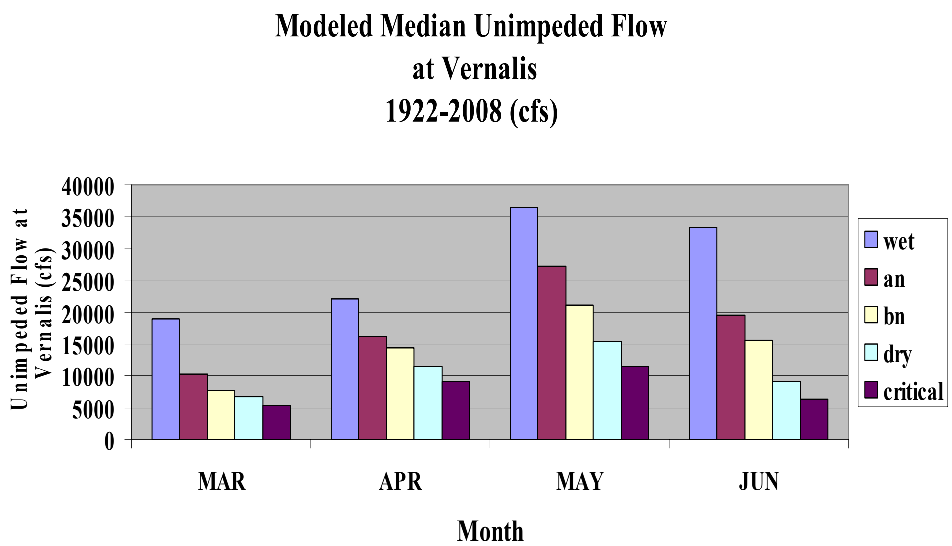
NMFS initially examined the historical hydrographs for the San Joaquin River basin from a variety of sources to determine the pattern of flows that existed in the basin prior to the construction of dams (Figure 3).

Figure 3:



Within the San Joaquin River basin, snowmelt driven runoff peaked in the Months of May and June, with approximately 45 percent of the annual runoff occurring within those two months. Following construction of dams on the main tributaries, peak runoff was shifted to earlier in the year. Modeling of unimpeded flows in the basin by Derek Hilts (USFWS) indicated that flows, as measured at Vernalis, were consistently greater than 5,000 cfs. Such flows would allow the suggested flow conditions called for in the CVPIA Restoration Plan and the CDFG Fall-run Chinook salmon Population Model recommendations to the CWRCB for Vernalis flows (figure 4).

Figure 4:



However, since these flows were typical of the pre-project flows and are most likely not representative of current flow regimes in the highly managed San Joaquin River system, NMFS looked at gaged flows at Vernalis since 1922. The following flows for the month of April and May (Table 1) were derived from Tables 3 and 4 of Appendix A: Hydrologic Analysis of the San Joaquin River Agreement in Meeting Flow Objectives *in*: Meeting Flow Objectives for the San Joaquin River Agreement 1999-2010. Environmental Impact Statement and Environmental Impact Report –Final. June 28, 1999. State Clearing House #:98092062.

Table 1: San Joaquin River flows (cfs) measured at Vernalis for water years 1922 through 1992 for the months of April and May.

Years 1922 to 1992		April Flows	May Flows
Median Value		4895	4101
Average Value		6641	5832
Maximum Value		27742	25762
Minimum Value		1470	1180
1st Quartile		2579	2262
3rd Quartile		7930	6419

The following flows (Table 2) were gathered from the Draft Programmatic Environmental Impact Report for the San Francisco Public Utilities' Water System Improvement Program's Table 5.3.1-1: Mean Monthly Flows at Selected Locations on Waterways potentially affected by the Water System Improvement Program (cubic feet per second). Document found at: http://www.sfgov.org/site/uploadedfiles/planning/vol3_sec5-3_wsip-dpeir.pdf.

Table 2: Average Monthly Flows at Selected Sites in the San Joaquin River Basin

Location	Tuolumne River at Modesto	San Joaquin River at Vernalis	San Joaquin River at Newman
Period of record	1974-2004	1943-2004	1942-2004
Month			
January	1840	5353	2334
February	2236	6947	3249
March	2209	7061	3186
April	1835	6586	2989
May	1644	6730	2847
June	899	5181	3374
July	615	2322	1008
August	431	1496	510
September	711	1880	600
October	937	2422	704
November	724	2386	679
December	1142	3710	1189

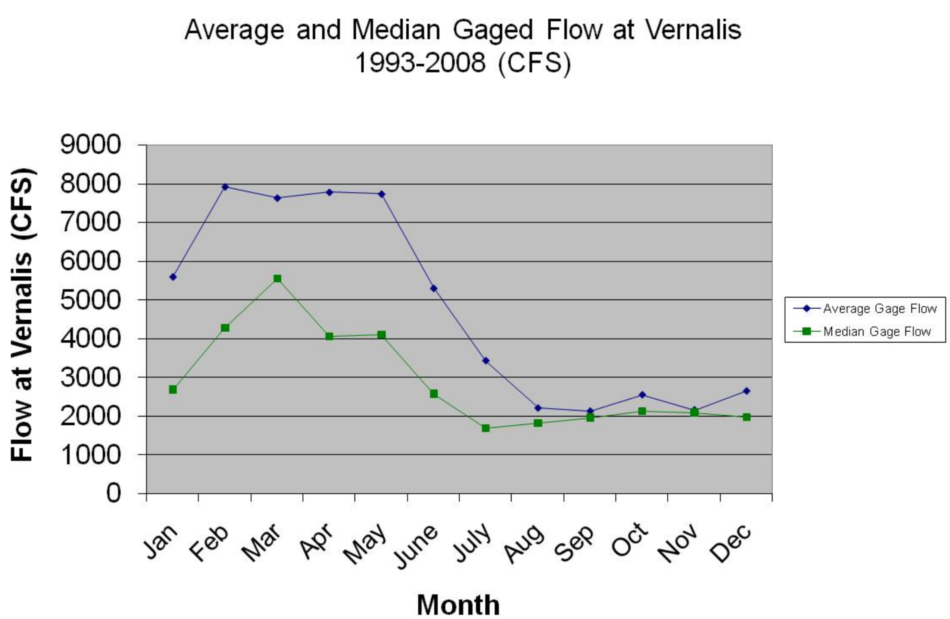
The following table (Table 3) uses the more recent gage readings from the Vernalis gage from 1993 through 2008. Data is from the California Data Exchange Center for the Vernalis gage (VNS) recorded from sensor 20 (Flow – mean daily). Information found at: http://cdec.water.ca.gov/cgi-progs/queryDaily?VNS.

Table 3: Average Monthly Flows at Vernalis (1993 – 2008) measured in cubic feet per second (cfs).

	Average	STD	95% CI	Median	Max	Min
Jan	5592	7694	3770	2690	32469	1684
Feb	7921	9191	4503	4283	32139	1895
Mar	7631	5805	2845	5553	19378	2131
Apr	7780	8118	3978	4061	28149	1869
May	7735	7707	3776	4107	26699	1964
June	5297	5835	2859	2580	18024	1095
July	3429	3989	1955	1698	14313	896
Aug	2203	1373	673	1820	5526	865
Sep	2123	1318	646	1971	5335	801
Oct	2545	1391	682	2131	5715	1006
Nov	2155	669	328	2099	3587	1087
Dec	2644	2397	1175	1982	11140	1192

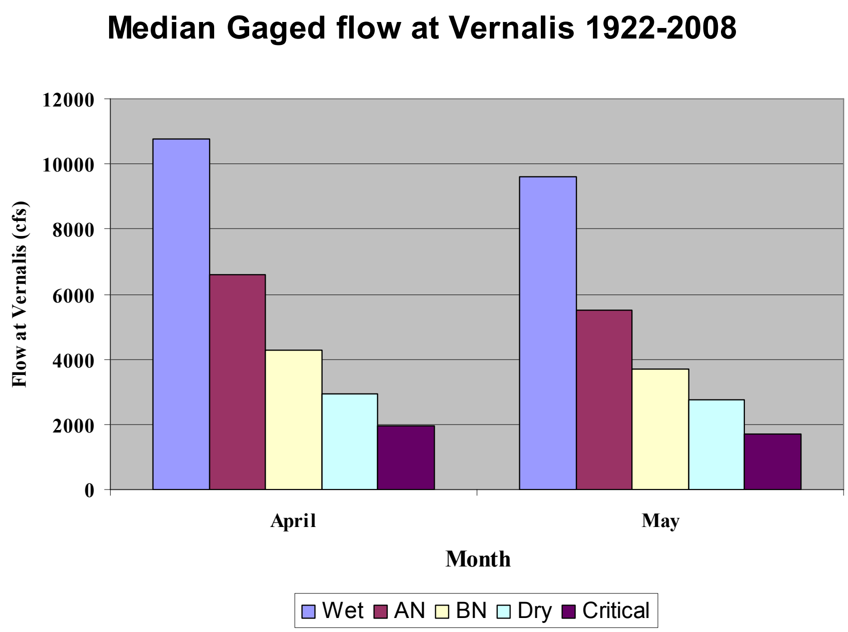
The following graph (Figure 5) represents the data from table 3.

Figure 5:



The gaged flows at Vernalis following the onset of water management of the system by reservoirs shows an altered pattern of runoff. Peak flows now occur earlier in the year during the months of February, March, April, and May, rather than in May and June as occurred under the unimpeded flow regime. The flow data indicates that the median flows at Vernalis for the period between 1922 and 1993 are typically highest from February through May before falling off in June. Previously, June had the highest amount of runoff and thus the highest flow levels. Based on the current data, average flows are typically higher than the median by approximately 4,000 cfs during the peak winter-spring runoff period. The flow data also indicates that sustained flows occur for more than 90 days, on average, during the winter. NMFS subsequently looked at the median gaged flow at Vernalis by water year type. The following bar graph (Figure 6) depicts the median gaged flow from 1922 to 1992 using the same data as Table 2 but segregated by water year type.

Figure 6:

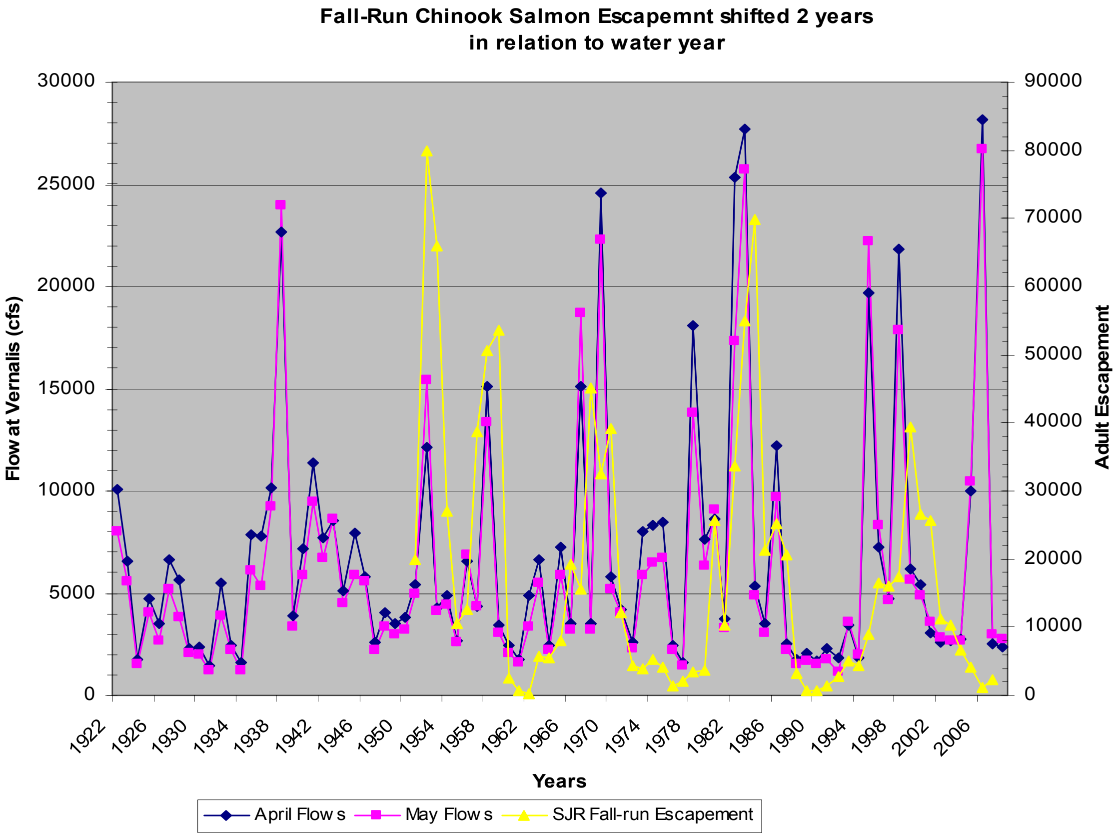


This data shows that approximately 6,000 cfs of flow is available at Vernalis in 50 percent of the wet and above normal water years. Approximately 4,000 cfs is available during below normal water years in April and May. Dry years have a median flow of approximately 3,000 cfs while critical years have approximately 1,800 cfs for both April and May. NMFS anticipates that March will have similar values and profiles over the 5 water year types.

These series of graphs and tables illustrate the substantial difference between the historical gage flow data at Vernalis and the restoration flows under the CVPIA and CDFG proposals. For instance, in wet years the CDFG restoration flows are approximately twice the gaged flows at Vernalis (20,000 cfs vs. 10,000 cfs) This would require a substantial shift in the allocation of water rights within the tributaries to achieve these water releases for fish (*e.g.*, an extra 1 million acre feet). In the current consultation for OCAP, Reclamation does not have authority to alter water rights and can only change deliverable water volumes to contract holders per their legal authority on the Stanislaus River. An alteration of water rights on the Stanislaus River, as well as on the other tributaries to increase flows to the levels required under the CVPIA or CDFG restoration criteria would have to occur under the authority of the SWRCB. Reclamation can utilize its powers under the CVPIA to utilize (b)(2) water and purchase other water (b)(3) to augment releases, but this is a limited resource.

NMFS plotted the relationship between fall-run Chinook salmon escapement and springtime gaged flow at Vernalis for the months of April and May (figure 7), the "middle" of the salmon smolt outmigration period according to CDFG data. The escapement numbers are from the 2009 edition of CDFG's grandtab spreadsheet.

Figure 7:



As previously described, increases in spring time flows during the period of smolt emigration from the tributaries through the delta result in corresponding increases in adult escapement 2.5 years later. A different graphical representation of this relationship is given in figure 8 below from Baker and Morhardt (2001). Flows below approximately 5,000 cfs have a high level of variability in the adult escapement returning 2.5 years later, indicating that factors other than flow may be responsible for the variable escapement returns. Flows above approximately 5,000 to 6,000 cfs begin to take on a linear form and adult escapement increase in relation to flow. Anomalies to the flow relationship (*i.e.*, subsequent low adult returns during high spring flows can be due to poor ocean conditions upon juvenile entry or low adult returns in the fall prior to the high spring flows (*e.g.*, 1977 low adult escapement with subsequent high spring flows in 1978 lead to poor adult escapement in 1980).

Figure 8:

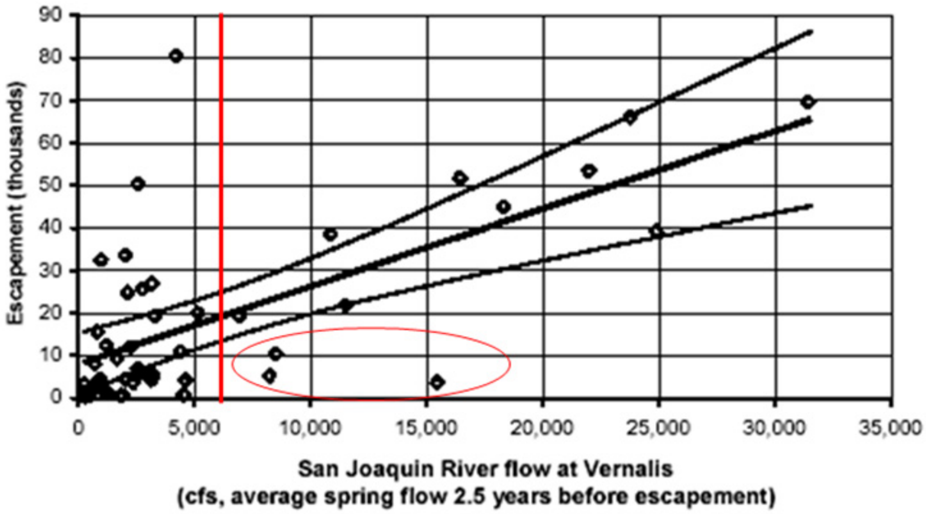


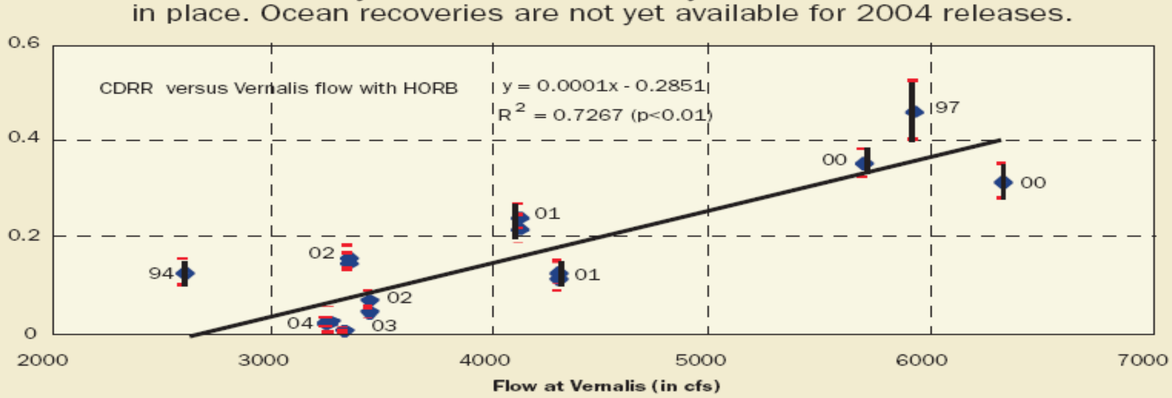
Figure 11 Total escapement to San Joaquin tributaries, 1951 through 1996, and spring flow in the San Joaquin River at Vernalis 2.5 years earlier. Fitted regression line and envelope of 95% confidence region for fitted line are shown.

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

Figure 9 illustrates the relationship between the point estimates for combined differential recovery ratios (CDRR) and San Joaquin River flow at Vernalis with the Head of Old River

Barrier in place during VAMP experiments (SJRGA 2007). The relationship is statistically significant ($p<0.01$) with Vernalis flows accounting for 73 percent of the variability observed in the survival data. CDRR are calculated as follows:

$$CDRR = CRR_u / CRR_d$$

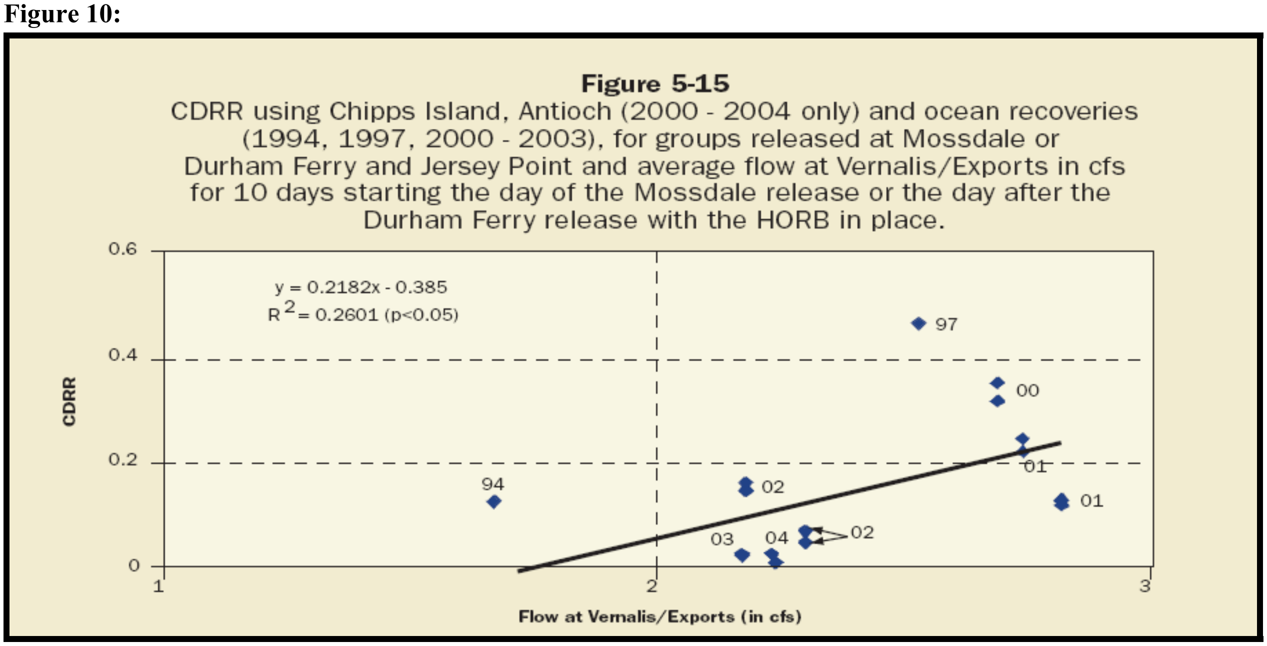
where CRR_u is the combined recovery rate for the upstream release group (Mossdale, Dos Reis, Durham Ferry), and CRR_d is the combined recovery rate for the downstream release group (Jersey Point). CRR is calculated as

$$CRR = R_{C+A+O} / ER$$

where R_{C+A+O} is the combined recoveries at Antioch, Chipps Isalnd, and in the ocean fishery of a CWT group. ER is the effective release number for that CWT group.

The next figure (Figure 10) shows the relationship between Vernalis flow and export ratio and the CDRR using data from Chipps Island, Antioch, and ocean fisheries recoveries. The trend line is positive for increasing survival with increasing flow to export ratios but is not statistically significant at the $p< 0.05$ level. Potential reasons for this lack of significance include the relative lack of difference between the two export rates tested (≈ 1500 cfs and 2250 cfs) during the VAMP experiments. The sensitivity of the recovery measurements may not allow discrimination between export levels this close in magnitude.

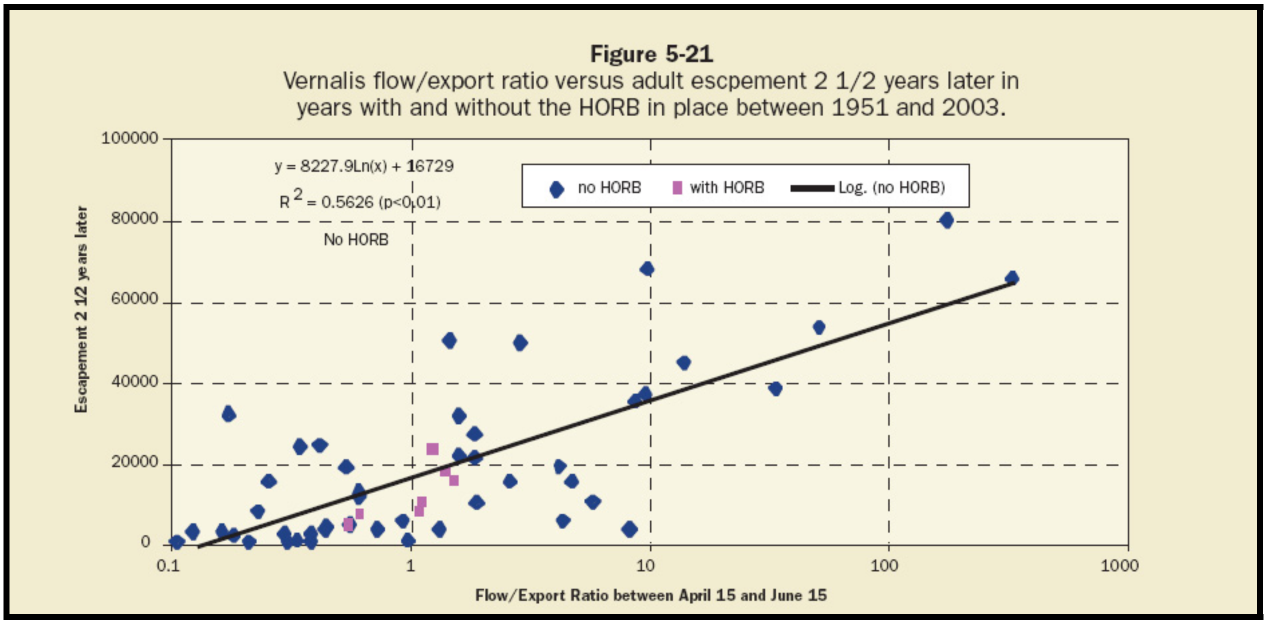
Figure 10:



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

Figure 11 illustrates that adult escapement 2.5 years later is correlated with the flow:export ratio between April 15 and June 15 of the year that the smolts migrated downstream. The data covers the period from 1951 to 2003. In most years the HORB was not installed. Analysis of this data by Dr. Ken Newman (USFWS) using a K-fold cross validation, where K=5, found that the total absolute prediction error was about 15 percent less using the model that incorporated the flow/export variable, indicating that it better predicts the data than the model using flow alone. These adult escapement relationships would indicate that as you increase flows and decrease exports relative to the flows there should be corresponding increases in smolt survival and adult escapement 2.5 years later (SJRGA 2007).

Figure 11



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

In developing the RPA for the San Joaquin River, NMFS assessed the tools available through the consultation process with Reclamation to achieve modification of flows in the San Joaquin River basin. Reclamation has the authority to re-operate the releases of water from New Melones Reservoir, implement its authorities under the CVPIA, particularly the use of (b)(2) water and purchase of additional water from willing sellers (b)(3), and modify its CVP exports. There were fewer options for the state side of the consultation. Only modifications to exports were determined to be readily available since the state did not control any reservoirs in the basin. NMFS also made the assumption that Reclamation in cooperation with DWR would continue its obligation to install the spring Head of Old River Barrier or similar device for fish protection (3406 (b)(15) of the CVPIA) for at least 31 days in the April to May time period. NMFS approached the minimum flow targets for Vernalis from two directions. The first was based on the water that was reasonably available based on the historic flow patterns since 1922. NMFS initial estimate of minimum feasible flows that could be achieved at Vernalis were flows of 6,000 cfs at Vernalis in all but critical years and flows of 3,000 cfs in critical years for the period between March 15 and June 30. These flows appeared feasible, based on the gaged flows at Vernalis. Wet and above normal water years were already at or above this level. Below normal years would require approximately an additional 2,000 cfs for 90 days at Vernalis, while dry years would require an additional 3000 cfs over the 90 day period. Critical years would require approximately 1,200 cfs over the 90 day period. The information presented in the flow to escapement relations presented a second avenue to estimate minimum flow needs, particularly figure 8, which indicated that flows over 5,000 to 6,000 cfs were required to move into the linear phase of increasing fish escapement. NMFS interpreted this to represent a minimum flow goal.

In order to further enhance the benefits of increased flows at Vernalis, NMFS looked at the second variable that it could manipulate the level of exports at the CVP and SWP facilities. Exports have been perceived as an adverse environmental factor affecting movement and survival of salmonids moving through the Delta (see earlier background discussion). As shown in the figures 9 and 10, there is a positive trend to juvenile survival and adult Chinook salmon escapement when the ratio of flows in the San Joaquin River increases relative to the level of exports. Although, the CDFG population model report, as well the recent Newman (2008) report, did not find statistical significance in these differences, both studies indicated that there were potential effects that were confounded by the high variability in the data, and the narrow range of exports tested. In comparison to the flow variable, exports appeared to have a minor role in survival or escapement. The CDFG report further elucidated the beneficial aspects of higher flow to export conditions in salmon survival and abundance.

NMFS, in consideration of the potential benefit that maintaining low exports during smolt emigration would have in enhancing the effects of available flow on survival, developed measures to incorporate reduced exports into its RPA for the San Joaquin River. NMFS looked at San Joaquin River flow to export ratios as a method for providing flexibility in the operations of the CVP and SWP rather than capping the exports at fixed levels. Starting with the minimum export level that would maintain health and safety criteria (1,500 cfs), different ratios were assessed. The data from the ongoing VAMP experiments provided useful information in developing the ratio. Current VAMP studies have ratios of flow to exports clustered around 2:1, which have provided low survival indices for upstream releases compared to downstream releases, particularly in recent years. Studies which would have had higher flows (*i.e.*, 7,000 cfs) to export (1,500 cfs) ratios were not conducted, since the necessary environmental conditions to implement this part of the study protocol never occurred. Recent conditions in which high flows did occur in the San Joaquin River basin and which would have given flow to export ratios greater than 3:1 in 2005 and 10:1 in 2006 were confounded by poor ocean conditions during the smolts entry into the marine environment, and returning adult fall-run Chinook salmon escapement numbers from these brood years were very low (brood years 2004, 2005 which returned in 2007 and 2008). From the available data, including the information contained in figures 10 and 11, flow to export ratios should be at least 2:1 and preferably higher to increase survival and abundance. In light of these factors, NMFS initially developed flow to export ratios of 4:1 for wet, above normal, below normal, and dry years, based on the minimum export level of 1,500 cfs and a targeted minimum Vernalis flow of 6,000 cfs. Flows in critically dry years were targeted to be a minimum 3,000 cfs which gives a flow to export ratio of 2:1 when exports are targeted to be 1,500 cfs. These flow and export levels were then assessed through computer modeling.

Modeling

NMFS engaged the services of Derek Hilts (USFWS) to assist in modeling the proposed San Joaquin River RPA of 6,000 cfs minimum flows at Vernalis during wet, above normal, below normal, and dry years with a flow to export ratio of 4:1, and the critically dry flow minimum of 3,000 cfs at Vernalis with a flow to export ratio of 2:1 during the period between March 15 and June 30. The initial modeling runs performed by Mr. Hilts examined the unimpeded flows in the San Joaquin River Basin and the ability to provide the targeted flows at Vernalis with the corresponding flow to export ratios described in the initial RPA. Based on the specified flow objectives and the monthly unimpaired flow estimates, the months of March through June for each water year were classified based on the ability to meet the flow objectives. If all four months for a specific water year met the flow criteria, then that year was considered as hydrologically feasible. If any of the four months were unable to meet the flow criteria, but excess water was theoretically available from a previous month to supplement that dry month's shortfall, then that year was also considered as hydrologically feasible. If any of the four months could not meet the flow criteria and excess water volume was unavailable for transfer, then that year was considered as hydrologically infeasible. The modeling indicated that in all but 4 years of the simulation period (1921to 2008) the flow objectives could be met (see internal memo from C. Anderson to Maria Rea, dated March 13, 2009).

A second run was conducted on March 9, 2009 (RPA_VNS2EXP-Analysis_4NOAA) that modeled the ability of the basin to meet the proposed criteria for the RPA. The basin was simulated for the years 1922 through 1994 assuming approximately current conditions. The model had the following assumptions:

- modeled period is March 15 to June 30.
- 4:1 San Joaquin River (SJR) ratio of 4:1 in non-critical years, 2:1 in critical years.
- assumed minimum exports of 1,500 cfs (total Tracy and Banks) and an inflow at Vernalis of 6,000 cfs in non-critical years and 3000 cfs in critical years.
- Run "A" is the base case with 1641 standards, no minimum instream flows (MIF) and current level of development (LOD).
- Initial comparative test run with full contract deliveries.
- Second test run with uniform 25 percent reduction in contract deliveries and releasing water from New Melones, New Don Pedro, and New Exchequer reservoirs to meet the Vernalis standard.

The initial results indicated that it was not physically possible to meet the RPA criteria with full contract deliveries. The RPA with full contract deliveries drained the reservoirs in drought years. The subsequent run with 25 percent reduction in contract deliveries was physically possible, with little overall change to the reservoir storage in the basin. New Melones reservoir was affected the most, with significant carryover storage differences in drought years compared to the base case. The reservoir retained approximately 300 taf of carryover storage in the 30's drought and approximately 400 to 500 taf in the subsequent droughts in '48, '61, and '77.

Three subsequent modeling runs were conducted on March 18 and 20, 2009. The first modeling run (Chg_In_Dry_Yeartype_SJR-to-Exports ratio_4NOAA_20090318) was based on discussions to change the dry year criteria from 4:1 export ratios to 2:1 for the period between March 15 and June 30. In addition, contract reductions were reduced to 10 percent rather than 25 percent (90 percent contract deliveries) which was considered a more realistic condition. The change to 10 percent reductions in contract deliveries understandably exacerbated reservoir drawdown in the drought conditions over the 25 percent delivery reduction scenario above and drained the reservoirs in drought conditions. The change in dry year export ratios from 4:1 to 2:1 (run F) resulted in some relief in the reduction in carryover storage in the reservoirs, but reservoirs were still drawn down considerably in the drought periods. The second modeling run (run G) reduced the period of compliance in June from June 30 to June 15, allowing exports and reservoir releases to be dictated by D-1641 criteria and compared it to run F above. The shortened June compliance period helped reduce reservoir drawdown during drought periods and had similar carryover volumes to the 25 percent delivery reduction in the first series of runs for the reservoirs. The final simulation compared the shortened June compliance alternative (run H) with the base case run (run A). Run H is identical to run G except that D-1641 associated MIF's were used in the March 1 to 15 and June 16 to June 30 time period rather than the estimated half month flows based on the RPA flow criteria (6000/2 and 3000/2). The New Melones reservoir carryover storage in run H conformed well to the base case carryover storage in the 1920-30's drought, running consistently below the base case, but never draining the reservoir. Minimum pool was approximately 250 taf. The drought in the late 1940's was slightly different. The base case reservoir carryover storage remained above 1000 taf, while run H depleted the reservoir carry over storage to approximately 300 taf. Similar depletions occurred in 1955 and 1977. It was determined that minimum flow off ramps should be incorporated into the RPA for consecutive drought years in order to minimize these large drops in reservoir carryover storage.

A new series of simulations (NOAA_draft_VNS-to-Exp_RPA_analysis_RunsILM&HIst_20090325) were run that compared the baseline condition (pre-smelt B.O. base case - run I) with alternatives that contained off ramps for consecutive critically dry years (relaxation of the 3,000 cfs minimum for dry and critical years to 1,500 cfs). New in the run L and run M simulations were MIF's for the Stanislaus River that reflected CDFG fish flows based on water year type (New Melones carryover storage). The base case (run I) does not include these minimum flows. Run L has the relaxed minimum flow for back to back critical years. The minimum flow at Vernalis is reduced from 3,000 cfs to 1,500 cfs in the second critically dry year. Exports are constrained to 1,500 cfs from March 15 to June 15 to provide the appropriate flow to export ratios. Major diverter's water demands were reduced by the uniform 10 percent as before. In run M, the CDFG fish water releases were relaxed somewhat when water supply levels in New Melones reservoir were lower 1,500 taf. As seen before, reservoirs are drawn down considerably in drought years when applying the RPA, reaching very low levels in the 1930 drought period. The incorporation of the CDFG fish flows into the alternative modeling runs reduced carryover storage in the New Melones reservoir. Relaxing the CDFG fish flows in low water years helped relieve some of the demand on the reservoir. Flows were increased in 25 of the 73 years of record at Vernalis. In 14 years flows were increased to 6,000 cfs when baseline conditions were lower and in 11 years flows were increased to 3,000 cfs when baseline conditions were lower than the minimum.

Further refinement of these simulations (NOAA_draft_VNS-to-EXP_RPA_analysis_916RunsACD&HIST_20090401) reduced critical water year minimum flows at Vernalis to 1,500 cfs with a corresponding flow:export ratio of 1:1 (run D01). This improved reservoir carryover in drought conditions by not drawing as heavily on the system in these demanding conditions. New Melones was still drawn down significantly during the 1930's drought. New Don Pedro and New Exchequer reservoirs performed well. In 15 years out of 73, run D01 increased flows above 6,000 cfs when baseline conditions were lower. However, in conditions where the baseline predicted flows would be below 3,000 cfs, run D01 increased flows in 5 instances. This is a reflection of the changed minimum flow criteria for critical years.

Refinements to the proposed RPA on April 28, 2009, (NOAA_draft_VNS_to_EXP_RPA_analysis_Runs917_A1_D1_D3_&HIST_20090428) have the following changes made to the different alternatives. The base run alternative Run 917 A01 has no MIF requirements at Vernalis and Tracy and Banks exports are constrained by D-1641 standards. Stanislaus River major diverters (Oakdale Irrigation District [OID] and South San Joaquin Irrigation District [SSJID]) are shorted based on the inflow to New Melones reservoir. Water sold to Stockton East Water District (SEWD) is considered part of OID's demand. The Tuolumne River's major diverters, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) and the Merced's major diverter, Merced Irrigation District (MeID) full contract amounts are shorted 25 percent in dry years and 50 percent in critical years. Water quality criteria are met as in earlier versions. Alternative 1 (run 917 D01) is the same as base run 917 A01 except that in wet, above normal, and below normal years, minimum flows at Vernalis are 6,000 cfs from March 15 through June 15. In dry water years, the minimum flow at Vernalis is 3,000 cfs from March 15 through June 15. In critical water years Vernalis minimum flow is 1,500 cfs from March 15 to June 15. During the time period between March 15 and June 15 combined exports are modeled as 1,500 cfs to provide the 4:1, 2:1, and 1:1 ratios to the minimum flows. The Stanislaus River is modeled with the CDFG year type base schedule with a slight modification to include relaxation to 98.9 taf when the water supply parameter is between 1,000 and 1,400 taf of storage. Stanislaus diverters (OID and SSJID) are shorted 25 percent of their full monthly deliveries in dry years and 50 percent in critical years. Alternative 2 (run 917 D03) is the same as 917 A01 except that minimum flows at Vernalis are 6,000 cfs in wet and above normal water years, 4,500 cfs in below normal water years, 3,000 cfs in dry water years and 1,500 cfs in critical water years from April 1 through May 31. In years in which the sum of the current water year's index, according to the 60-20-20 San Joaquin River Basin Indices, plus the two previous years indices sum up to 6 or less, the minimum flows at Vernalis will be reduced to 1,500 cfs to protect reservoir carryover storage. The SJR Basin index is as follows: wet =5, above normal =4, below normal = 3, dry = 2, and critical =1. Tracy and Banks combined export rates are modeled as 1,500 cfs in all years. The Stanislaus River is modeled with the CDFG year type base schedule with a slight modification to include relaxation to 98.9 taf when the water supply parameter is between 1,000 and 1,400 taf of storage. Stanislaus diverters (OID and SSJID) are shorted 25 percent of their full monthly deliveries only in critical years. Alternative 2 has greatly reduced the demand on the reservoirs and the impacts to export yield while meeting the required flow criteria at Vernalis. Most needs for water at Vernalis are satisfied by releases for other purposes such as instream flow requirements on the Stanislaus River for water quality or fishery releases. The reduction of the RPA duration from 90 days to 60 days (April 1 through May 31) was carried forward into subsequent modeling runs. The 60 day duration reduced reservoir draw downs in drought years.

April 28, 2009, and May 1, 2009. Further adjustments to the proposed RPA were made to the April 28, 2009, simulations on May 1, 2009. The May 1, 2009, simulations revised previous CALSIM II simulations done to date. The base case run used the OCAP study 8.0 data from the June 28, 2008, simulation conducted by Reclamation. This run used the 2030 level of development (LOD), required no minimum in-stream flows at Vernalis, and constrained the exports at the Tracy and Banks facilities to D-1641 standards and rarely to (b)(2) based actions. Demands on water use in the San Joaquin Basin are based on the current land use patterns. An updated (less demanding) water salinity relationship for Vernalis was used in this version of the base case OCAP 8.0 simulation. Additional water for water quality needs at Vernalis were allocated on an as needed basis, except in the driest years, when allotments were relaxed. Dissolved oxygen (DO) requirements were supposed to be relaxed in critically dry years, but the simulation code was reversed in the base OCAP 8.0 run and relaxed the DO standard to the environmental surrogate flow of 200 cfs on the Stanislaus River at Ripon during the June to September period in normal years. This base case representation of OCAP 8.0 is used in this simulation and subsequent simulations to represent the BA modeling runs. The files are named *Compare3runs_20090501*.

The alternative 1 case is a modification of the OCAP 8.0 base case run. It has th esame parameters except for these modifications. The simulation removes the cap on non-flood flows on the Stanislaus River. Currently flows are capped at 1,500 cfs to prevent downstream seepage into the riparian orchards and properties adjoining the river. In addition, the DO allocation problem as described above was fixed. Allocations of water to meet Vernalis flow requirements were revised from zero allocations to the following criteria:

Water Supply Parameter (WSP) (taf)	Annual Allocation to Water Quality Control Plan Flows (taf)
0-1000	0-0
1000-1399	0-120
1400-1724	120-240
1725-1999	240-400
2000-2177	400-9999 (unlimited)
2178-2386	Maximum amount
2387-2761	Maximum amount
2762-6000	Maximum amount

The second alternative simulation run (Alt 2 = Alt 1 + NOAA Stan & VNS RPAs) includes the modifications in alternative 1 with the following changes. The "high drop" modification to the Stanislaus River flow was incorporated into the alternative. It has the following parameters;

Water Supply Parameter (WSP) (taf)	Annual Allocation to in-stream flows on the Stanislaus River (taf)
0-1000	0-98.9
1000-1399	98.9-98.9
1400-1724	185.3-185.3
1725-2177	234.1-234.1
2178-2386	346.7-346.7
2387-2761	455.3-455.3
32762-6000	557-557

Allocations of water from New Melones reservoir for Vernalis flows under the Water Quality Control Plan (WQCP) were increased from zero to unlimited in all but the driest years. The Vernalis minimum in-stream flows include the D-1641 base flows, VAMP pulse flows, and the proposed NMFS Vernalis RPA which included elevated flows from April 1 - May 31 with the following flow criteria:

Water Year Type based on the San Joaquin Basin Index	Minimum Flows at Vernalis in cfs
Wet	6000
Above Normal	6000
Below Normal	4500
Dry	3000
Critical	1500

The effects of the changes in the two alternatives are readily apparent when examining the annual storage of New Melones reservoir. The simulation for alternative 1, which is a modified base case simulation for OCAP's run 8.0, showed consistently lower storage for New Melones reservoir over the 81 year simulation period. Alternative 1 was able to mimic the trace of the base case and refill the reservoir in wet years to essentially the same levels as the base case simulation. During dry conditions, the alternative 1 simulation allocated more water downstream and the reservoir pool did not recover as much as the base case the following year. This indicates that the modified base, with the corrections explained above, utilized the reservoir storage more frequently than the base case simulation.

The second alternative simulation run, which incorporated the additional water demands, depleted the reservoir storage in New Melones to an even greater extent than alternative 1 did. Alternative 2 incorporated the additional releases from New Melones required to meet the proposed Stanislaus River RPA as well as the Vernalis RPA flow requirements. The additional water demands required to meet the flow criteria in the Stanislaus River below Goodwin Dam and at Vernalis on the SA Joaquin River resulted in consistently lower reservoir storage levels than seen in the base case or alternative 1. The greater drawdown effects of the combined RPAs are clearly evident in dry year cycles. Reservoir storage has been drawn down below 250 taf in 3 of the drought cycles observed in the 81 year period of record for the simulation. The cascading effect of the severe drawdown in each drought cycle is also evident. The reservoir is unable to fill to the levels observed in the base case simulation since with each subsequent dry year the storage starts out lower and fails to catch up with either the base case or alternative 1 scenario.

Storage at New Don Pedro reservoir and at New Exchequer resrvoir appear to be unaffected by the two alternative simulations. Since actions are focused on the Stanislaus River, it is not unexpected that storage levels would remain unaffected following implementation of the alternative RPAs in New Don Pedro or New Exchequer reservoirs.

Flows on the Stanislaus River below Goodwin dam are predominantly composed of releases for fish and for Vernalis Water Quality Control Plan requirements. Additional releases may be made for DO compliance at the Ripon monitoring gage and to reduce salinity as measured by electrical conductivity at Vernalis.

Minimum in-stream flow requirements at Vernalis were typically made up by the releases under the two alternatives. Failure to meet the Vernalis minimum in-stream flow requirement occurred infrequently, typically occurring in drought years in the 1970s and 1980s.

May 8, 2009. Additional, comparative simulations were run on May, 8, 2009. These runs compared several different combinations of CALSIM II runs which used different variations of the OCAP study 8.0, Stanislaus fish action releases from Goodwin Dam, and revised Vernalis RPAs. There were 5 files generated for these comparisons. The 5 files are: *CompareManyRuns4NOAA_20090508.xls, Compare3runs_w20090430run.zip, Compare3runs_w20090508run.zip, Compare3runs_w20090507run.zip,* and *Compare3runs_w20090506run.zip.*

The file *Compare3runs_w20090430run.zip* used the Stanislaus "high drop" RPA with the water year based Vernalis minimum in-stream flow requirement (wet = 6000 cfs, above normal = 6000 cfs, below normal = 4500 cfs, dry = 3000 cfs, and critical - 1500 cfs) with an off ramp for drought conditions. The off ramp used the sum of the past three consecutive water years; based on the San Joaquin River basin Index, to determine if the flows requirements would be relaxed. If the sum of the past three consecutive years was less than 6, then flows were relaxed to 1500 cfs to conserve water in the reservoir. This run is referred to as "NOAA HiDrop/WYT VNS."

The file *Compare3runs_w20090506run.zip* uses a Stanislaus River "high drop" RPA with a Vernalis flow RPA linked to the New Melones reservoir water supply parameter (WSP). The WSP is equal to the New Melones storage in February plus the predicted inflow from March 1 to September 30. The following table conveys the details of the flow categories under this RPA.

New Melones WSP (taf)	Vernalis Flow requirements (cfs)
0-499	0 cfs
500-1399	1500 cfs
1400-1999	3000 cfs
2000-2499	4500 cfs
2500-2999	6000 cfs
≥ 3000	6000 cfs

This particular arrangement of water storage levels and Vernalis flows is referred to as "WSPVNS (high) and the run is named "NOAA Hidrop Stan/WSPVNS (high).

The third simulation in the comparison is the file *Compare3runs_w20090507run.zip* compiled on May 7, 2009. It also uses the "high drop" Stanislaus River flow RPA criteria. The Vernalis flow requirements are a modification of the previous "WSPVNS (high)" relationships. This version has lower flow criteria in all years except wet years. It was designed to put less demand on New Melones reservoir storage. The following table shows the WSP and flow relationship for the modified Vernalis RPA.

New Melones WSP (taf)	Vernalis Flow requirements (cfs)
0-499	0 cfs
500-1399	1500 cfs
1400-1999	1500 cfs
2000-2499	3000 cfs
2500-2999	4500 cfs
≥ 3000	6000 cfs

This Vernalis flow RPA is called "WSPVNS(low)" and the run is named "NOAA(hi drop) Stan/ WSPVNS (low)".

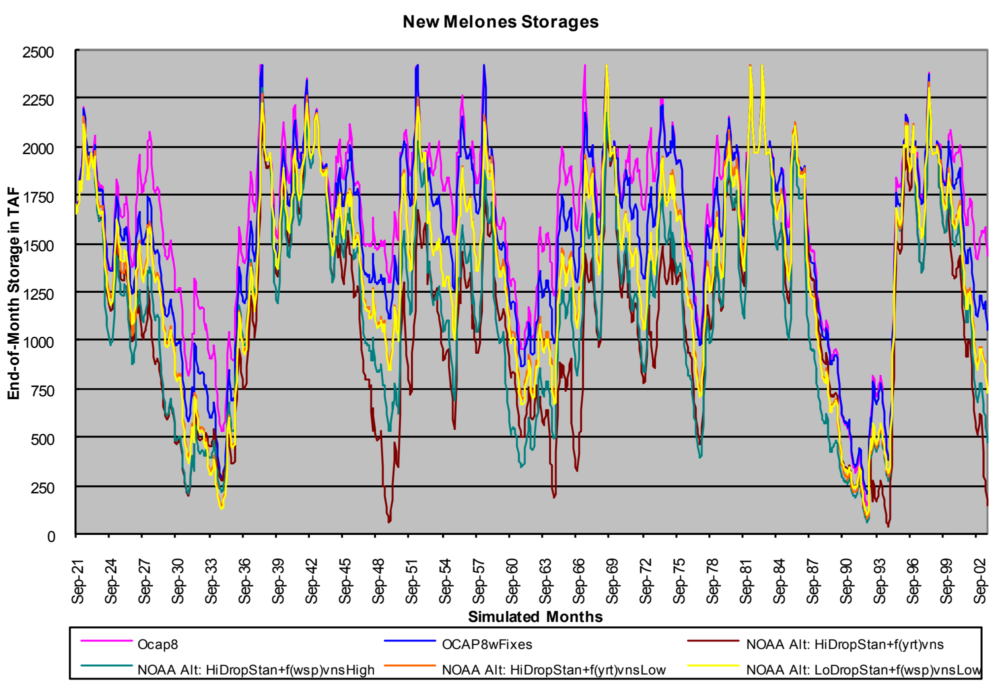
The fourth simulation used in this set of comparisons is *Compare3runs_w20090508run.zip*. This particular simulation run used the Stanislaus River "low drop" RPA criteria. The "low drop" differs from the "high drop" in that slightly higher allocations are made to in-stream flows when New Melones reservoir has more storage: 461.7 taf versus 455.3 taf at a WSP of 2387-2761 taf and 586.9 taf versus 557.0 at a WSP of 2762 - 6000 taf. This reduces the drop in stream flows on the Stanislaus River during ramping down actions following higher flows. It is designed to minimize stranding issues and protect out migrating salmonids, including threatened Central Valley steelhead. This simulation also utilizes the "low flow" Vernalis option (WSPVNS [low]) for setting the minimum in-stream flow requirements for the San Joaquin River at Vernalis. This simulation is called "NOAA (low drop) Stan/ WSPVNS (low)".

The overall comparison looked at the six different alternatives, which include the four runs just described, in addition to the base case OCAP 8.0 simulation and the modified OCAP 8.0 with fixes simulation. Each of the simulations provided information on reservoir storage at New Melones, New Don Pedro, and New Exchequer reservoirs, releases from Goodwin Dam to the Stanislaus River, identifying the relative contribution of different "sources" of water to the Stanislaus releases, CALSIM II modeling of Goodwin Dam releases (*i.e.,* flows), and finally flows at Vernalis. Interpretation of results was used to assess the differences between the RPA options modeled in these comparisons.

The results of the comparisons indicate that the most "aggressive" use of New Melones occurs with the "*NOAA hidrop Stan/WYTVNS*" simulation. This RPA scenario depleted storage frequently during the dry year sequences in the 81 year time frame. Reservoir storage fell below 250 taf during most dry year cycles ('31, '49, '64, the early 90s, and 2002). The two simulations that were most conservative in use of the New Melones storage were the NOAA hidrop

Stan/WSPVNS (low) and NOAA lo drop Stan/WSPVNS (low). These two simulation runs provided almost identical traces of annual storage for New Melones over the 81 year period of the simulation. The two RPA scenarios consistently had higher reservoir storage levels than either the *NOAA hidrop Stan/WYTVNS* run or the fourth scenario "*NOAA hi drop Stan/WSPVNS (high)*except for the low points in 1933 and 1992. This too is to be expected as the WYTVNS and WSPVNS (high) alternatives make greater use of the storage capacity available in New Melones (see figure 12). This is reflected in the simulations of river flow below Goodwin dam and flows at Vernalis.

Figure 12: Simulated end-of-month storage for New Melones Reservoir from 1921 to 2002 for the May 8, 2009, comparison of four alternative RPAs.



There were no obvious difference between any of the 6 simulations in the reservoir storage patterns in New Don Pedro and New Exchequer. This was not unexpected as the Stanislaus River and New Melones to meet RPA conditions.

The hidrop/WYTVNS simulation consistently had different releases at Goodwin Dam compared to either the high drop/WSPVNS (high), high drop/WSPVNS(low), or low drop/WSPVNS(low) simulations. Both magnitude of peaks and the frequency of higher releases were greater for the water year type Vernalis flow RPA than the Vernalis flow schedules tied to the New Melones water supply parameter. This is reflected by the greater reservoir draw downs already observed.

The graphics representing Vernalis flow requirements also indicated that the WYTVNS flow RPA had greater minimum in stream flow requirements tied to the New Melones water supply parameters. This was particularly evident in the non-wet years when the storage volume parameters in New Melones reduced flow requirements to a greater degree than the water year type controlled Vernalis flow RPA.

May 14, 2009. The series of Ecosim simulations run on May 14, 2009, (NOAA_draft_VNS-to-Exp_RPA_analysis_Runs917_A1_D3_D4-&_Hist_20090514) utilized the base case Run 917 A01 as well as 2 RPA alternatives to represent potential future scenarios. The base case simulation had no minimum in-stream flow requirements at Vernalis and Tracy and Banks export fcilities were constrained by D-1641 water quality control plan requirements and some (b)(2) elements. Level of development is approximately the current LOD, with full contract demands being made in the San Joaquin Basin. The Stanislaus River major diverters (Oakdale Irrigation District [OID] and South San Joaquin Irrigation District [SSJID]) are shorted water in dry years based on inflow into New Melones reservoir. Stockton East Water District (SEWD) deliveries are part of OID demand. The full contract demands on the Tuolumne River (Modesto Irrigation District [MID] and Turlock Irrigation District [TID]) and the Merced River (Merced Irrigation District [MeID]) are shorted 25 percent in dry years and 50 percent in critical years. Dilution flows for salinity control at Vernalis are included in the base run. This run is very similar to the base case OCAP 8.0 simulation run.

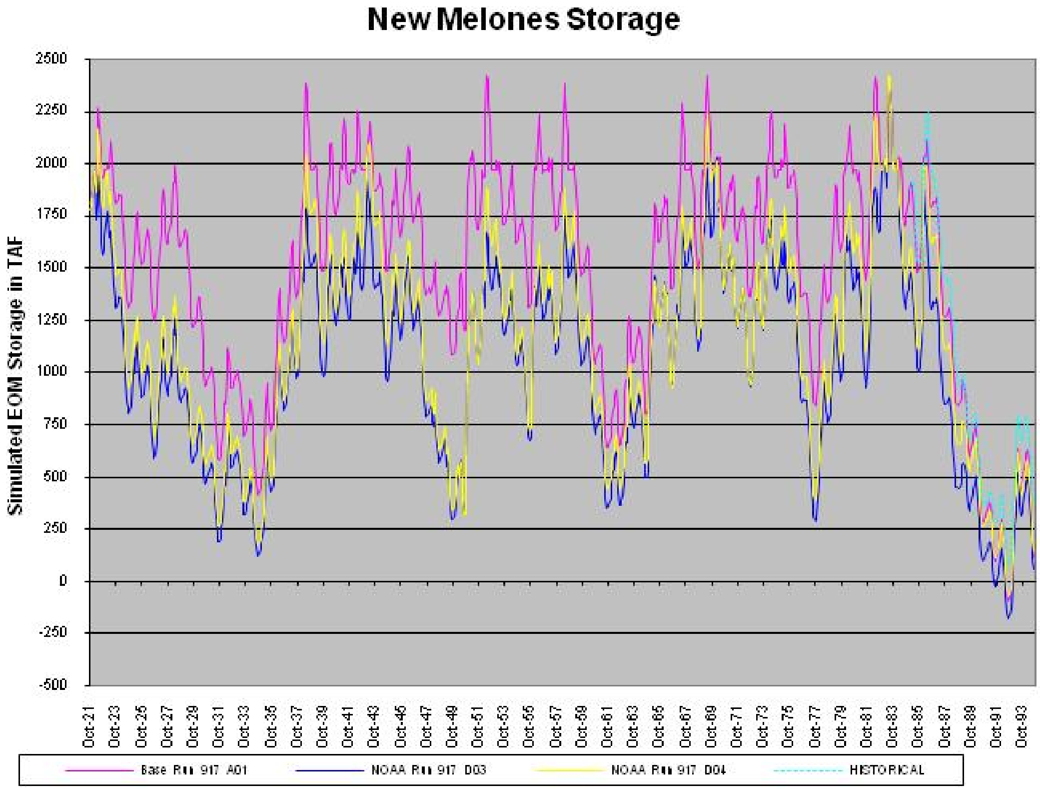
The two alternative RPA simulations used the base case information and added new parameters to it. Alternative 1 (NOAA_Run_917_D03) uses the water year typing to set the Vernalis minimum instream flow requirements for April and May. Briefly, wet and above normal years have 6000 cfs minimum instream flow requirements at Vernalis, 4500 cfs for below normal years, 3000 cfs for critical years, and 1500 cfs for critical years. This version of Vernalis flow RPAs also includes the off ramp action for third year drought events. Exports are held at 1500 cfs for April and May. Stanislaus River flows below Goodwin Dam are in accordance with the CDFG fish flow schedule. Stanislaus River diverters (OID and SSJID) are shorted 25 percent in critical years. Alternative 2 (NOAA_Run_917_D04) is the same as the base run (917 A01) and includes the Vernalis water year type flow RPA described for alternative 1 above. Stanislaus diverters are also shorted 25 percent in critical years in this alternative. The main difference between alternative 1 and alternative 2 is the change in Stanislaus River flows below Goodwin Dam which incorporates the April 28, 2009, version of this RPA.

There are no obvious differences between alternative 1 and alternative 2 in the annual storage of water in New Melones reservoir. Both alternatives draw down New Melones in prolonged drought conditions but didn't drain the reservoir (note: except for the late 1980s drought that drained the reservoir in the historical data simulation run as well as the three Ecosim runs, A01, D03, and D04). The greater utilization of reservoir storage water to meet the Stanislaus River and Vernalis flow requirement is clearly represented by the difference between the base case (emulating the OCAP study 8.0 runs) and the two alternative cases which include versions of eh RPA requirements. Larger draw downs also affect the ability to refill the reservoir in the following winter and spring runoff period (see figure 13).

There appears to be minimal effects of the two alternative runs on the storage levels in either New Don Pedro Reservoir or New Exchequer Reservoir. The base case and two alternative runs tracked very closely with one another, but with both alternative 1 and 2 tracking slightly lower than the base case. It is unclear why this occurs as no actions are occurring on the Tuolumne or Merced Rivers that would not occur in all three runs (shorting of deliveries in dry and critical years).

In the simulations for Stanislaus River operations, alternatives 1 and 2 slightly lower water delivery to the major diverters by the 25 percent as required in critical years. Deliveries are approximately three times higher in volume than flows released to the river from Goodwin Dam. Most of the water released into the Stanislaus River is derived from water required for fisheries purposes, Vernalis water quality requirements, or for maintaining the DO levels at Ripon. The total flow released into the Stanislaus River from Goodwin dam is the sum of all of the required releases. In the two RPA alternatives, releases for fish purposes occur more frequently, and release greater amounts of water than the other sources of water (*e.g.*, water quality or DO). During the summer months when releases for water quality occur more frequently, the two RPAs also released more water for in-stream fishery purposes than was observed in the base case simulations.

Figure 13: Simulated end -of -month storage for New Melones Reservoir from 1921 to 1993 for the May 14, 2009, comparison of runs A01, D03, and D04.



When comparing the simulated base case (OCAP 8.0) with the two alternatives, annual combined exports were always higher in the base case. Differences were greatest in the wet years when RPAs did not restrict exports in the base case. This allowed more water to be pumped than under the restrictions imposed by the Vernalis RPAs (see figure 14).

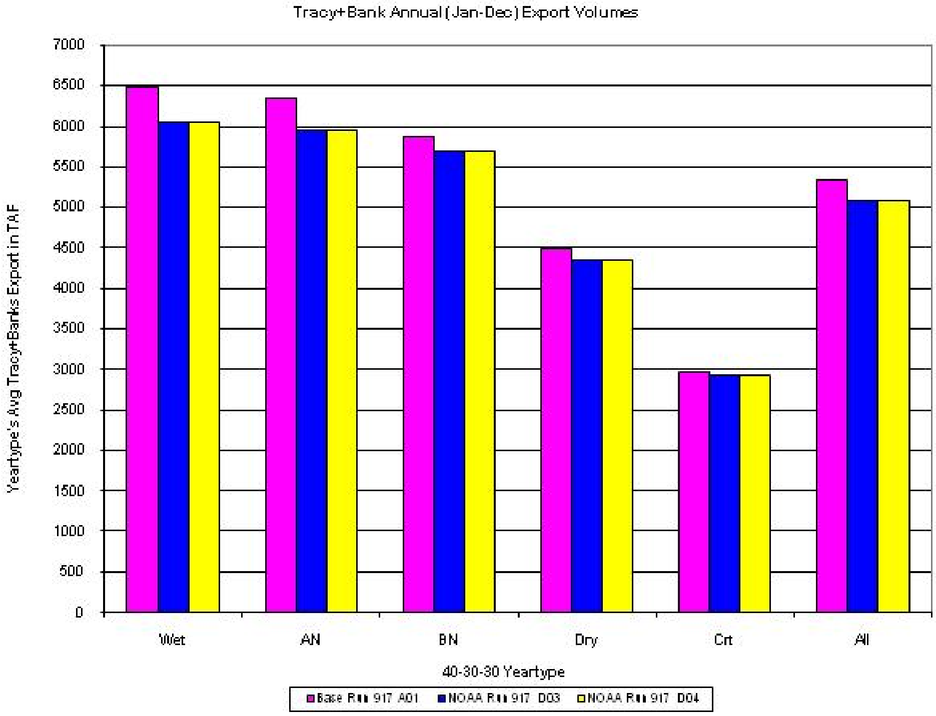


Figure 14: Combined annual export volumes for the Tracy and Banks facilities by water year type for the period 1922 to 1994. Comparisons of runs 917 A01, 917 D03, and 917 D04.

The two alternative simulations reduced annual exports approximately 4 to 5 percent based on the probability of exceedance plot. The differences between the base case run (917 A01) and the two alternative runs (917 D03 and 917 D04) are less at lower export levels and greater at higher export levels (see figure 15).

The plot of monthly average exports shows that from October through March, differences in exports between the base case run (917 A01) and the two alternative RPA runs (917 D03 and 917 D04) are minimal. The largest difference occurs in April and May when the export curtailments under the WYT Vernalis RPA reduce exports to a minimum of 1500 cfs (as modeled). Exports increase significantly in June in both the base case, and in the two alternative simulations (see figure 16). The simulations indicate that exports increase from approximately 90 taf per month in April and May (1500 cfs) to approximately 400 taf in June and 480 taf in July (6700 cfs and 8000 cfs, respectively). Conversely, the base case has exports of only 360 taf in June (6000 cfs) and 415 taf in July (6900 cfs). The base case exports remain below those for the two alternatives through august and September, indicating that the CVP and SWP are making up for the April and May export reductions during the June through September period.

The average annual export volumes by water year type indicate that the two alternative simulations (D03 and D04) are always less than the base case. The differences are greater in wet and above normal water year types, when the difference in export volume is approximately 7 to 8 percent. In drier water year types, the percentage difference decreases, until there is essentially no difference in critical water year types. The average over all water year types is approximately 4.7 percent.

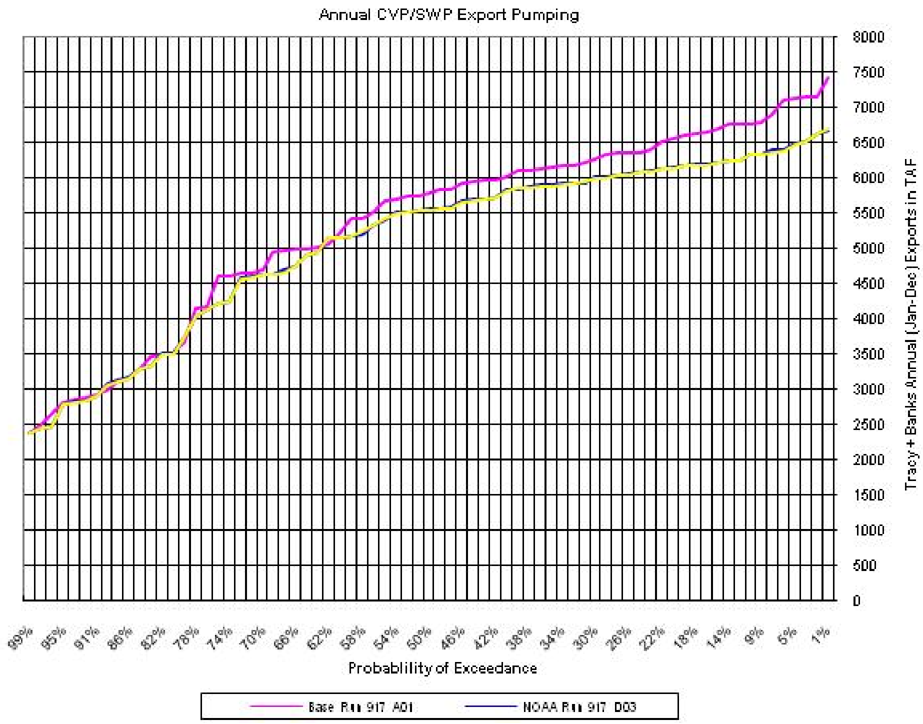


Figure 15: Exceedance plot for the annual combined export pumping from the Tracy and Banks facilities for simulation runs 917 A01, 917 D03, and 917 D04.

The minimum instream flow requirements at Vernalis were modeled for the 917 A01 (base case), 917 D03, 917 D04, and the CALSIM II run 2005A01A. In nearly every year, the flows required for the Vernalis minimum in-stream flow requirement were met under the base case scenarios. When the base case did not meet the minimum requirements, the alternative runs (917 D03 and D04) made up the difference.

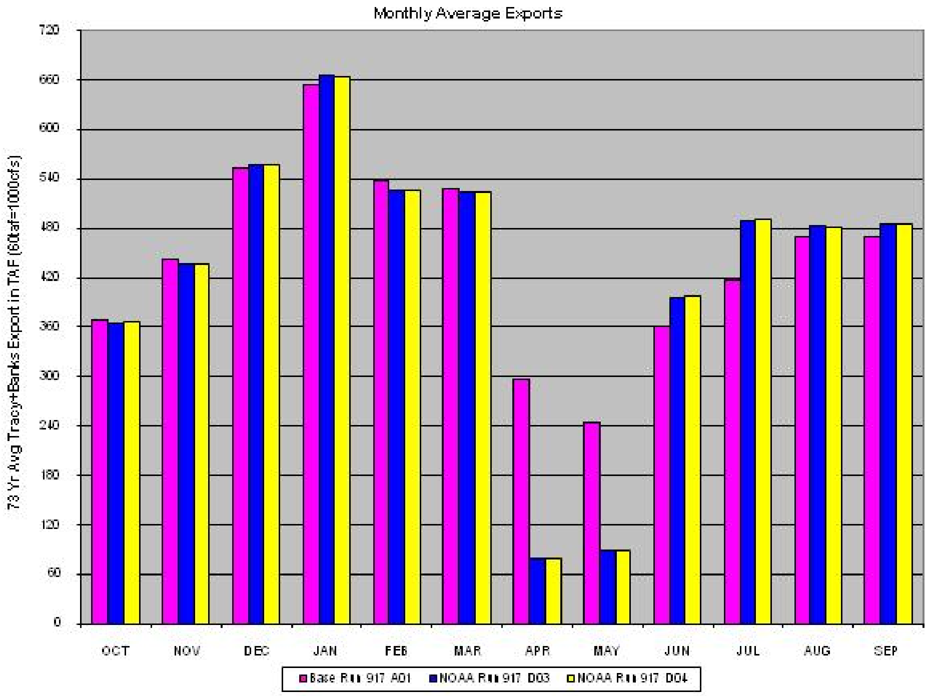


Figure 16: Monthly average combined exports for the CVP and SWP for simulation runs 917 A01, 917 D03, and 917 D04 (May 14, 2009).

The inflow to export ratios for the Vernalis RPAs indicate that in March, sufficient flow is available to have inflow to export ratios greater than 1 in most years. The proposed RPAs continue this trend in April and May, while the base case run (917 A01) illustrates how export pumping exceeds San Joaquin River inflow and ratios are frequently below 1:1 (inflow equals exports). By June, when export curtailment ends and the CVP and SWP are allowed to export more, the ratio falls below the 1:1 inflow to export ratio in most modeled years (exports higher than the inflow volume).

May 15, 2009. Based on the findings of the May 14, 2009, simulations, additional computer simulations were run to compare the OCAP 8.0 baseline with 2 alternative cases. The first alternative used the revised WQCP requirements for Vernalis and the "low drop" Stanislaus River RPA requirements. The second alternative changed the modified Vernalis WQCP flows to an unlimited flow schedule except in the driest years. The flow requirements included not only the Vernalis WQCP flows form D-1641, but also added VAMP pulse flows and the Vernalis flow standards from NMFS' Vernalis RPA. This draft Vernalis flow RPA is the same as in the WSPVNS (high) simulation run on May 6, 2009, which use the New Melones water supply parameter to determine required Vernalis flows. However, this RPA is meshed with VAMP in this simulation. The RPA runs from April 1 through May 31. From April 15 through May 15, the higher flow requirements from either the VAMP flow criteria or the WSPVNS RPA governs. Releases from New Don Pedro and New Exchequer reservoirs continue per the VAMP agreement as needed to reach target flows between April 15 and May 15. The file name for this comparison of alternative runs is "*Compare3runs_w20090515run_v20090515*."

New Melones Reservoir is operated more aggressively under alternative 1 and alternative 2 than under the base case run emulating the OCAP study 8.0 simulation. However, as indicated in the background notes for this series of comparisons, the OCAP study 8.0 simulation was initially flawed due to a lack of Vernalis WQCP flows, and reversal of the coding for the Ripon DO criteria. This made the OCAP 8.0 base case more conservative in its use of reservoir storage water from New Melones, since it did not accurately reflect the releases needed for water quality and DO levels downstream. Both alternative 1 and 2 in this simulation draw down New Melones to approximately 250 taf in the early 1930s drought. Alternative 2 (plus Vernalis RPA) draws down New Melones storage in dry periods to a greater extent than alternative 1, reflecting the greater demands on water resources to meet the Vernalis flow criteria. As a consequence of these greater depletions on storage volume, subsequent refilling of the reservoir does not reach the levels achieved under the base case condition with the same volume of inflow. Complete reservoir refilling occurs in only the very wet years under alternative 2, indicating the greater available storage volume in the reservoir at the end of the water year.

As seen in earlier simulation runs, the effects of the proposed RPAs for the Stanislaus River and Vernalis flow requirements do not have any apparent effect on New Don Pedro or New Exchequer reservoirs. The trace for the reservoir storage for the base case without RPAs is essentially identical to the traces for the two alternative runs with the Stanislaus River and Vernalis RPAs.

The simulations indicate that by incorporating the Vernalis flow requirements, increased water releases for fish on the Stanislaus River are diminished in frequency. This is due to the reduced storage levels available in New Melones Reservoir under the conditions of alternative 2. The increased demand on reservoir water to meet the Vernalis flow requirements in alternative 2 reduces the end of year storage in the reservoir. As previously described, this reduces the subsequent year's storage volume and thus reduces the water supply parameter for the next year. The lower water supply parameter influences the volume of water released for Stanislaus River fish flows under the Stanislaus River RPA. This reduces the frequency that the necessary water supply parameters are reached to release the higher in-stream flows (Figure 17) and shifts the exceedance plot to the right (yellow line).

The simulation comparisons also indicate based on a monthly average, that substantially greater releases are made from Goodwin Dam in April and May under the second alternative than under the base case or alternative 1 (figure 18). This is due to the increased flow requirements in April and May to comply with the Vernalis flow RPA. This enhances fish migration downstream and increase flows in the main stem of the San Joaquin River (as measured at Vernalis) which enhances fish survival and migration into the Delta.

The frequency of meeting the Vernalis flow requirements were presented in an exceedance probability graph for April and May (see figure 19). The two months had essentially identical traces for the probability of exceedance. Flows at or above 6000 cfs accounted for approximately 25 percent of the time, based on the exceedance plots.

Figure 17: Exceedance plot of annual Stanislaus River fish allocations according to alternative 1 and alternative 2.

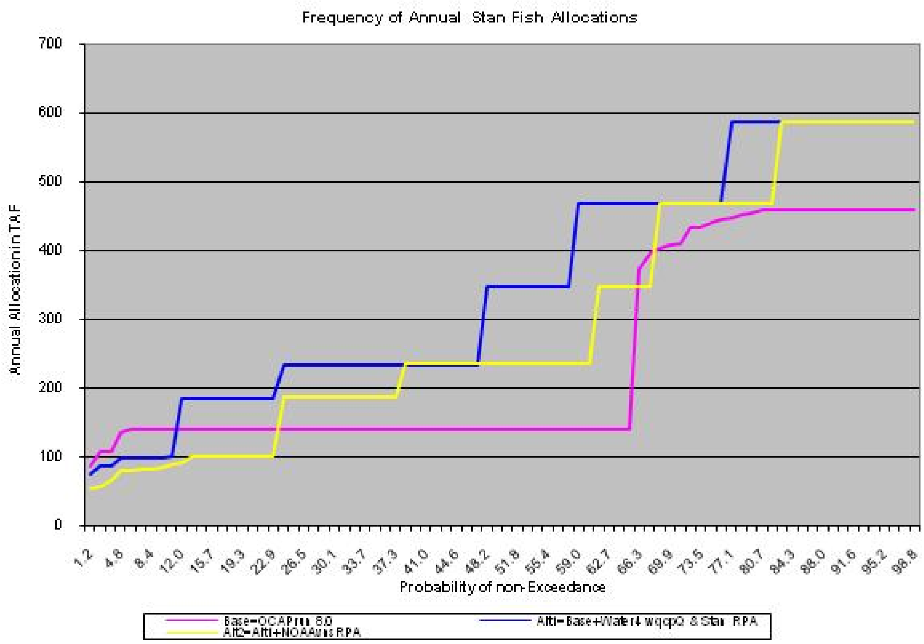


Figure 18: Monthly average flows on the Stanislaus River based on Goodwin Dam releases for the simulated runs for alternative 1 and alternative 2.

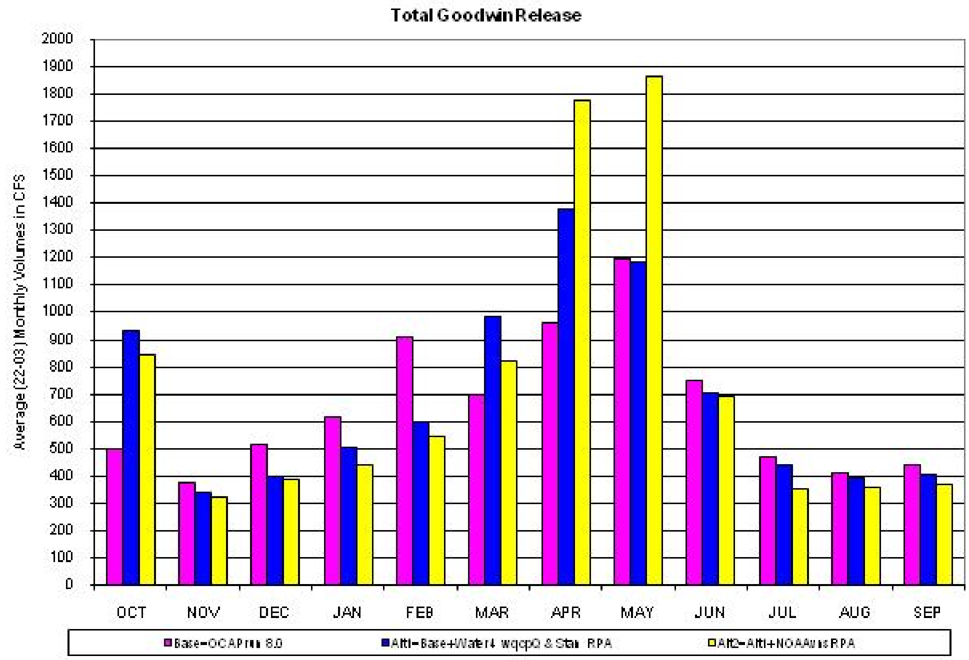
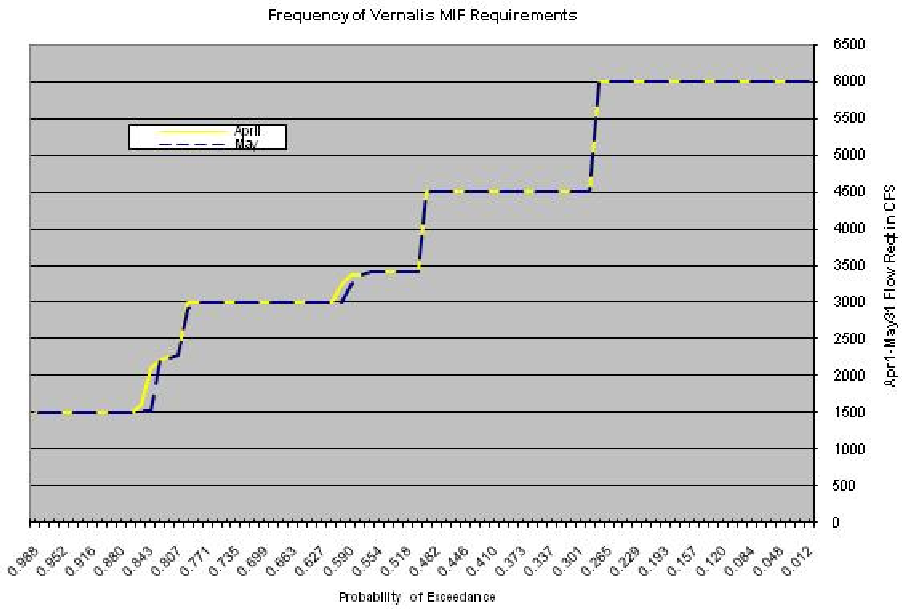
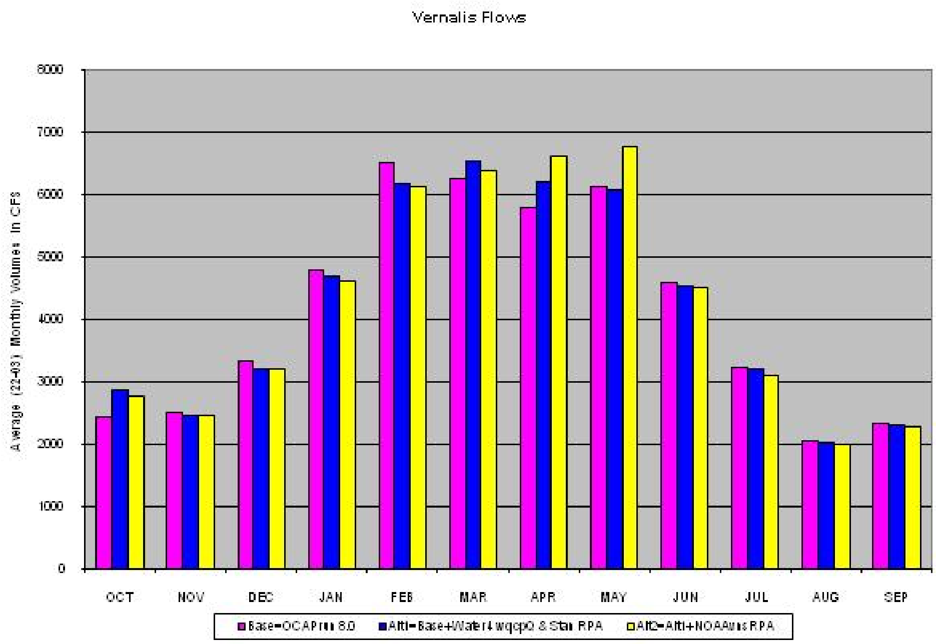


Figure 19: Exceedance plot for flows at Vernalis for the months of April and May (May 15, 2009 simulation).



The May 15, 2009, simulation also compared average monthly flows at Vernalis over the 1922 to 2003 period of record. Overall the three runs have similar behavior in seasonal flow patterns. A significant difference between the base case run and alternative 2 is the period in which peak flows occur at Vernalis. Under the base case, peak flows at Vernalis (≈ 6500 cfs) occur in February, then begin to gradually decline through May before dropping sharply in June. Alternative 2 peaks in April and May (≈ 6000-6700 cfs) before sharply dropping in June. The later peak in flows overlaps with the observed peaks in steelhead emigration at Vernalis and sustains higher flows through the February through May period. The base case peaks in February, which is earlier than the peak of steelhead migration and is too early for steelhead smolts to use effectively, as most fish are still above Caswell on the Stanislaus River according to rotary screw trap data. The median date for steelhead to pass through Caswell is early March (figure 20).

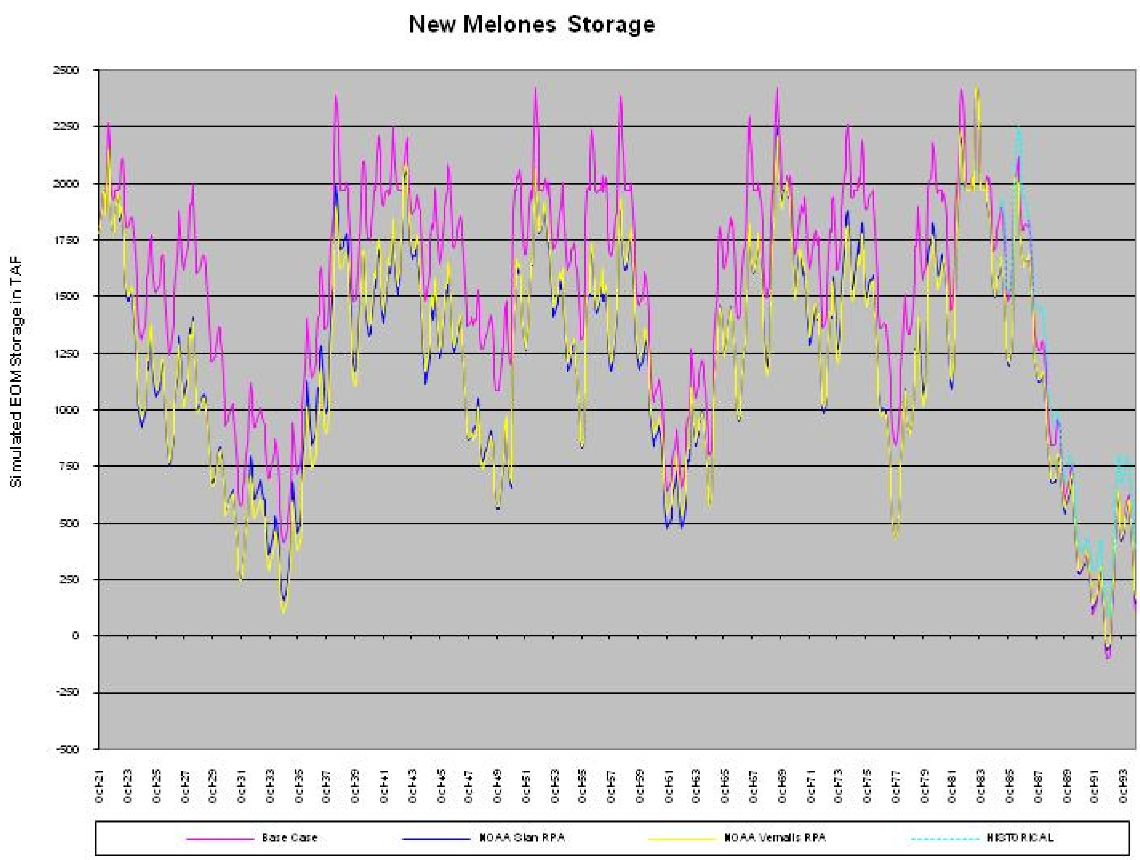
Figure 20: Average monthly flows at Vernalis for the simulated Alternative 1 and Alternative 2 runs (May 15, 2009 simulations)



Long term operations of the project were assessed in the computer simulations carried out on May 19, 2009. The file name is "NOAA_draft_VNS_to_Exp_LT_RPA_analysis_run917_A1_F2_E2_&_HIST_20090519." The base case is the same as in the May 14, 2009, simulation. Alternative 1 (917 F02) uses the minimum instream flow requirements from May 4, 2009, and decreases deliveries to OID and SSJID by 25 percent in critical years. Alternative 2 (917 E02) is similar to the base case (917 A01) except that the WYT VNS RPA is used to determine Vernalis minimum instream flows and the "off ramp" to 1500 cfs is in place when the sum of the current water year and the past two water years indices using the 60-20-20 San Joaquin Basin index sums to 6 or less. The April and May Vernalis RPA flow requirements replace the VAMP flow objectives in the long term modeling and upstream reservoirs are modeled to use dynamic sharing based on reservoir conditions. The minimum instream flow requirements on the Stanislaus use the May 4, 2009 RPA (low drop). These same parameters were carried forward to the final long term simulation for the Stanislaus and Vernalis RPAs under the file name: (NOAA_draft_VNS_to_Exp_LT_RPA_analysis_run917_A1_F2_E2_&_HIST_20090529."

New Melones Reservoir storage is operated more opportunistically and aggressively than the base case and hence has greater storage depletions than the base case. This also means that recovery of storage volumes is less likely to occur during the subsequent refilling phase the next spring. This is the tradeoff between providing more water for instream flows on a regular basis or maintaining reservoir carry over for dry years see Figure 21). The reservoir storage dropped to a low point during the early 1930s drought of 102 taf (simulated) under the simulated Vernalis RPA, while the Stanislaus River RPA dropped to 169 taf. The base case low point for the same time point was 434 taf. Similar trends are seen in the late 1940s drought, the early 1960s drought, and the drought in the mid 1970s, where the base case reservoir storage remained above the Stanislaus River and Vernalis RPAs

Figure 21: Annual storage at New Melones Reservoir simulated for the Long term implementation of the Stanislaus River and Vernalis RPAs

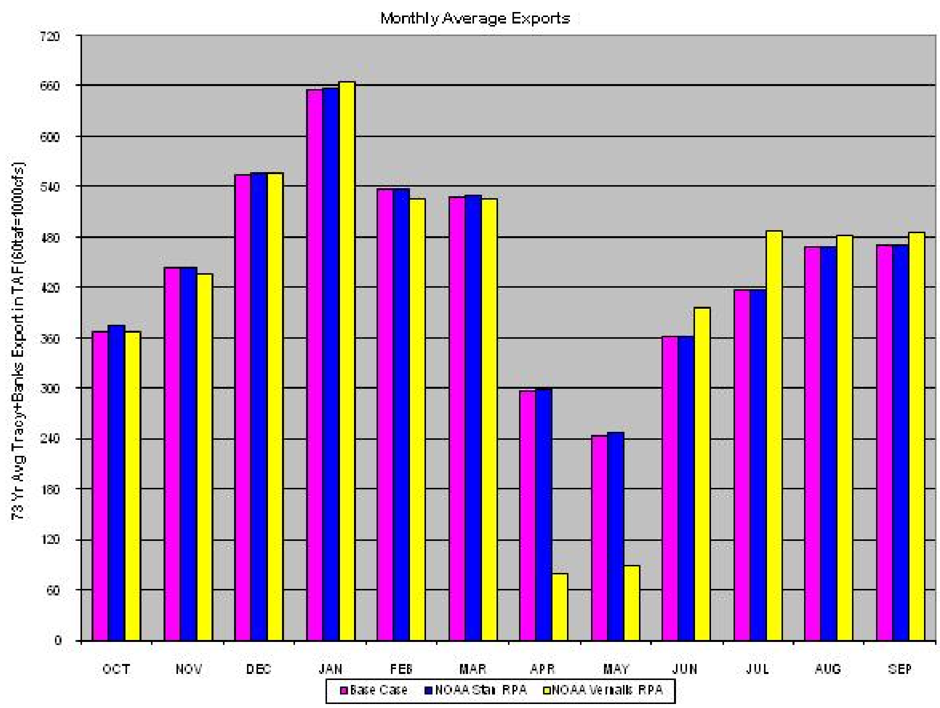


Under the long term RPA actions there is a slight increase in the use of reservoir storage in New Don Pedro and New Exchequer reservoirs. This is likely due to the dynamic operations of the basin reservoirs particularly during the prolonged dry periods. Increased "sharing" between the basin reservoirs during dry periods was simulated in the long term modeling.

The combined exports of the Tracy and Banks facilities were also modeled. As seen in earlier simulations, exports were very similar during the period between October and March. Differences in the export rates became obvious in April and May when the Vernalis RPAs curtailed exports to 1500 cfs combined pumping. After May, the export rates for the Vernalis

RPAs remained elevated over the base case and Stanislaus levels until October. There was very little difference between the export rates for the Stanislaus RPA and the base case simulation (see figure 22). The reduced exports in April and May are a direct result of the protective actions taken by the Vernalis RPA to minimize exposure of emigrating fish in the San Joaquin Basin to the effects of the export pumps as they move from the lower San Joaquin River into the delta region. The drop in monthly exports from 296 taf to 81 taf in April represents a 73 percent reduction in exports. The reduction in May is from 244 taf to 90 taf, a 67 percent drop in the monthly exports level.

Figure 22: Average monthly export rates for the Tracy (CVP) and Banks (SWP) export facilities for the base run and two RPA simulation runs over the 73 year period of comparison.



As seen in earlier comparisons, the percentage of reduction in annual exports is greater during wet and above normal water year types for the Vernalis RPA. Annual export reductions are lower in drier years and are essentially equivalent in critically dry years to the base case. The Stanislaus RPA has annual export rates that are equivalent to the base case in all water year types as the RPA does not restrict exports in its implementation. Annual export reductions range from a maximum of 7 percent during wet years to 1.2 percent in critically dry years. The average reduction in exports attributed to the Vernalis RPA over all water year types is 4.5 percent (see Figure 23). The reduction in exports is also conveyed by the exceedance plot for annual exports. The wet years would be represented by the right side of the graph, where base line exports are higher and the difference between the baseline trace and the Vernalis RPA trace are greatest. The maximal level of annual exports (1 percent exceedance) is 7441 taf under the base case conditions. The Vernalis RPA reduces this by 10 percent to 6700 taf exported annually. The

Stanislaus RPA has an equivalent level of maximum annual export to the base case for the reasons already stated. This plot illustrates that the protective action of the Vernalis export reduction only has a maximal cost of 10 percent export reduction in 1 percent of the years. It is typically less than this, and is only 5.25 percent less at the 50 percent exceedance level (see figure 24).

Figure 23: Annual export levels across water year types for the base case and the Stanislaus and Vernalis RPAs simulated for the long term implementation of the RPAs.

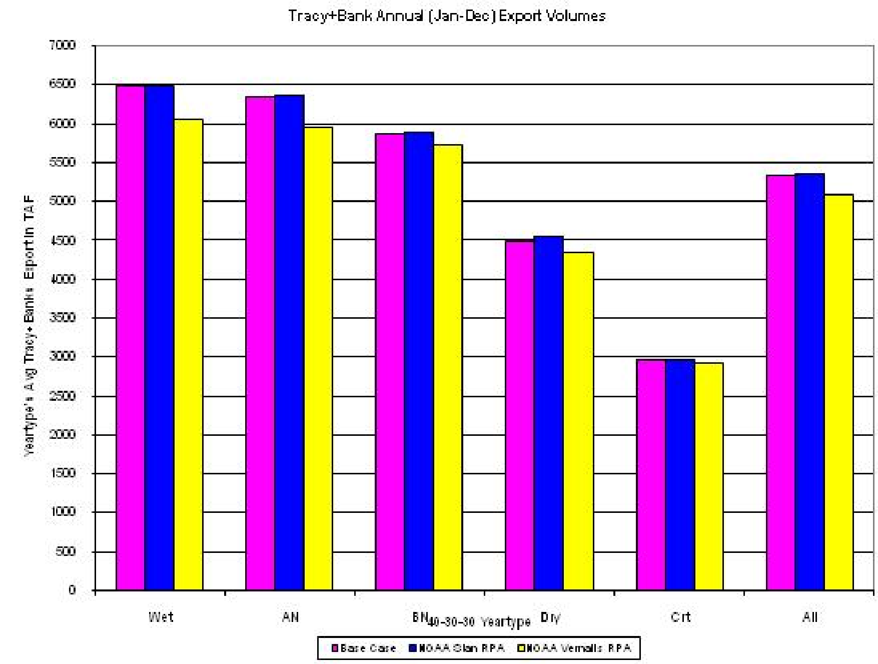
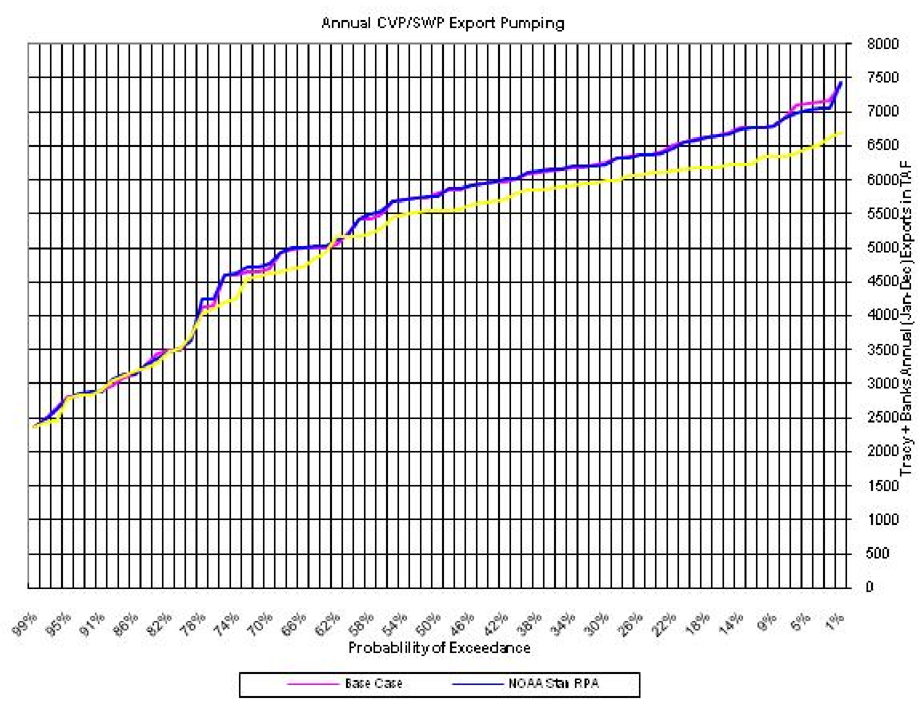


Figure 24: Exceedance plot for the annual export volume of the combined Tracy (CVP) and Banks (SWP) for the base case and the Stanislaus and Vernalis RPAs for the long term implementation of the RPAs.



The long term modeling of the implementation of the Stanislaus and Vernalis RPAs also assessed the flows at Vernalis. The Vernalis flows implemented under the proposed long term RPA peak from February through May. The flows under the long term Vernalis RPA remain higher than the flows under the base case and Stanislaus RPA during April and May, providing additional benefits to emigrating steelhead (as well as other salmonids such as fall-run Chinook salmon) in the basin. The flows in the base case, Stanislaus RPA, and Vernalis RPA fall off sharply in June, although the Vernalis RPA flows still maintain a slightly elevated level compared to the base case and Stanislaus conditions.

In addition to the flow rates, the Vernalis RPA also increases the inflow to export ratio during the April and May. The model simulation shows the changes that occur as the flows are increased during the March through May period with the concurrent export reductions in April and May. As an example, the March Inflow to export ratio indicates that exports are approximately equal to inflow with the inflow to export ratio fluctuating around "1." Conversely in April when the exports are reduced to 1500 cfs and the ratio portion of the RPA is implemented, the inflow to export ratio for the Vernalis RPA substantially increases above "1" indicating that flows at Vernalis are greater than the level of exports. This condition is designed to be protective of fish emigrating through the lower portion of the San Joaquin River basin where they are at increased risk to entrainment at the pumps or diversion into one of the channels leading to the export facilities. This risk has been described earlier in this document. In June, when the export curtailment is lifted, the ratio of inflow to exports drops sharply below "1" indicating that exports are greater than the flows in the San Joaquin River at Vernalis. This has been identified in the figures 22 and 25 in which increased exports in June are demonstrated and reduced San Joaquin River flows are indicated. Please see figure 26, 27, and 28 for depictions of the inflow to export ratios in March April, and June.

Figure 25: Simulated annual monthly averages of flow at Vernalis for the base case, Stanislaus RPA, Vernalis RPA, and CALSIM 2005A01A simulations for the 73 year period between 1922 and 1995.

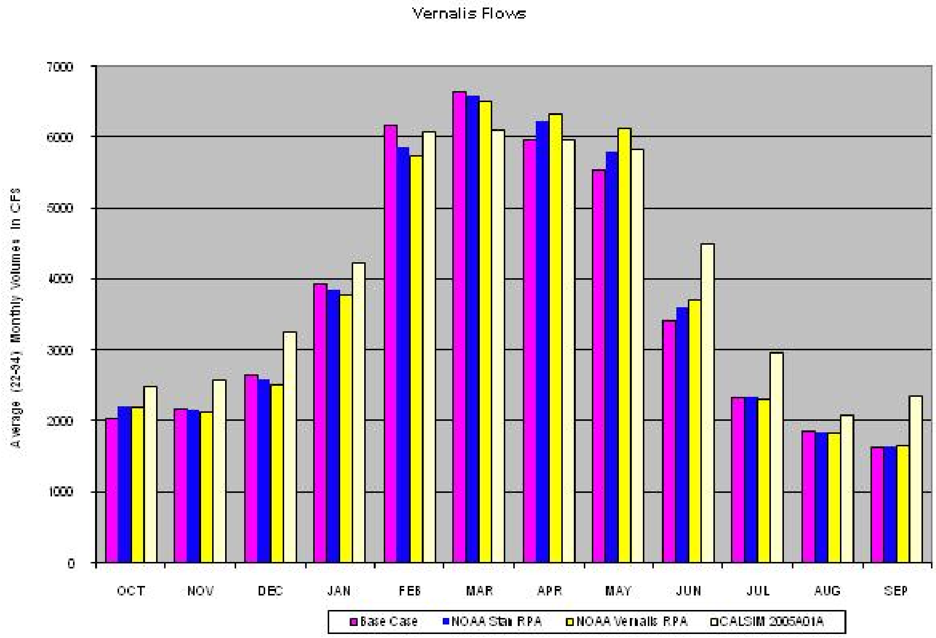


Figure 26: Vernalis Flow to export ratios for the month of March comparing the base case simulation with the simulations for the Stanislaus RPA and the Vernalis RPA.

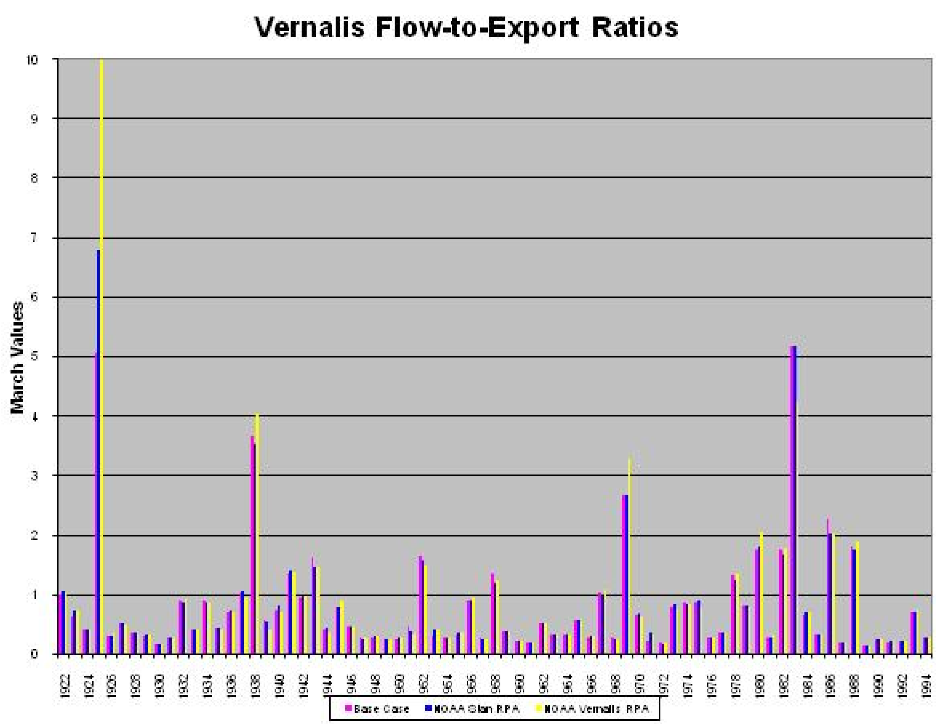


Figure 27: Vernalis Flow to export ratios for the month of April comparing the base case simulation with the simulations for the Stanislaus RPA and the Vernalis RPA.

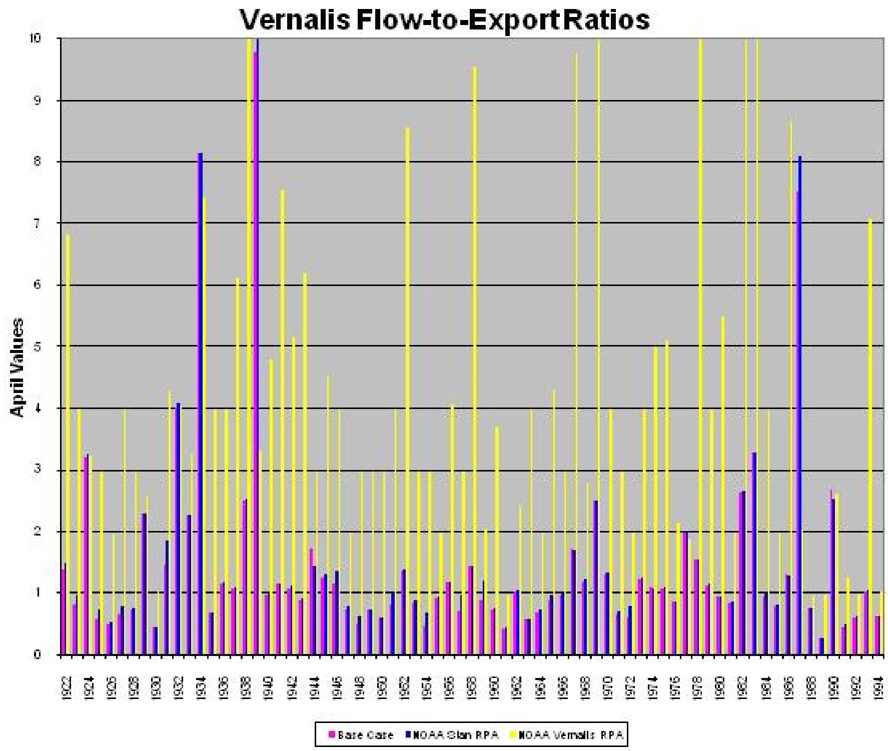
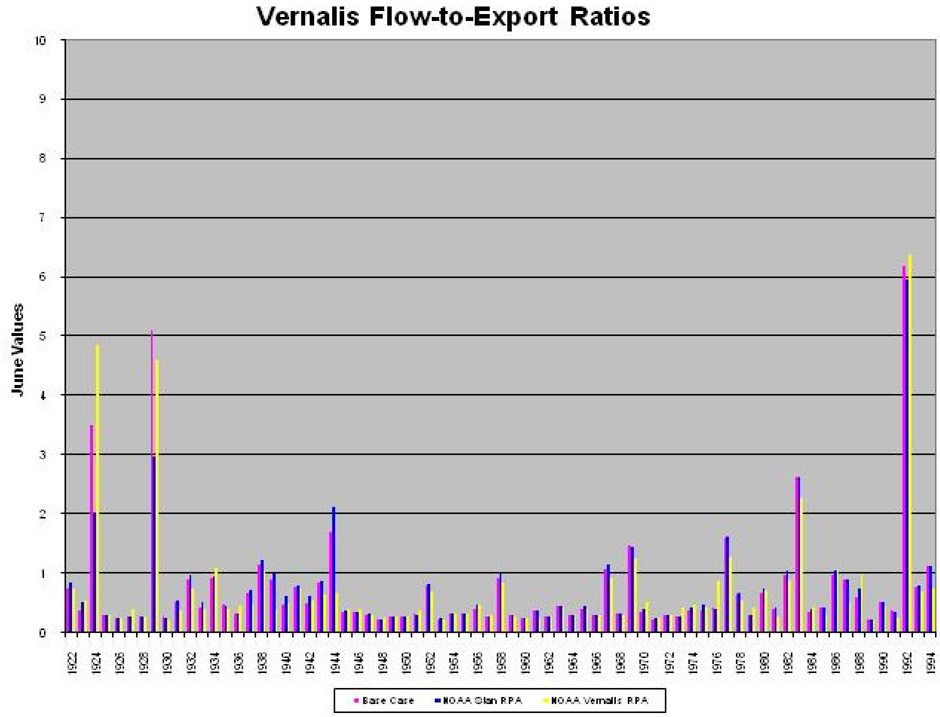


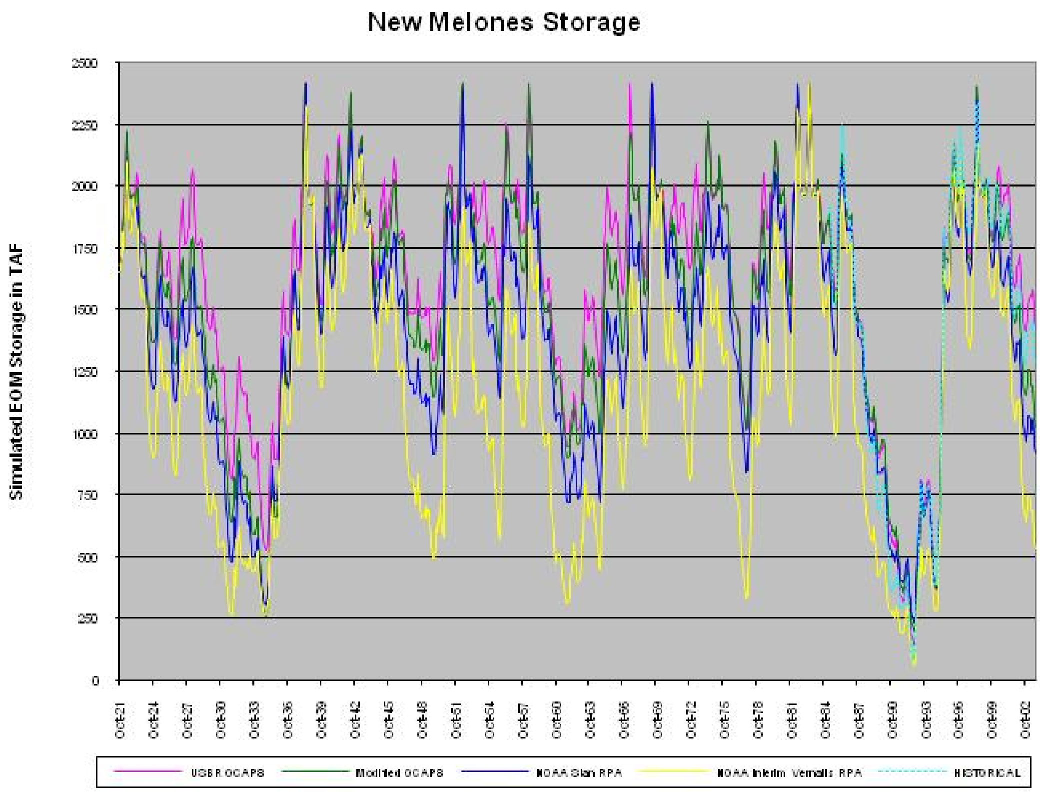
Figure 28: Vernalis Flow to export ratios for the month of June comparing the base case simulation with the simulations for the Stanislaus RPA and the Vernalis RPA.



In addition to the long term RPA actions, NMFS modeled the interim RPA actions for the Stanislaus River actions and the Vernalis actions. Interim operations of the project were assessed in the computer simulations carried out on May 20, 2009. The file name is "Compare4runs_w20090515run_ver20090520." The base case is the same as in the May 15, 2009, simulation using the USBR OCAP 8.0 baseline data. In addition to the base case, a modified OCAP 8.0 was developed as an alternate base case that included water releases for the Vernalis WQCP, water releases for the CDFG fish plan that were revised to follow the two-year workbook used as guidance by the USBR operators, the water supply parameter is redefined to be the Interim Operations Plan criteria which uses February New Melones storage + forecasted March through September inflows, removal of the cap on non-flood flows above 1500 cfs on the Stanislaus River and fixing the DO coding reversal. The Stanislaus River RPA uses the "low drop" criteria as modified on May 4, 2009. The Vernalis RPS uses the water supply parameters for New Melones storage and the flow schedule used in the May 6, 2009, simulations, *i.e.,* the WSPVNS (high) parameters. These same parameters were carried forward to the final interim simulation for the Stanislaus and Vernalis RPAs under the file name: (Compare4runs_w_20090515run_ver-20090529).

New Melones Reservoir is operated opportunistically in the interim period too. Like the long term operations it is also drawn down during drought periods, but to a lesser degree. The modified OCAP 8.0 base case draws more water out of the reservoir as is expected due to its increased releases of water for water quality purposes and fishery needs. The low point during the 1930s drought is less for the interim period, which may indicate a less aggressive use of water due to the use of the water supply parameters instead of the water year type to implement the Vernalis RPAs. Figure 29 shows the New Melones annual storage for the interim simulation. As previously discussed the more opportunistic use of the storage water in New Melones provides additional water annually, but impedes the refilling of the reservoir to a full capacity. This increases risks during a drought cycle when low carryover storage is carried from one year to the next.

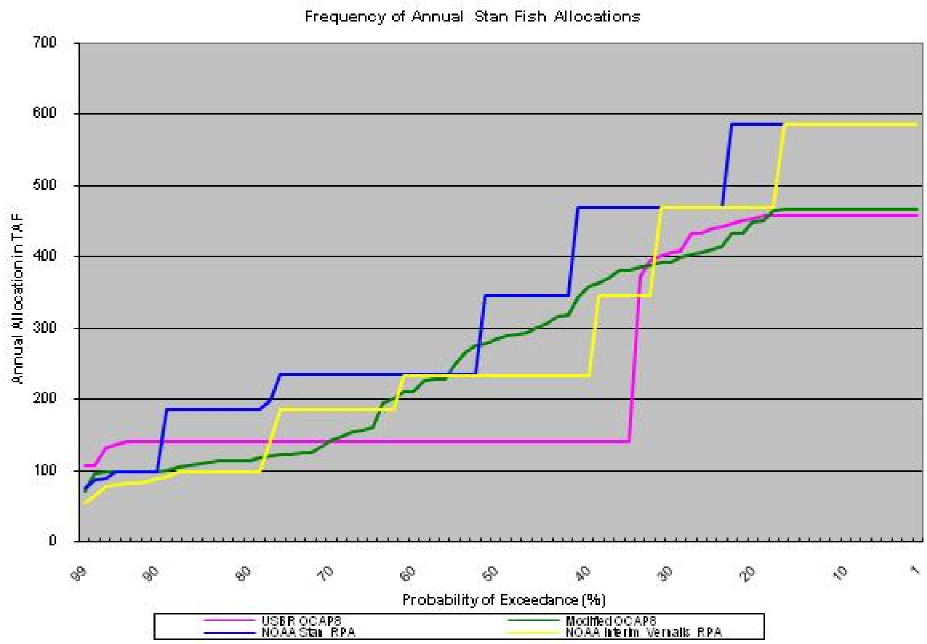
Figure 29: Annual storage at New Melones Reservoir simulated for the interim implementation of the Stanislaus River and Vernalis RPAs.



Under the interim simulation there are no discernable differences between the four runs in the traces of the annual storage in either New Don Pedro or New Exchequer reservoirs. This is not unexpected as the RPAs for the Stanislaus River and Vernalis do not affect operations on these two reservoirs.

The implementation of the Vernalis RPA affects the release of water from Goodwin dam as already discussed in the long term RPA section. Increased use of storage water reduces the amount of annual carry over water in the reservoir, thereby reducing the water supply parameter index for the next year. This in turn reduces the frequency that additional water can be released under the Stanislaus River RPA for fishery purposes (figure 30). The reduction in the water supply index shifts the curve to the right (yellow trace).

Figure 30: Exceedance plot of annual Stanislaus River fish allocations according to the interim Stanislaus RPA and Vernalis RPA.



The average monthly releases from Goodwin Dam are increased under the interim Stanislaus and Vernalis RPAs. More water is released under the Stanislaus River RPA from October through March compared to the Vernalis RPA, but he later releases more water from April through June. Both RPAs release more water than either the OCAP base case or the modified OCAP base case. This enhances environmental conditions in the river for steelhead and other salmonids such as Fall-run Chinook salmon (See figure 31).

Flows at Vernalis increase under the interim RPA for Vernalis and to a lesser extent under the Stanislaus River RPA. These increased flows enhance environmental conditions for emigrating fish in April and May. The average flows at Vernalis exceed 6000 cfs from February through May with an increasing trend through May before dropping sharply in June. A similar pattern was seen in the long term RPA simulation (see figure 32). The median values for Vernalis also show increased flows during the same time period; however the flows are lower, particularly in February and March when the median value is only about 3500 cfs rather than the 6000 cfs value seen in the figure depicting average flows at Vernalis (see figure 33).

The flow exceedance plot for Vernalis is similar to the long term exceedance plot. For the months of April and May flows are at least 6000 cfs for approximately 28 percent of the time (Vernalis RPA), 20 percent of the time flows are 4500 cfs (Vernalis RPA) and 7 percent of the time it meets D-1641criteria of 3420 cfs. Flows are 3000 cfs for 18 percent of the time (Vernalis

RPA), 2100 cfs (D-1641 criteria) and finally1500 cfs for 16 percent of the time (Vernalis RPA) (see figure 34).

Deliveries to Stanislaus contractors during the interim period of the RPA implementation are depicted in figures 35 and 36. Average annual deliveries to the major diverters (OID and SSJID) are decreased approximately 3 percent from 503 taf to 489 taf for the combined effects of the two RPAs. Decreases to SEWD and CSJWCD are larger. Deliveries decrease from 77 taf to 56 taf for the combined effects of the two RPAs for a decrease of 22 percent.

Figure 31: Annual median release from Goodwin Dam to the Stanislaus River under the interim Stanislaus RPA and the Vernalis RPA

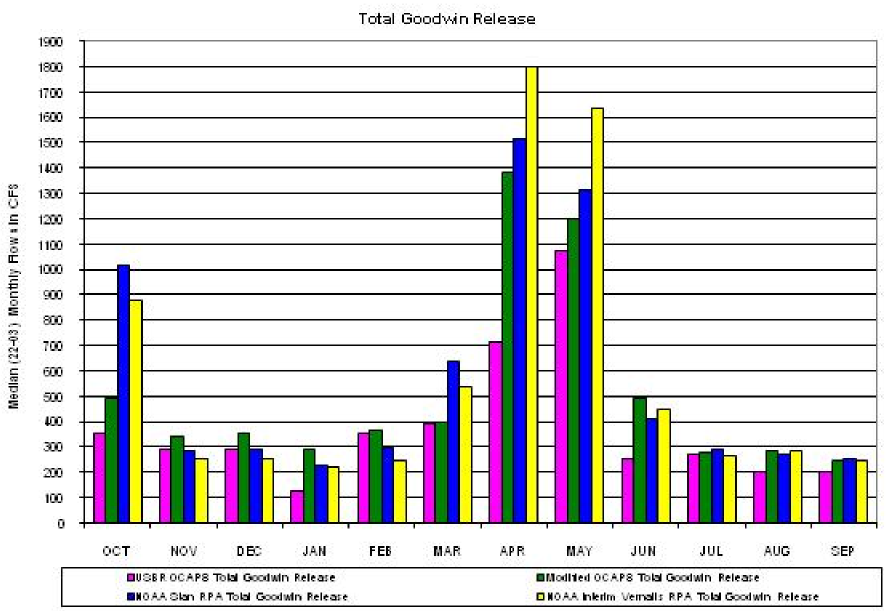


Figure 32: Average annual flows at Vernalis for the interim RPAs for the Stanislaus River and Vernalis.

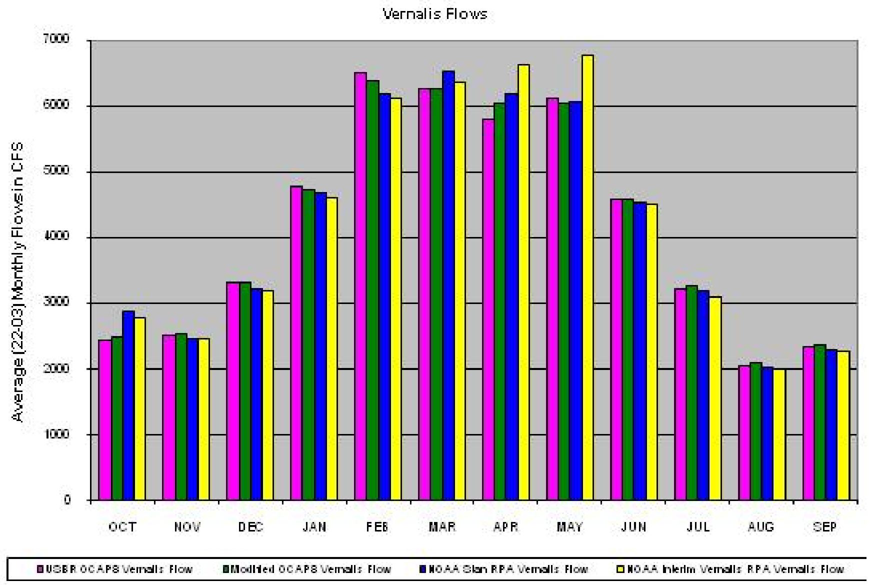


Figure 33: Median annual flows at Vernalis for the interim RPAs for the Stanislaus River and Vernalis.

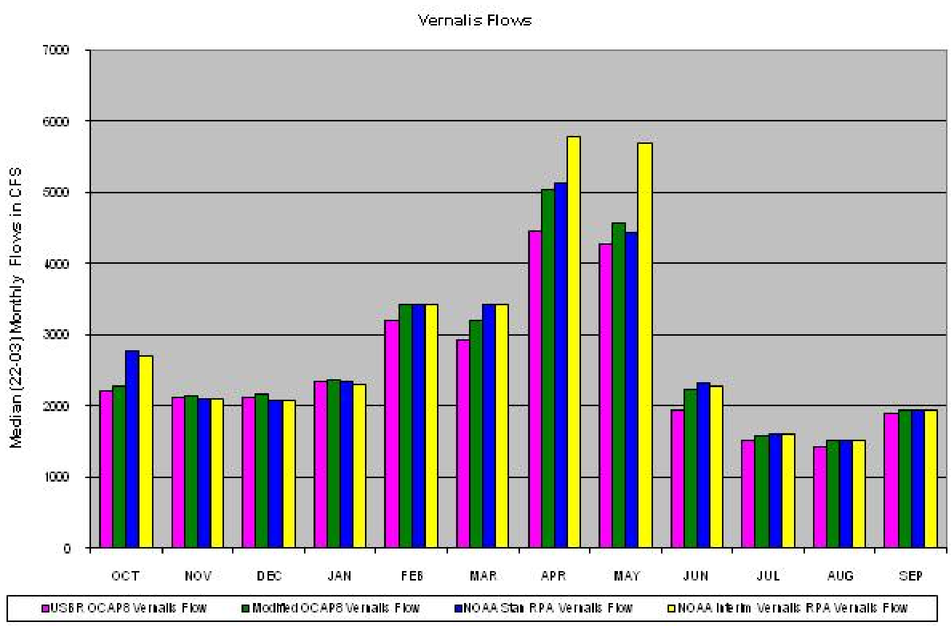


Figure 34: Exceedance plot for flows at Vernalis for the months of April and May for the interim Vernalis and Stanislaus RPAs.

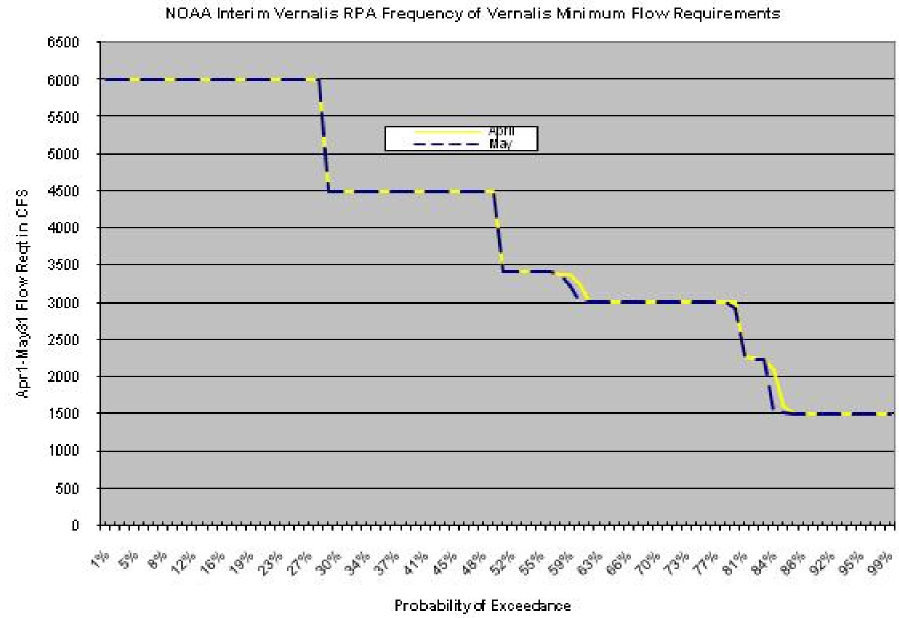


Figure 35: Impacts to Stanislaus River Major diverters OID and SSJID) from the interim RPAs for the Stanislaus River and Vernalis.

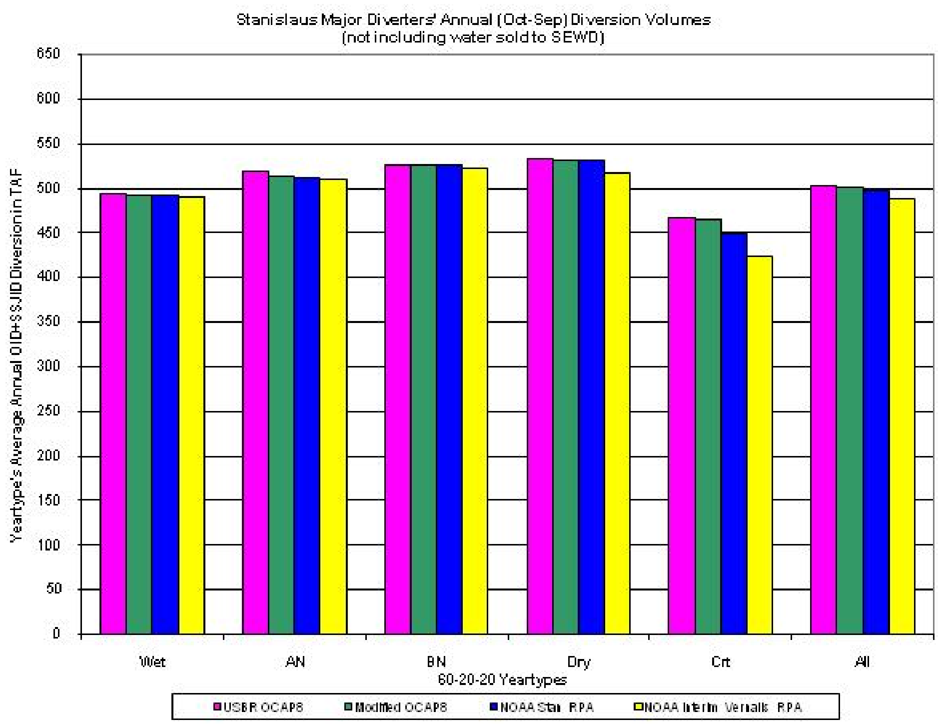
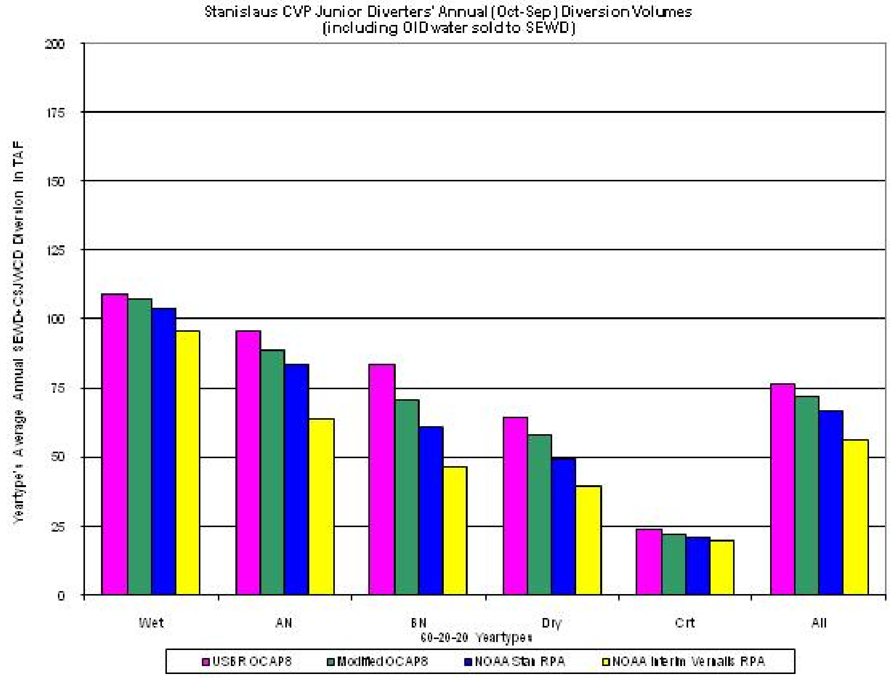


Figure 36: Impacts to junior diverters (*i.e.*, SEWD, CSJWCD) on the Stanislaus River from the implementation of eh interim RPAs for the Stanislaus River and Vernalis.



The impacts of the Stanislaus and Vernalis RPAs on the operations of project reservoirs, exports and delta hydrology were analyzed through CalLite computer simulations incorporating the USFWS delta smelt opinion as part of the baseline. The effects of the Stanislaus and Vernalis RPAs are evaluated using the Old and Middle River flows (OMR) as part of the existing baseline for evaluating the additional impacts of the RPAs. The baseline includes the 2030 LOD and no minimum instream flow requirements at Vernalis other than what is already imposed by D-1641. The exports by the Tracy and Banks facilities are constrained by the existing D-1641 standards and the OMR restrictions defined below:

60-20-20 Index	Wet	Above Normal	Below Normal	Dry	Critical
Dec	-5000	-5000	-5000	-5000	-5000
Jan	-5000	-5000	-2500	-2500	-2500
Feb	-5000	-3500	-2500	-2500	-2500
Mar	-5000	-3500	-2500	-2500	-2500
Apr	-5000	-3500	-2500	-2500	-2500
May	-5000	-3500	-2500	-2500	-2500
Jun	-5000	-3500	-2500	-2500	-2500

For the long term analysis, the baseline (1641fwsBObase Long term) used in ECOSIM-W run 917 A01 was used in defining the San Joaquin Basin assumptions

For the interim analysis, the baseline used the same baseline restrictions as described above as well as the assumptions contained in the CALSIM II run "OCAP Future Study 8 modified 20090520." The OMR values listed in the above table are applicable to the interim baseline.

The comparison of the long term Stanislaus and Vernalis RPAs with the December 15, 2008, USFWS delta smelt biological opinion's baseline uses the following factors in determining the minimum flow at Vernalis during the long term period of the RPA.

- 2030 LOD
- D-1641 requirement for water during non-pulse periods for water quality
- Off ramp to 1500 cfs Vernalis flow if the sum of the current year's 60-20-20 San Joaquin Basin index and the preceding two years indices are 6 or less.

The Vernalis flow requirements for the long term RPA uses the water year type to determine the level of necessary flow in the San Joaquin River at Vernalis for the period between April 1 and May 31. The flow levels are described in the following table.

Water year type as defined by the 60-20-20 San Joaquin Index	Required Flow at Vernalis in cfs for the period between April 1 and May 31
Wet	6000 cfs
Above Normal	6000 cfs
Below Normal	4500 cfs
Dry	3000 cfs
Critical	1500cfs

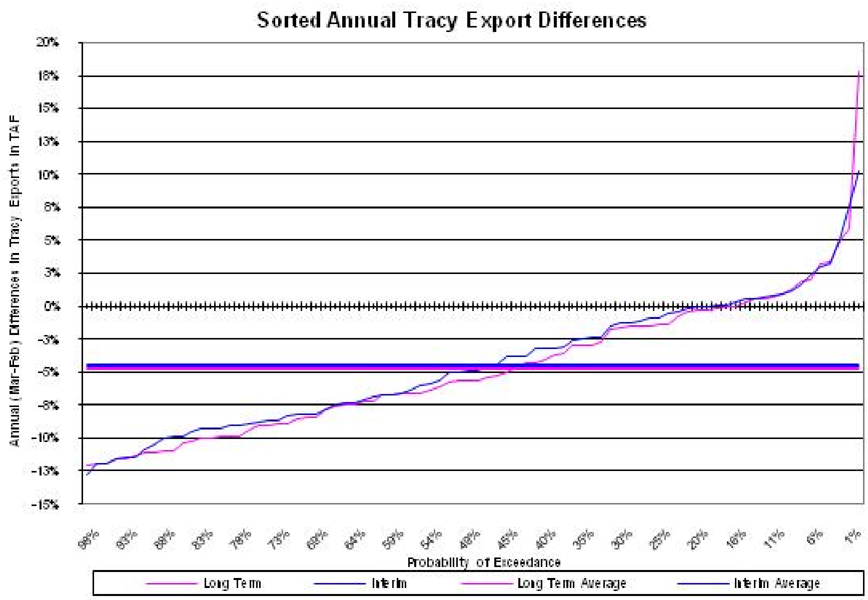
The interim period for the implementation of the Stanislaus and Vernalis RPAs uses the same OMR flow schedule as depicted in the above table. Interim Vernalis RPA flows are based on the New Melones water supply parameters according to the following table:

New Melones WSP (taf)	Vernalis Flow requirements (cfs)
0-499	0 cfs
500-1399	1500 cfs
1400-1999	3000 cfs
2000-2499	4500 cfs
2500-2999	6000 cfs
$\geq$ 3000	6000 cfs

For the April 1 through April 14 and May 16 through May 31 periods, the Vernalis minimum flow requirement is the maximum of either the D-1641 required flow or the appropriate value from the above table. For the April 15 through May 15 period, the Vernalis minimum flow is the maximum of either the targeted VAMP flow or the value in the table above. New Don Pedro and New Exchequer reservoirs and the exchange contractors only release water to meet the VAMP objectives if needed per the VAMP agreement.

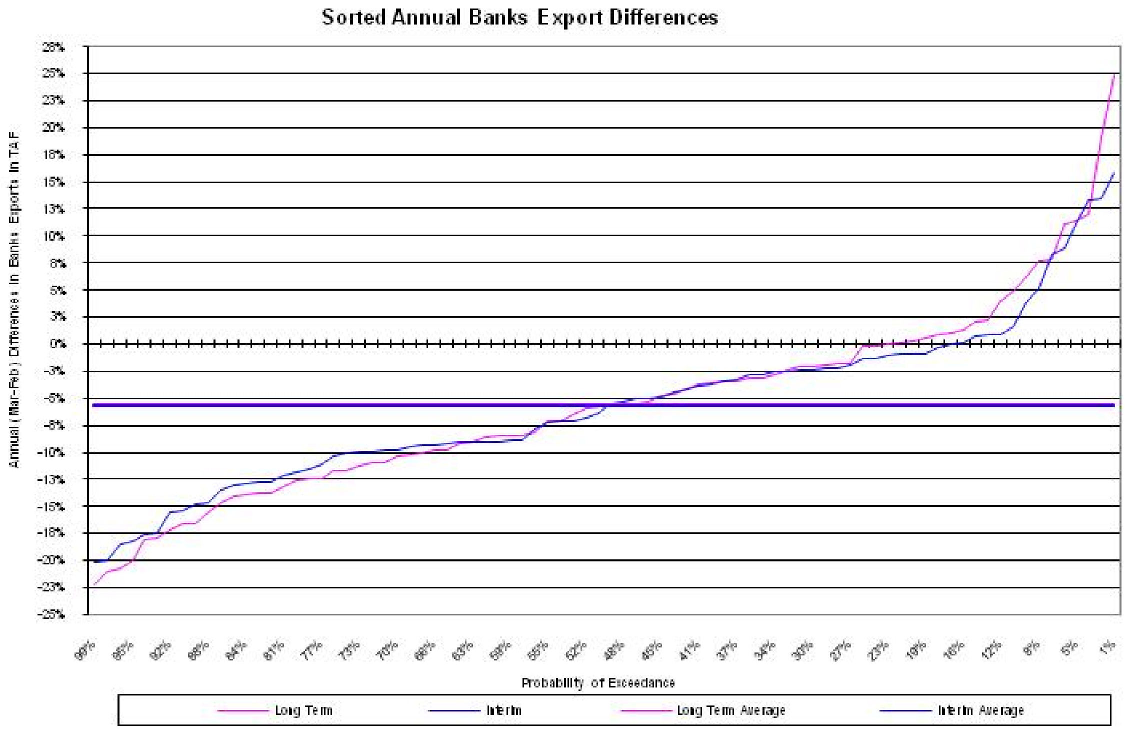
The exports are influenced by the Stanislaus River and Vernalis RPAs. The average impact to the Tracy exports is approximately -4.6 percent (median equal to -5.2 percent) or approximately 130 taf per year based on the average values over the 82 year period covered by the simulations. This is graphically represented in figure 37.

Figure 37: Probability of exceedance plot depicting the annual difference between the baseline exports at Tracy under the USFWS Delta smelt BO and the NMFS RPAs for long term and interim actions



The annual exports at Banks were similarly diminished in their magnitude by the new NMFS RPAs. The impacts to Banks were slightly greater, with an average difference of -5.7 percent (median difference is -5.8 percent) or approximately 200 taf per year based on the average values over the 82 year period covered by the simulations. This is graphically represented in figure 38.

Figure 38: Probability of exceedance plot depicting the annual difference between the baseline exports at Banks under the USFWS Delta smelt BO and the NMFS RPAs for long term and interim actions.



The exceedance plot for the annual combined export rates indicates that the incorporation of the NMFS RPAs decreases the annual magnitude of combined exports at the Tracy and Banks facilities from that observed in the baseline conditions (see figure 39). The largest decreases occur in the wetter years when combined exports are higher. This is expected since the Vernalis export curtailments in April and May further decrease the level of exports beyond the baseline levels present under the USFWS biological opinion (see figure 40). Combined exports are decreased approximately 60 percent in April and May from the baseline conditions depicted by the USFWS biological opinion baseline due to the implementation of the Vernalis RPA. Export levels are not substantially different between the baseline and the NMFS RPAs during the other months of the year. Differences are typically 5 percent or less during these other months. Individually, the state is affected more by the implementation of the NMFS RPAs. This may be an artifact of the simulation coding in the CalLite program based on the assumptions made during the development of the code. Figure 41 depicts the individual monthly export rates of the Banks and Tracy facilities in both the long term and interim simulations.

Figure 39: Probability of exceedance plot depicting the annual difference between the baseline combined exports at Banks and Tracy under the USFWS Delta smelt BO and the NMFS RPAs for long term and interim actions.

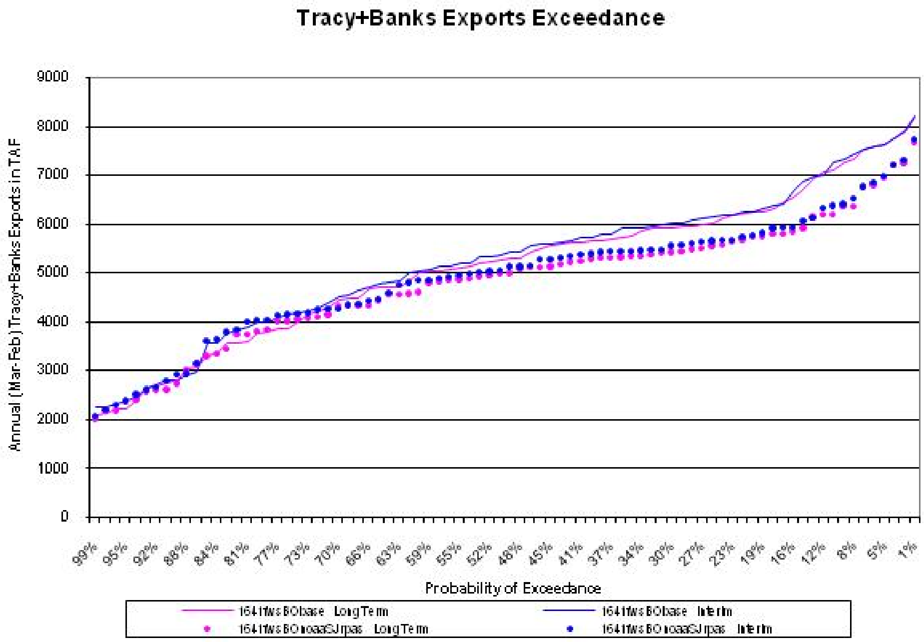


Figure 40: Monthly average of combined exports from the Tracy and Banks export facilities comparing the implementation of the NMFS RPAs with the USFWS biological opinion baseline under long term and interim conditions.

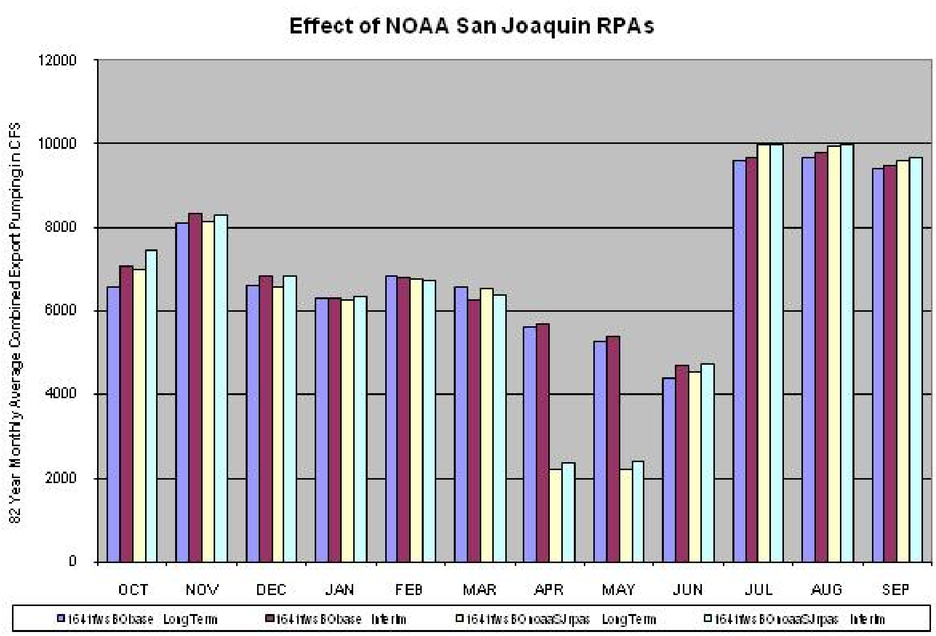
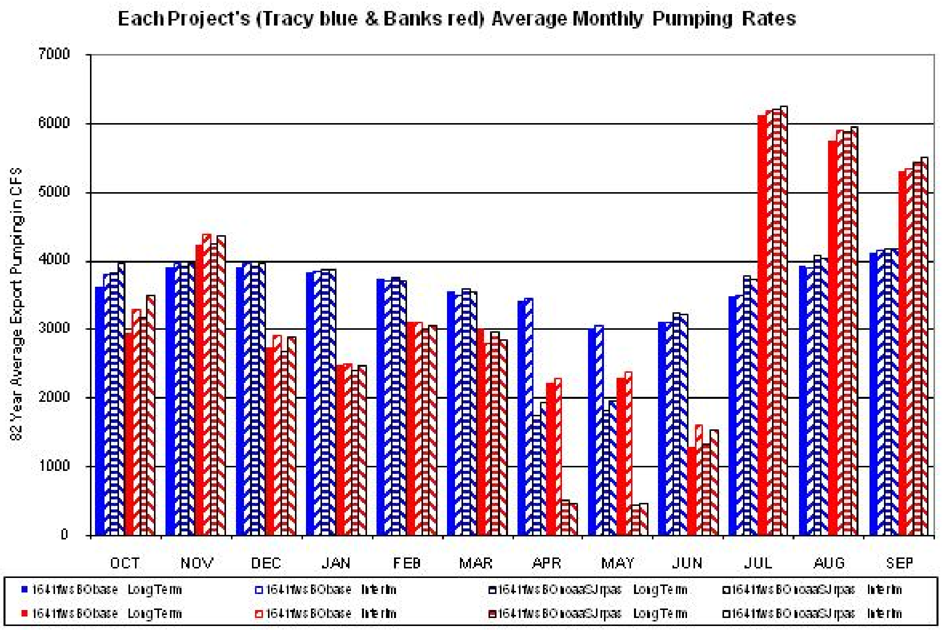


Figure 41: Comparison of monthly export rates for the Banks and Tracy export facilities for both the interim and long term NMFS RPAs and the USFWS Biological Opinion baselines.



Vernalis flows are increased during the February through May period for both the long term and interim simulations. Likewise, both the baseline and RPA simulations depict increases during this period. The NMFS RPAs increase flows to a greater extent during the March, April, and May period than seen under the baseline condition. The increased flows benefit out migrating steelhead while reductions in the April and May export rates provide additional protection to the fish from entrainment into the Delta export facilities and diversion into secondary channels leading towards the facilities. In addition, the increased flows and reduced exports have created conditions in which the OMR flows in the channels of Middle and Old River become positive during the April and May period (see figure 42). Furthermore, the indices of Delta outflow and Qwest have increased indicating an enhanced movement of water through the Delta system and westwards towards the ocean (see figures 43 and 44). All of these parameters imply an enhanced environment for steelhead emigration to the ocean and a reduction in the vulnerability to the State and Federal export facilities. Not only do San Joaquin Basin steelhead benefit from these hydrological conditions, but fish entering from the Sacramento River basin via Georgiana Slough incur benefits from the positive outflow, which moves them westwards towards the ocean. During the April and May time frame, Central Valley steelhead, Central Valley spring-run Chinook salmon, and Central Valley fall-run Chinook salmon are migrating into the Delta from the Sacramento River basin. Negative flows are associated with increased vulnerability to diversion into the central and south delta waterways and an elevated potential of eventual entrainment at the export facilities.

As part of the modeling exercise, storage in the northern reservoirs operated by Reclamation and the State, impacts from the implementation of NMFS' San Joaquin RPAs were assessed. Based on the simulations, there are no discernable effects on the carryover storage capacities of Trinity Reservoir, Lake Shasta, Lake Oroville reservoir, and Folsom Lake reservoir arising from the implementation of the San Joaquin RPAs (see figures 45, 46, 47, and 48). However, south of Delta storage appears to be impacted by the implementation of NMFS' San Joaquin RPAs. San Luis Reservoir is particularly vulnerable to the RPA implementation as it relies on the export facilities to provide water to it. San Luis acts as a huge storage pond for the State and Federal water system, and allows the CVP and SWP to pump water from the delta when it is "available" and store it until it is called upon for delivery to clients south of the Delta (see figures 49 and 50). When the exports are curtailed in April and May, coupled with the export reductions already occurring due to the OMR flows, water deliveries to San Luis Reservoir decrease.

Figure 42: Response of Old and Middle River flows to the implementation of the Vernalis RPA

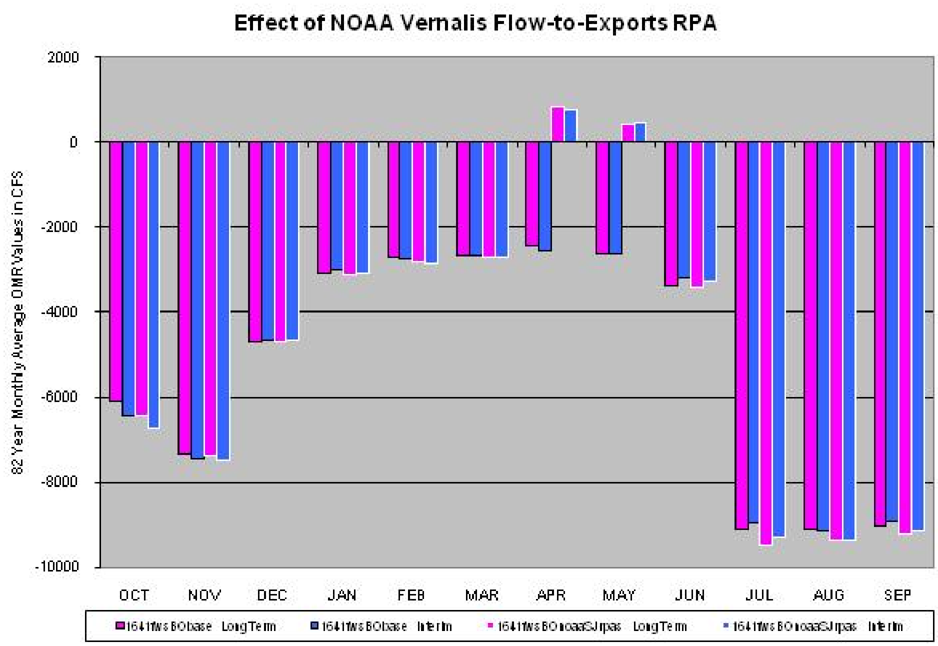


Figure 43: Response of Delta outflow to the implementation of the Vernalis RPA.

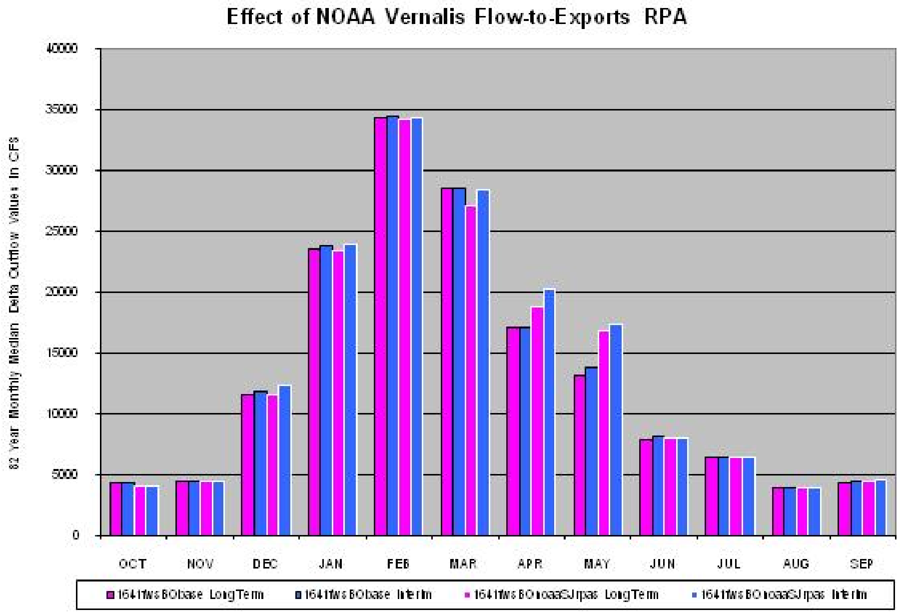


Figure 44: Response of QWEST to the implementation of the Vernalis RPA.

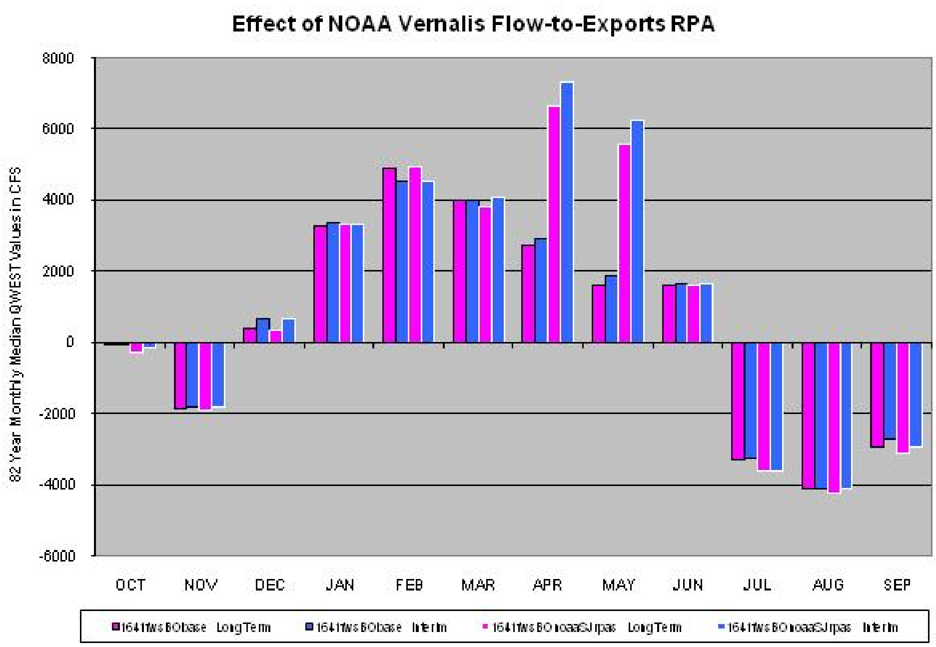


Figure 45: Simulated End -of-month Storage for Trinity Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.

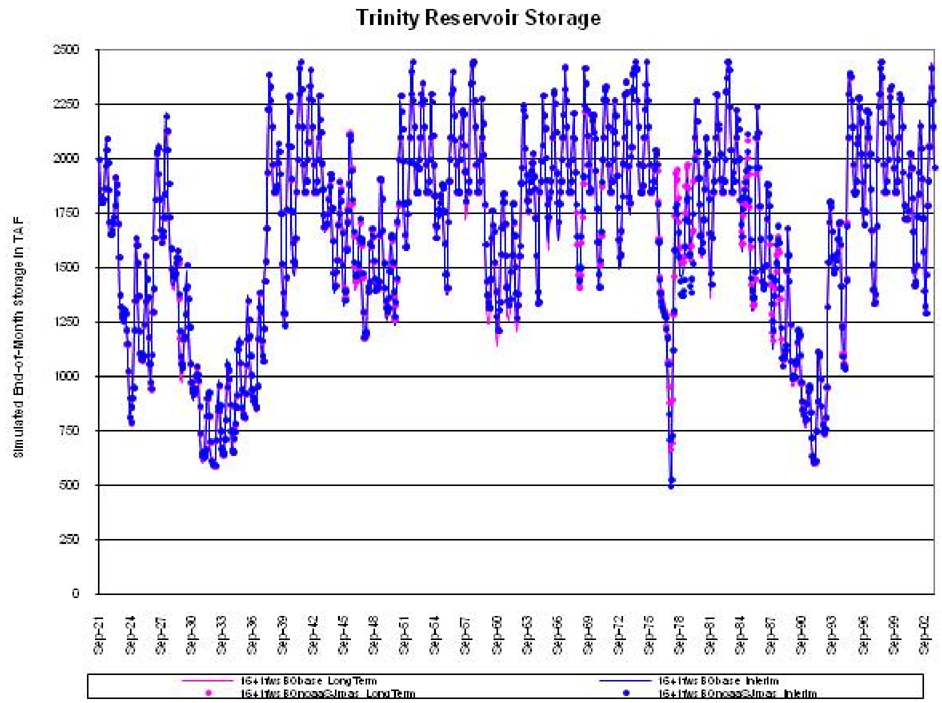


Figure 46: Simulated End -of-month Storage for Shasta Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.

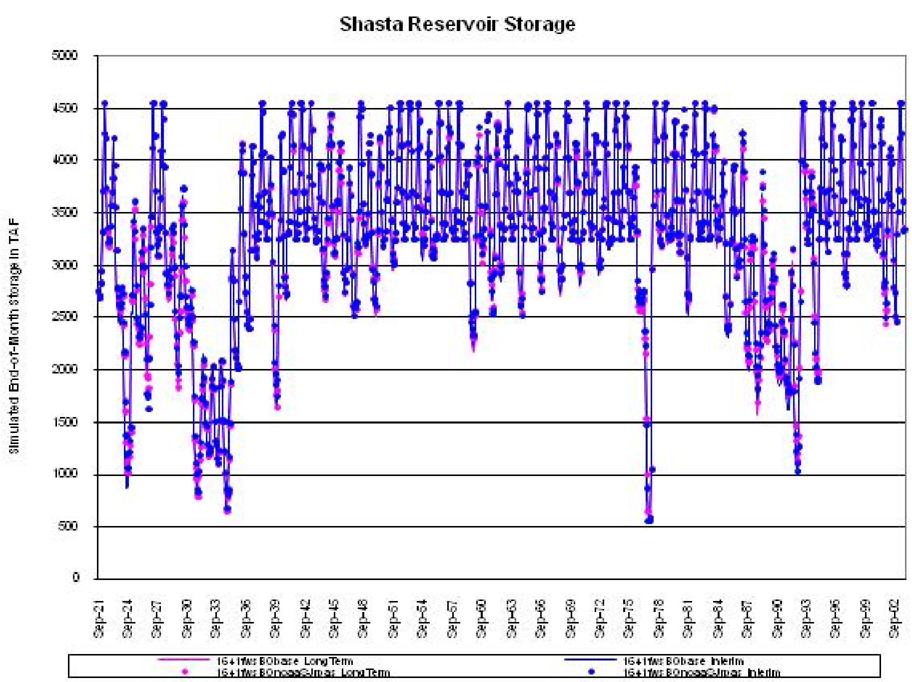


Figure 47: Simulated end-of -month storage for Oroville Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.

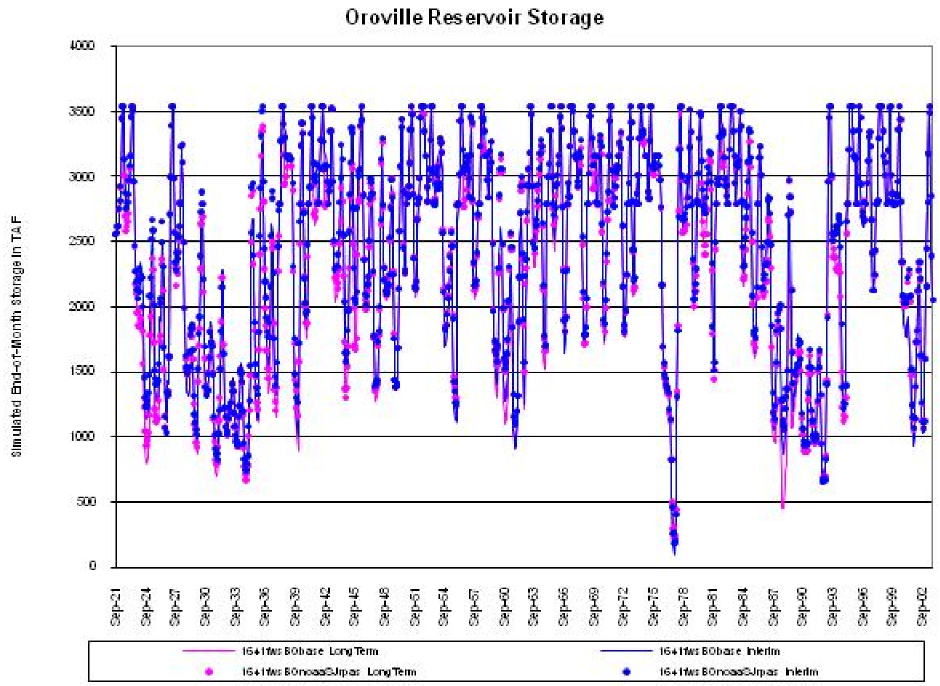


Figure 48: Simulated end-of -month storage for Oroville Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.

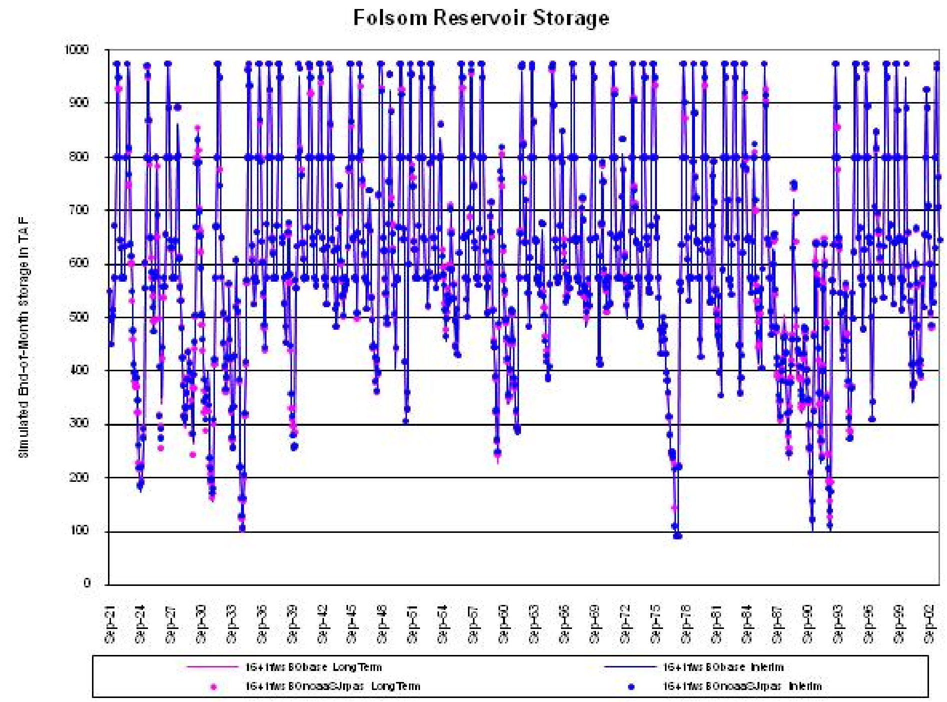


Figure 49: Simulated end-of August storage for the CVP portion of San Luis Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.

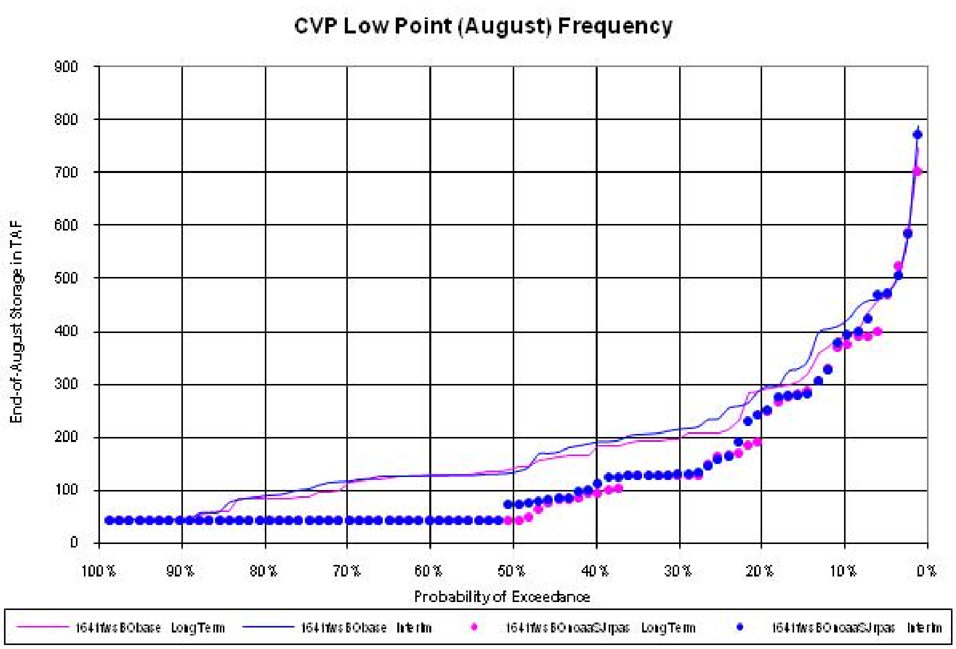
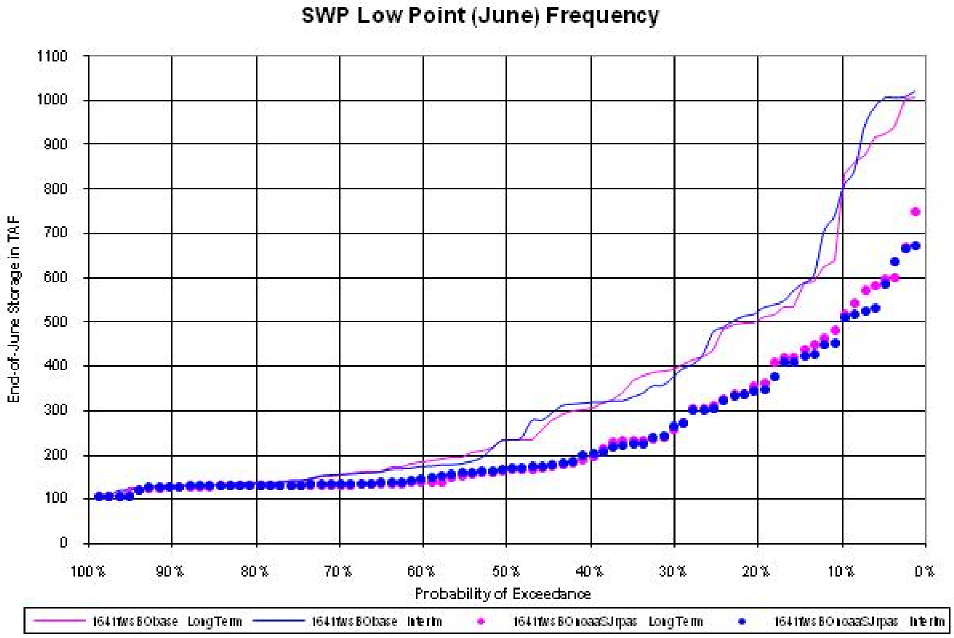


Figure 50: Simulated end-of June storage for the SWP portion of San Luis Reservoir following implementation of the NMFS RPAs for the Stanislaus and Vernalis.



Current Status of Consultation

Both the Bureau of Reclamation and DWR have strong initial opposition to the proposed RPA. DWR has indicated that the RPA is unfeasible as it currently written. They have proposed alternative actions that NMFS has investigated.

DWR proposed real time monitoring at Mossdale utilizing additional Kodiak trawling. As previously discussed, recoveries of steelhead in the Mossdale trawl are a rare event and in many years only a handful of fish are recovered. Given these rare recoveries of fish, an appropriate trigger to initiate flow increases or export reductions in a timely manner to protect outmigrating fish would be difficult to determine. DWR has not specified in their proposed monitoring how the capture of fish in the monitoring program would be used to trigger such actions. If in years when low numbers of fish are captured, protective measures would require actions to be triggered by "one fish" to ensure adequate actions are implemented. Furthermore, outmigration of steelhead occurs over several months and it appears that low levels of fish are intermittently exiting the system during this time, based on the rotary screw trap data from the Stanislaus River. Therefore, what parameters would DWR suggest to indicate when the pulse of steelhead is exiting the system? A broad period of water releases and export curtailments spanning several weeks to months would be more protective than the action suggested by DWR as it would protect a large segment of the steelhead population emigrating from the basin without relying on the efficiency and sensitivity of the trawling action to detect steelhead and trigger such actions.

DWR has also proposed relying on an experimental non-physical barrier (the bubble barrier concept) to replace the current rock barrier at the Head of Old River in lieu of the proposed RPA. They have also proposed installing such barriers in other channel bifurcations lower in the Delta where emigrating salmonids are vulnerable to diversion into the south delta and potential entrainment at the export facilities. This barrier is still highly experimental. It consists of behavioral barriers utilizing an air bubble curtain, light emitting diode strobe lights, and acoustic speakers which can emit sound energy tuned to frequencies to which salmonids are sensitive. The barriers have been tested in the lab and currently an experimental prototype is being tested in the Delta. The current experimental prototype is being deployed under very low flow conditions (approximately 1,800 cfs) and its efficacy at higher flows is unknown. While initial results are promising, it is not 100 percent effective at preventing fish from passing through it, even at these low flows. The barrier concept has potential as a component of a larger and more diverse action to enhance survival of emigrating salmonids, but in its current state, it is still too uncertain to be relied on as the sole action for an RPA. Further testing and analysis of its performance is warranted.

Trapping and hauling of emigrating steelhead has been proposed as a potential alternative by Reclamation to move fish from the tributaries to the western Delta and avoid the exports entirely. Reclamation has indicated that a focused trap and haul program located on the Stanislaus (and potentially other tributaries) will serve as a bridge to future actions, allowing time to formulate such actions. However, reclamation did not provide any specific details for this proposal nor how it would ultimately be implemented. This suggestion has multiple drawbacks which can limit its ultimate success. Placement of the trap would have to be located in a stream reach where capture of the entire or at least a significant proportion of the year's outmigration would occur. Fish handled through the trapping, hauling, and release procedure would be subject to intrinsic morbidity and mortality from this action. Reclamation has not identified this level of loss or what effects it would have to the small populations it impacts. Furthermore, those fish that avoided trapping, would have to swim downstream through the terminal end of the tributary, presumably under lower flow conditions and thus incur higher losses.

DWR has presented several modeling runs and analysis of data to support their opposition to the proposed RPA. They have consistently objected to the use of Particle Tracking Models in the development and monitoring of the RPA, yet have not presented a better alternative to help in the development of the RPA. DWR's reliance on the coded wire tag data developed during the VAMP experiments without fully describing the major limitations of that experiment confuses the interpretation of their results. The recovery of the fish at Chipps Island represents but a fraction of the released fish, and may be biased towards certain behaviors, *e.g.*, fast downstream migration, versus slow downstream migration behavior. It also does not elucidate the behavior of fish between the release point and the recapture point, a major deficiency in determining the potential fates of migrating fish and their vulnerabilities to different actions. Slow migratory behavior would have a higher risk of loss due to variables such as predation or diversion, and thus would never be sampled at Chipps Island. Recent acoustic tagging studies by Dave Vogel in support of the 2007 VAMP studies showed that tagged fish released upstream had faster initial downstream migration rates than those fish released farther down in the Delta. Vogel surmised that the slower migratory rates in the Delta proper were due to the tidal oscillation in the delta waterways and that the upstream migration rates were due to the higher flow velocities in the river channels upstream of the delta. Fish released at Mossdale or Durham ferry took about three to six days to reach the San Joaquin River near R16 (a channel marker near Headreach Cutoff and Ward Island). Fish released in Old River downstream of the Head exhibited slower migration rates than those released in the San Joaquin River main stem. This was attributed to slow river flows in the channels of the South Delta. It took approximately 3 to 4 days for fish released just downstream of the HORB to reach the export facilities. These fish moved with river and tidal currents, in an analogous way to particles moving with the current. If fish had "concerted directed" movement as championed by DWR, then migratory rates should be relatively constant, and not influenced by the location and ambient flow conditions of a particular location.

For lack of an alternative tool, PTM simulations still have utility, even with the shortcomings described by DWR. It remains one of the tools available to consider using in the development and monitoring of the RPA as needed, particularly when transit times in the upper river reaches are being considered. The PTM simulations characterize the movement of water in the Delta, which then allows NMFS to assess the vulnerability of migrating fish to different operational changes that affect water movement. At this juncture, CWT data does not provide a probability assessment of fish movement within the Delta.

Current Proposal:

The overall objective of *Action Suite IV.2: Flow Management*, as part of the Delta Division, is to maintain adequate flows in both the Sacramento River and San Joaquin River basins to increase survival of steelhead emigrating to the estuary from the San Joaquin River, and of winter-run, spring-run, CV steelhead, and green sturgeon emigrating from the Sacramento River through the Delta to Chipps Island. Numerous studies have found positive associations between increased river flows and increased survival of salmon smolts through the Delta and the adult escapement of that cohort several years later when they return to spawn (see earlier discussions in this document). Increased flows and greater smolt survival have been positively associated in other river systems as well. Increased flows reduce the travel time of smolts moving through the river and Delta system, thus reducing the duration of their exposure to adverse effects from predators, water diversions, and exposure to contaminants.

More specifically, the objective of *Action IV.2.1: San Joaquin River Inflow to Export Ratio* is to reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to diversion into the channels of the south Delta and thereby increasing their risk of eventual entrainment at the export pumps due to the diversion of water by the export facilities in the south Delta. By increasing the inflow to export ratio and providing greater net downstream flows, the likelihood of salmonids successfully exiting the Delta at Chipps Island, through the creation of more suitable hydraulic conditions in the main stem of the San Joaquin River, will be enhanced. Action IV.2.1 consists of two implementation phases and multiple sub-components and is summarized below as per the June 1, 2009 draft version of the RPA document.

Phase I: pertains to the interim operations period and is implemented during 2010 and 2011.

From April 1 through May 31:

1. Flows at Vernalis (7-day running average shall not be less than 7 percent of the target requirement) shall be based on the New Melones Index[1]. In addition to the Goodwin flow schedule for the Stanislaus River prescribed in Action III.1.3 and Appendix 2-E, Reclamation shall increase its releases at Goodwin Reservoir, if necessary, in order to meet the flows required at Vernalis, as provided in the following table. NMFS expects that tributary contributions of water from the Tuolumne and Merced rivers, through the SJRA, will continue through 2011 and that the installation of a fish barrier at the Head of Old River will continue to occur during this period as permitted.

New Melones Index (TAF)	Minimum flow required at Vernalis (cfs)
0-999	No new requirements
1000-1399	D1641 requirements or 1500, whichever is greater
1400-1999	D1641 requirements or 3000, whichever is greater
2000-2499	4500
2500 or greater	6000

2. Combined CVP and SWP exports shall be restricted through the following:

Flows at Vernalis (cfs)	Combined CVP and SWP Export
0-6,000	1,500 cfs
6,000-21,750[2]	4:1 (Vernalis flow:export ratio)

[1] The New Melones Index is a summation of end of February New Melones Reservoir storage and forecasted inflow using 50% exceedance from March through September.
[2] Flood warning stage at Vernalis is 24.5 feet, flow is 21,750 cfs at this point. Flood stage is 29 feet with a corresponding flow of 34,500 cfs. Data from CDEC looking at April 8-9, 2006 period. As such, recognizing that

21,750 or greater	Unrestricted until flood recedes below 21,750

In addition:

1. Reclamation/DWR shall seek supplemental agreement with the SJRGA as soon as possible to achieve minimum long term flows at Vernalis (see following table) through all existing authorities.

San Joaquin River Index (60-20-20)	Minimum long-term flow at Vernalis (cfs)
Critically dry	1,500
Dry	3,000
Below normal	4,500
Above normal	6,000
Wet	6,000

Rationale:

1. Flows at Vernalis: Reclamation has limited discretion to require additional flows from the Tuolumne and Merced rivers that are necessary in the long run to meet the needs of outmigrating juvenile steelhead. Modeling for our analysis of the East Side Division show that relying on New Melones Reservoir to provide the flows at Vernalis cannot be sustained, and attempting to do so would likely have additional adverse effects on CV steelhead. Reclamation and DWR have obtained additional flows in the Tuolumne and Merced rivers through CVPIA authorities, including options to purchase water from willing sellers, and entered into the SJRA which expires on December 31, 2009. Reclamation is in negotiations to extend the current agreement to 2011. The flows required in Phase I at Vernalis were developed through iterative modeling and will provide an important increment of additional flow to provide for outmigration of steelhead smolts, while not unduly depleting New Melones Reservoir storage. Using CVPIA authorities, it is important that Reclamation seek to immediately change the terms of the existing SJRA to achieve the long-term flows.

2. The rationale for the export curtailments is provided in the rationale for Phase II.

3. The SWRCB has initiated proceedings to establish minimum flows in the San Joaquin River basin. The proceedings are scheduled to conclude in 2011. Flow requirements for fish will be provided by this action in the interim.

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the flows associated with these stages do vary, the trigger allowing unrestricted exports will be a Vernalis stage of 24.5 feet.

Phase II: Beginning in 2012:

From April 1 through May 31:

1. Reclamation shall continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action III.1.3 and Appendix 2-E.

2. Reclamation and DWR shall implement the Vernalis flow-to-combined export ratios in the following table, based on a 14-day running average.

San Joaquin Valley Classification	Vernalis flow (cfs):CVP/SWP combined export ratio[3]
Critically dry	1:1[4]
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750.

Exception procedure for multiple dry years: If the previous 2 years plus current year of San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and Indicator as defined in D-1641 and provided in following table, is 6 or less, AND the New Melones Index is less than 1 MAF, exports shall be limited to a 1:1 ratio with San Joaquin River inflow, as measured at Vernalis.

San Joaquin Valley Classification	Indicator
Critically dry	1
Dry	2
Below normal	3
Above normal	4
Wet	5

Exception procedure for Health and Safety: If, by February 28 of a given year, Reclamation and DWR predict that they will not be able to achieve these ratios and make deliveries required for human health and safety, even after pursuing all options to augment inflow while preserving

[3] Exception to the ratio is provided for floods, where exports are not restricted until the flood recedes. See footnote 2 above.
[4] Minimum combined CVP and SWP exports is for health and safety.

the ability to meet fish flow needs in all seasons, the agencies may submit a plan to NMFS to maximize anadromous fish benefits while meeting health and safety needs. The project agencies' current estimate of health and safety needs is a combined CVP/SWP export rate of 1,500 cfs. The plan must demonstrate that all opportunities for purchasing water in the San Joaquin Basin have been or will be exhausted, using b(3) or other water purchasing authority.

Meeting the long-term biological requirements of listed species and providing adequate water deliveries for these needs under the current system configuration may not be compatible, particularly considering anticipated hydrologic patterns associated with climate change. For this reason, Reclamation and DWR may propose a reconfiguration of the water conveyance system to allow diversion from the Sacramento River. Such an alteration of the conveyance system is being considered in the BDCP planning process. The operation of a conveyance structure that diverts water directly from the Sacramento River carries additional risk for listed species that migrate, spawn, or rear in the Sacramento River or North Delta. As detailed in this Opinion, the status of those species is precarious. Any new conveyance will be subject to section 7 consultation, and issues of injury or mortality of juvenile fish associated with all diversion facilities, reduction of flow variability for fish life history functions, reduction of Shasta Reservoir storage necessary for main stem temperature control, and other potential adverse effects must be adequately addressed in any conveyance proposal.

Rationale: VAMP studies of CWT Chinook salmon smolts indicate that in general, fish released downstream of the zone of entrainment created by the export pumps (*e.g.*, Jersey Point) have higher survival indices to Chipps Island than fish released higher up in the system (*e.g.*, Durham Ferry, Mossdale, or Dos Reis). Studies identify increased flows as a factor that increases survival of tagged Chinook salmon smolts. To date, most VAMP experiments have utilized San Joaquin River flows to export pumping ratios of approximately 2:1. Survival to Chipps Island of smolts released upstream has been relatively low under these conditions. (Kjelson *et al*. 1981, Kjelson and Brandes 1989, SJRGA 2007). Historical data indicates that high San Joaquin River flows in the spring result in higher survival of outmigrating Chinook salmon smolts and greater adult returns 2.5 years later (Kjelson *et al.* 1981, Kjelson and Brandes 1989, USFWS 1995) and that when the ratio between spring flows and exports increase, Chinook salmon production increases (CDFG 2005, SJRGA 2007). NMFS, therefore, concludes that San Joaquin River Basin and Calaveras River steelhead would likewise benefit under higher spring flows in the San Joaquin River in much the same way as fall-run do.

Increased flows within the San Joaquin River portion of the Delta will also enhance the survival of Sacramento River salmonids. Those fish from the Sacramento River which have been diverted through the interior Delta to the San Joaquin River will benefit by the increased net flow towards the ocean caused by the higher flows in the San Joaquin River from upstream and the reduced influence of the export pumps. Such flows will reduce the proportion of Sacramento

River fish that continue southwards toward the pumps and increase the percentage that move westwards toward Chipps Island and the ocean. Although the real environment is much more complex than this generality, in theory, increasing the speed of migration through a particular reach of river, or shortening the length of the migratory route decrease the extent of exposure to factors causing loss (Anderson *et al.* 2005)

Acoustic Tag Experiments

The overall objective of Action IV.2.2., the Six Year Acoustic Tag Experiment is to confirm proportional causes of mortality due to flows, exports and other project and non-project adverse effects on steelhead smolts out-migrating from the San Joaquin basin and through the southern Delta. In order to gather this important information, Reclamation and DWR shall fund a 6-year research-oriented action concurrent with Action IV.2.1. The research shall be composed of studies utilizing acoustically-tagged salmonids, and will be implemented to assess the behavior and movement of the outmigrating fish in the lower San Joaquin River. The studies will include three releases of acoustic tagged fish, timed to coincide with different periods and operations: March 1 through March 31, April 1 through May 31, and June 1 through June 15. NMFS anticipates that studies will utilize clipped hatchery steelhead and hatchery fall-run as test fish.

During the period from March 1 through March 30, the exports will be operated in accordance with the requirements dictated by action IV.2.3. (Old and Middle River Flow Management**).** During the 60-day period between April 1 and May 30, exports will be dictated by the requirements of action IV.2.1. Reclamation shall operate to a minimum 1:1 inflow to export ratio during the period between June 1 and June 15, allowing exports to vary in relation to inflows from the San Joaquin to test varying flow to export ratios during this period. If daily water temperatures at Mossdale exceed 72^{o}F for seven consecutive days during the period between June 1 and June 15, then the inflow to export ratio may be relaxed. NMFS anticipates that warm water conditions in the lower San Joaquin River will not be suitable for steelhead under these conditions.

Implementation procedures:

1) By September 1, 2009, Reclamation/DWR shall convene DOSS for the purpose of refining the study design for this experiment. The experiments shall be developed to ensure that results are statistically robust and uncertainties due to experimental design have been minimized to the fullest extent possible. Additional expertise may be included in the workgroup, at the discretion of the agencies.

2) Issues relevant to listed anadromous fish species that shall be addressed include, but are not limited to:

- Increasing survival of emigrating smolts from the tributaries into the main stem of the San Joaquin River.
- Increasing survival of emigrating smolts through the main stem of the San Joaquin River downstream into the Delta.
- Increasing survival of emigrating smolts through the Delta to Chipps Island.
- The role and influence of flow and exports on survival in these migratory reaches.
- Selection of routes under the influence of flows and exports.
- Identifying reach-specific mortality and or loss.
- The effectiveness of experimental technologies, if any, *e.g.,* non-physical barrier ("bubble curtain**.")**

3) Annual reviews of the study results shall be conducted by the DOSS group. At the end of the 6-year period, a status review of Action IV.2.1 shall be prepared by the DOSS group. The status review shall be used to assess the success of Action IV.2.1 in increasing survival through the Delta for San Joaquin River basin salmonids, but in particular, steelhead. Based on the findings of the status review, the DOSS group will make recommendations to NMFS, Reclamation, CDFG, DWR, and USFWS on future actions to be undertaken in the San Joaquin River basin as part of an adaptive management approach to the basin's salmonid stocks.

4) Complementary studies to achieve performance goals**:** At its discretion, Reclamation and DWR also may develop and propose complementary studies to examine alternative actions that would accomplish the targeted survival performance goals. A primary effort of these studies will be to establish an appropriate survival goal for out-migrating steelhead smolts from Vernalis to Chipps Island in all water year types. Reclamation and DWR may propose studies which test actions that incorporate non-flow or non-export related actions. The studies shall contain specific actions within the authority and discretion of Reclamation and/or DWR, an evaluation of the projected benefits of each action with respect to increasing survival to the performance goal, evidence used to support this evaluation including literature citations, particle tracking modeling and other predictive tools, to demonstrate that the survival will be achieved, and a demonstration that the actions are reasonably certain to occur within the term of the study period. Any complementary study proposal shall be peer reviewed by the Calfed Science Program (or other comparable science group) and by the DOSS workgroup prior to being submitted to NMFS.

Upon receipt of the complementary study proposal, NMFS will review the draft proposal for sufficiency of information, experimental design, and likelihood to meet performance goals and provide comments back to Reclamation and DWR within 30 days of receipt. If NMFS concurs with the complementary study proposal, and finds the studies do not conflict with the actions implemented under the RPA, then the study may be conducted concurrently with the actions set forth above (Action IV.2.1 and IV.2.2). Throughout the six years of study, all new data will be annually evaluated by the proposed DOSS group, which will then provide recommendations through a written report to the management of NMFS and Reclamation for continuing actions in the San Joaquin River basin in support of CV steelhead.

Exception: If, despite Reclamation and DWR's best efforts, the new experiment is not ready for implementation in 2010, then VAMP study design may continue for one year, upon written concurrence of NMFS.

Rationale: This experiment will provide important information about the response of fish migration to flows, exports, and other stressors in the San Joaquin River corridor. Flows and exports will be varied according to time period. From March 1 through March 31, the studies will assess the relationship of the Vernalis flow-to-export ratio under the OMR flow restriction (see Action IV.2.3) to route selection at channel bifurcations in the South Delta and main stem San Joaquin River, survival in the different channels reaches of the South Delta, and ultimately through the Delta to Chipps Island as a whole.

From April 1 through May 30, the studies will assess the effectiveness of varying ratios by water year type (see Action IV.2.1) by comparing channel selection, route survival, and overall through-Delta survival during this period of stabilized conditions to the other two periods.

From June 1 to June 15, the studies will focus on the relative importance of exports, as compared to flows, by deliberately varying exports under similar flow conditions. Acoustic tagging studies have the potential to provide this level of resolution. Results from these studies may be able to indicate, at a fine temporal and spatial scale, how exports and flow influence route selection of migrating fish and their survival probabilities in the different channel reaches. Knowledge of these factors should aid in the management decision process and reduce project impacts to listed salmonids based on findings with strong scientific foundations.

Summary

The management of river flows on the San Joaquin River is intended to avoid jeopardy to the Central Valley steelhead population currently residing in the San Joaquin Basin and its tributaries. The RPA identifies actions that shall be implemented in consideration of maintaining appropriate river flows in the main stem San Joaquin River at Vernalis that are beneficial to CV steelhead based on the life history requirements identified in this document. Management of exports as part of the implementation of this RPA will enhance the benefits derived from increasing flows on the San Joaquin River. The incorporation of the six year acoustic tag experiments provides a vehicle to monitor the efficacy of the RPA in achieving its objectives. Results from this experiment as well as the collection of data from ongoing studies throughout the Delta will be used to adaptively manage the lower San Joaquin River and Delta to benefit steelhead and other listed fish.

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