Chapter 13 CVP and SWP Delta Effects on Species

Introduction

This chapter deals with the effects the Central Valley Project (CVP) and State Water Project (SWP) may have on delta smelt, and on steelhead, Chinook salmon, and green sturgeon while the latter three species are present in the Delta. The Delta effects on these species are presented in detail in this Chapter in two separate sections for the purpose of clarity and because the effects are significantly different for the resident pelagic species versus migratory species. The first section describes the Delta effects on delta smelt and the second section addresses the effects on steelhead, Chinook salmon and the green sturgeon.

It is important to note that this chapter focuses specifically on the effects of the projects on these species. However, these effects are evaluated in context with the broader factors that influence abundance and distribution as described in Chapter 4 (steelhead) Chapter 6 (Chinook salmon) Chapter 7 (delta smelt) and Chapter 8 (green sturgeon).

In the section discussing delta smelt and referred material in Chapter 7 some of the likely contributing causes of the POD such as toxic effects from agro-chemicals are discussed that may be unrelated to water project operations; however others such as entrainment are in fact directly related. The discussion in this chapter outlines both the direct and indirect potential effects in addition to modeling results related to Delta pumping, in-Delta flows (represented by Old and Middle River flows) and X2 for both current and future conditions.

In the second section, which discusses the Delta effects on steelhead, Chinook salmon, and green sturgeon, the impacts seem to be primarily associated with direct entrainment at various project pumping facilities and fish passage issues at the Suisun Marsh Salinity Control Gates. In addition, this section provides a description of the CVP and SWP monitoring data and modeling results estimating the salvage and loss of fish by species and life stage.

The general approach taken here considers both direct entrainment at the Jones and Banks facilities and indirect effects that may occur elsewhere in the Delta. The objective is to evaluate effects that current and future water project operations may have on each species. Evaluation of the effect of future operations is in each case accomplished by quantitative comparison of relevant variables in models representing future cases with the corresponding variables in the present-operations case. Evaluation of the effects of present operations varies by species. There is substantial uncertainties about the importance of some effects. These uncertainties are usually limited to the magnitude of the effect. Whether an effect is likely harmful or beneficial is usually more certain. It should also be noted that potential effects might be amplified or muted by variation in distribution of fishes in the Delta (which changes from year to year and among months within years), unanticipated secondary biological effects, or by unanticipated effects emerging from climate change. A summary of conclusions drawn from these analyses is presented in Chapter 15.

CVP and SWP Delta Effects on Delta Smelt

Statistical analyses of the long-term delta smelt abundance trends (Manly and Chotkowski 2006) confirm that there has been a long-term decline of delta smelt, with substantial interannual variation. A period of increase in the late 1990s was followed by a rapid and sustained decline beginning about 2000. Current delta smelt numbers are at or near their all-time low since monitoring began (Baxter et al. 2008, DFG unpublished 2008 monitoring results). The 2007 POD Synthesis report posits that delta smelt abundance has been strongly influenced since the start of that decline by adult abundance, habitat conditions, and entrainment (Baxter et al. 2008 and see Chapter 7). Feyrer et al. (2007) found that there has been a significant stock-recruit relationship (i.e., adults affect juvenile production) since 1987; this relationship was improved by including fall habitat conditions (as defined by salinity and turbidity), indicating that habitat also affects abundance. Long-term temperature increases in the Delta (Jassby 2008) may further constrain habitat, particularly in summer (Nobriga et al. 2008). Food availability may also have been historically important to this planktivorous fish as Kimmerer (in review) noted a statistically significant relationship between juvenile smelt survival and zooplankton biomass over the long term. The decline in the mean size of adult delta smelt following the introduction of the overbite clam *Corbula* (Sweetnam 1999; Bennett 2005), which caused declines in key zooplankton prey, is also consistent with food web effects. Feyrer et al. (2007) also found that stock and habitat effects were important when food supply was low following the invasion of *Corbula*. It may also be that the delta smelt population is now at such low levels that large increases in a single year are unlikely, but will require multiple years of successful reproduction and recruitment.

While some of the likely causes of the POD, such as the gradual accumulation of ecologically disruptive exotic species in the Delta, may have developed independently or partially independently of water project operations, other likely contributing causes are clearly related to water project operations. The degree of project effects on delta smelt varies considerably among years and may also vary substantially from month to month, depending on changing distribution of fish, Delta hydrology, and other factors. The POD analysis proposes that changes in water project operational regimes have contributed to the recent decline both directly (via entrainment) and indirectly (via habitat alteration). During some of the recent POD years, increased water project exports during winter resulted in higher losses of adult smelt (Chapter 7), particularly early spawning fish (and their offspring) that may be proportionally more important to the population. By contrast, reduced exports during spring may have increased survival of later-spawned larvae in recent years. Reduced spring exports from the Delta have been partially the result of the Vernalis Adaptive Management Plan (VAMP), a program designed to improvie survival of outmigrating juvenile Chinook salmon. VAMP has been operating since 2000.

With respect to an indirect effect, habitat alteration, a long-term upstream shift of X2 during fall has negatively affected delta smelt habitat and has been linked to changes in delta smelt abundance (Feyrer et al. 2007). The steady-state location of the low-salinity zone is a function of total Delta outflow, which under most non-flood conditions is determined primarily by the operations of the CVP and SWP. However, non-CVP and SWP factors such as increased diversions from, and accretions to Delta tributaries may have contributed to the upstream shift of X2 in the fall months. The relative contributions of all factors contributing to the fall shift has not been determined, and probably vary from year to year.

Seasonal Breakdown of Potential Effects

Evidence of a role for each of the factors developed in the POD investigation in the long-term and recent abundance patterns of delta smelt is described in detail below for each season (Baxter et al. 2008). Note that this is a general summary of the broad suite of factors that may affect delta smelt during different seasons; however, the subsequent effects analysis is focused on a subset of these factors known to be related to water project operations.

It is also important to recognize that the present understanding of the factors affecting smelt has many limitations. As described in Baxter et al. (2008), many studies used for the recent POD synthesis are works-in-progress that have not reported final results. Preliminary results from these studies have been provided whenever possible, but peer-reviewed products from these studies may not be available for some time to come. As a consequence, while this review uses such results because they represent the best available science, Baxter et al. (2008) encouraged users of their POD synthesis report to be cautious when evaluating the relative importance of the different factors. Specifically, statements not based on well-developed and peer-reviewed literature should be viewed with more skepticism.

Summer

Summer is the season that usually has the highest primary and secondary productivity in a temperate zone estuary. Given their annual life cycle, summer represents the primary growing season for delta smelt. However, the availability of prey species is strongly affected by food web changes stemming from changes in grazing pressure from the benthos (particularly *Corbula amurensis*). Moreover, in the decade including the early POD years, there has been a further decline in the abundance of calanoid copepods in Suisun Bay and the west Delta (Kimmerer et al., in prep, Mueller-Solger et al., in prep.), part of the core summer habitat of delta smelt (Nobriga et al. 2008). At the same time, these calanoid copepods are being replaced by the small cyclopoid copepod *L. tetraspina* which is presumed to be a less suitable prey species (Bouley and Kimmerer 2006).

The long-term reduction in preferred prey availability has likely resulted in slower growth rates of delta smelt, detectable as a reduction in the mean size of delta smelt in autumn since the early 1990s (Sweetnam 1999; Bennett 2005). The latest POD report (Baxter et al. 2008) proposes that over the long term, reduced summer growth rates have reduced the survival of juvenile delta smelt, perhaps from predation, as smaller fish remain more vulnerable for longer periods (Bennett et al. 1995; Houde 1987). As evidence that changes in prey availability have had survival consequences for this fish species, Kimmerer (in press) found a statistically significant relationship between summer-to-fall delta smelt survival and zooplankton biomass in the low salinity zone from 1972 to 2005. Recent preliminary analyses suggest that total zooplankton biomass may not have changed substantially within the core summer habitat of delta smelt, at least when all species including *L. tetraspina* are included (Mueller-Solger, unpublished data). In 2006, zooplankton biomass, including the biomass of the important food organism *P. forbesi*, even increased substantially in the delta smelt summer habitat, but this was not followed by a recovery of delta smelt. Moreover, summer-to-fall survival since 2000 does not appear to be substantially different from survival for all other years since 1972. Survival since 2000 has actually been somewhat higher than in 1972—1980 when delta smelt abundance indices were much higher than they are now (Mueller-Solger, unpublished data). Finally, summer and fall delta smelt abundance indices have been closely correlated to each other during the POD years. However, while the fall abundance indices since 2000 have spanned almost the full range of delta smelt abundance indices during the previous three decades, the summer abundance indices have remained in the lower portion of the pre-POD summer abundance range.

These results suggest that impaired recruitment, growth, and survival before the summer period may also have been important during the POD years. It is possible that summer food limitation was a more important stressor when population densities were higher and that the decline in summer food availability has contributed more to the long-term decline in delta smelt abundance than to its dramatic deterioration in the POD years (Mueller-Solger, unpublished data).

Summer habitat may be more restricted than in the past. Nobriga et al. (2008) noted a complete absence of delta smelt in the southern Delta that coincided with increased water clarity. However, although these changes in turbidity appear to play a role in the longer-term declines in delta smelt, they are unlikely to be an important new cause of the post-2000 declines because delta smelt have not successfully utilized the southern and central Delta in large numbers since the late 1970s. Nobriga et al. also noted that delta smelt distribution is affected by temperature. Moreover, Jassby (2008) found regional increases in water temperature, including areas within the range of delta smelt. Hence, delta smelt may be affected by long-term increases in water temperature in the Estuary.

Direct entrainment effects at the CVP and SWP export facilities in the south Delta are not thought to have been important during most summers because the delta smelt population is north and west of the zone affected strongly by water exports and delta smelt salvage is generally very near zero from July-November (IEP unpublished data). When the toxic blue-green alga *M. aeruginosa* blooms during summer, it occurs primarily upstream of delta smelt, so it is unlikely to have been a major factor in the delta smelt’s historical decline. This may have changed in 2007, when *M. aeruginosa* blooms extended into eastern Suisun Bay, well into the historical rearing habitat of delta smelt. Other water quality variables such as contaminants could be important, but are yet to be identified as seasonal stressors for this species.

In summary, there is evidence of bottom-up and habitat suitability effects on delta smelt during the summer over the long-term, but the evidence suggests that since 2000, delta smelt population dynamics have been largely driven by factors occurring in seasons other than summer. Near zero salvage suggests SWP/CVP entrainment effects are minimal during this period under historical flow conditions. Nonetheless, better habitat and food conditions during the summer might improve long-standing effects and increase survival as well as individual fitness of maturing delta smelt.

Fall

Fall represents the time period when the delta smelt year class matures to adulthood. The evidence to date indicates that habitat is a significant issue for delta smelt in fall (Feyrer et al. 2007). Delta smelt presence is strongly associated with low salinity and water clarity, which can be used to index the “environmental quality” of habitat for the species. Feyrer et al. (2007) report that fall environmental quality has declined over the long-term in the core range of delta smelt, including Suisun Bay and the Delta. This decline was largely due to changes in salinity in Suisun Bay and the western Delta, and changes in water clarity within the Delta. There is statistical evidence that these changes have had adverse population-level effects (Feyrer et al. 2007). A multiple linear regression of fall environmental quality in combination with adult abundance provided statistically significant predictions of juvenile production the following year. Hence, both habitat and stock-recruit factors are important issues during fall.

Reduction of habitat area as defined by environmental quality likely interacts with bottom-up and top-down effects. Restricting fish to a smaller geographical area with inadequate food supply would likely maintain or even magnify the bottom up and top down effects already occurring during the summer, although these factors are poorly-understood during fall. Greater mortality due to predation, small adult size by the end of the fall, and the low fecundity of smaller fish likely all contribute to the adult abundance effect observed by Feyrer et al. (2007).

Direct entrainment has not historically been a major stressor during the fall. Delta smelt are usually not salvaged in substantial numbers at the CVP and SWP until late December. However, distribution of suitable habitat (as indexed by salinity and water clarity) affects the location of delta smelt in fall, which may contribute to their subsequent vulnerability to entrainment in winter by advancing them into the geographical area influenced by the pumps. In summary, both bottom-up effects and habitat restriction appear to be important during the fall. Slow growth because of food limitation combined with habitat restriction may also have resulted in higher mortality due to predation. Poor growth in the summer and fall likely contribute to reduced size and fecundity of maturing fish.

Winter

Winter represents the main period of adult delta smelt migration and spawning. Entrainment of adults and larvae (top-down effects) are particularly important to the delta smelt population during this critical season. The increase in salvage of adult delta smelt during winter since 2000 suggests that entrainment levels have been higher as a proportion of the population during the POD years (Baxter et al. 2008; Grimaldo et al. in review). Although in long-term analyses monthly or semi-monthly export volumes explain only 1-3 percent of the variability in same-water year delta smelt abundance (Manly and Chotkowski 2006), these losses may still be important to the population as a component of the total array of pressures on the species. First, this was a long-term analysis. There is a clear coincidence between higher entrainment and population decline in the short period from 2000 (and especially 2002) onward, a period for which there are even now few data with which to fit elaborate statistical models. Moreover, it has been proposed that entrainment losses may manifest effects in the following water year. For example, Bennett (unpublished) has hypothesized that losses of larger females may have a disproportionate effect on the delta smelt population. Specifically, losses of more fecund, early spawning large females and their offspring could eliminate a portion of the cohort most likely to survive to reproductive age, and possibly most likely to be fecund. Winter exports may also have an effect on the number of adults which survive a second year, a possible important factor affecting delta smelt population resilience (Bennett 2005). Manly and Chotkowski (unpublished workshop presentation) note that export effects may not be large during many years, especially very wet years, because exports by the water projects are relatively small compared to Delta inflow and outflow. However, they may be larger in a minority of years when various (at present mostly undescribed) factors affecting the spawning distribution of delta smelt converge to place larger numbers of smelt in areas vulnerable to entrainment.

There is presently no evidence of habitat constriction or food limitation during winter (Baxter et al. 2008); however, no studies have addressed these questions. Contaminant effects are possible during flow pulses, but there is no major evidence yet that these events have caused toxicity to delta smelt. One toxics issue that may have winter-spring effects and is under investigation is the potential role toxic concentrations of free ammonium ion contained in partially treated wastewater discharged into the Sacramento River in the north Delta may have on adult, larvae, and juvenile delta smelt in that region (Werner et al. unpublished data).

Spring

Bennett (unpublished analysis) proposes that reduced spring exports resulting from VAMP has selectively enhanced the survival of delta smelt larvae that emerge during VAMP by reducing direct entrainment. Initial otolith studies by Bennett's lab suggest that these spring-spawned fish dominate subsequent recruitment to adult life stages; by contrast, delta smelt spawned prior to the VAMP have been poorly-represented in the adult stock in recent years. He further proposes that the differential fate of winter and spring cohorts may affect sizes of delta smelt in fall because the spring cohorts have a shorter growing season. These results suggest that direct entrainment of larvae and juvenile delta smelt during the spring may be a significant issue in some years.

Because of natural variability and the CVP's and SWP's operations to meet X2 water quality standards, there is no long-term trend in spring salinity (Jassby et al. 1995; Kimmerer 2002a). This suggests there was unlikely to have been a recent change in spring habitat availability or suitability. However, other habitat effects including contaminants or disease could play a role during spring.

Summary of Potential Project Effects

The previous section provided a generalized discussion of the the suite of factors thought to seasonally affect delta smelt. The following summarizes project-specific issues considered relevant for the effects analysis. Note that the following evaluation does not take into account the fact that the climate and geography could be markedly different in the future. A global rise in temperatures, rising sea levels, and changes in streamflow could substantially affect the status of delta smelt including their distribution, population viability, and vulnerability to project effects. There is substantial effort underway to try to model climate conditions 500-100 years away, although the "state of the art" in these simulations is changing almost monthly. Moreover, as the climate-change review in this Biological Assessment indicates, there is no clear prediction whether overall precipitation rates in these watersheds will rise or fall as a result of climate change (see Appendix R). Given these uncertainties, our evaluation focuses on what is known about the current biology and distribution of delta smelt and water project operations.

Direct entrainment of geographically vulnerable delta smelt is likely to occur during a period extending from mid-December through mid-July. Adults are likely to be entrained during their spawning migration from mid-December to April, while juveniles are likely to be entrained from April until environmental conditions, particularly water temperatures, drive surviving juveniles into the west Delta in June or July. The onset of winter entrainment often coincides with the "first flush" of turbid water through the Delta following early rainstorms in December.

Direct entrainment risk varies with rate of export pumping, and is also affected by other factors, including atmospheric conditions, the tides, and the Delta's tributary inflows. The rate of export pumping and these other factors jointly determine the geographical boundary of the "zone of entrainment", described as the zone within which passive, neutrally buoyant particles are moved toward, and eventually entrained into, either Clifton Court Forebay and the Banks Pumping Plant in Byron or the Jones Pumping Plant in Tracy (see development of this concept in Kimmerer and Nobriga 2007). Because other factors modulate the effect of export pumping, the actual boundary of this zone is in constant motion. However, with other factors being held constant, the average northward reach of the pumps increases with pumping rate.

In this analysis, we assume that the net change in direct entrainment risk varies linearly with both total export pumping rate and Old and Middle River (OMR) flow. We also assume that actual historical entrainment varied in proportion to empirically measured salvage at the Jones and Banks facilities. In the following discussion, evidence of a linear or quasi-linear relationship between salvage at the Jones and Banks facilities and export pumping or OMR flow is interpreted as evidence of qualitatively similar relationships between actual entrainment and those hydrodynamic variables. It is important to note that salvage imperfectly indexes actual entrainment. The reasons for skepticism include (1) unknown and possibly substantial size-filtering of the incoming fish by the physical screen system, which does not divert fishes of all sizes with equal likelihood; (2) unknown effects of incoming water velocity on the efficiency of the screening system; (3) unknown (for delta smelt) prescreen mortality in Clifton Court Forebay, which presumably depends on the residence time of fish in the forebay before salvage. The assumption of linearity has general support both regressions of salvage against OMR flow (Grimaldo et al. in review; P. E. Smith, unpublished but influential analysis cited in Baxter et al. 2008). We expect the relationship between entrainment and OMR flow to be somewhat cleaner than that between salvage and total export pumping rate because of the variable time delay and other complications created by Clifton Court Forebay. However, that the known salvage-OMR relationship for adult smelt appears to increase faster than linearly at high negative OMR flow suggests that our assumption of linearity will not overstate the increase in risk at higher pumping, and might understate it.

We have not attempted to separately evaluate the effects of Jones and Banks pumping here, because the hydrodynamic effects of pumping, with which we associate fish transport and entrainment, result from the combined effect of pumping at both facilities. Furthermore, incidental take restriction on the export facilities is administered as a combined limit. Finally, the present analysis does not take into account finer scale factors that may have a substantial effect on entrainment risk. As described in Grimaldo et al. (in review), peaks in adult entrainment at the wate projects coincide closely with turbidity pulses into the Delta. At present, we do not have the capability to model how different operational scenarios would change the pattern of winter turbidity pulses into the Delta. Future models and monitoring may allow better prediction of these events.

Change in the availability of habitat of the proper low salinity and turbidity and in habitat quality can be caused by water project operations through alteration of Delta outflow and in the sources of water permitted to reach the western Delta. As described above, the disposition of the low salinity zone may be important to delta smelt during the summer, and is likely to be important during the fall. Unlike the fall, the there is no simple linkage between summer Delta salinity and delta smelt abundance (Nobriga et al. 2008). During the winter, turbidity associated with flow pulses may be an important migratory cue for delta smelt (Grimaldo et al. in review). In this analysis, we use the location of the 2 ppt isohaline (hereafter called “X2”) to index the location of the low salinity zone, which in part identifies suitable habitat for post-larval delta smelt. The definition and measurement of X2 is technically complicated, because isohaline location varies with depth and is in constant tidal motion. Regulation of X2 at specific locations between February and June is among the criteria controlling water project operations under Water Rights Decision D-1641 and other authorities. However, it is allowed to vary at other times, including the fall, during which the position of the low salinity zone is useful as an index of environmental quality for delta smelt as described in Chapter 7 and above.

The environmental quality work described above and in Chapter 7 indicates that the historical movement of fall X2 upstream from Suisun Bay is associated with declines in environmental quality for delta smelt during the same period. In particular, movement of the low salinity zone upstream of Collinsville (at River Kilometer Index 81) is associated with a sharp decrease in the quality of delta smelt habitat. In this analysis, we present the projected X2 in each month of the year under the scenarios described in CalSim II studies 6.0, 7.0, 7.1, and 8.0. In each case, we examine the base X2 in Study 6.0 and departures from that location in the other studies. The data are also binned by hydrology. For October through December, we have used the water-year type of the previous water year; for January through May we used quintiles of the Eight River Index, which represents the unimpaired runoff in the Sacramento and San Joaquin watersheds; for the remaining months, we used the water-year type of the current water year. For convenience the Eight River Index quintiles are represented by the same five labels as the water-year types.

Model Results Used

This analysis is organized around monthly comparisons because the CalSim II model results, which are presented on a monthly timestep, are the only available simulations representing all the studies considered in this Biological Assessment. In each model case comparison, we have considered (1) changes in total exports at the CVP and SWP export facilities for each month of the year with respect to Study 6.0; (2) predicted net OMR flow during each month; and (3) X2 and changes in it among the studies for each month. Study 6.0 was used as the basis for comparison because its assumptions match those of the “present conditions” Study 3a in the 2004 OCAP consultation. However, it is important to note that for the upcoming consultation Study 7.0 is the baseline case representing current conditions. Given that changes in water project operations are likely a contributing, or partial, cause of the POD, it is important to provide comparisons that give some indication of differences in water project operations immediately before and after the POD. Use of actual pre-POD operations data to impute characteristics of the CVP and SWP operations in non-wet pre-POD years is impractical because of the overall wet climate during the 1994—1999 period. Study 6.0 comparisons are provided because we believe Study 6.0 is more similar to the operating regime in the years immediately before the POD than the other model cases. We have used OMR flow results generated via DSM2 modeling, which is regarded as more credible for OMR the CalSimII modeling. However, the DSM2 results were only available for studies 7.0, 7.1, and 8.0, so no comparisons involving Study 6.0 were possible. As noted previously, it was not feasible at this time to meaningfully incorporate potentially major future changes in climate, streamflow, and geography into the modeling approach. Hence, many of the conclusions may not be robust on the time scale of 50-100 years from now.

The studies examined here model the base operation of the water projects in each scenario. They do not incorporate adjustments to water operations that might be implemented by the Water Operations Management Team to avoid adverse impacts on listed species, including delta smelt, that might be caused by export pumping, Old and Middle River flow, or low salinity zone location. Such operational adjustments would be based on actual conditions at the time. For this reason, actual impacts, where adverse impacts are predicted to occur, might be smaller than the following results indicate.

Analyses and Results

Direct Entrainment at the CVP and SWP

Some delta smelt are entrained by the south Delta export facilities, with most dying in the process. Because the species is migratory, entrainment is seasonal. Adult delta smelt may be present in the south Delta and vulnerable to entrainment from December through April; larvae and juveniles are likely to be present and vulnerable during late March through early July.

Export Pumping

To evaluate the effects of direct entrainment we reviewed the total CVP + SWP pumping (as “Jones” plus “Total Banks”) in the CalSimII output. Hydrologic data from the years 1921 to 2003 were used to fit the model. For each comparison presented in Tables 13-1 through 13-12, differences among model cases are presented as average percent change from the average total pumping in Study 6.0. We have not calculated a numerical estimate of the change in salvage of delta smelt, because that is not a necessary step in evaluating the differences in risk among studies. The export pumping numbers represent the average pumping (in cfs) reported in the CalSimII simulations for a given month and water year type.

It is important to note that the base operating regime simulated in Study 6.0 represents high levels of winter and spring pumping that have been implicated as a likely contributing cause of the Pelagic Organism Decline (see Chapter 7 and introductory discussion of winter pumping above). Hence study comparisons principally serve to indicate where this existing risk might be redistributed, enhanced, or diminished by the assumptions made in studies 7.0, 7.1, and 8.0. Percentage changes in pumping in studies 7.0, 7.1, and 8.0 represent the average differences between corresponding cases, and we interpret them to represent predicted average differences in entrainment during the water-year types and months represented in each table.

The risk of entrainment depends not only on export pumping rates, but also on the distribution of fish. The distribution of delta smelt may vary substantially from year to year and between months. For example, in years which do not have a significant “first flush” event in December or early January, adult smelt might not be in the central Delta, and might therefore be at lower risk of entrainment during that period. The pumping values and differences reported below should be used to infer an average level or average difference in entrainment risk.

Results: During October through December, total pumping in studies 7.0, 7.1, and 8.0 is generally 2-10 percent lower than in Study 6.0 (Table 13-1 through Table 13-3). These reductions would be expected to reduce losses of delta smelt; however, salvage is typically low prior to the “first flush” that often occurs late in this period, so the reductions are likely to make little difference in terms of direct losses of delta smelt. Exceptions include Below Normal, Dry, and Critically Dry years in studies 7.1 and 8.0, which featured 2.8-9.4 percent increases in pumping over Study 6.0 in December.

Table 13-1 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for October.

OCTOBER WY Type	Study 6.0 CFS	Study 7.0 CFS	Change	Study 7.1 CFS	Change	Study 8.0 CFS	Change
Wet	9360	9054	-3.3%	8915	-4.8%	9083	-3.0%
Above Normal	8141	7982	-1.9%	7362	-9.6%	7722	-5.2%
Below Normal	8623	8100	-6.1%	7717	-10.5%	7729	-10.4%
Dry	7603	8111	6.7%	7325	-3.7%	7567	-0.5%
Critically Dry	6868	6799	-1.0%	6460	-5.9%	6468	-5.8%

Table 13-2 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for November.

NOVEMBER WY Type	Study 6.0 CFS	Study 7.0 CFS	Change	Study 7.1 CFS	Change	Study 8.0 CFS	Change
Wet	10247	10503	2.5%	10743	4.8%	10699	4.4%
Above Normal	8198	8414	2.6%	8581	4.7%	8422	2.7%
Below Normal	9077	8851	-2.5%	8829	-2.7%	8922	-1.7%
Dry	7628	7416	-2.8%	7717	1.2%	7748	1.6%
Critically Dry	6424	6278	-2.3%	6391	-0.5%	5801	-9.7%

Table 13-3 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for December.

DECEMBER WY Type	Study 6.0 CFS	Study 7.0 CFS	Change	Study 7.1 CFS	Change	Study 8.0 CFS	Change
Wet	11000	10438	-5.1%	11515	4.7%	11585	5.3%
Above Normal	10085	8870	-12.1%	10012	-0.7%	9662	-4.2%
Below Normal	9260	8770	-5.3%	9829	6.1%	9876	6.7%

Dry	9548	8924	-6.5%	9816	2.8%	9817	2.8%
Critically Dry	7183	7107	-1.1%	7855	9.4%	7522	4.7%

During January and February, most of the differences in pumping are reductions in 7.0, 7.1, and 8.0 with respect to 6.0 (Table 13-4 through Table 13-6). These reductions make 7.0, 7.1, and 8.0 more protective of delta smelt than 6.0 in January and February. In March, though, there are consistently substantial (3.1 percent to 15.7 percent) increases in 7.0, 7.1, and 8.0 over 6.0 in Wet and Above Normal water years. These increases would be expected to increase losses of delta smelt. Salvage is often low during these wetter years, although the hydrograph can have a substantial effect on the magnitude and timing of losses. Hence, it is difficult to assess the relative importance of the higher March export levels. It is important to note that the base pumping in Study 6.0 during these months may have contributed to excessive winter and spring delta smelt entrainment during the POD years.

Table 13-4 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for January.

Critically Dry 7183 7107 -1.1% 7855 9.4% 7522 4.7%

JANUARY	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	11007	10668	-3.1%	11537	4.8%	11425	3.8%
Above Normal	11679	10074	-13.7%	11433	-2.1%	11539	-1.2%
Below Normal	10996	9908	-9.9%	10815	-1.6%	10960	-0.3%
Dry	10041	8410	-16.2%	9584	-4.5%	9682	-3.6%
Critically Dry	7899	7224	-8.5%	7646	-3.2%	7986	1.1%

Table 13-5 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for February.

FEBRUARY	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	10361	10295	-0.6%	10507	1.4%	10617	2.5%
Above Normal	10951	10143	-7.4%	10728	-2.0%	11062	1.0%
Below Normal	9802	9759	-0.4%	9625	-1.8%	9171	-6.4%
Dry	8533	8322	-2.5%	7982	-6.5%	8137	-4.6%
Critically Dry	5620	5154	-8.3%	6061	7.9%	5853	4.2%

Table 13-6 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for March.

MARCH	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	8729	10099	15.7%	9138	4.7%	9524	9.1%
Above Normal	9374	10386	10.8%	9660	3.1%	10138	8.2%
Below Normal	8328	8692	4.4%	8387	0.7%	8472	1.7%
Dry	7235	7367	1.8%	7270	0.5%	7188	-0.6%
Critically Dry	4449	3798	-14.6%	4316	-3.0%	4241	-4.7%

During April through May most of the differences between 6.0 and the other studies represent lower pumping in the other studies, including substantially proportionately lower pumping in some cases, particularly in Study 7.0 (Tables 13-7 through 13-9). However, in June there are large increases (up to 134 percent, representing an increase of about 2000 cfs in average export pumping) in Dry and Critically Dry years in 7.0, 7.1, and 8.0. The net result of these changes is that losses of larvae and early juveniles should be lower in early spring, but with increased losses of juveniles in the late spring of drier years.

Table 13-7 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for April.

APRIL	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	7155	6226	-13.0%	6944	-2.9%	6987	-2.3%
Above Normal	6262	5488	-12.4%	6173	-1.4%	6226	-0.6%
Below Normal	5460	4472	-18.1%	4737	-13.2%	4708	-13.8%
Dry	3532	2716	-23.1%	3329	-5.7%	3339	-5.5%
Critically Dry	1891	1780	-5.9%	2035	7.6%	1893	0.1%

Table 13-8 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for May.

MAY	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	7160	6114	-14.6%	6950	-2.9%	6924	-3.3%
Above Normal	5544	4174	-24.7%	5193	-6.3%	5011	-9.6%
Below Normal	4746	3069	-35.3%	4149	-12.6%	4051	-14.7%
Dry	3769	2222	-41.0%	3259	-13.5%	3073	-18.5%
Critically Dry	1783	1595	-10.5%	1751	-1.8%	1644	-7.8%

Table 13-9 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for June.

JUNE	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	7930	8414	6.1%	8635	8.9%	8616	8.7%
Above Normal	6937	7344	5.9%	7961	14.8%	7802	12.5%
Below	6296	6480	2.9%	6988	11.0%	6890	9.4%

Normal							
Dry	4429	5621	26.9%	6212	40.3%	6118	38.1%
Critically Dry	1513	3540	133.9%	2754	82.0%	2416	59.7%

The trend of higher pumping in June is continued in July, with substantial (14 percent to 179 percent) increases in pumping in all water year types. These increases would cause correspondingly higher juvenile smelt entrainment in some years. In August there is higher (9.4 percent to 95.9 percent) pumping in all water year types Study 7.0, with corresponding increases in Wet, Above Normal, and Below Normal years in studies 7.1 and 8.0. In September most changes were small, with only Critically Dry years standing out (+24 percent) in Study 7.0 and Dry years in 7.1 and 8.0 (-17 percent and -19 percent, respectively) being substantial different from Study 6.0. Since delta smelt entrainment tends to be very low in August and September, these changes in late summer are not expected to have significant population effects.

Table 13-10 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for July.

JULY	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	8898	10154	14.1%	10773	21.1%	10875	22.2%
Above Normal	6936	8899	28.3%	10037	44.7%	9736	40.4%
Below Normal	7907	10476	32.5%	11111	40.5%	10641	34.6%
Dry	6747	10593	57.0%	10539	56.2%	10123	50.0%
Critically Dry	1887	5270	179.3%	3675	94.8%	3359	78.0%

Table 13-11 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for August.

AUGUST	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	10010	11549	15.4%	11491	14.8%	11627	16.2%
Above Normal	8969	11474	27.9%	11082	23.6%	11168	24.5%
Below	8676	10514	21.2%	9814	13.1%	9717	12.0%

Normal							
Dry	6958	7611	9.4%	5720	-17.8%	5277	-24.2%
Critically Dry	2156	4224	95.9%	2020	-6.3%	1880	-12.8%

Table 13-12 Comparison of total export pumping in studies 7.0, 7.1, and 8.0 with Study 6.0 for September.

SEPTEMBER	Study 6.0	Study 7.0		Study 7.1		Study 8.0	
WY Type	CFS	CFS	Change	CFS	Change	CFS	Change
Wet	10804	11469	6.2%	11249	4.1%	11315	4.7%
Above Normal	10320	10498	1.7%	10325	0.1%	10710	3.8%
Below Normal	9998	10128	1.3%	9755	-2.4%	9924	-0.7%
Dry	8475	8571	1.1%	7024	-17.1%	6838	-19.3%
Critically Dry	4706	5828	23.8%	4922	4.6%	4777	1.5%

Old and Middle River Flow

Old and Middle River flow provides an alternative approach to estimating entrainment risk. It provides a direct measure of the strength of the transport process responsible for the movement of delta smelt to the export facilities (Grimaldo et al. in review). As with X2 and the boundary of the zone of entrainment, OMR flow is in a constant state of flux because of the tides, wind, river flows, operation of the South Delta Temporary Barriers, and export pumping. The relevant quantity for analyzing the transport of fish is the tidally averaged net OMR flow. It is not possible to accurately predict OMR flow from CalSimII output. Here we use DSM2-based OMR flow predictions provided by CDWR instead of CalSimII. Only cases representing studies 7.0, 7.1, and 8.0 were provided.

In this analysis, we review the median OMR flow for each month, binned by water year type. Data from the years 1975 to 1991 were used to fit the model. The figures represent medians computed over full months. Because there are only 16 years of data, water year types are consolidated into Wet + Above Normal, Below Normal + Dry, and Critically Dry. According to CDWR (Aaron Miller, pers. Comm..), there are strong antecedent effects from the boundary conditions used to frame each monthly time period that may skew the results to some extent.

The Smelt Work Group (SWG, formerly the Delta Smelt Work Group) used DSM2-based particle tracking methods to analyze the effects of OMR on the limits of the zone of entrainment during the winter and spring of 2008 (See also Kimmerer and Nobriga 2008 for a more general exposition). The SWG concluded that under hydrodynamic conditions prevailing during March and April 2008 a daily net OMR flow no more negative than -2000±500 cfs effectively prevented entrainment of simulated particles injected into the San Joaquin River as far southeast as the mouth of Potato Slough (a fish monitoring location known as “Station 815”). In this analysis, we consider -2000 cfs to be a rough indicator of the limit beyond which increasingly negative OMR flow causes the zone of entrainment to expand beyond the south Delta into the San Joaquin River at Station 815 and farther downstream under operational circumstances similar to those existing in spring 2008.

In the following tables, two blocks of months are presented: December through March, representing the period of adult delta smelt vulnerability to entrainment, and April through July, representing juvenile vulnerability.

In Wet + Above Normal years, the results suggest median OMR flows are usually downstream during the winter months (Table 13-13). However, they become negative in June (-3506 to -3869 cfs) and July (-6652 to -7996 cfs) (Table 13-14). This suggests that losses of adult delta smelt and early juveniles would result in very low levels of losses. Negative flows during later months would result in more substantial losses of juvenile delta smelt from the central Delta and north of it.

Table 13-13 Projected monthly net OMR flow for Wet + Above Normal years during months of adult delta smelt entrainment vulnerability

WYTS:
W/AN

Study	December	January	February	March	Average
OCAP 7.0	1437	206	2759	5819	2555
OCAP 7.1	-127	-713	5719	8029	3227
OCAP 8.0	-152	-506	5860	7713	3229

Table 13-14 Projected monthly net OMR flow for Wet + Above Normal years during months of juvenile delta smelt entrainment vulnerability

WYTS:
W/AN

Study	April	May	June	July	Average
OCAP 7.0	3666	931	-3869	-6652	-1481
OCAP 7.1	3469	75	-3666	-7647	-1942
OCAP 8.0	3444	42	-3506	-7996	-2004

In Below Normal + Dry years, the results indicate strong negative OMR flows (-4645 cfs to -6793 cfs) for the months of December through March (Table 13-15). Moderately negative flows in April and May (-897 cfs to -2845 cfs) are followed by strong negative flows in June (-5551 cfs to -6644 cfs) and even stronger negative flows in July (-9028 cfs to -11014 cfs) (Table 13-16). Analyses of particle tracking (see above) and salvage data (Grimaldo et al., In review) indicate that winter losses of adults would likely occur in these drier years, but losses of early larvae and juveniles would likely be relatively low in spring. Strong negative flows in June and July would be expected to result in substantial losses of juveniles from the central Delta and probably the lower Sacramento River in these drier years.

Table 13-15 Projected monthly net OMR flow for Below Normal + Dry years during months of adult delta smelt entrainment vulnerability

WYTS: BN/D

Study	December	January	February	March	Average
OCAP 7.0	-5203	-4645	-6763	-6146	-5689
OCAP 7.1	-6212	-6104	-5660	-4692	-5667
OCAP 8.0	-6793	-5759	-6207	-4756	-5879

Table 13-16 Projected monthly net OMR flow for Below Normal + Dry years during months of juvenile delta smelt entrainment vulnerability

WYTS: BN/D

Study	April	May	June	July	Average
OCAP 7.0	-897	-1258	-5551	-9028	-4183
OCAP 7.1	-2199	-2845	-6644	-11014	-5676
OCAP 8.0	-2181	-2676	-6654	-10908	-5605

In Critically Dry years, strong negative OMR flows in December (-4637 cfs to -6419 cfs) are followed by moderately to weakly negative flows (-837 cfs to -1594 cfs) in January through March (Table 13-17). April and May (-1335 cfs to -1698 cfs) feature moderately negative OMR flows, while June and July (-3195 cfs to -5490 cfs) feature moderate to strong flows (Table 13-18). Analyses of particle tracking (see above) and salvage data (Grimaldo et al., In review) indicate that losses of adults would occur December of Critically Dry years, with much lower losses in the later winter months. Losses of early larvae and juveniles would be expected to be relatively low in spring. Strong negative flows in June and July would be expected to result in substantial losses of juveniles in these very dry years.

Table 13-17 Projected monthly net OMR flow for Below Normal + Dry years during months of adult delta smelt entrainment vulnerability

WYTS: C

Study	December	January	February	March	Average
OCAP 7.0	-5829	-1000	-1040	-825	-2173
OCAP 7.1	-6419	-1031	-2022	-976	-2612
OCAP 8.0	-4637	-1525	-1594	-1087	-2211

Table 13-18 Projected monthly net OMR flow for Below Normal + Dry years during months of juvenile delta smelt entrainment vulnerability

WYTS: C

Study	April	may	June	July	Average
OCAP 7.0	-1335	-1574	-4493	-5490	-3223
OCAP 7.1	-1642	-1698	-3195	-3573	-2527
OCAP 8.0	-1655	-1509	-2354	-3350	-2217

X2

We used projected X2 from the CalSimII simulations to estimate X2 in each model case for each of the 12 months. These are presented as Figure 13-1 through Figure 13-36. Each figure consists of five panels representing hydrologic classification as described above. Months using an Eight Rivers Index classification use the same bin names for consistency. In all panels the “x” axis represents X2 in kilometers in Study 6.0, while the “y” axis represents the departure from that X2 in another study. The dashed lines in each figure are smooths. A full set of monthly figures for studies 7.0, 7.1, and 8.0 is presented, but the months of greatest potential significance for delta smelt are, as discussed above, those falling in the summer and fall seasons.

The general disposition of X2 in Study 6.0 varies by month and hydrology. Early and late in the water year, X2 tends to be compressed into a narrow range between approximately 83 and 90 km in drier years, while in wet years values range from the low 70s to the high 80s. In the middle of the water year, X2 varies considerably in all hydrologic categories, depending on the weather. This means that in drier years, especially during the summer and fall months, X2 in Study 6.0 is usually above Collinsville (RKI 81), often by as much as 5 km. Analyses of historical data indicates that habitat conditions are relatively poor and contribute to delta smelt producing fewer offspring in years when X2 is located above Collinsville during autumn (Feyrer et al. 2007). The effects in summer are less clear, with no simple correlation between Delta salinity (a surrogate for X2) and delta smelt abundance during summer (Nobriga et al. 2008).

Summer X2 Deviation in Studies 7.0, 7.1, and 8.0

In Wet and Above Normal years, July X2 is usually similar to Study 6.0, though there is some scatter both below and above parity (Figures 13-10, 22, 34). Below Normal, Dry, and Critically Dry years show progressively greater upstream deviation from Study 6.0, though it is usually of less than 5 km. This pattern is repeated in August, with a small positive offset in all hydrologic categories (Figures 13-11, 23, 35). The upstream X2 deviation in a Dry or Critically Dry August is usually 3-5 km. These results suggest little consistent pattern in the amount of habitat (based on salinity) available to delta smelt during summer for the different studies, except in very dry years. Note that this result is congruent with the finding that there is no long-term trend in summer X2 (Kimmerer 2002). Moreover, there is no simple linkage between summer Delta salinity and delta smelt abundance (Nobriga et al. 2008).

Fall X2 Deviation in Studies 7.0, 7.1, and 8.0

Although Most of September properly belongs to the summer, it is included here for consistency with Feyrer's habitat analysis. In September, studies 7.0, 7.1, and 8.0 all feature substantial upstream shifts of X2 in all five hydrologic categories, with most differences being approximately 5 km (Figures 13-12, 24, 36). In October and November, studies 7.0, 7.1, and 8.0 all feature substantial (5+ km) upstream shifts of X2 in the the four driest year categories (Figures 13-1,2,13,14,25,26). In December, there is a general tendency for X2 in studies 7.0, 7.1, and 8.0 to deviate farther upstream than Study 6.0 in years where Study 6.0 X2 was 70 km or greater (Figures 13-3,15,27). Below that, deviations were generally negative except for very low Study 6.0 X2 (less than approx. 55 km). Hence, the effects changes in X2 on delta smelt habitat and juvenile production would be mixed, depending on Delta outflow.

Based on analyses for the entire autumn (Feyrer et al. 2007), the consistent upstream shift in X2 during September through November (and December in years with high X2) relative to Study 6.0 and high absolute X2 would be expected to reduce the amount of habitat for delta smelt and subsequent production of juveniles. The movement of X2 upstream by several km during drier years might also shift the distribution of delta smelt far enough east that adult entrainment might begin to occur in Fall under circumstances of high export pumping, or at least to occur earlier than it would otherwise. Similarly, it may also position delta smelt geographically closer to the export pumps at the time of “first flush” and make them more vulnerable to entrainment.

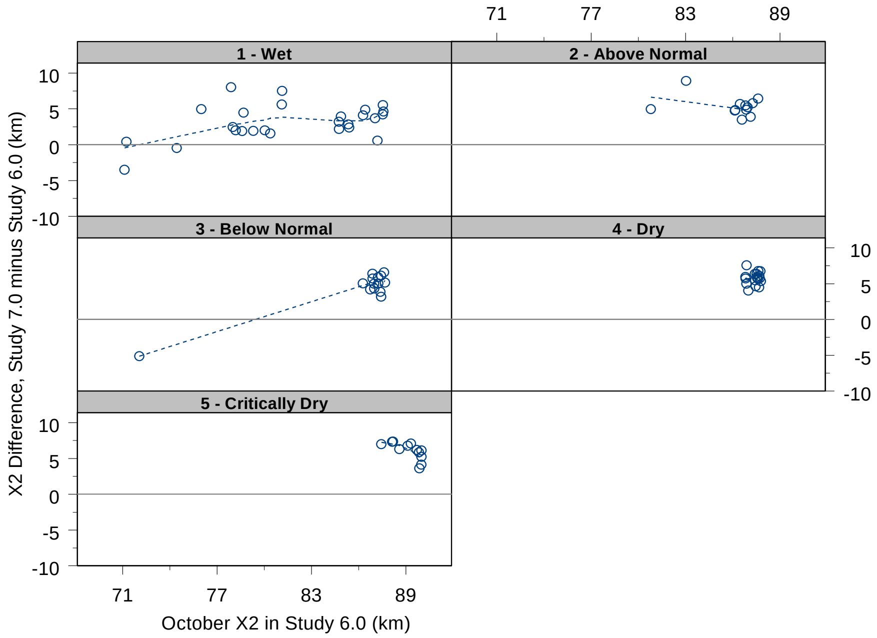

Figure 13-1 Variation in X2 in Study 7.0 with respect to Study 6.0 in October

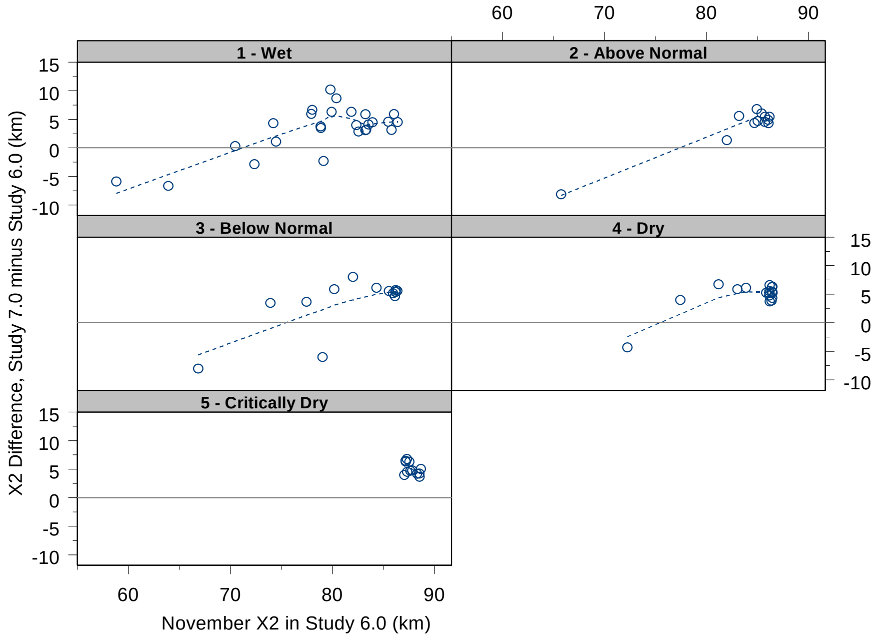

Figure 13-2 Variation in X2 in Study 7.0 with respect to Study 6.0 in November

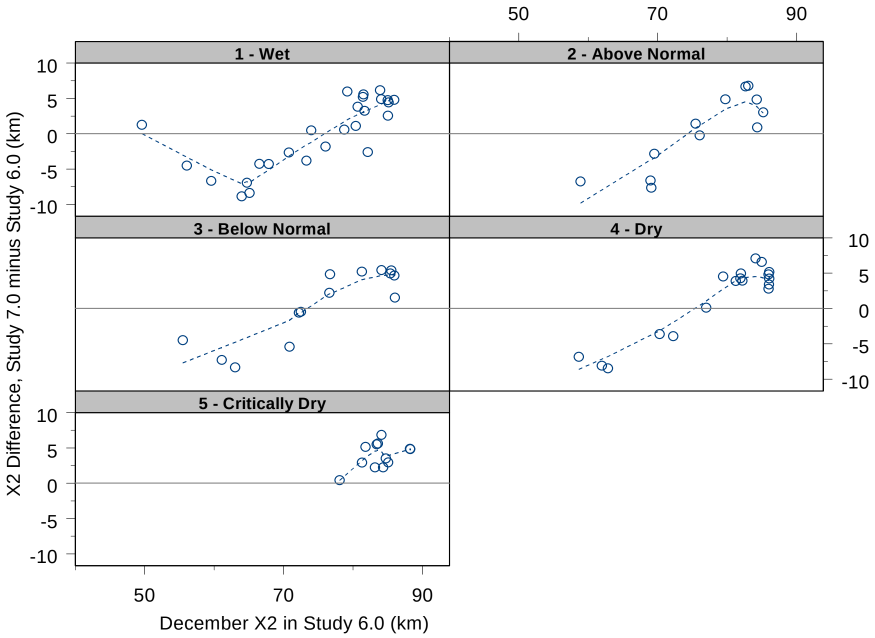

Figure 13-3 Variation in X2 in Study 7.0 with respect to Study 6.0 in December

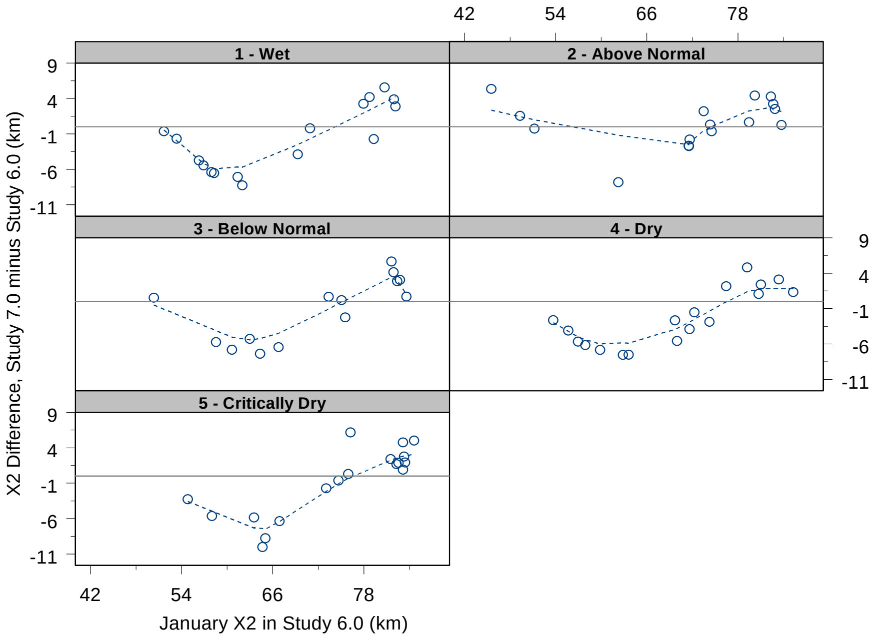

Figure 13-4 Variation in X2 in Study 7.0 with respect to Study 6.0 in January

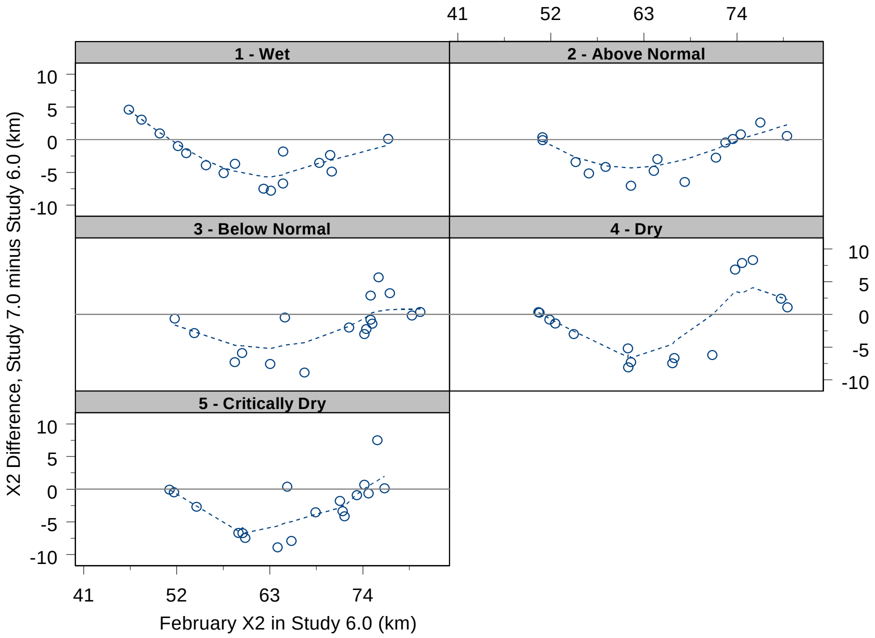

Figure 13-5 Variation in X2 in Study 7.0 with respect to Study 6.0 in February

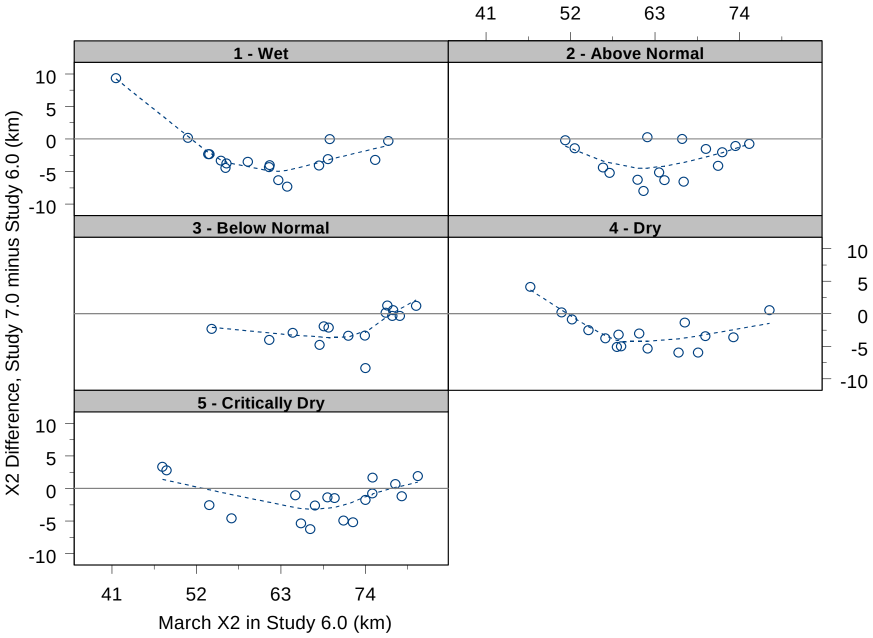

Figure 13-6 Variation in X2 in Study 7.0 with respect to Study 6.0 in March

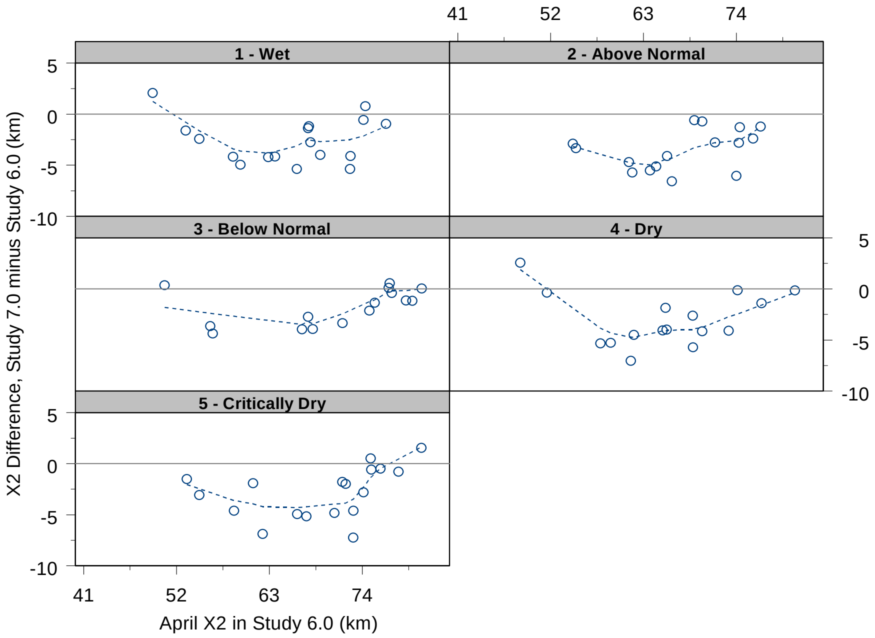

Figure 13-7 Variation in X2 in Study 7.0 with respect to Study 6.0 in April

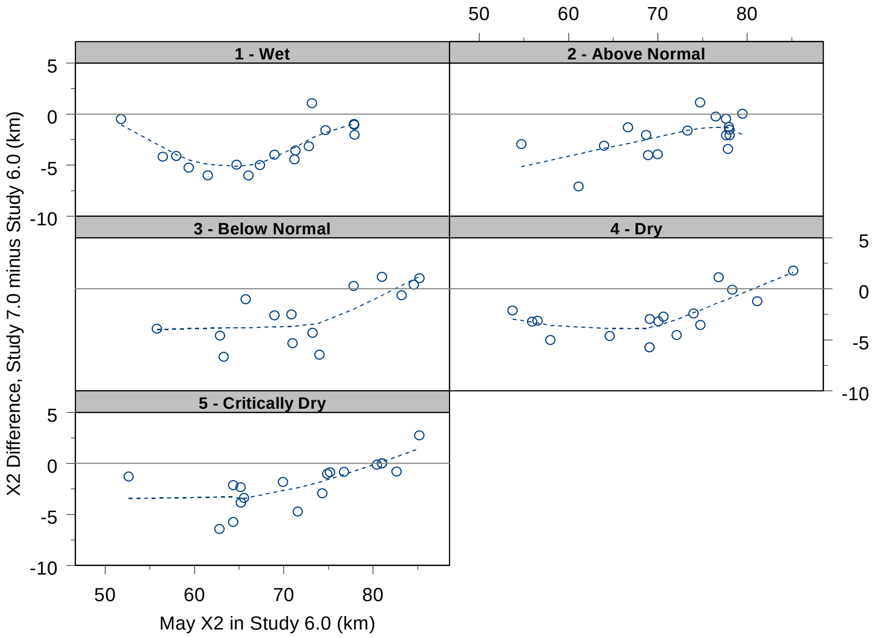

Figure 13-8 Variation in X2 in Study 7.0 with respect to Study 6.0 in May

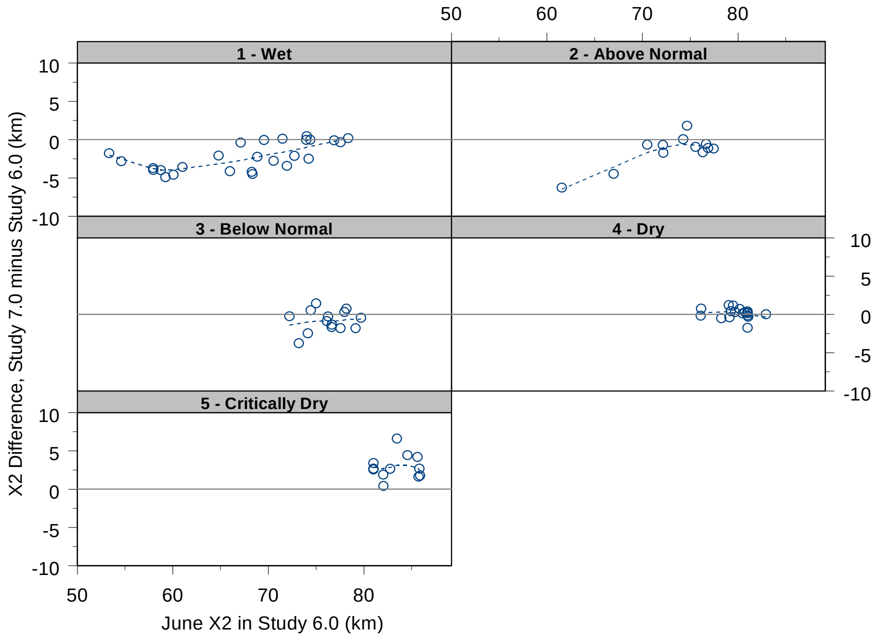

Figure 13-9 Variation in X2 in Study 7.0 with respect to Study 6.0 in June

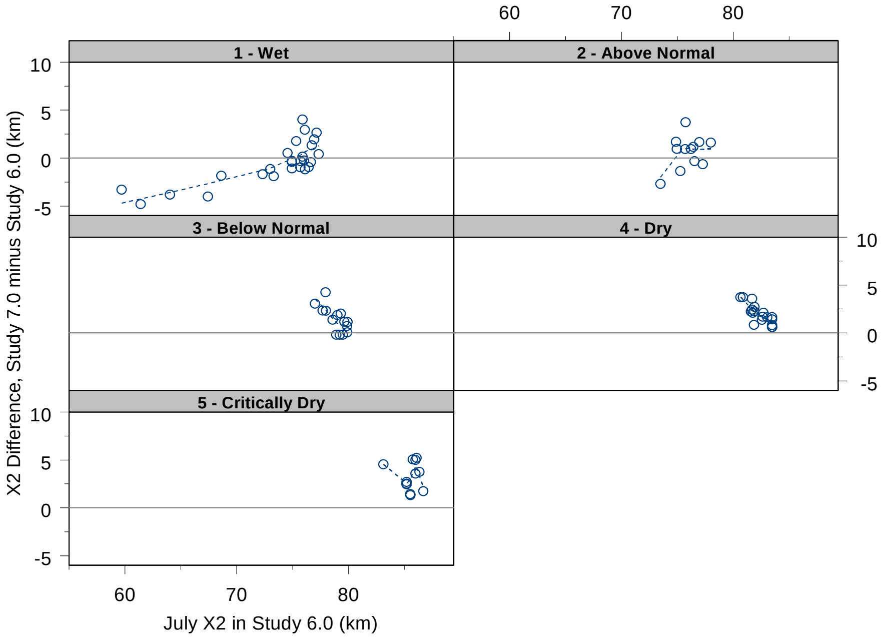

Figure 13-10 Variation in X2 in Study 7.0 with respect to Study 6.0 in July

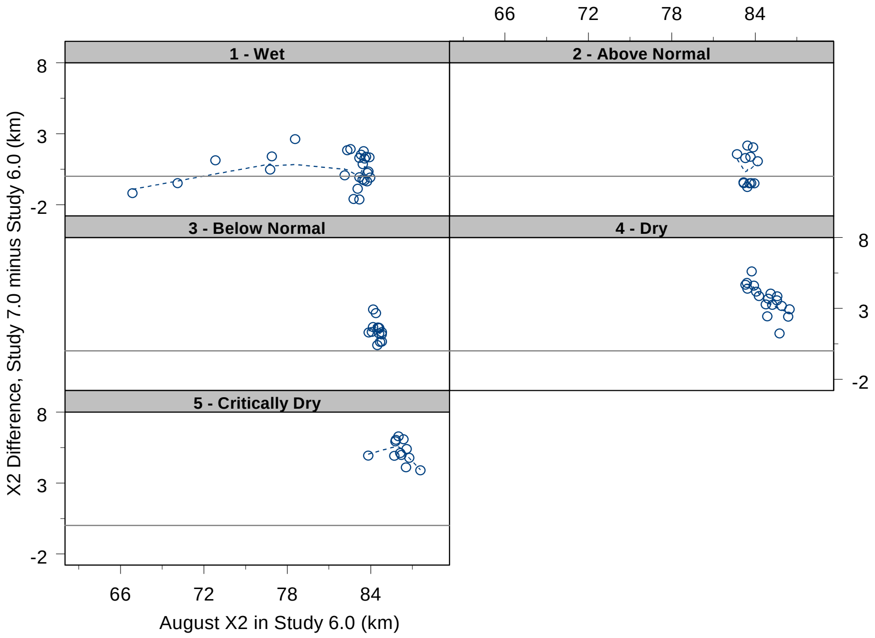

Figure 13-11 Variation in X2 in Study 7.0 with respect to Study 6.0 in August

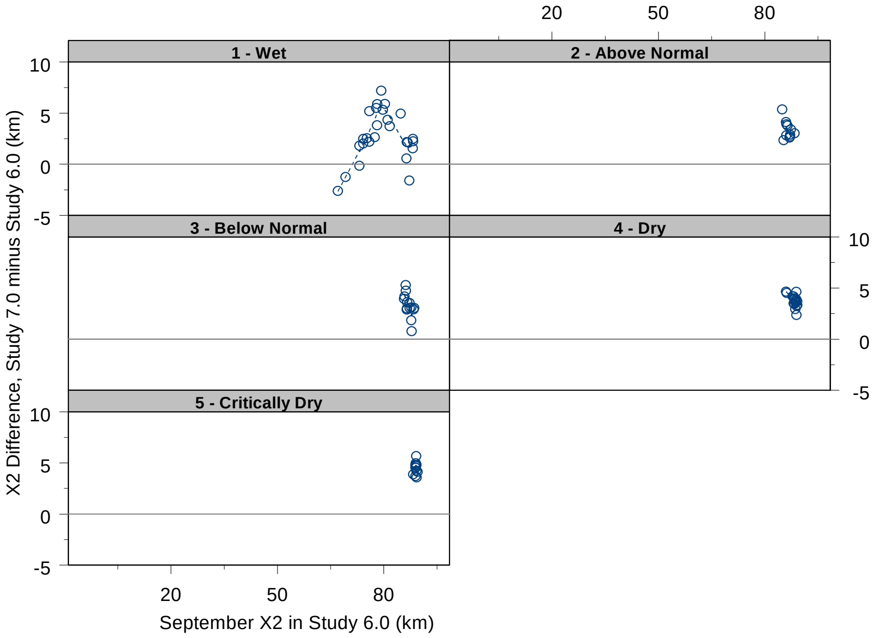

Figure 13-12 Variation in X2 in Study 7.0 with respect to Study 6.0 in September

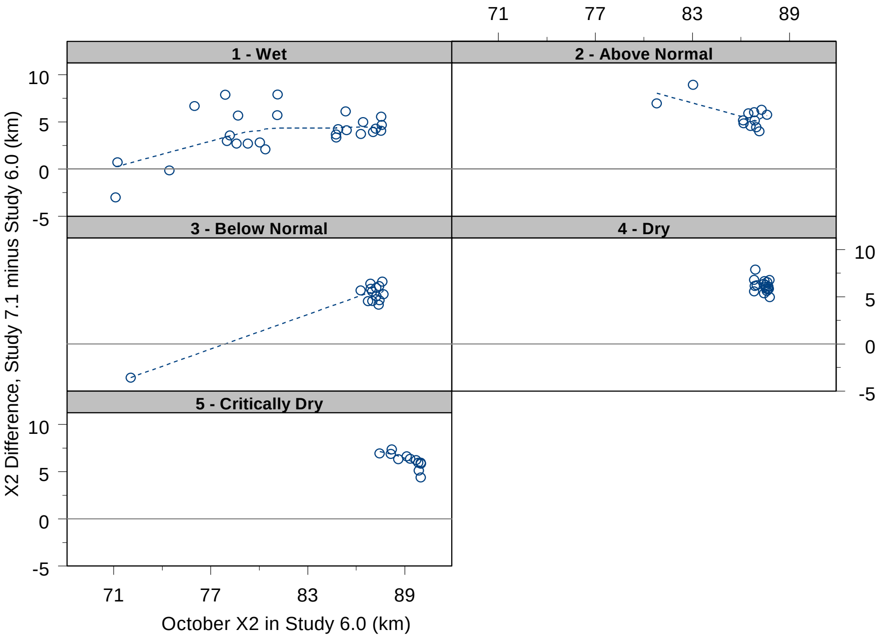

Figure 13-13 Variation in X2 in Study 7.1 with respect to Study 6.0 in October

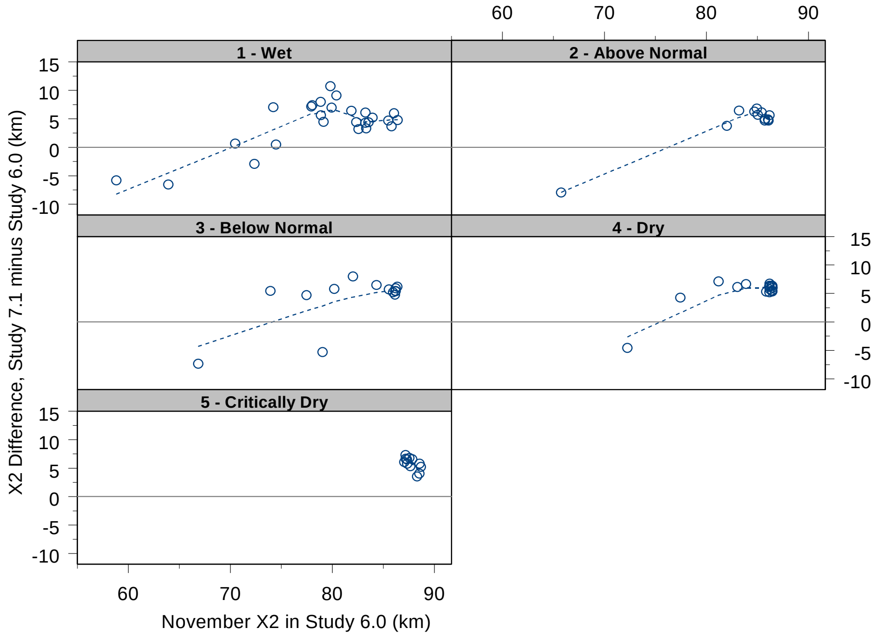

Figure 13-14 Variation in X2 in Study 7.1 with respect to Study 6.0 in November

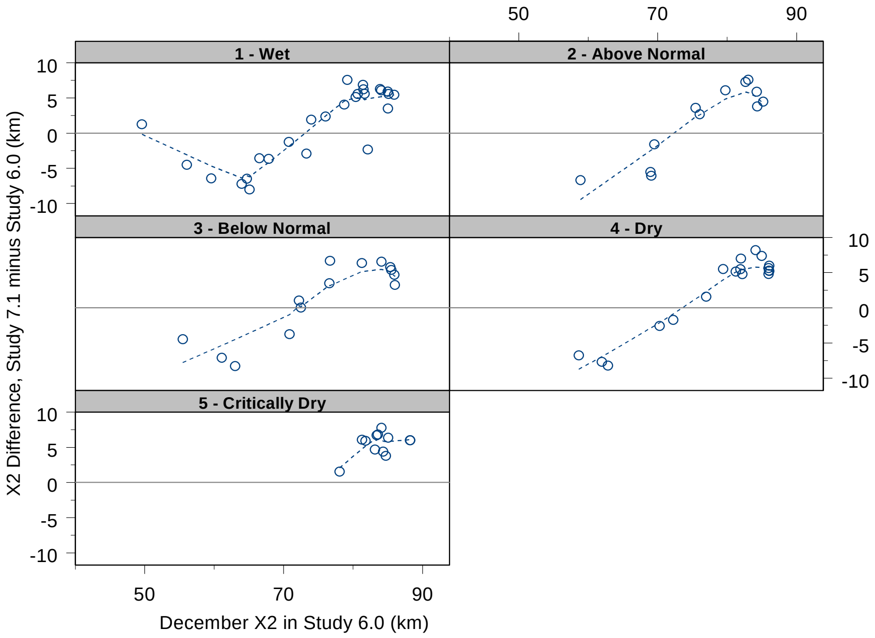

Figure 13-15 Variation in X2 in Study 7.1 with respect to Study 6.0 in December

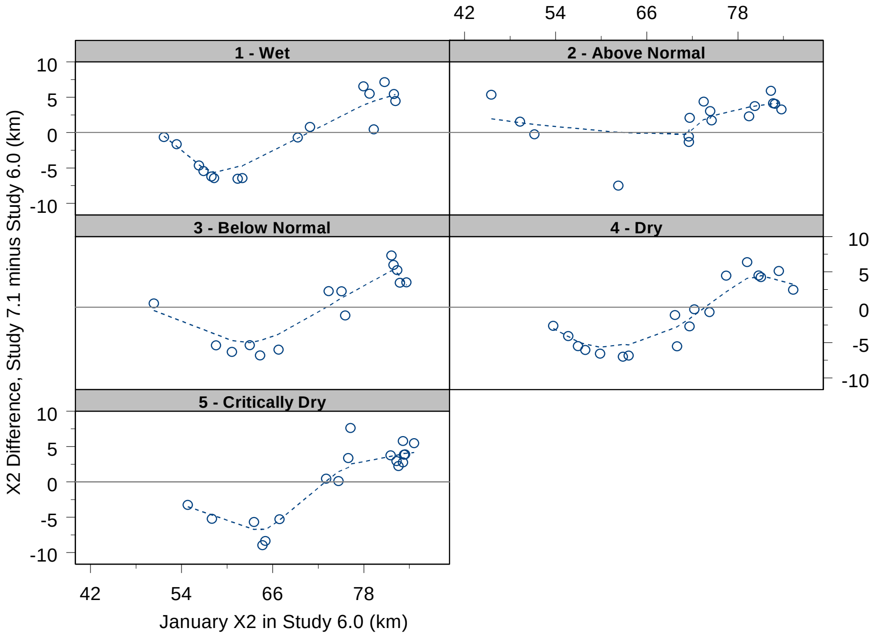

Figure 13-16 Variation in X2 in Study 7.1 with respect to Study 6.0 in January

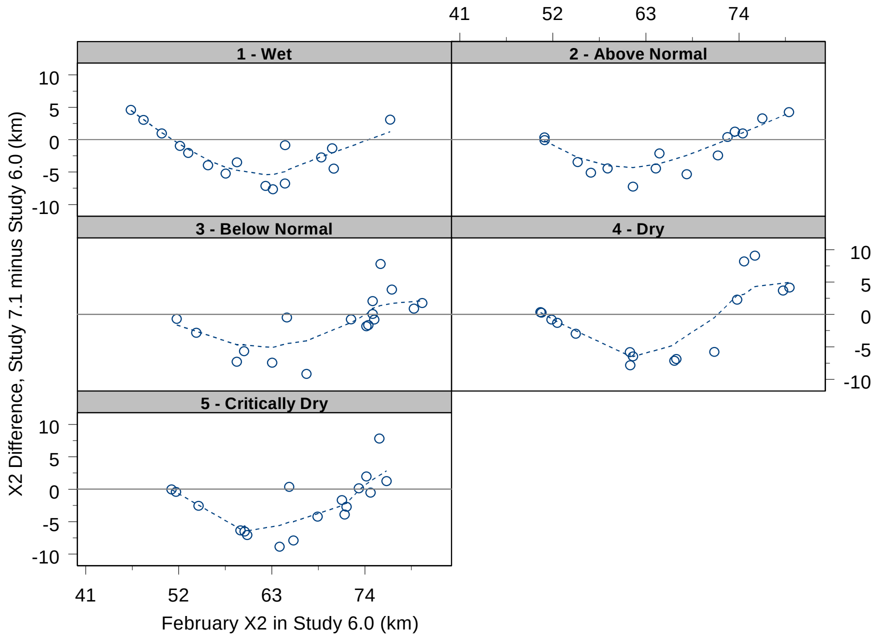

Figure 13-17 Variation in X2 in Study 7.1 with respect to Study 6.0 in February

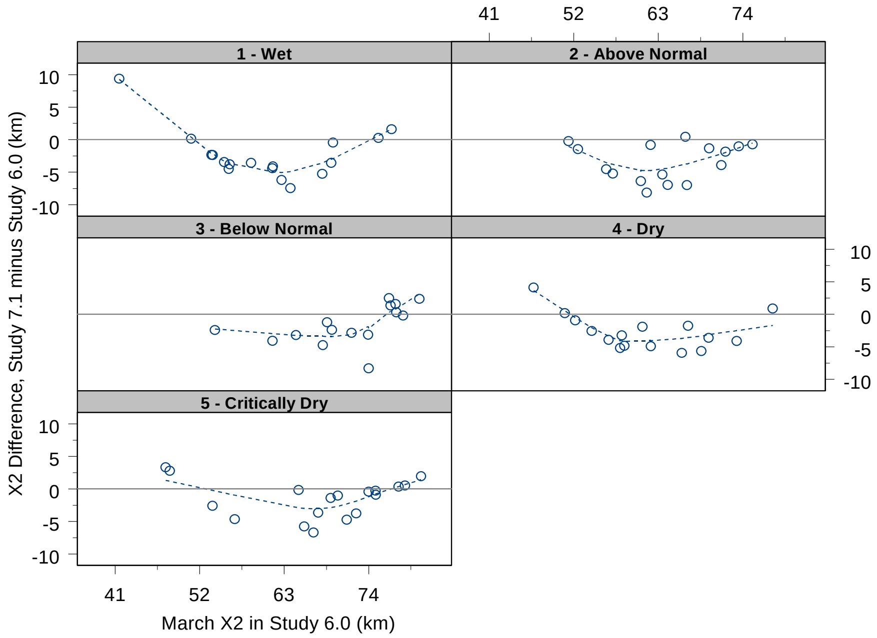

Figure 13-18 Variation in X2 in Study 7.1 with respect to Study 6.0 in March

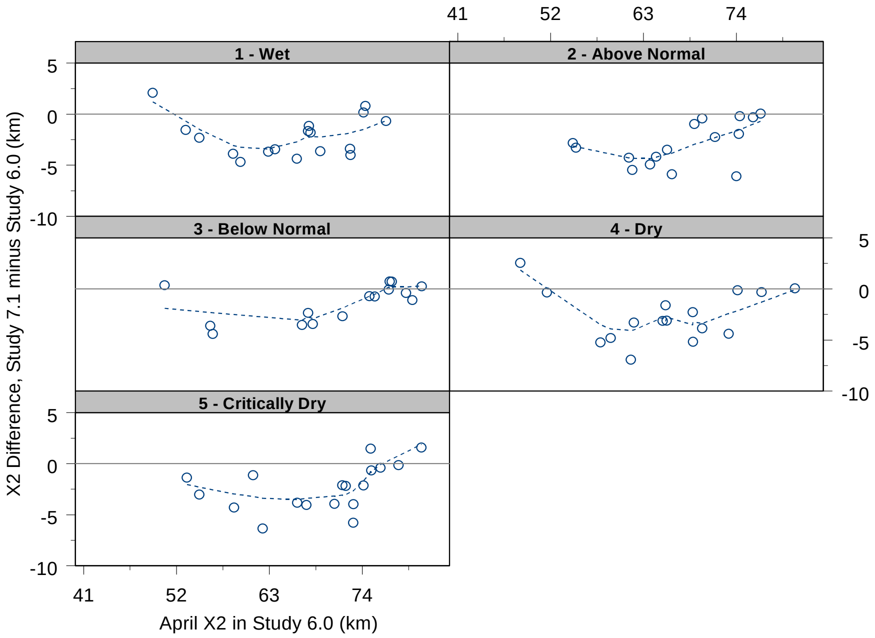

Figure 13-19 Variation in X2 in Study 7.1 with respect to Study 6.0 in April

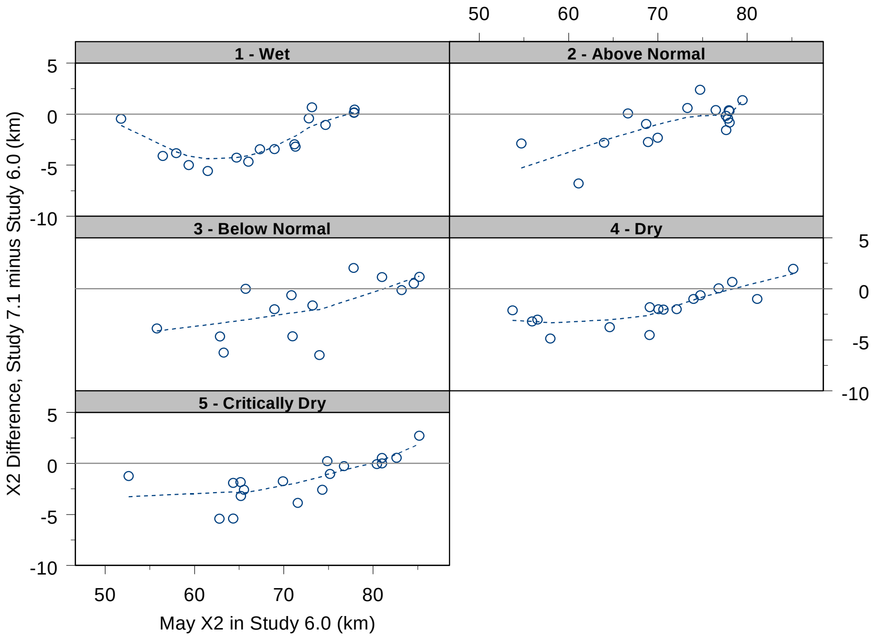

Figure 13-20 Variation in X2 in Study 7.1 with respect to Study 6.0 in May

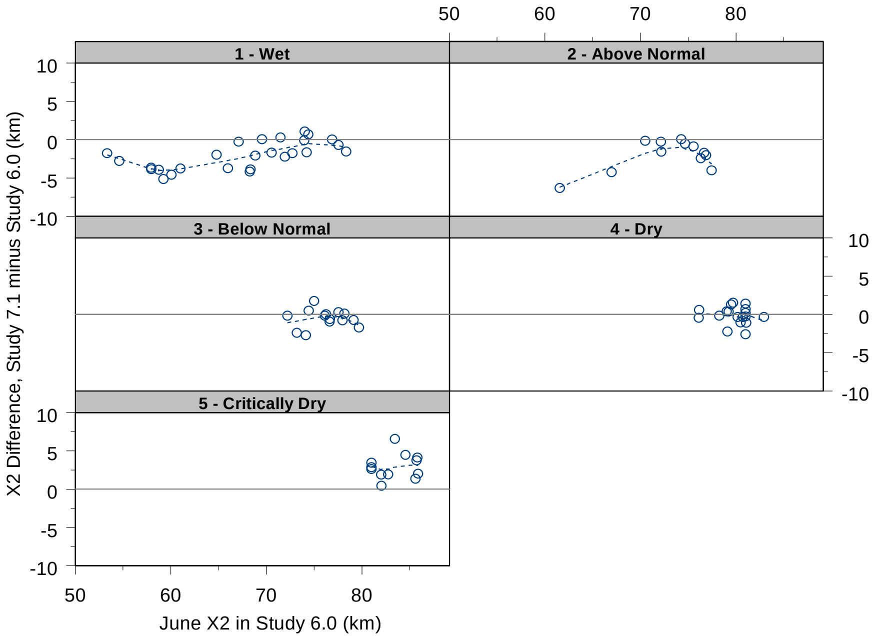

Figure 13-21 Variation in X2 in Study 7.1 with respect to Study 6.0 in June

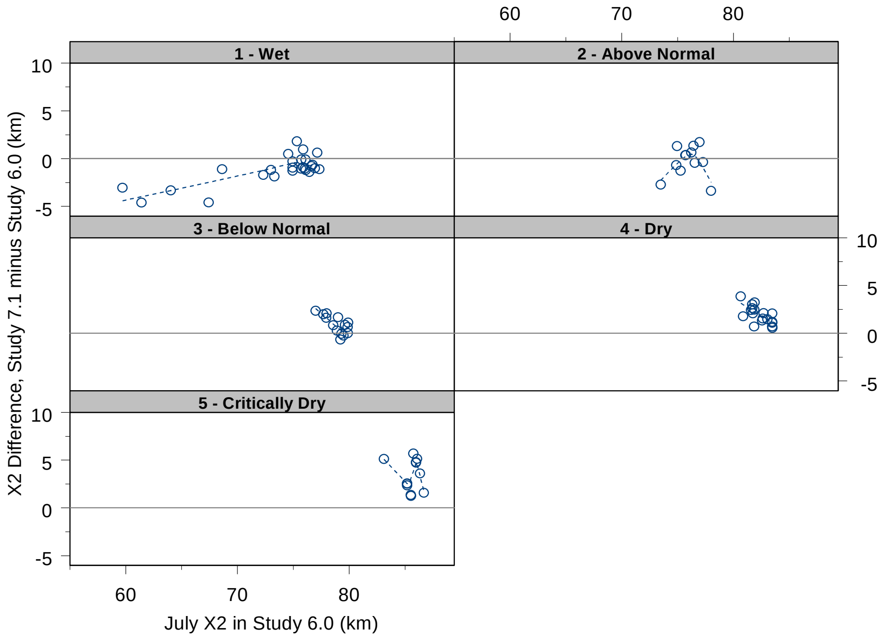

Figure 13-22 Variation in X2 in Study 7.1 with respect to Study 6.0 in July

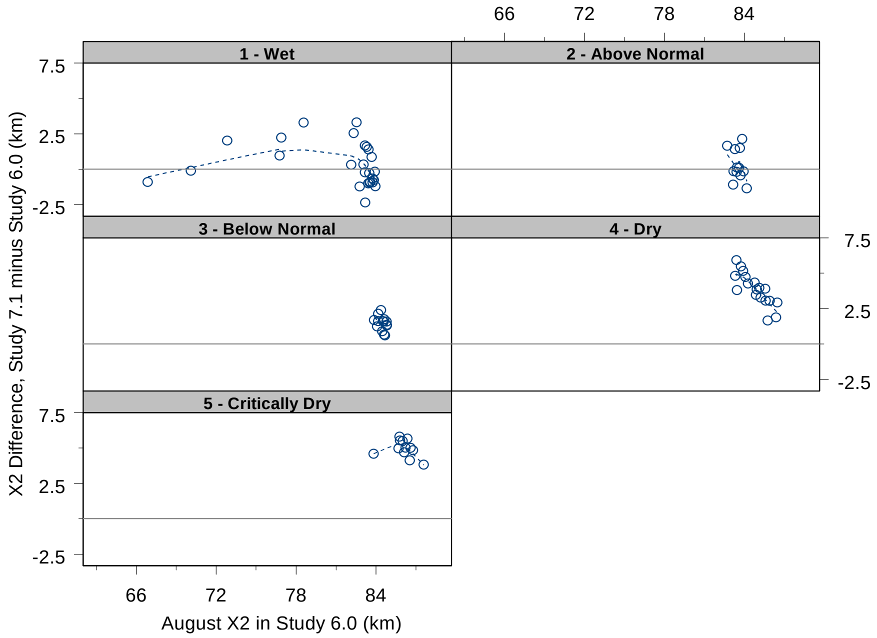

Figure 13-23 Variation in X2 in Study 7.1 with respect to Study 6.0 in August

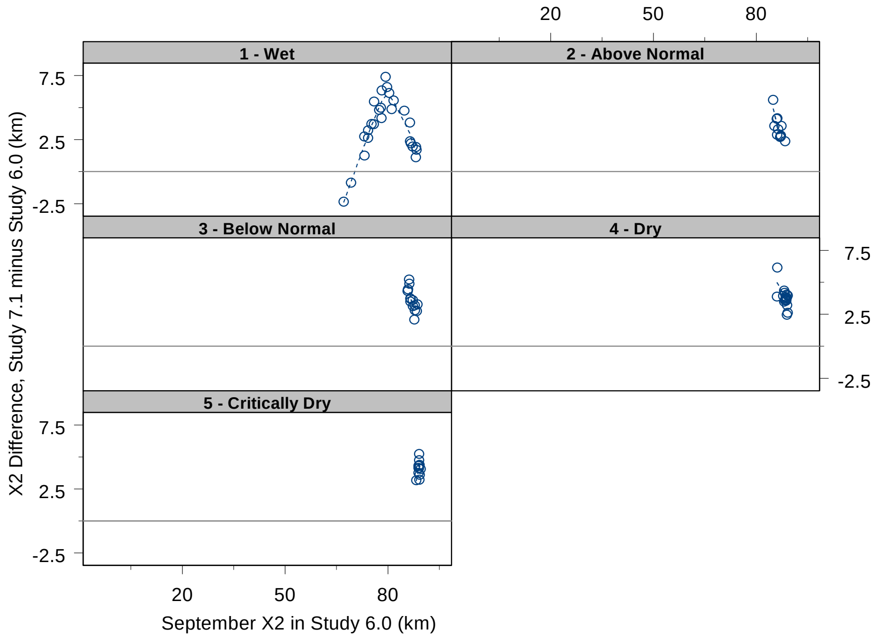

Figure 13-24 Variation in X2 in Study 7.1 with respect to Study 6.0 in September

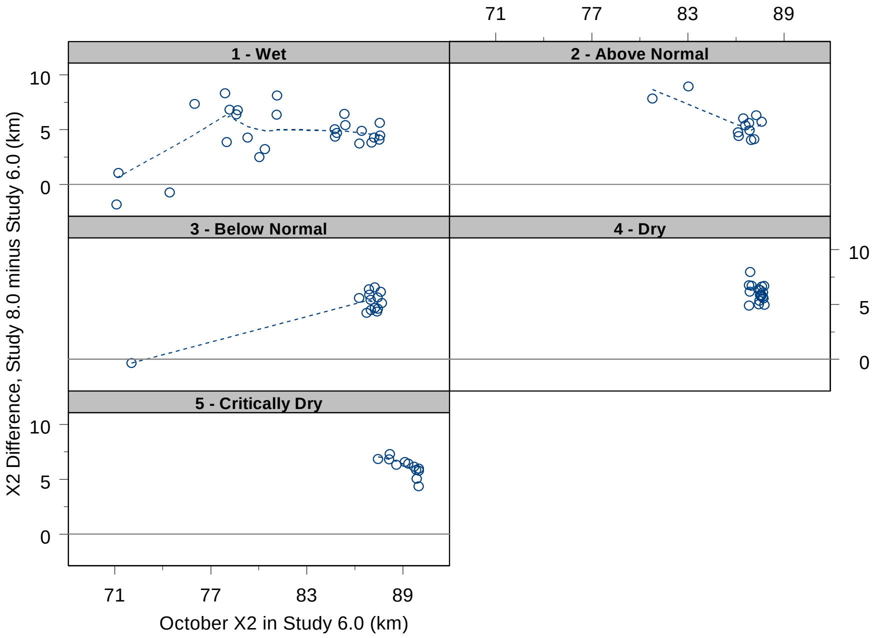

Figure 13-25 Variation in X2 in Study 8.0 with respect to Study 6.0 in October

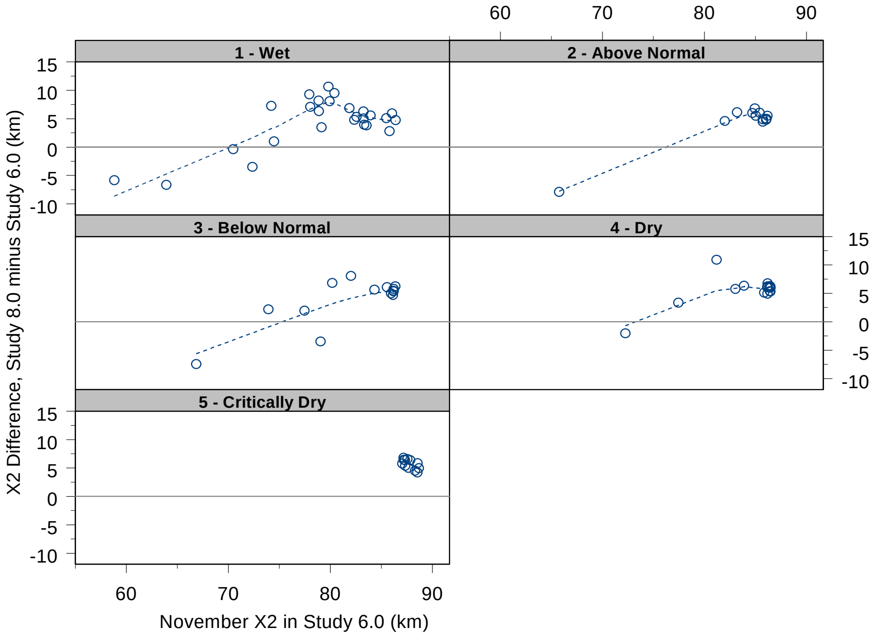

Figure 13-26 Variation in X2 in Study 8.0 with respect to Study 6.0 in November

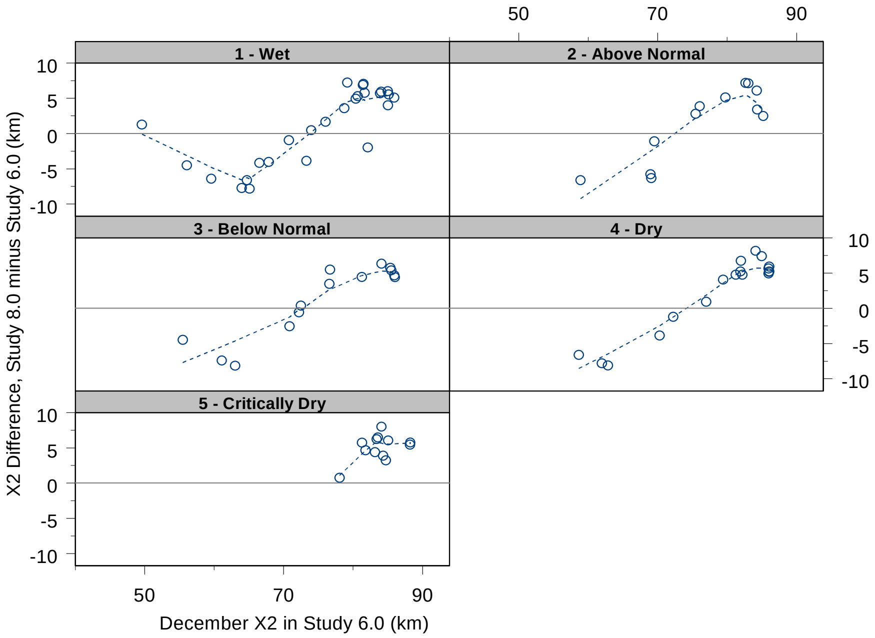

Figure 13-27 Variation in X2 in Study 8.0 with respect to Study 6.0 in December

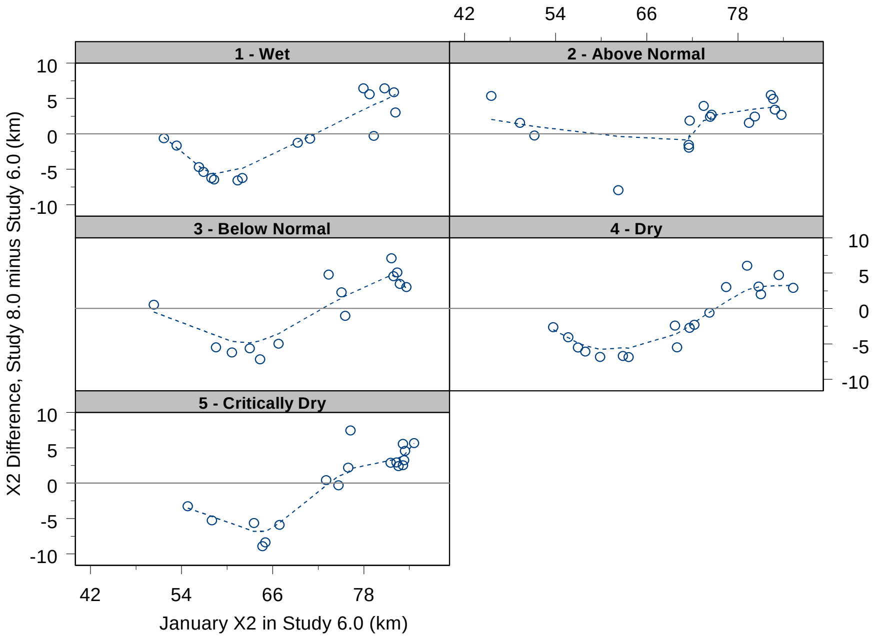

Figure 13-28 Variation in X2 in Study 8.0 with respect to Study 6.0 in January

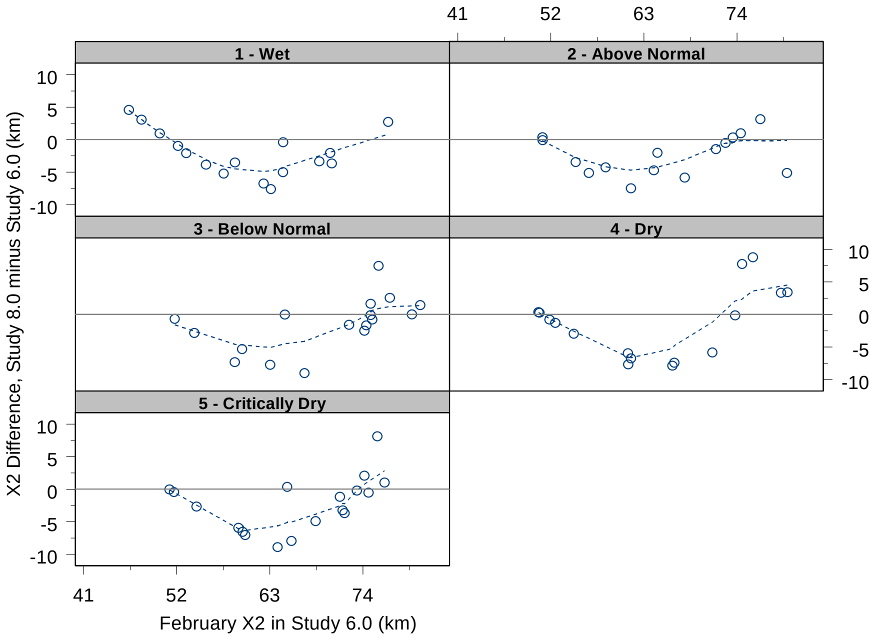

Figure 13-29 Variation in X2 in Study 8.0 with respect to Study 6.0 in February

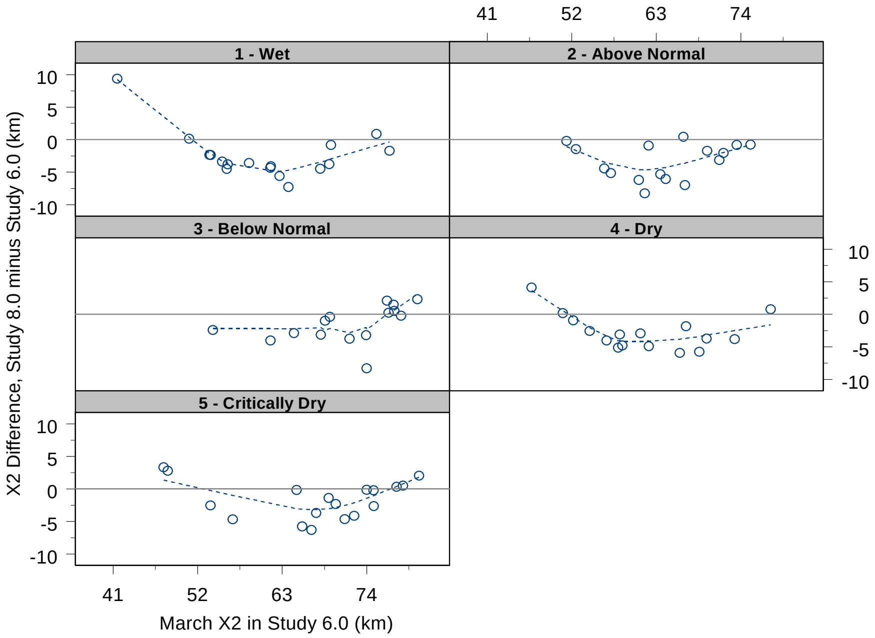

Figure 13-30 Variation in X2 in Study 8.0 with respect to Study 6.0 in March

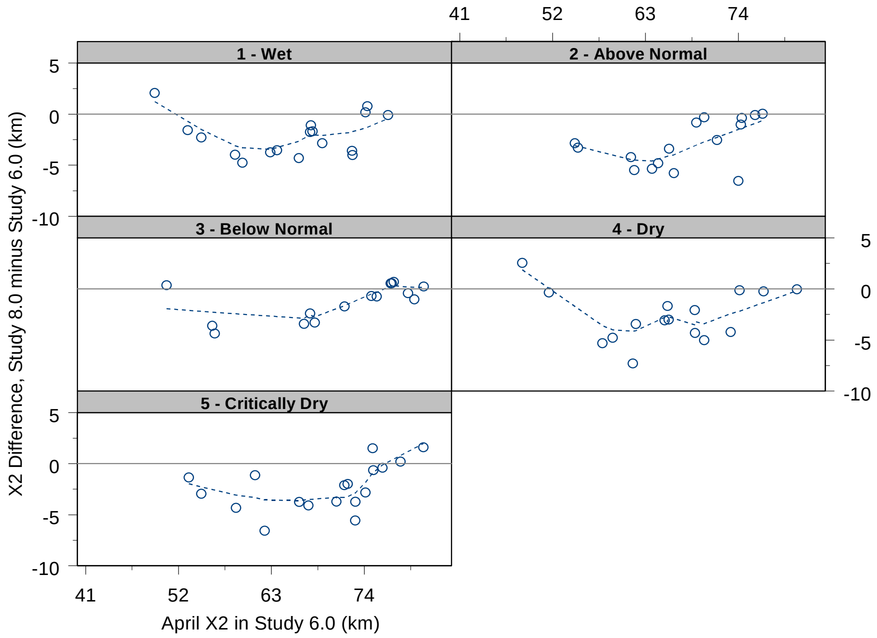

Figure 13-31 Variation in X2 in Study 8.0 with respect to Study 6.0 in April

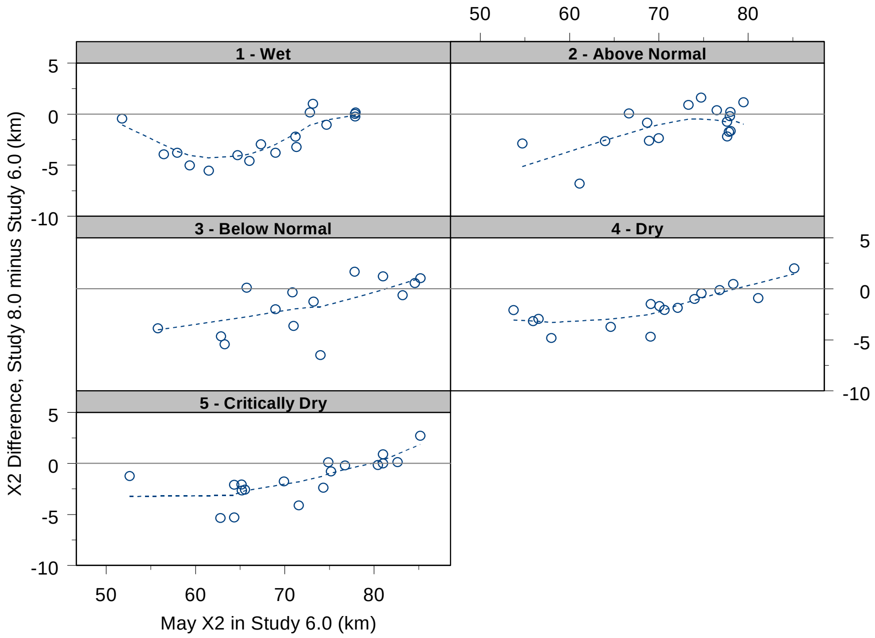

Figure 13-32 Variation in X2 in Study 8.0 with respect to Study 6.0 in May

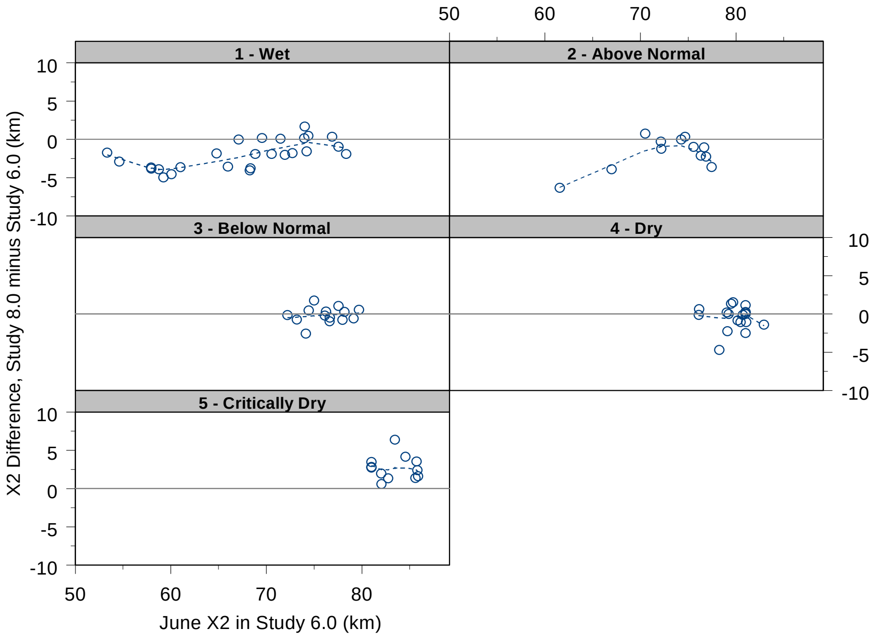

Figure 13-33 Variation in X2 in Study 8.0 with respect to Study 6.0 in June

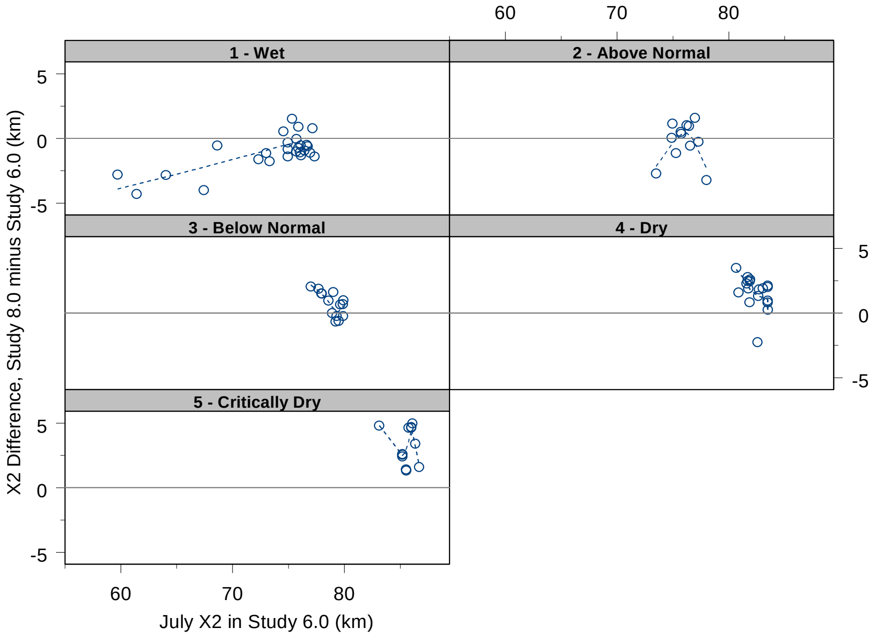

Figure 13-34 Variation in X2 in Study 8.0 with respect to Study 6.0 in July

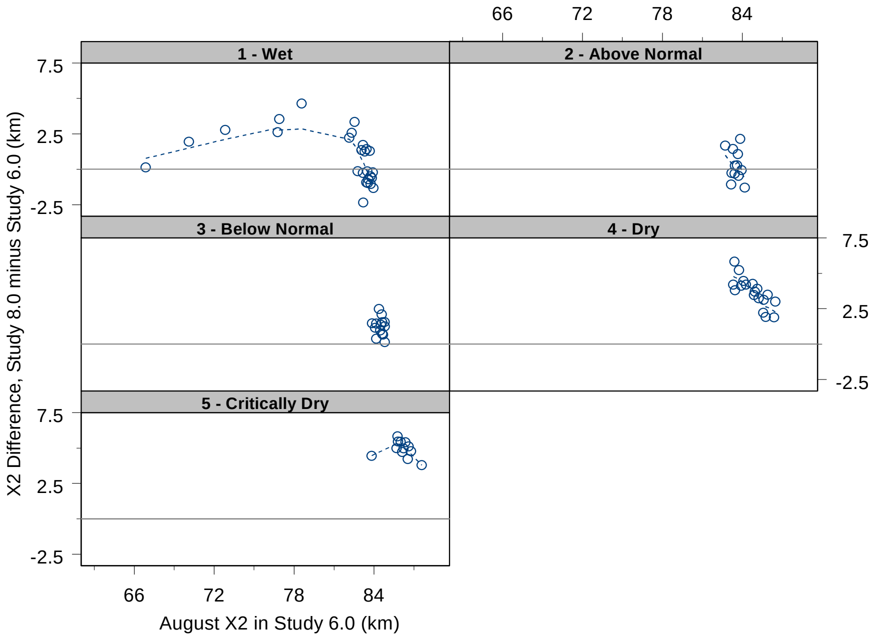

Figure 13-35 Variation in X2 in Study 8.0 with respect to Study 6.0 in August

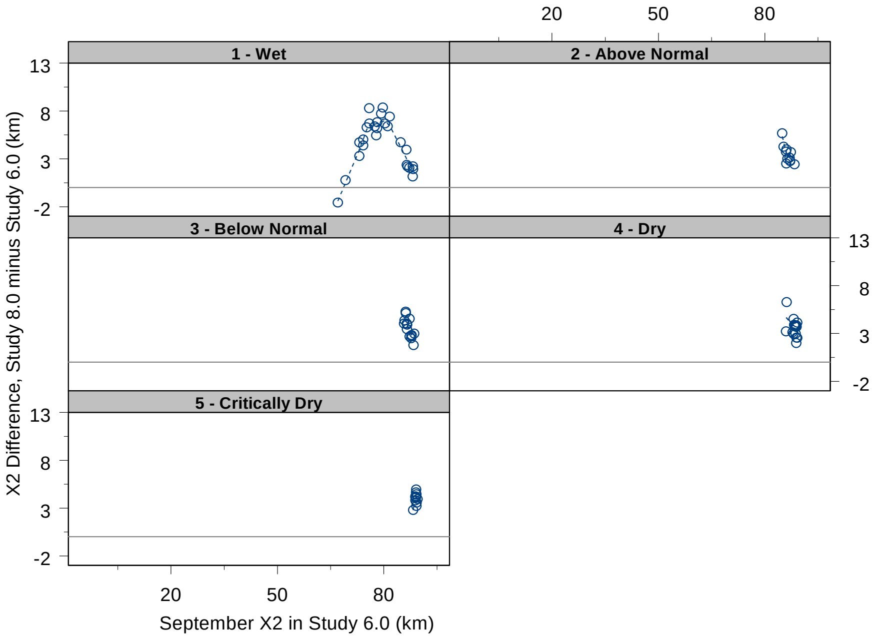

Figure 13-36 Variation in X2 in Study 8.0 with respect to Study 6.0 in September

Effects on Critical Habitat

The USFWS designated designated delta smelt critical habitat to include “areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and constrained in Suisun Bay (including the continguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the Delta.” (U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: Critical habitat determination for the delta smelt. December 19, 1994. Federal Register 59(242): 65256-65279 [Rule]). Both direct and indirect effects described here for the CVP and SWP upon delta smelt take place within these geographical boundaries. Present and future operations described in studies 6.0, 7.0, and 7.1 are likely to affect the primary constituent elements of delta smelt critical habitat as follows.

Spawning Habitat

As described by the Rule, delta smelt require “shallow, fresh or slightly brackish backwater sloughs and edgewaters for spawning. To ensure egg hatching and larval viability, spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation).” In recent years the densest spawning aggregations of adult delta smelt have been found in the Cache Slough/Sacramento Deepwater Ship Channel complex in the north Delta, with delta smelt also distributed at lower densities in the central and occasionally the south Delta. Current and future CVP and SWP operations described in studies 7.0, 7.1, and 8.0 are unlikely to affect spawning habitat in the interior and north Delta because the projects do not contribute pollutants or otherwise physically or chemically disturb this habitat. Water project operations might adversely affect spawning habitat in the west Delta and Suisun Marsh if persistently elevated salinities in those regions resulted in changes in the quality of edgewater habitat and spawning substrate through changes in the plant and animal assemblages that occur there. The extent to which such changes might reduce the overall availability of good-quality spawning habitat is unknown, but given historical geographical patterns of delta smelt is likely to be small.

Larval and Juvenile Transport

As described in the Rule, to ensure transport of delta smelt larvae from the areas where they hatch to productive rearing or nursery habitat, “the Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance…and flow disruption (eg. Water diversions that result in entrainment and in-channel barriers or tidal gates). Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Additionally, river flow must be adequate to prevent interception of larval transport by the State and Federal water projects…” Both current and future CVP and SWP operations described in this Biological Assessment are likely to adversely affect larval and juvenile transport by flow disruption and interception (and subsequent entrainment) of fish transport. As discussed above, it is known that export pumping affects adult delta smelt production, albeit weakly over the long-term (Manly and Chotkowski 2006, IEP 2005; also see discussion in Chapter 7), and that both the entrainment rate (as indexed by salvage) and extent of the zone of entrainment are affected by export rates and especially the degree of upstream flow in Old and Middle Rivers (PE Smith, unpublished analysis, Grimaldo et al. in press, Kimmerer and Nobriga 2008). While the evidence from the POD investigation principally implicates direct entrainment of adults, larvae, and early juveniles as possible contributing causes of the recent decline of delta smelt, late emerging juvenile delta smelt have historically also been entrained in relatively large numbers during May—July of some years. Increases in the strength of negative OMR flow in June and especially July that are predicted under all model scenarios may have a significant effect in years when the spawning distribution of delta smelt intrudes farther than usual southeast.

Rearing Habitat

According to the Rule, "[m]aintenance of the 2 ppt isohaline according to the historical salinity conditions…and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow, protective, food-rich environment in which to mature to adulthood. This placement of the 2 ppt isohaline also serves to protect larval, juvenile, and adult delta smelt from entrainment in the State and Federal water projects." As discussed above and in Chapter 7, changes in X2 alter the distribution and availability of pelagic habitat suitable for delta smelt. Upstream X2 movements of several kilometers predicted for the fall months in studies 7.0, 7.1, and 8.0, relative to Study 6.0, are likely to be associated with a reduction in the quality and availability of rearing habitat.

Adult Migration

The Rule states that "[a]dult delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods." As described above and in Chapter 7, water project operations affect delta hydrodynamics during this period by creating a zone of upstream flows north of the facilities, causing water to move south in OMR under most circumstances. Export pumping levels described in Study 6.0 during the winter and spring may have contributed to the Pelagic Organism Decline. Alterations of those levels in studies 7.0, 7.1, and 8.0 provide more protective flow conditions in general during winter and early spring (with exceptions in March, June, and July), but OMR flow modeling predicts conditions in most of the winter and spring to cause some entrainment of adults, larvae, and juveniles present in the central Delta and areas north of it in June and July.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions affecting listed species that are reasonably certain to occur in the area considered in this biological assessment. Future Federal actions not related to this proposed action are not considered in determining the cumulative effects, because they are subject to separate consultation requirements pursuant to section 7 of the Act. Any continuing or future non-Federal diversions of water that may entrain adult or larval fish might contribute to cumulative effects to the smelt. Water diversions through intakes serving numerous small, private agricultural lands contribute to these cumulative effects. These diversions also include municipal and industrial uses. State or local levee maintenance may also destroy or adversely modify spawning or rearing habitat and interfere with natural long term habitat-maintaining processes. Operation of flow-through cooling systems on electrical power generating plants that draw water from and discharge into the area considered in this biological assessment may also contribute to cumulative effects to the smelt.

Additional cumulative effects result from the impacts of point and non-point source chemical contaminant discharges. These contaminants include but are not limited to free ammonium ion, selenium, and numerous pesticides and herbicides, as well as oil and gasoline products associated with discharges related to agricultural and urban activities. Implicated as potential sources of mortality for smelt, these contaminants may adversely affect fish reproductive success and survival rates. Spawning habitat may also be affected if submersed aquatic plants, used a substrates for adhesive egg attachment, are lost due to toxic substances.

Other cumulative effects could include: the dumping of domestic and industrial garbage may present hazards to the fish because they could become trapped in the debris, injure themselves, or ingest the debris; golf courses reduce habitat and introduce pesticides and herbicides into the environment; oil and gas development and production may affect habitat and may introduce pollutants into the water; agricultural activities on levees reduce riparian and wetland habitats; and grazing activities may degrade or reduce suitable habitat, which could reduce vegetation in or near waterways.

The cumulative effects of the proposed action are not expected to alter the magnitude of cumulative effects of the above described actions upon the critical habitat's conservation function for the smelt.

CVP and SWP Delta Effects on Steelhead, Chinook Salmon, and Green Sturgeon

This section addresses the effects associated with Delta pumping on winter-run Chinook, yearling and young-of-the-year (yoy) spring-run Chinook, steelhead and green sturgeon. Fish monitoring programs for CVP and SWP facilities are described, and salvage and loss estimates provided by species and life stage. Instream temperature effects on salmonids resulting from CVP and SWP operations were discussed in Chapter 9, and addressed separately in the effects determination for that section.

CVP and SWP South Delta Pumping Facilities

Winter-run and spring run losses are seasonally significant, December through May. The majority of winter-run losses occur December through April (Figure 13-37), yearling spring run surrogate losses December through March, and yoy spring run losses January through May. Distinguishing the four runs of Chinook is difficult; therefore we use a couple of different methods to estimate run losses. Winter run loss is based on length/date criteria (or growth rate criteria) developed by FWS in the upper Sacramento River. Yearling spring run loss is based on using Coleman Hatchery late-fall juveniles as surrogates for yearling spring run. Young-of-the-year spring loss is based on using the entire yoy loss as a relative index of yoy spring run loss.

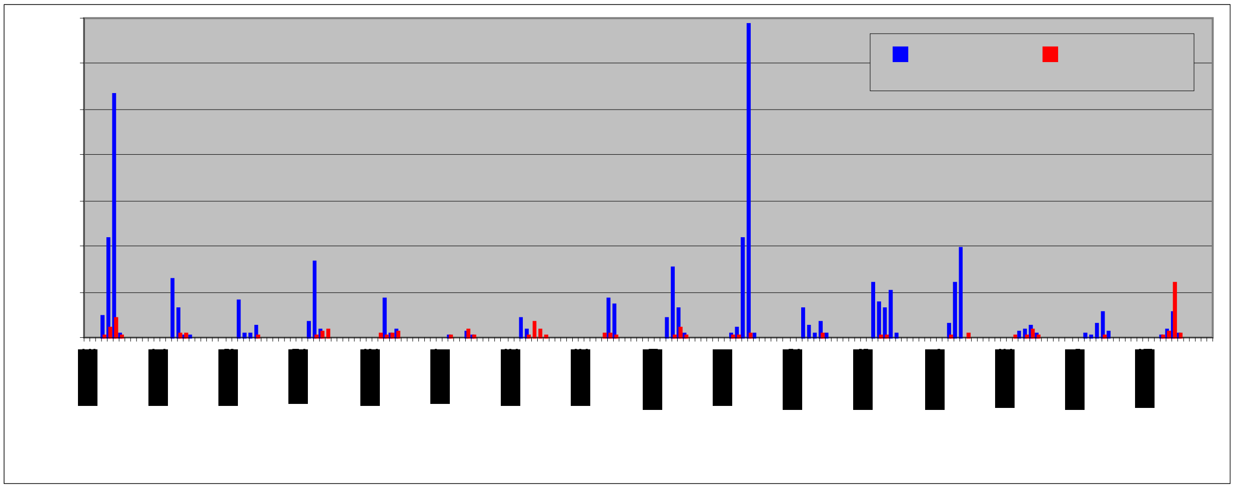

Figure 13-37 Historical juvenile non-clipped winter-run Chinook loss, WY 1992-2007

Steelhead salvage is seasonally significant, January through June (Figure 13-38 and Figure 4-4). As discussed in Chapter 4, there is a positive correlation to export rates at both the CVP (Figure 4-2) and SWP (Figure 4-3) facilities in the south Delta, although the steelhead salvage-export relationships are confounded by (1) breakdown in the relationships during months fringing the salvage “season;” (2) a decline in steelhead salvage since 1992 due to changes in export operations; and (3) a positive correlation between salvage and the Chipps Island abundance estimate.

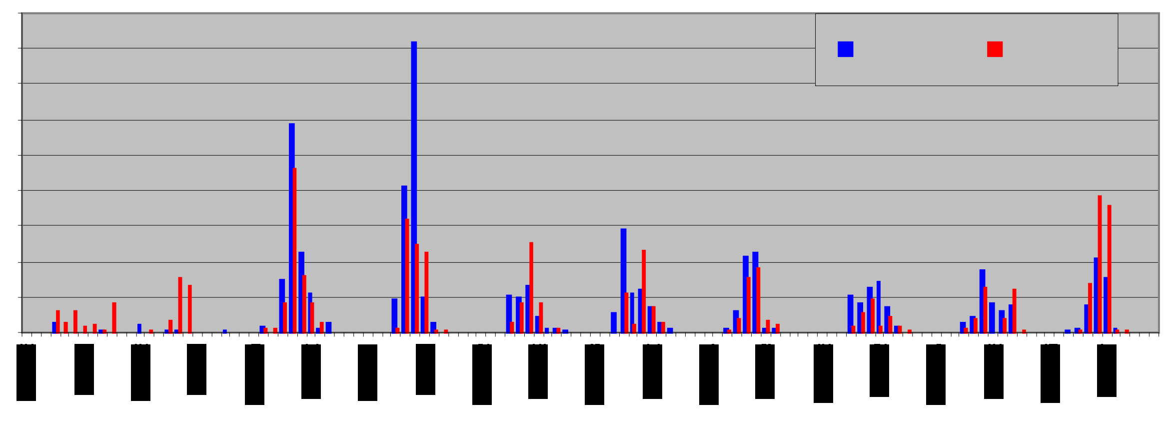

Figure 13-38 Historical Juvenile Non-Clipped Steelhead Salvage, WY 1998-2007

Green sturgeon salvage is low; therefore seasonal trends are difficult to determine (Figure 13-39).

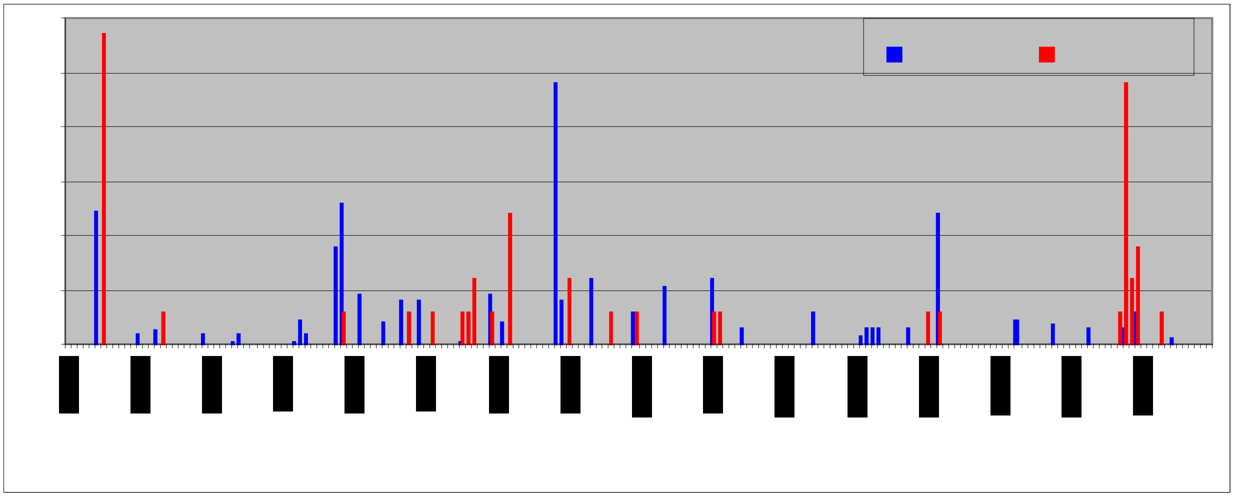

Figure 13-39 Historical juvenile green sturgeon salvage, WY 1992 - 2007

Figures 13-40 and 13-41 are the green sturgeon salvage grouped by water year type and month at each facility. At Banks, there is a slight trend of higher salvage in wet and critical years, and earlier salvage in wet years than critical years. This trend doesn't occur at Jones.

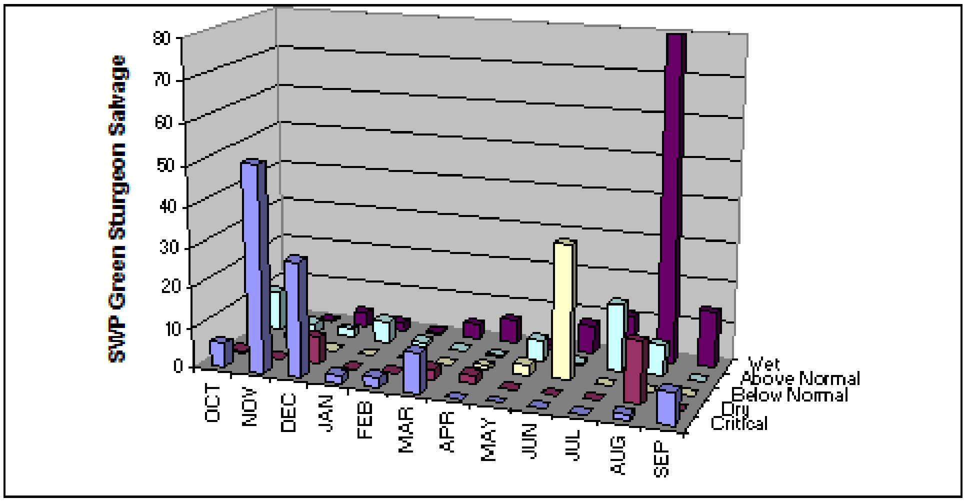

Figure 13-40 Green sturgeon salvage at Banks grouped by water year type and month

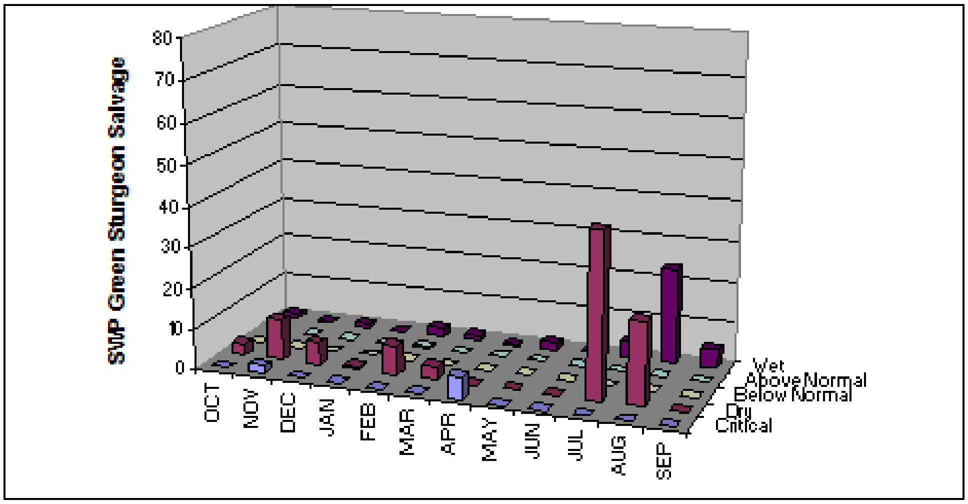

Figure 13-41 Green sturgeon salvage atJones grouped by water year type and month

Direct Losses to Entrainment by CVP and SWP Export Facilities

Table 13-19 is the average loss of winter-run Chinook, yearling spring-run Chinook, and average salvage of steelhead and green sturgeon used in the effects analysis grouped by water-year type and month. We used Chinook loss data starting from 1993 through 2007 because 1993 was the first year for which adipose fin clip was recorded in the salvage database. Prior to that year, we can not distinguish clipped Chinook from non-clipped Chinook. We used steelhead salvage data starting from1998 because 1998 was the first year for which all hatchery steelhead were clipped. Prior to that year, we can not distinguish clipped from non-clipped steelhead. Due to the limited years of data for Chinook and steelhead, we combined loss and salvage for the water years classified as critical and dry, and used those values for dry; combined loss and salvage for the water years classified as wet, above normal and below normal, and used those values for wet. Loss for winter-run and spring-run was calculated using the Four Pumps Mitigation Agreement method. We used the period of record (starting in 1968) for green sturgeon salvage; therefore we had enough years of data to calculate an average for all 5 water year types.

Table 13-19 Average loss of winter-run, yearling-spring-run and young-of-the-year spring-run Chinook, and steelhead and green sturgeon salvage by export facility, water-year type and month. Winter run loss was based on non-clipped juveniles in the winter run length range 1993 - 2007.

NOTE: **Yearling spring run loss was based on Coleman Hatchery late-fall hatchery surrogates as described in the Salmon Protection Plan 1995-2007. Young-of-the-year spring run loss was based on total, non-clipped young-of-the-year juvenile loss as a surrogate 1993-2007. Steelhead salvage was based on non-clipped steelhead 1998 – 2007. Due to limited data availability, all average salmonid salvage and loss was categorized into two year types; dry (1994, 2001, 2002, 2004, 2007) and wet (1993, 1995-2000, 2003, 2005, 2006). Green sturgeon average salvage was based on the period of record, 1968 – 2007, and categorized into all 5 water year types.**

BANKS													
YEARTYPE	**SPECIES**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**
Dry	Winter Run	0	0	518	429	1966	5119	128	6	1	0	0	0
Wet	Winter Run	0	0	418	1074	711	735	234	3	0	0	0	0
Dry	Yearling Spring	0	0.00%	1.21%	1.09%	2.94%	44.00%	1.00%	0	0	0	0	0
Wet	Yearling Spring	0	0.00%	0.09%	0.17%	0.06%	0.01%	0.00%	0	0	0	0	0
Dry	Steelhead	0	0	8	133	400	691	153	27	5	3	0	0
Wet	Steelhead	7	6	19	200	276	215	136	58	46	1	1	0
Critical	Green Sturgeon	6	51	28	2	2	10	0	0	0	0	1	8
Dry	Green Sturgeon	1	0	7	0	0	2	2	0	0	0	15	0
Below Normal	Green Sturgeon	2	3	0	0	0	0	1	2	33	0	0	0
Above Normal	Green Sturgeon	10	3	2	6	1	0	0	5	1	17	8	0
Wet	Green Sturgeon	2	0	4	2	0	4	6	1	7	11	81	14
JONES													
YEARTYPE	**SPECIES**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**
Dry	Winter Run	0	0	31	64	291	786	83	0	0	0	0	0
Wet	Winter Run	0	0	30	42	68	144	39	3	0	0	0	0
Dry	Yearling Spring	0	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0	0	0	0	0
Wet	Yearling Spring	0	0.01%	0.20%	0.35%	0.10%	0.01%	0.00%	0	0	0	0	0
Dry	Steelhead	0	0	3	41	345	531	349	19	12	0	0	0
Wet	Steelhead	0	6	4	105	253	267	62	55	49	32	0	0
Critical	Green Sturgeon	0	2	0	0	0	0	5	0	0	0	0	0
Dry	Green Sturgeon	3	10	6	1	7	3	0	0	0	40	20	0
Below Normal	Green Sturgeon	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	Green Sturgeon	0	0	0	0	1	0	0	0	0	0	0	0
Wet	Green Sturgeon	1	0	1	0	2	1	0	2	1	4	24	5

Table 13-20 is the average change in Banks and Jones Pumping grouped by water year type comparing Study 7.1 to Study 7.0, and Study 8.0 to Study 7.0. The relative change in fish loss and salvage will be based on the relative change in pumping.

Table 13-20 Average change in Banks and Jones pumping grouped by water year type.

Facility	WaterYearType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Study 7.1 compared to 7.0													
Banks	Critical	-3.1%	3.7%	12.5%	3.8%	17.9%	16.9%	21.6%	-3.8%	-21.0%	-18.9%	-43.1%	9.1%
Banks	Dry	-9.5%	-2.3%	7.4%	12.6%	1.4%	-0.2%	18.7%	44.2%	22.8%	1.5%	-18.9%	-9.5%
Banks	Bl Normal	-3.6%	-6.0%	8.9%	10.0%	5.2%	8.7%	16.7%	52.5%	20.0%	5.4%	-1.5%	2.4%
Banks	Ab Normal	-7.0%	-5.4%	5.2%	11.0%	11.8%	4.3%	22.2%	38.5%	15.8%	12.4%	-1.3%	0.7%
Banks	Wet	-1.9%	-0.8%	7.4%	5.2%	5.0%	2.3%	21.2%	24.4%	3.5%	7.6%	-0.7%	-2.0%
Jones	Critical	8.6%	3.0%	8.5%	8.1%	8.8%	5.7%	19.2%	23.5%	4.1%	4.1%	-17.5%	-1.3%
Jones	Dry	6.0%	9.0%	13.9%	14.0%	-9.8%	-6.0%	19.6%	54.7%	-5.4%	6.4%	-18.0%	-2.8%
Jones	Bl Normal	1.8%	7.7%	15.9%	5.9%	-11.6%	-21.7%	-5.9%	12.8%	0.3%	9.1%	-6.6%	2.7%
Jones	Ab Normal	8.2%	8.6%	25.5%	14.7%	-1.9%	-21.9%	-4.8%	3.7%	0.8%	11.7%	-0.8%	6.9%
Jones	Wet	9.1%	8.1%	16.4%	10.7%	-5.3%	-25.9%	-1.6%	2.8%	0.5%	7.8%	0.2%	6.3%
Study 8.0 compared to 7.0													
Banks	Critical	-0.7%	-4.6%	6.2%	10.9%	14.5%	33.9%	16.1%	-7.9%	-19.1%	-20.4%	-44.2%	11.0%
Banks	Dry	-0.9%	3.9%	7.4%	15.8%	4.6%	-0.4%	22.1%	44.9%	29.2%	-4.0%	-17.8%	-12.8%
Banks	Bl Normal	-2.9%	-1.5%	10.6%	14.6%	-1.7%	7.8%	16.4%	53.4%	23.3%	5.7%	-1.5%	6.0%
Banks	Ab Normal	-1.3%	-15.3%	2.4%	12.8%	10.9%	5.3%	22.7%	38.6%	13.8%	11.3%	1.4%	8.1%
Banks	Wet	1.4%	-3.4%	7.0%	5.1%	6.2%	4.5%	21.8%	25.3%	3.7%	10.3%	1.1%	-1.0%
Jones	Critical	8.4%	-6.3%	7.2%	11.3%	6.0%	-8.2%	10.0%	22.4%	-23.3%	-11.2%	-20.0%	-12.8%
Jones	Dry	9.5%	8.7%	13.6%	12.6%	-11.6%	-8.6%	16.5%	35.3%	-20.3%	3.6%	-31.9%	-10.0%
Jones	Bl Normal	2.9%	7.3%	14.0%	3.6%	-12.7%	-17.5%	-7.0%	4.3%	-5.7%	-2.3%	-10.5%	0.8%
Jones	Ab Normal	12.4%	5.6%	19.3%	15.2%	7.9%	-8.1%	-3.7%	-11.1%	-1.9%	0.3%	-5.7%	0.7%
Jones	Wet	15.4%	9.2%	17.1%	7.6%	-4.8%	-19.5%	-1.0%	0.4%	0.1%	3.1%	0.0%	4.6%

Table 13-21 represents potential loss and salvage changes for winter-run, yearling and yoy spring run, steelhead and green sturgeon comparing operations today to future operations (Model 7.1 vs 7.0, model 8.0 vs 7.0) if we assumed that salvage is directly proportional to the amount of water exported (i.e. doubling the amount of water exported doubles the number of fish salvaged). Because there is not a direct method to estimate yoy spring run loss, we used the combination of yoy fall- and spring-run losses as a surrogate for you spring run loss and reported just the percentage change for yoy spring run loss. The highlight cells represent just a visual inspection of the months and water year types with the relatively largest changes in loss or salvage. The values in each table are different because they are in terms of the take statement in the current Biological Opinion (BO). Take for winter run is in terms of loss, for yearling spring run in terms of the percentage of released hatchery juveniles subsequently lost at the Delta pumping facilities, steelhead and green sturgeon are in terms of salvage. Take for young of the year spring run isn’t defined in the current BO because there is no method to identify spring run available for management use. Since the values or metrics are different for each species, the values from one table (or species) aren’t relative to another table or species.

Table 13-21 Average change in winter run, yearling spring run and young-of-the-year spring run loss, and steelhead and green sturgeon salvage by species, model, facility, water-year type and month assuming a direct relationship between monthly exports and monthly salvage.

NOTE**: Winter run loss was based on non-clipped juveniles in the winter run length range 1993 - 2007. Yearling spring run loss was based on Coleman Hatchery late-fall hatchery surrogates as described in the Salmon Protection Plan 1995-2007. Young-of-the-year spring run loss was based on total, non-clipped young-of-the-year juvenile loss as a surrogate 1993-2007. Steelhead salvage were based on non-clipped fish 1998 – 2007. Due to limited data availability, all average salmonid salvage and loss was categorized into two year types; dry (1994, 2001, 2002, 2004, 2007) and wet (1993, 1995-2000, 2003, 2005, 2006). Green sturgeon average salvage was based on salvage period of record, 1968 -2007, and categorized into all 5 water year types.**

Species	**Facility**	**WYType**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**
Model 7.1 compared to 7.0														
Winter-Run Loss	Banks	Critical	0	0	65	17	352	865	28	0	0	0	0	0
Winter-Run Loss	Banks	Dry	0	0	38	54	28	-10	24	3	0	0	0	0
Winter-Run Loss	Banks	Bl	0	0	37	107	37	64	39	2	0	0	0	0
Winter-Run Loss	Banks	Ab	0	0	22	118	84	31	52	1	0	0	0	0
Winter-Run Loss	Banks	Wet	0	0	31	56	35	17	50	1	0	0	0	0
Winter-Run Loss	Jones	Critical	0	0	3	5	26	45	16	0	0	0	0	0
Winter-Run Loss	Jones	Dry	0	0	4	9	-28	-47	16	0	0	0	0	0
Winter-Run Loss	Jones	Bl	0	0	5	2	-8	-31	-2	0	0	0	0	0
Winter-Run Loss	Jones	Ab	0	0	8	6	-1	-31	-2	0	0	0	0	0
Winter-Run Loss	Jones	Wet	0	0	5	4	-4	-37	-1	0	0	0	0	0
Model 8.0 compared to 7.0														
Winter-Run Loss	Banks	Critical	0	0	32	47	284	1735	21	0	0	0	0	0
Winter-Run Loss	Banks	Dry	0	0	38	68	91	-22	28	3	0	0	0	0
Winter-Run Loss	Banks	Bl	0	0	44	156	-12	58	38	2	0	0	0	0
Winter-Run Loss	Banks	Ab	0	0	10	137	77	39	53	1	0	0	0	0
Winter-Run Loss	Banks	Wet	0	0	29	55	44	33	51	1	0	0	0	0
Winter-Run Loss	Jones	Critical	0	0	2	7	17	-65	8	0	0	0	0	0
Winter-Run Loss	Jones	Dry	0	0	4	8	-34	-68	14	0	0	0	0	0
Winter-Run Loss	Jones	Bl	0	0	4	2	-9	-25	-3	0	0	0	0	0
Winter-Run Loss	Jones	Ab	0	0	6	6	5	-12	-1	0	0	0	0	0
Winter-Run Loss	Jones	Wet	0	0	5	3	-3	-28	0	0	0	0	0	0

Species	Facility	WYType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Model 7.1 compared to 7.0														
Yearling Spring Run	Banks	Critical	0	0.000%	0.013%	0.004%	0.024%	0.007%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Dry	0	0.000%	0.008%	0.014%	0.002%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Bl	0	0.000%	0.008%	0.017%	0.003%	0.001%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Ab	0	0.000%	0.004%	0.019%	0.007%	0.001%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Wet	0	0.000%	0.006%	0.009%	0.003%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Critical	0	0.000%	0.006%	0.012%	0.019%	0.015%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Dry	0	0.000%	0.008%	0.017%	0.006%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Bl	0	0.000%	0.009%	0.025%	-0.001%	0.001%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Ab	0	0.000%	0.002%	0.022%	0.006%	0.001%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Wet	0	0.000%	0.006%	0.009%	0.003%	0.001%	0.000%	0	0	0	0	0
Study 8.0 compared to 7.0														
Yearling Spring Run	Banks	Critical	0	0.000%	0.001%	0.001%	0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Dry	0	0.000%	0.001%	0.002%	-0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Bl	0	0.000%	0.001%	0.001%	-0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Ab	0	0.000%	0.002%	0.002%	0.000%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Banks	Wet	0	0.000%	0.001%	0.002%	0.000%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Critical	0	0.000%	0.001%	0.002%	0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Dry	0	0.000%	0.001%	0.002%	-0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Bl	0	0.000%	0.001%	0.001%	-0.001%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Ab	0	0.000%	0.002%	0.002%	0.000%	0.000%	0.000%	0	0	0	0	0
Yearling Spring Run	Jones	Wet	0	0.000%	0.001%	0.001%	0.000%	0.000%	0.000%	0	0	0	0	0

Species	Facility	WYType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Model 7.1 compared to 7.0														
YOY Spring Run Loss	Banks	Critical	0	0	0	3.8%	17.9%	16.9%	21.6%	-3.8%	-21.0%	0	0	0
YOY Spring Run Loss	Banks	Dry	0	0	0	12.6%	1.4%	-0.2%	18.7%	44.2%	22.8%	0	0	0
YOY Spring Run Loss	Banks	Bl	0	0	0	10.0%	5.2%	8.7%	16.7%	52.5%	20.0%	0	0	0
YOY Spring Run Loss	Banks	Ab	0	0	0	11.0%	11.8%	4.3%	22.2%	38.5%	15.8%	0	0	0
YOY Spring Run Loss	Banks	Wet	0	0	0	5.2%	5.0%	2.3%	21.2%	24.4%	3.5%	0	0	0
YOY Spring Run Loss	Jones	Critical	0	0	0	8.1%	8.8%	5.7%	19.2%	23.5%	4.1%	0	0	0
YOY Spring Run Loss	Jones	Dry	0	0	0	14.0%	-9.8%	-6.0%	19.6%	54.7%	-5.4%	0	0	0
YOY Spring Run Loss	Jones	Bl	0	0	0	5.9%	-11.6%	-21.7%	-5.9%	12.8%	0.3%	0	0	0
YOY Spring Run Loss	Jones	Ab	0	0	0	14.7%	-1.9%	-21.9%	-4.8%	3.7%	0.8%	0	0	0
YOY Spring Run Loss	Jones	Wet	0	0	0	10.7%	-5.3%	-25.9%	-1.6%	2.8%	0.5%	0	0	0
Study 8.0 compared to 7.0														
YOY Spring Run Loss	Banks	Critical	0	0	0	5.1%	6.2%	4.5%	21.8%	25.3%	3.7%	0	0	0
YOY Spring Run Loss	Banks	Dry	0	0	0	12.8%	10.9%	5.3%	22.7%	38.6%	13.8%	0	0	0
YOY Spring Run Loss	Banks	Bl	0	0	0	14.6%	-1.7%	7.8%	16.4%	53.4%	23.3%	0	0	0
YOY Spring Run Loss	Banks	Ab	0	0	0	15.8%	4.6%	-0.4%	22.1%	44.9%	29.2%	0	0	0
YOY Spring Run Loss	Banks	Wet	0	0	0	10.9%	14.5%	33.9%	16.1%	-7.9%	-19.1%	0	0	0
YOY Spring Run Loss	Jones	Critical	0	0	0	7.6%	-4.8%	-19.5%	-1.0%	0.4%	0.1%	0	0	0
YOY Spring Run Loss	Jones	Dry	0	0	0	15.2%	7.9%	-8.1%	-3.7%	-11.1%	-1.9%	0	0	0
YOY Spring Run Loss	Jones	Bl	0	0	0	3.6%	-12.7%	-17.5%	-7.0%	4.3%	-5.7%	0	0	0
YOY Spring Run Loss	Jones	Ab	0	0	0	12.6%	-11.6%	-8.6%	16.5%	35.3%	-20.3%	0	0	0
YOY Spring Run Loss	Jones	Wet	0	0	0	11.3%	6.0%	-8.2%	10.0%	22.4%	-23.3%	0	0	0

Species	Facility	WYType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Model 7.1 compared to 7.0														
Steelhead Salvage	Banks	Critical	0	0	1	5	72	117	33	-1	-1	-1	0	0
Steelhead Salvage	Banks	Dry	0	0	1	17	6	-1	29	12	1	0	0	0
Steelhead Salvage	Banks	Bl	0	0	2	20	14	19	23	31	9	0	0	0
Steelhead Salvage	Banks	Ab	0	0	1	22	33	9	30	22	7	0	0	0
Steelhead Salvage	Banks	Wet	0	0	1	10	14	5	29	14	2	0	0	0
Steelhead Salvage	Jones	Critical	0	0	0	3	30	30	67	4	0	0	0	0
Steelhead Salvage	Jones	Dry	0	0	0	6	-34	-32	69	10	-1	0	0	0
Steelhead Salvage	Jones	Bl	0	0	1	6	-29	-58	-4	7	0	3	0	0
Steelhead Salvage	Jones	Ab	0	1	1	15	-5	-58	-3	2	0	4	0	0
Steelhead Salvage	Jones	Wet	0	0	1	11	-13	-69	-1	2	0	2	0	0
Model 8.0 compared to 7.0														
Steelhead Salvage	Banks	Critical	0	0	0	15	58	234	25	-2	-1	-1	0	0
Steelhead Salvage	Banks	Dry	0	0	1	21	19	-3	34	12	1	0	0	0
Steelhead Salvage	Banks	Bl	0	0	2	29	-5	17	22	31	11	0	0	0
Steelhead Salvage	Banks	Ab	0	-1	0	25	30	11	31	22	6	0	0	0
Steelhead Salvage	Banks	Wet	0	0	1	10	17	10	30	15	2	0	0	0
Steelhead Salvage	Jones	Critical	0	0	0	5	21	-44	35	4	-3	0	0	0
Steelhead Salvage	Jones	Dry	0	0	0	5	-40	-46	57	7	-2	0	0	0
Steelhead Salvage	Jones	Bl	0	0	1	4	-32	-47	-4	2	-3	-1	0	0
Steelhead Salvage	Jones	Ab	0	0	1	16	20	-22	-2	-6	-1	0	0	0
Steelhead Salvage	Jones	Wet	0	1	1	8	-12	-52	-1	0	0	1	0	0

Species	Facility	WYType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Model 7.1 compared to 7.0														
Green Sturgeon	Banks	Critical	0	2	4	0	0	2	0	0	0	0	-1	1
Green Sturgeon	Banks	Dry	0	0	0	0	0	0	0	0	0	0	-3	0
Green Sturgeon	Banks	Bl	0	0	0	0	0	0	0	1	7	0	0	0
Green Sturgeon	Banks	Ab	-1	0	0	1	0	0	0	2	0	2	0	0
Green Sturgeon	Banks	Wet	0	0	0	0	0	0	1	0	0	1	-1	0
Green Sturgeon	Jones	Critical	0	0	0	0	0	0	1	0	0	0	0	0
Green Sturgeon	Jones	Dry	0	1	1	0	-1	0	0	0	0	3	-4	0
Green Sturgeon	Jones	Bl	0	0	0	0	0	0	0	0	0	0	0	0
Green Sturgeon	Jones	Ab	0	0	0	0	0	0	0	0	0	0	0	0
Green Sturgeon	Jones	Wet	0	0	0	0	0	0	0	0	0	0	0	0
Model 8.0 compared to 7.0														
Green Sturgeon	Banks	Critical	0	-2	2	0	0	3	0	0	0	0	-1	1
Green Sturgeon	Banks	Dry	0	0	0	0	0	0	0	0	0	0	-3	0
Green Sturgeon	Banks	Bl	0	0	0	0	0	0	0	1	8	0	0	0
Green Sturgeon	Banks	Ab	0	0	0	1	0	0	0	2	0	2	0	0
Green Sturgeon	Banks	Wet	0	0	0	0	0	0	1	0	0	1	1	0
Green Sturgeon	Jones	Critical	0	0	0	0	0	0	1	0	0	0	0	0
Green Sturgeon	Jones	Dry	0	1	1	0	-1	0	0	0	0	1	-6	0
Green Sturgeon	Jones	Bl	0	0	0	0	0	0	0	0	0	0	0	0
Green Sturgeon	Jones	Ab	0	0	0	0	0	0	0	0	0	0	0	0
Green Sturgeon	Jones	Wet	0	0	0	0	0	0	0	0	0	0	0	0

The months of greatest changes in loss or salvage between the base case (Study 7.0) and the future (Studies 7.1 and 8.0) are December through June for salmonids. Green sturgeon change is too irregular to summarize.

Indirect Losses to Entrainment by CVP and SWP Export Facilities

The FWS Service has conducted survival experiments in the Delta for many years. They have conducted yoy fall run survival experiments in the spring months, and late-fall run survival experiments in the fall and winter months using hatchery reared juvenile Chinook. One of the purposes of these experiments has been to try to determine the "indirect" effects of Delta exports on juvenile Chinook survival as they emigrate through the Delta. Ken Newman (2003) published an analysis using yoy fall run survival experiment results. Banks and Jones exports were significant in all three types of Newman's analyses (Table 13-22). It is difficult to separate Delta mortality caused by with Delta exports from natural Delta mortality. Newman's results are a low to moderate adverse effect of exports on Delta survival, of which direct mortality is a small part. Without more sophisticated modeling exercises, indirect Delta mortality caused by Delta exports are a relatively small adverse effect on salmonids and steelhead.

Table 13-22 Estimated coefficients and standard errors as subscripts for models of S and p under the TBP, PL and hierarchical formulations (Newman, 2003).

	Release-specific probability					
	Tri-Binomial Product		Pseudo Likelihood		Bayesian Hierarchical	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Intercept	1.31	0.06	1.66	0.37	0.59	0.1
Log flow	1.40	0.05	1.63	0.38	0.86	0.12
Turbidity	1.33	0.05	1.62	0.32	0.38	0.13
Gate	***-0.77***	***0.08***	***-1.19***	***0.65***	***-0.78***	***0.15***
Sacramento	-0.68	0.07	-0.79	0.65	-0.56	0.16
Release temp.	-0.58	0.03	-0.71	0.2	-0.80	0.09
Salinity	0.53	0.03	0.54	0.21	0.30	0.09
Exports	***-0.44***	***0.03***	***-0.38***	***0.25***	***-0.31***	***0.1***
Hatchery temp.	-0.31	0.03	-0.37	0.2	0.00	0.09
Tide	0.09	0.02	0.16	0.2	-0.04	0.06
Size	-0.05	0.03	-0.16	0.18	0.23	0.06
Courtland	0.01	0.07	0.31	0.57	-0.02	0.17
Intercept p	*	*	*	*	*	*
1988p	*	*	*	*	*	*
Variance Survival	*	*	*	*	0.14	0.01
Variance Probabilit	*	*	*	*	*	*

Clifton Court Forebay Aquatic Weed Control Program

The Department of Boating and Waterways (DBW) prepared an Environmental Impact Report (2001) for a two-year Komeen research trial in the Delta. They determined there were potential impacts to fish from Komeen treatment despite uncertainty as to the likelihood of occurrence. Uncertainties exist as to the direct impact that Komeen and Komeen residues may have on fish species. "The target concentration of Komeen is lower than that expected to result in mortality to most fish species, including delta smelt (Huang and Guy 1998). However, there is evidence that, at target concentrations, Komeen could adversely impact some fish species. The possibility exists that Komeen concentrations could be lethal to some fish species, especially during the first nine hours following application. Although no tests have examined the toxicity of Komeen to Chinook salmon or steelhead, LC50 data for rainbow trout suggest that salmonids would not be affected by use of Komeen at the concentrations proposed for the research trials. No tests have been conducted to determine the effect of Komeen on splittail, green sturgeon, pacific lamprey or river lamprey." (DBW, 2001).

In 2005, no fish mortality or stressed fish were reported during or after the treatment. The contractor, Clean Lakes, Inc was looking for dead fish during the Komeen application. In addition, no fish mortality was reported in any of the previous Komeen or Nautique applications. In 2005, catfish were observed feeding in the treatment zone at about 3 pm on the day of the application (Scott Schuler, SePro). No dead fish were observed. DWR complied with the NPDES permit that requires visual monitoring assessment.

Due to the uncertainty of the impact of Komeen on fish that may be in the Forebay, we will assume that all winter- and spring-run Chinook salmon, steelhead, and delta smelt in the Forebay at the time of application are taken. There has been only one green sturgeon at the SWP, 6/26/1996, in the salvage record during the April through June period. Figure 13-42 and Figure 13-43 are illustrations of the total (all runs) Chinook salmon loss at the SWP BPP during the period two weeks before and after Komeen or Nautique treatments from 1995 to 2006. The daily loss values vary greatly within treatments, between months and between years. Figure 13-46 illustrates the presence of delta smelt in the Forebay during treatments. There are no loss estimates for delta smelt, so the relationship between salvage and true loss of delta smelt in the Forebay in unknown.

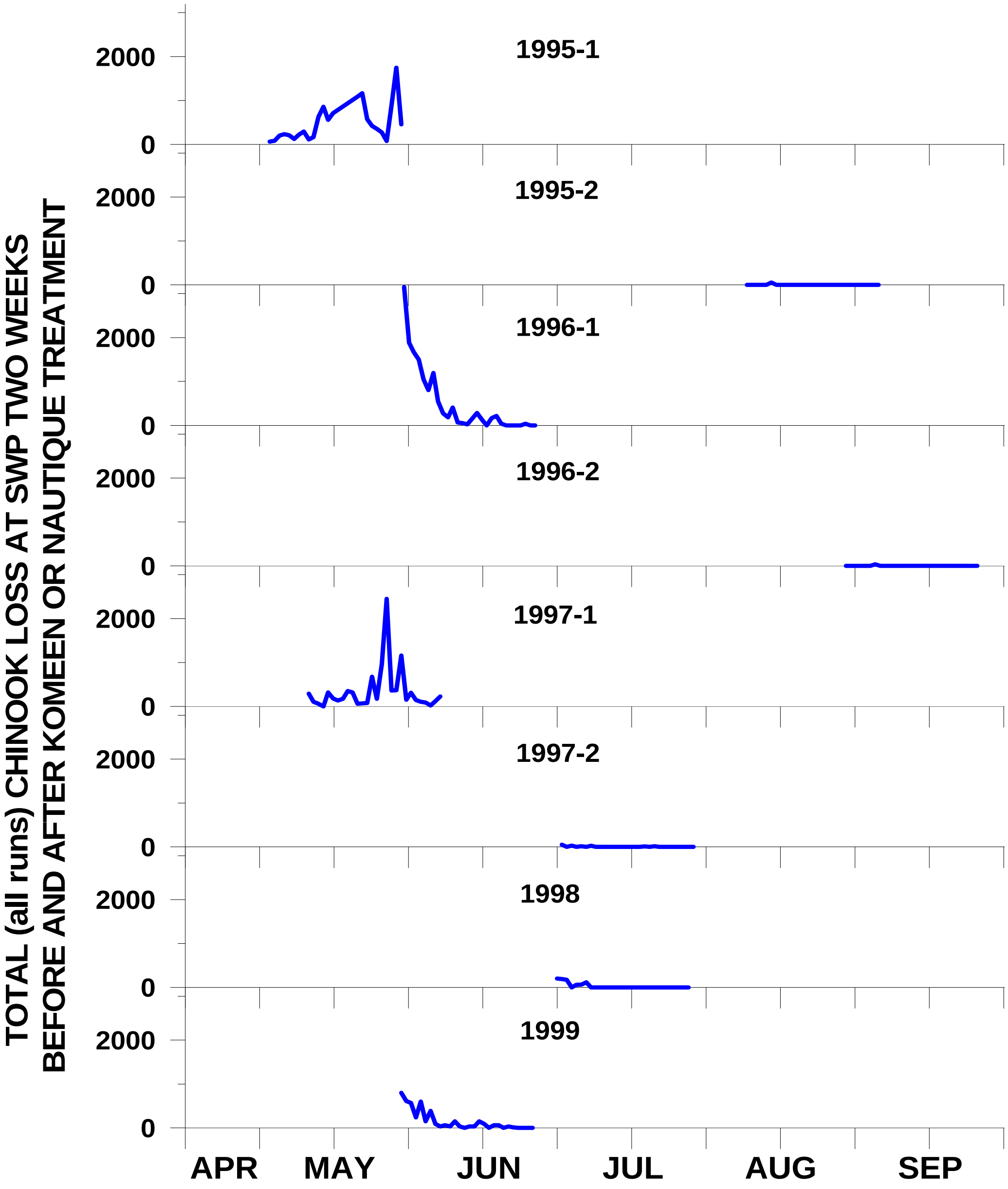

Figure 13-42 Total (all four runs) Chinook loss at the SWP Banks Pumping Plant two weeks before and after Komeen or Nautique aquatic weed treatment, 1995 – 1999.

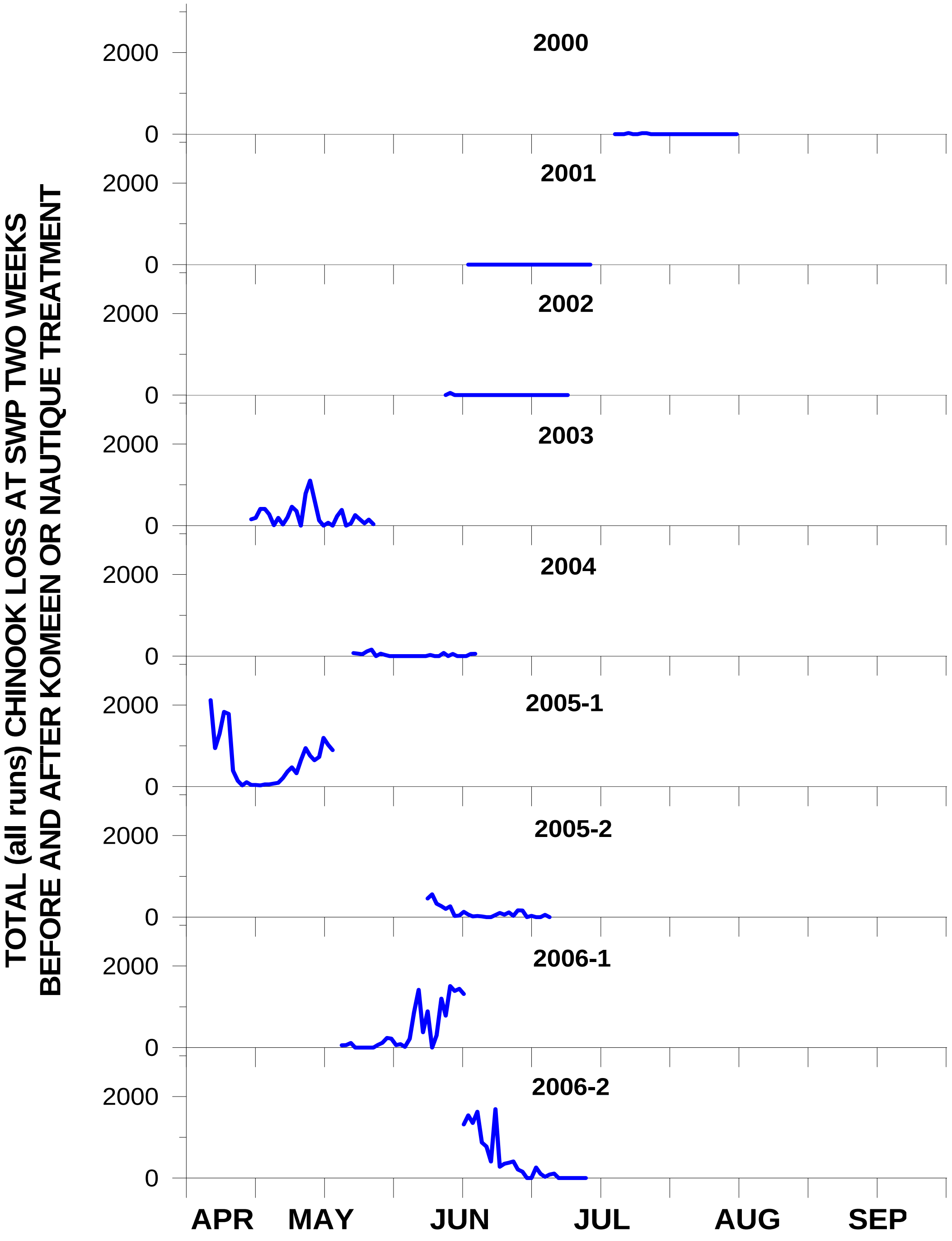

Figure 13-43 Total (all four runs) Chinook loss at the SWP Banks Pumping Plant two weeks before and after Komeen or Nautique aquatic weed treatment, 2000 - 2006.

Figure 13-44 and Figure 13-45 are illustrations of the steelhead salvage at the SWP BPP during the period two weeks before and after Komeen or Nautique treatments from 1995 to 2006. The salvage values vary greatly within treatments, between months and between years.

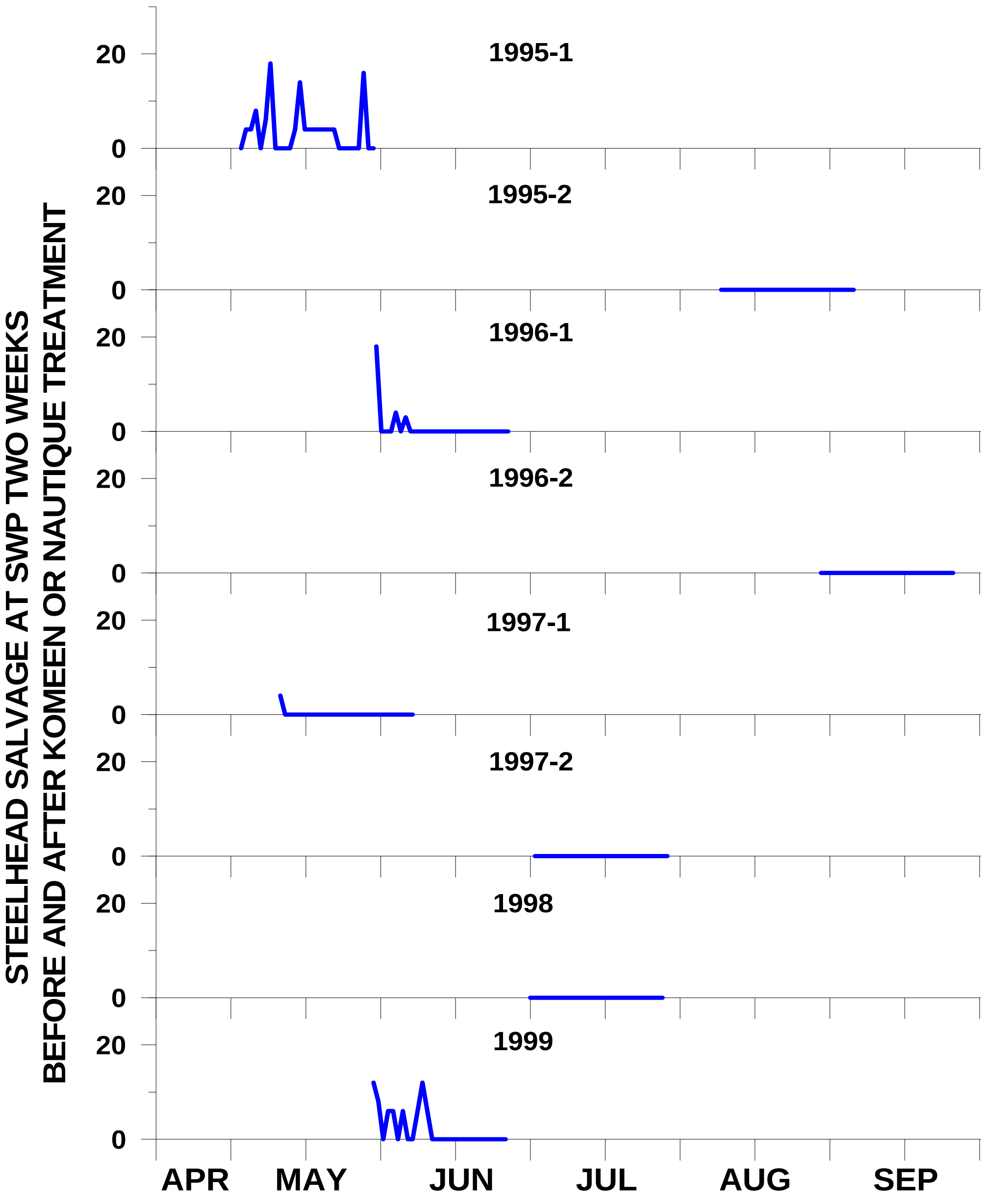

Figure 13-44 Steelhead salvage at the SWP Banks Pumping Plant two weeks before and after Komeen or Nautique aquatic weed treatment, 1995 – 1999.

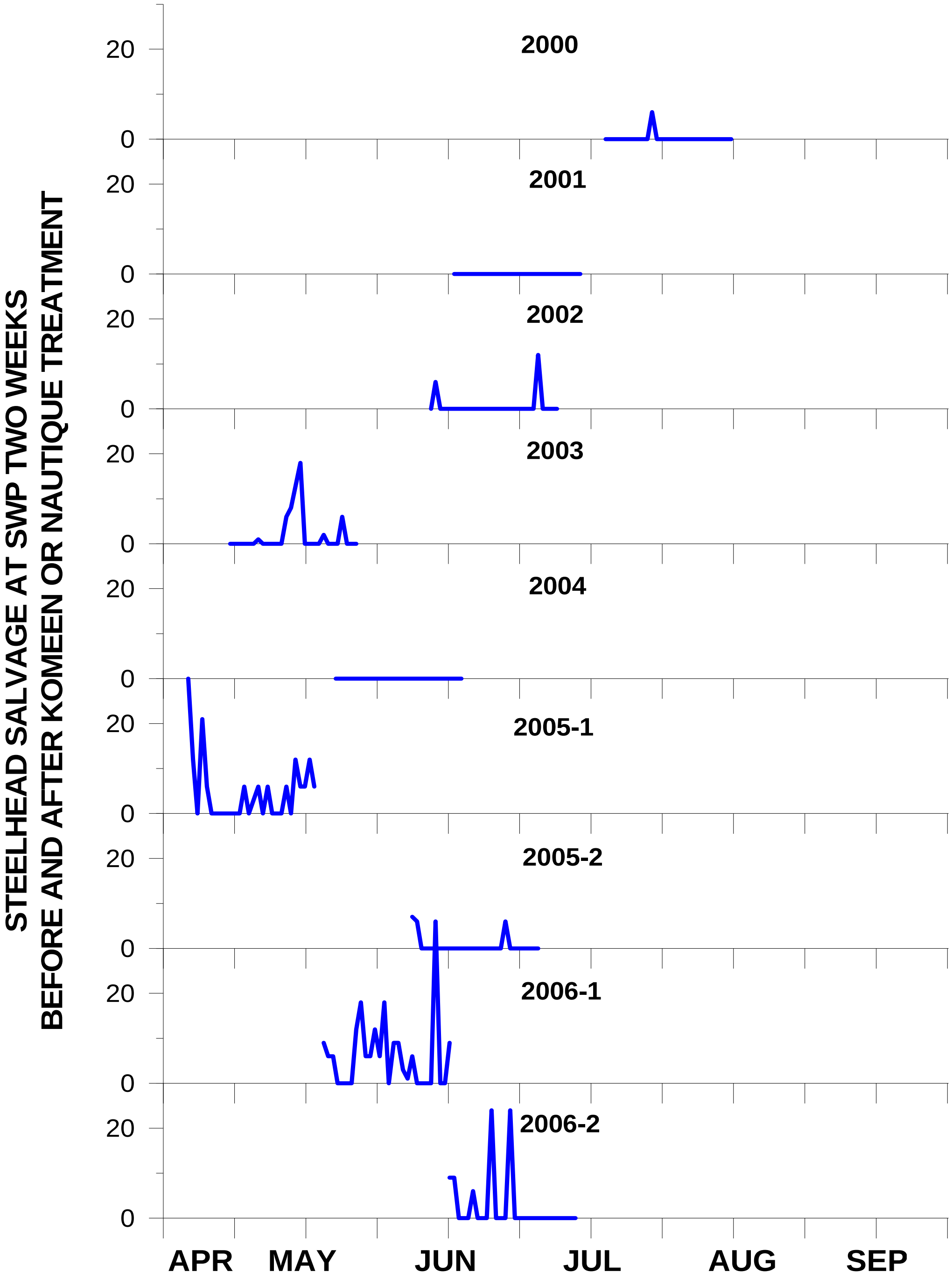

Figure 13-45 Steelhead salvage at the SWP Banks Pumping Plant two weeks before and after Komeen or Nautique aquatic weed treatment, 2000 – 2006.

To estimate the loss of listed Chinook salmon, winter and spring run, at the salvage facilities during Komeen or Nautique treatments, we used genetic characterization. The four Chinook runs look alike at the juvenile lifestage; therefore we used the average fraction of genetically identified winter- and spring-run Chinook lost at the SWP Salvage Facilities, during the historical treatment periods to extrapolate to the actual treatment times. The averages for winter run were 0 percent from the last half of April through July, and for spring run: last half of April – 1 percent, May – 5 percent, June – 1 percent, and July 0 percent. Table 13-23 is the fraction of genetically identified winter and spring-run Chinook lost at the SWP salvage facilities during the historical Komeen or Nautique treatment periods.

Table 13-23 Fraction of salvage sampled, fraction winter run of total Chinook loss based on genetic characterization, and fraction spring run of total Chinook loss based on genetic characterization. Time intervals are two weeks starting Mid-April and ending July.

			later April	
Year	Facility	Fraction Sampled	Fraction WinterRun	Fraction SpringRun
1997	SWP	0.21	0.00	*
1999	SWP	0.04	0.00	*
2000	SWP	0.05	0.00	*
2006	SWP	0.99	0.00	0.00
2007	SWP	0.99	0.00	0.02
Average			0.00	0.01

			earlier May			later May	
Year	Facility	Fraction Sampled	Fraction WinterRun	Fraction SpringRun	Fraction Sampled	Fraction WinterRun	Fraction SpringRun
1997	SWP	0.19	0.00	*	0.21	0.00	*
1999	SWP	0.08	0.00	*	0.10	0.00	*
2000	SWP	0.07	0.00	*	0.05	0.00	*
2006	SWP	0.98	0.00	0.00	1.00	0.00	0.06
2007	SWP	0.97	0.00	0.06	0.87	0.00	0.00
Average			0.00	0.03		0.00	0.03

			earlier June			later June	
Year	Facility	Fraction Sampled	Fraction WinterRun	Fraction SpringRun	Fraction Sampled	Fraction WinterRun	Fraction SpringRun
1997	SWP	0.33	0.00	*	0.30	0.00	*
1999	SWP	0.17	0.00	*	0.37	0.00	*
2000	SWP	0.00	*	*	0.00	*	*
2006	SWP	1.00	0.00	0.01	0.97	0.00	0.01
2007	SWP	1.00	0.00	0.00	*	*	*
Average			0.00	0.01		0.00	0.01

			earlier July			later July	
Year	Facility	Fraction Sampled	Fraction WinterRun	Fraction SpringRun	Fraction Sampled	Fraction WinterRun	Fraction SpringRun
1997	SWP	0.00	*	*	0.00	*	*
1999	SWP	0.00	*	*	*	*	*
2000	SWP	0.00	*	*	0.00	*	*
2006	SWP	0.91	0.00	0.00	*	*	*
2007	SWP	*	*	*	*	*	*
Average			0.00	0.00		*	*

To estimate the take of listed Chinook salmon and steelhead associated with Komeen or Nautique treatments, we estimated the total (all runs) Chinook salmon and steelhead in the Forebay from 1995 to 2006 during treatment times. We averaged the loss and salvage densities over the week prior to treatment, adjusted the total Chinook loss by the fractions of winter and spring run based on genetic identification, and extrapolated the loss and salvage densities to the approximate volume of water in the Forebay at treatment time. Table 13-24is the estimated take of listed Chinook salmon and steelhead in the Forebay during Komeen or Nautique treatments.

Table 13-24 Estimated take of listed Chinook (winter and spring run), and steelhead in the Forebay during Komeen or Nautique aquatic weed treatments, 1995 – 2006.

Date	Total Chinook Take In Forebay	Winter Chinook Take In Forebay	Spring Chinook Take In Forebay	Steelhead Take In Forebay
5/15/1995	2084.46	0.00	0.00	12.54
8/21/1995	0.00	0.00	0.00	0.00
6/11/1996	264.43	0.00	0.00	0.00
9/10/1996	1.59	0.00	0.00	0.00
5/23/1997	2010.80	0.00	0.00	0.00
7/14/1997	0.00	0.00	0.00	0.00
7/13/1998	0.00	0.00	0.00	0.00
6/11/1999	520.77	0.00	0.01	32.39
7/31/2000	5.88	0.00	0.00	1.24
6/29/2001	0.00	0.00	0.00	0.00
6/24/2002	0.00	0.00	0.10	0.00
5/12/2003	2923.82	0.00	0.00	9.59
6/3/2004	24.63	0.00	0.53	0.00
5/3/2005	846.09	0.00	0.00	17.64
6/20/2005	71.94	0.00	0.53	0.00
6/1/2006	554.64	0.00	0.40	53.44
6/28/2006	1089.62	0.00	0.00	13.21

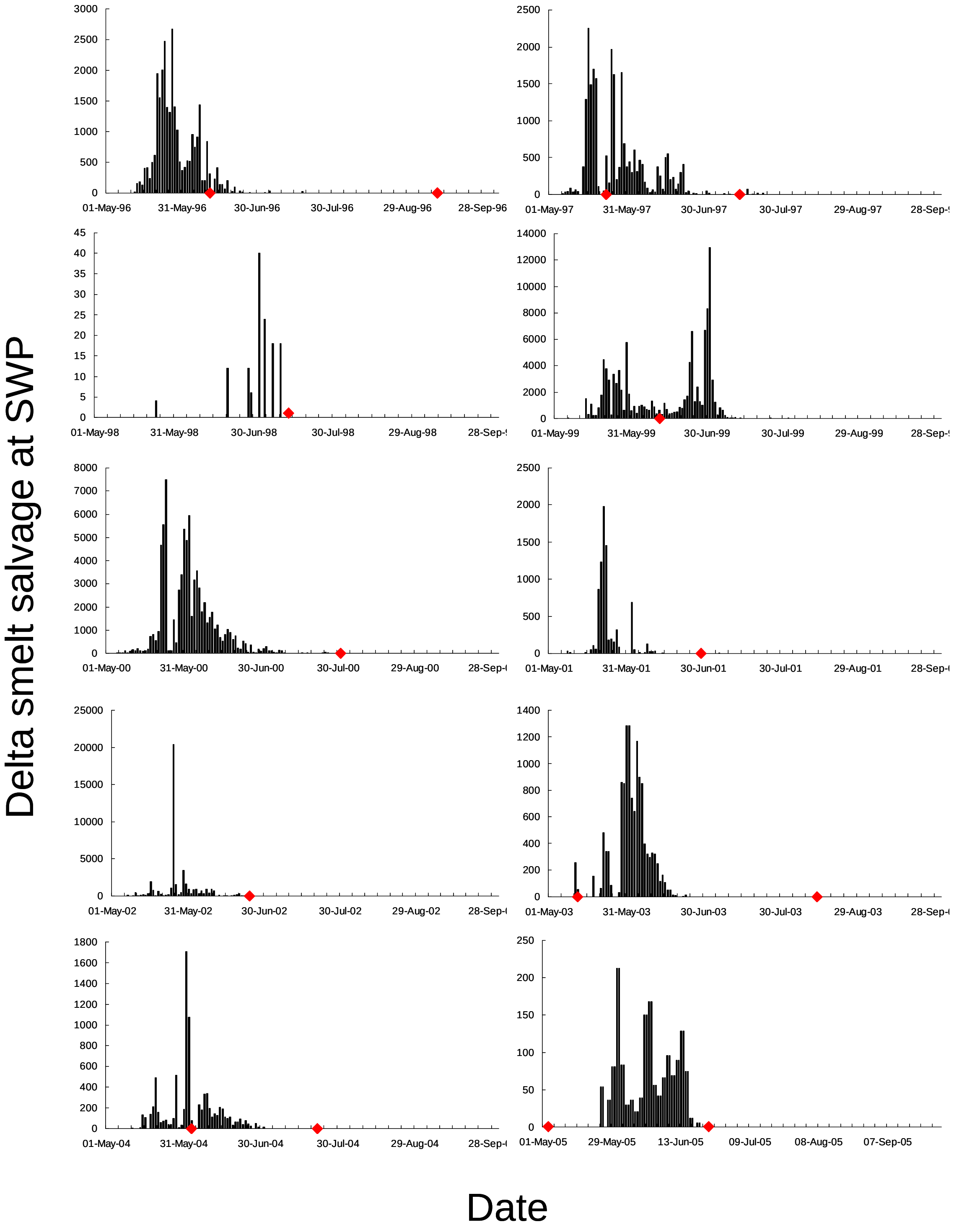

Figure 13-46 May-September delta smelt salvage at the SWP Banks Pumping Plant, 1996-2005, with the start and end dates of Komeen or Nautique aquatic weed treatment indicated by the red diamonds.

South Delta Temporary Barriers Project (TBP)

The TBP causes changes in the hydraulics of the Delta, which may pose impacts to fish. The TBP does not alter total Delta outflow, thus the position of X2, the linear position where bottom salinity measures two parts per million in the estuary, will not be affected by the project. However, the TBP does cause hydrodynamic changes within the interior of the Delta. When the HORB is in place, most water flow is effectively blocked from entering Old River. This in turn increases the flow in Turner and Columbia Cuts, two major central Delta channels that flow towards the south Delta (DWR 1992). The underlying result of this hydrodynamic change is that there is an increase in reverse flow in these and other interior Delta channels. In most instances, net flow is directed towards the CVP and SWP pumps. The directional flow towards the pumping facilities may increase the vulnerability of fish to entrainment by the pumps. Larval and small fishes are especially susceptible to these flows.

Unfortunately, the varying operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables prohibit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. The most effective direct method for examining the effect of the hydrodynamic consequences of the TBP on fish is by examining real-time fish salvage, however statistical results are lacking. Nobriga and others (2000) and Grimaldo (unpublished data) found that under certain conditions, salvage of delta smelt could increase dramatically when the TBP is operational. In 1996, the installation of the spring HORB caused a sharp reversal of net flow in the south Delta to the upstream direction. Coincident with this change was a strong peak in delta smelt salvage. This data indicates that short-term salvage, especially that of delta smelt and other small species and juveniles can significantly increase when the TBP is installed in such a manner that causes a sharp change or reversal of positive daily flow in the interior south and central Delta. Tidally averaged daily flow data for the south Delta was obtained from the U.S. Geological Survey to look for similar phenomena in previous years for a variety of fish species, however nothing was found to be as dramatic as that which occurred in 1996.

The Vernalis Adaptive Management Plan (VAMP), initiated in 2000 as part of the State Water Resources Control Board’s Decision 1641, is a large-scale, 12-year, interdisciplinary experimental program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Delta. VAMP is studying how salmon survival rates change in response to alterations in San Joaquin River flows and SWP/CVP exports with the installation of the HORB. VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future (USFWS 2007). In each year, VAMP schedules and maintains pulse San Joaquin River flows and reduced project exports for a one month period, typically from April 15 - May 15 (May 1-31 in 2005/06). Tagged salmon smolts released in the San Joaquin River are monitored as they move through the Delta in order to determine their fate. While VAMP studies attempt to limit project impacts to salmonids, the associated reduction in exports reduces the upstream flows that occur in the south and central Delta. This reduction limits the southward draw of water from the central Delta, and thus shortens the Projects’ zone of influence with regard to the passive entrainment of fishes.

DWR is applying particle tracking modeling techniques in an attempt to determine the effect of TBP operations on entrainment risk of fishes occurring within the vicinity of the south Delta pumps, with mixed but promising results (DWR 2006; Grimaldo unpublished data) (2007 Temporary Barrier Project Supplemental Biological Assessment).

The South Delta Temporary Barriers hydrodynamic effects were analyzed as part of the Initial Study/Negative Declaration in November 2000 for the years 2001-2007. As part of the analysis of effects of the project, an Action Specific Implementation Plan (ASIP) "was prepared by DWR for the South Delta Temporary Barriers Project under the guidelines of the CALFED document "User Guide for Preparing an Action Specific Implementation Plan (ASIP) under the CALFED Programmatic Multi-species Conservation Plan" and is tiered from the CALFED Programmatic EIR/EIS, Certified/Record of Decision issued August 28, 2000. ***The ASIP in whole is incorporated by reference as a part of this Initial Study***. "

Impacts to Fish.

The primary potential impacts of the project on the fish species are summarized on a month-by-month basis in Table 13-25. Expanded evaluations of specific impacts on each of the species are presented in detail in the ASIP.

Table 13-25 Summary of potential project related impacts of TBP to CALFED fish species

Month	Fish Species and Impacts
January	• No project
February	• No project
March	• No project
April 15 - 30	• Winter-run: adult/juvenile – } • Spring-run: adults – } • Fall-run: juveniles – }— blocked passage; increased reverse flow • Steelhead: juveniles – } • Delta smelt adults/juveniles/larvae – } • Splittail: adults/juveniles – }
May	• Winter-run: adults/juveniles – } • Spring-run: adults – } • Fall-run: juveniles – }— blocked passage; increased reversed flow • Steelhead: juveniles – } • Delta smelt: adults/juveniles/larvae –} • Splittail: adults/juveniles – }

June	• Fall-run: juveniles – } • Delta smelt: juveniles/larvae – }— blocked passage • Splittail: adults/juveniles – }
July	• Delta smelt: larvae – increased reverse flow; juveniles/larvae: blocked passage • Splittail: adults/juveniles – blocked passage
August	• Splittail: juveniles – increased reverse flow
September	• Fall-run: adults – increased reverse flow • Splittail: juveniles – increased reverse flow
October	• Winter-run juveniles: export losses; increased reverse flow • Fall-run: adults – increased reverse flow • Late fall-run: adults – increased reverse flow • Steelhead: adults – increased reverse flow; blocked passage
November 1-15	• Spring-run: juveniles – export losses; increased reverse flow • Late fall-run: juveniles – export losses; adults/juveniles – increased reverse flow • Steelhead: adults – blocked passage; increased reverse flow
December	• No project

Water year type and the specific distribution of fishes during a particular month may influence degree of project impacts. The potential impacts are described below:

Blocked passage due to barriers: Barriers impede or delay fish movements, resulting in increased risk to young fish of predation or entrainment in agricultural diversions, and reduced reproductive success of adult fish attempting to return to natal streams to spawn. The Fall HOR barrier is designed to improve salmon migration in the San Joaquin River but it may also block salmon that migrate through the interior Delta. The barrier is notched in the center to facilitate salmon passage. The three agricultural barriers will also be notched in the fall.

Increased reverse flow: Increased net upstream flow in channels leading from the central to the south Delta due to HOR barrier or three agricultural barriers acting together to form a hydraulic barrier. Result in transport of eggs and larvae to the south Delta, causing increased risk of predation, entrainment and other mortality. Also may and disorient migrating fish resulting in straying of juveniles and adults, causing increased mortality and reduced growth and reproductive success.

Export losses: Includes increased direct export losses due to entrainment, predation, and salvage losses at the SWP and CVP south Delta facilities. Also includes increased indirect losses due to effects of export pumping on in-Delta flow patterns, which affects transport and straying as described above.

Passage impacts to fish: The physical presence of the TBP facilities may block the passage of migratory or highly mobile fish in the Delta. To date, there is no direct blockage data available for any fish species, thus the potential impacts discussed below are inferred from historical migration timing and occurrence in the south Delta. The California Department of Fish and Game will be conducting a salmon tracking study during the fall of 2000 which, in part, is designed to assess the potential for migration blockage of the Temporary Barriers on fall- and late fall-run Chinook salmon. Information gained from this study can be used in the future to further assess impacts to migratory fish species.

Listed below are the mitigation measures DWR has done for the present permitted project operation period, followed by the mitigation measures DWR proposes for the next permitted operation period. The proposed conservation/mitigation measures for the next operational period are subject to CALFED regulatory agency approval. DWR will continue with a monitoring plan for the project in attempt to learn more about the environmental impacts caused by the placement of barriers in the south Delta. The elements of the monitoring plan are presented in Chapter 11.

Past Measures

Under Terms and Conditions 1 (e) of the USFWS Biological Opinion (4/26/96), DWR was required to install at least three fish screens on agricultural diversions per year in the Delta. To date, DWR has installed a total of 14 screens on agricultural diversions and has capped another diversion at Sherman Island, for a total of 15 screens (3 screens per year for the permit period). DWR also contributed to funding a study that examined the entrainment patterns of two side-by-side screened and unscreened diversions at Sherman Island.

Under Terms and Conditions 3 of the USFWS Biological Opinion (4/26/96), DWR was required to mitigate for the footprint of the Grant Line Canal barrier. DWR fulfilled this requirement by acquiring a 1:1 ratio of 0.064 acres of riparian scrub, 0.011 acres of shaded mudflat, 0.411 acres of shallow water, and 0.250 acres of intertidal vegetation at Kimball Island.

Under Condition 11 of the DFG 1601 Agreement (5/2/96), DWR was required to mitigate for the impact to shallow water habitat. DFG agreed to credit the Kimball Island mentioned above habitat purchase to satisfy this mitigation requirement.

Under Condition 16 of the DFG 1601 Agreement (5/2/96), DWR was required to screen two agricultural diversions in the Bay-Delta Estuary. The fish screen project at Sherman Island fulfilled this requirement.

Proposed measures for the operational period

Appropriate mitigation for the adverse environmental impacts caused by the Temporary Barriers Project will be developed through ESA consultation with the CALFED regulatory agencies. The development of mitigation measures through the consultation process will ensure that all adverse impacts are fully mitigated, and that the mitigation is consistent with the goals and objectives of the CALFED program. Mitigation measures required will become part of the project description and be included in the Final Mitigated Negative Declaration and Initial Study prior to the project beginning.

In addition to the mitigation developed through consultation, DWR will continue the operation and maintenance of all 14 fish screens that have been installed at Sherman Island. The previously mentioned DWR study on the entrainment patterns of two side-by-side screened and unscreened diversions at Sherman Island provided evidence that screens can protect fish from entrainment into agricultural diversions (Nobriga and others 2000).

An additional mitigation/conservation measure will be to notch each of the agricultural barriers similar to the HORB fall barrier to provide passage for migrating adult salmon that have strayed into Old and Middle Rivers and Grant Line Canal.

Delta Cross Channel

Juvenile salmon survival is higher when the fish remain in the Sacramento River, than when they migrate through the central Delta (Kjelson et al. 1982, Brandes and McLain 2001; Newman 2002). This has not been studied for steelhead, but they are likely affected in a similar manner, although to a lesser extent because steelhead emigrants are larger than Chinook. SWRCB D-1641 provides for closure of the DCC gates from February 1 through May 20. During November through January, the gates may be closed for up to 45 days for the protection of fish. The gates may also be closed for 14 days during the period May 21 through June 15. Reclamation shall determine the timing and duration of the closures after consultation with FWS, DFG, and NMFS. Consultation with the CALFED Operations Group will also satisfy the consultation requirement. The CALFED Ops Group has developed and implemented the Salmon Protection Decision Process. The Salmon Protection Decision Process depends on identifying the time when young salmon are likely entering the Delta and taking actions to avoid or minimize the effects of DCC and other Project operations on their survival in the Delta. The decision process identifies “Indicators of sensitive periods for salmon” such as hydrologic changes, detection of spring–run or spring–run surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites. These actions should provide protection to both steelhead and Chinook salmon for much of their peak emigration period. Figure 13-47 and Figure 13-48 show the percent of the Sacramento River flow passing through the DCC and through Georgiana Slough during critically dry years. Figure 13-49 shows the percent continuing on down the main Sacramento River channel. During the other water year types a lower percentage of flow passes through the DCC with the lowest percentage occurring in wet years. The percentage passing through the DCC increases in the future in June and August. The increased flow through the DCC occurs when few juvenile salmon or steelhead are present in the Delta. The cross channel gate closure in February through May and low percentage passing through the channel in December and January avoids the majority of salmon and steelhead emigrating from the Sacramento system.

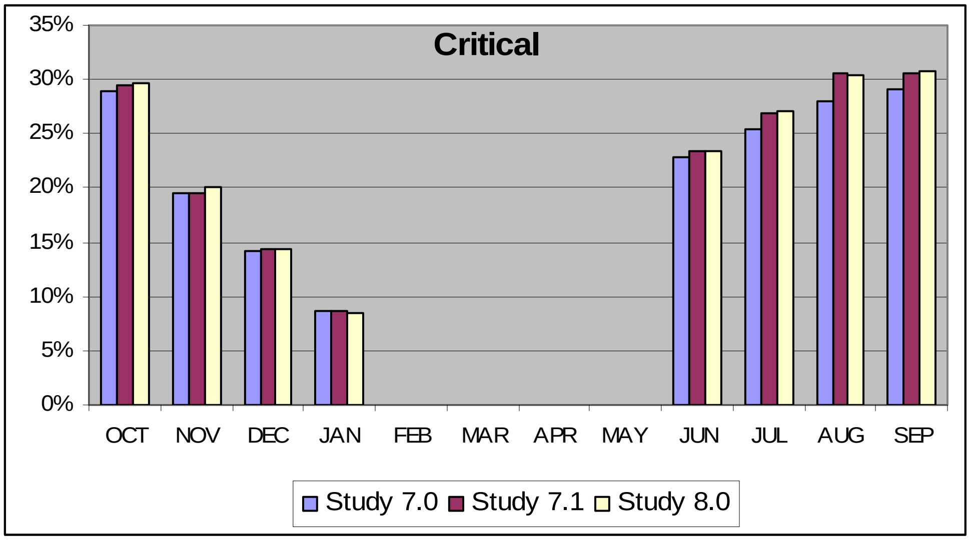

Figure 13-47 Percent of Sacramento River flow passing through the DCC during critically dry years under the three scenarios.

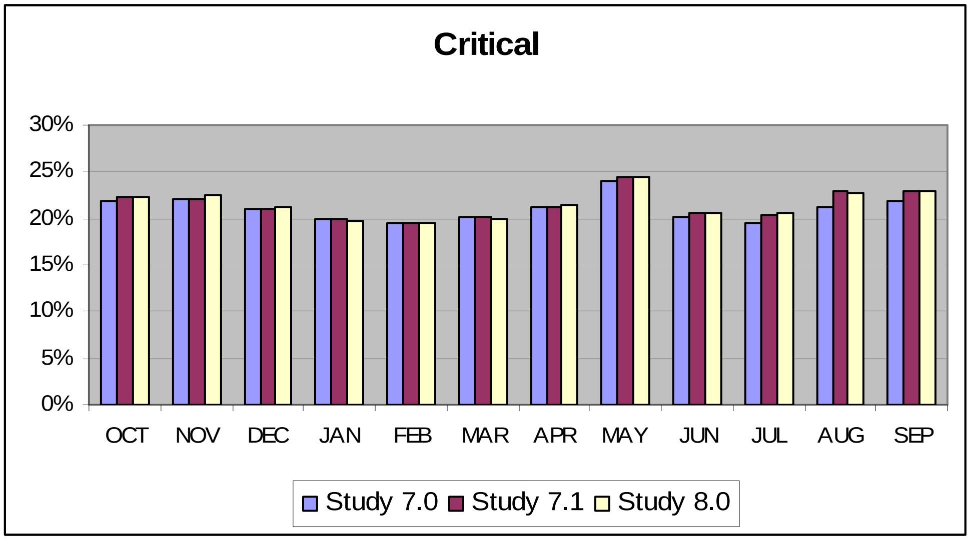

Figure 13-48 Percent of Sacramento River flow passing through Georgiana Slough during critically dry years under the three scenarios.

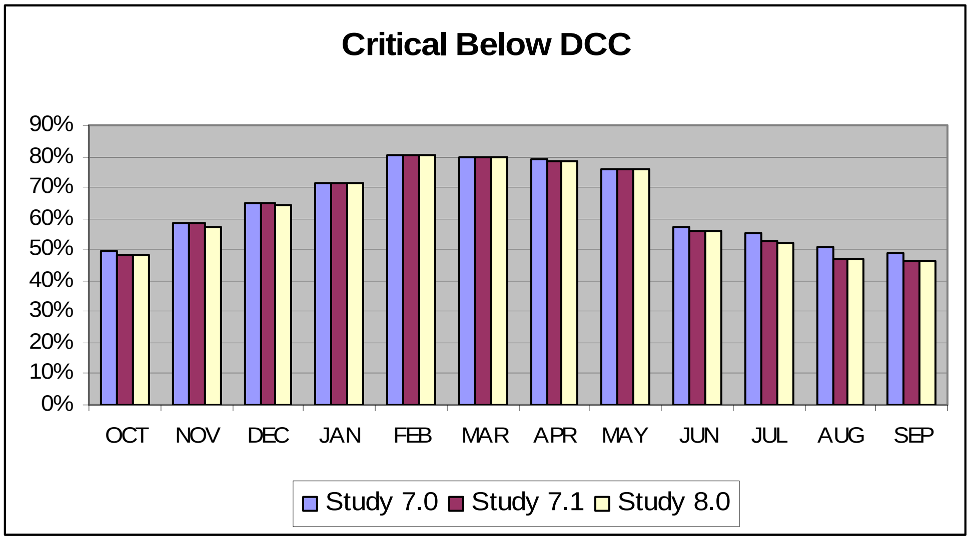

Figure 13-49 Percent of Sacramento River flow continuing down the main Sacramento River channel past the DCC and Georgiana Slough during critically dry years under the three scenarios.

North Bay Aqueduct

The maximum pumping capacity of the NBA facility is 175 cfs, but the mean is typically lower. The NBA facility has positive barrier fish screens built to DFG specifications to exclude juvenile salmon. The screens have approach velocities ranging between 0.2 and 0.4 feet per second. DFG has determined this is sufficient to prevent entrainment of juvenile salmonids. The facility is located at the end of Barker Slough, more than 10 miles from the mainstem Sacramento River. There is no information on salmonids migrating up Barker Slough.

Sommer et al. (2001b) reported the 1998 and 1999 Chipps Island survival indices were comparable to or higher for CWT Chinook released into Yolo Bypass than for fish released simultaneously in the Sacramento River. Similarly, Brandes and McLain (2001) found survival indices were higher for CWT Chinook that passed through the Steamboat-Sutter slough complex than for fish that traveled down the mainstem Sacramento River. Both Yolo Bypass and Steamboat Slough empty into Cache Slough placing fish closer to the NBA pumping plant than they would have been had they remained in the main river channel. This suggests the NBA facility does not significantly adversely impact juvenile salmonids traveling in the river or Cache Slough. The higher survival of Steamboat-Sutter smolts does not affect the conclusions of the Newman and Rice analyses.

Rock Slough Intake

CCWD diverts water from Old River via Rock Slough into the Contra Costa Canal at the Rock Slough Intake . The diversion is presently unscreened. Reclamation, in collaboration with CCWD, is responsible for constructing a fish screen at the Rock Slough Headworks under the Central Valley Project Improvement Act and under the 1993 USFWS Biological Opinion for the Los Vaqueros Project. Reclamation has received an extension on fish screen construction until December 2008, and is preparing to request a further extension until at least 2013 because the requirements for screen design will change as CCWD proceeds with its project to replace the earth-lined portion of the canal with a pipeline.

Before 1998, the Rock Slough Intake was CCWD's primary diversion point. It has been used less since 1998 when Los Vaqueros Reservoir and the Old River Pumping Plant began operating. The diversion at the headworks structure is currently sampled with a sieve net three times per week from January through June and twice per week from July through December. A plankton net is fished at the headworks structure twice per week during times larval delta smelt could be present in the area (generally March through June). A sieve net is fished at Pumping Plant #1 two times per week from the time the first Sacramento River winter-run Chinook salmon is collected at the CVP and SWP (generally January or February) through June. Numbers of listed fish species captured during monitoring are shown in Table 13-26.

The extrapolated numbers of steelhead entrained by the facility between 1994 and 1996 were low, ranging from 52 to 96 per year (Morinaka 1998). The extrapolated numbers of juvenile Chinook salmon (all races) entrained by the facility between 1994 and 1996 ranged from 262 to 642 per year (Morinaka 1998). Entrainment has decreased since Los Vaqueros Reservoir and the Old River Intake came on line in 1998 and Rock Slough Intake diversion decreased significantly. CCWD estimated entrainment levels based on salvaged fish numbers per amount of water pumped at the CVP and SWP from 1998 to 2008. They estimated entrainment within the Contra Costa Canal assuming diversions within Rock Slough of 37,700 acre feet per year for juvenile winter-run salmon are 8 per year and for juvenile spring-run salmon are 25 per year.

The Contra Costa Canal Replacement Project will replace the 4-mile unlined section of canal from Rock Slough to Pumping Plant #1 with a pipeline. The project is fully permitted (NMFS issued its concurrence letter on June 11, 2007 and USFWS issued a BO on June 21, 2007) and the first phase of the project is scheduled to begin in the Fall of 2008. When completed, the Canal Replacement project will eliminate tidal flows into the Canal intake section and should significantly reduce entrainment impacts and improve the feasibility of screening Rock Slough.

Because most diversions at the Rock Slough intake now occur during the summer months when salmon and steelhead are not present in the vicinity of the diversion and because very few listed fish species (one winter–run Chinook, 14 spring-run sized Chinook, 6 unclipped steelhead, and one delta smelt) have been captured during monitoring from 1998 to 2008, the Rock Slough diversion is not believed to be a significant source of mortality for any of the listed species. No green sturgeon have been captured at the site.

It is expected that entrainment in the future will be reduced with the addition of CCWD's Alternative Intake Project because CCWD diversions in general during the migration period will be reduced, with most of that reduction taking place at the Rock Slough intake. (See the July 3, 2007 NMFS biological opinion on the Alternative Intake Project). Few listed runs have been captured in sampling since 1996 so take of listed runs is expected to be very low, probably fewer than 50 spring–run, 50 winter–run, and 20 steelhead. Estimates of future losses of spring-run Chinook salmon and winter-run Chinook salmon at the Rock Slough Intake with the Alternative Intake Project in service have been made assuming future CCWD demands of 188,000 af/year. Based on average densities of the salmon in channels (from monitoring programs over the past 10 years), losses were estimated at about 5 winter-run and 16 spring-run juveniles per year.

Table 13-26 Summary of listed fish captured at the Rock Slough Headworks and Pumping Plant 1 and amount of water diverted each year, 1998 – 2008.

Summary of Sieve Net and Plankton Net Monitoring Conducted at the Rock Slough Headworks and Pumping Plant 1 (PP1) from August 1998 through March 2008.

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Totals
Months Monitoring Occurred	**Aug-Dec**	**Mar-Dec**	**Mar-Dec**	**Jan-Aug**	**Jan-Dec**	**Jan-Dec**	**Jan-Dec**	**Jan-Dec**	**Jan-Dec**	**Jan-Dec**	**Jan-Mar**	
Amount of Water Diverted at Rock Slough Acre Feet	68,683	43,037	51,421	26,749	35,904	27,302	31,283	35,686	43,273	39,366	5,848	408,552
Number of Headworks &PP1 Sieve Net Surveys	Unknown	Unknown	Unknown	Unknown	Unknown	35	102	131	133	107	54	**562**
Number of Headworks Plankton Net Surveys	Unknown	Unknown	Unknown	Unknown	10	0	34	26	15	23	10	**118**
Winter-run Chinook	Dec=1	0	0	0	0	0	0	0	0	0	0	**1**
Spring-run Chinook	0	0	0	0	0	0	Mar=1 Apr=5	May=4	May=4	0	0	**14**
Central Valley steelhead (unclipped)	0	0	0	0	0	0	0	Mar=2 Apr=1	Jan=1 Mar=1	May=1	0	**6**
Central Valley steelhead (clipped)	0	0	0	0	0	0	0	0	0	0	Feb=6 Mar=2	**8**
Central Valley steelhead (unknown)	0	0	0	0	0	0	0	Feb=1	0	0	0	**1**
Fall run/late fall run Chinook (unclipped)	0	0	May=3	0	0	0	Mar=2 Apr=3 May=1	Apr=2 May=6 Jun=1	May=1	0	0	**19**
Fall run/late fall run Chinook (clipped)	0	0	0	0	0	0	May=1	May=1	0	0	0	**2**
Green sturgeon	0	0	0	0	0	0	0	0	0	0	0	**0**
Delta smelt	0	0	0	0	0	0	0	Feb=1*	0	0	0	**1**
Longfin smelt	0	0	0	0	0	0	0	0	0	0	Mar=1**	**1**

Suisun Marsh Salinity Control Gates

The SMSCG could be operated as needed to meet State salinity standards in the marsh September through May, overlapping with an expected January through May peak emigration of steelhead through the Delta. However, young steelhead are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases revealed six steelhead were captured from 1979 through 1997. Only two of the six were sub-adult sized fish. The very low number of steelhead in the samples is partly due to poor capture efficiencies of the beach seines and otter trawl used in the UC Davis survey. However, 1,505 splittail greater than 200 mm, were collected by UC Davis sampling during the same period. Both adult splittail and yearling steelhead are excellent swimmers and are inefficiently sampled by the gear types used in this program. The much higher incidence of adult splittail in the samples suggests steelhead are relatively rare in the marsh. Furthermore, the marsh sampling collected more adult steelhead (4) than yearlings (2). The adults are larger and faster and therefore sampled less efficiently, providing additional evidence that yearling steelhead seldom occur in Suisun Marsh. The very infrequent occurrence of steelhead in the marsh suggests predation associated with migration delays is unlikely to significantly affect the steelhead population. As support for this hypothesis, steelhead were not listed as a prey item of striped bass or Sacramento pikeminnow captured near this facility between 1987 and 1993 (DWR 1997).

The Suisun Marsh Salinity Control Gates could potentially be operated September through May, overlapping with an expected November through May spring–run emigration. However, juvenile Chinook salmon of all races are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases showed only 257 juvenile Chinook salmon were captured from 1979 through 1997.

The infrequent occurrence of young Chinook in the marsh suggests that predation associated with migration delays is unlikely to significantly affect the spring–run or winter–run population. As support for this hypothesis, only three Chinook salmon were found in the stomachs of striped bass and pikeminnow captured near this facility between 1987 and 1993 (Heidi Rooks, pers. comm.).

Although young Chinook salmon will probably not be significantly affected by gate operations, it is possible upstream passage of adults could be influenced. Adult winter–run and spring–run may pass through the marsh channels from December through May when their migration could potentially be delayed. The SMSCG Steering Group decided based on preliminary results from the modified SMSCG tests that the slots resulted in less adult passage than the original flashboards. The modification made for the 2001-02 control season was to leave the boat lock at the SMSCG open at all times. This modification is currently being tested. It is hoped that this continuous opening at the structure will facilitate increased adult salmon passage. See “Suisun Marsh Salinity Control Gates” in Chapter 5 for more information.

Morrow Island Distribution System

The 1997 FWS BO issued for dredging of the facility included a requirement for screening the diversion to protect delta smelt. Due to the high cost of fish screens and the lack of certainty surrounding their effectiveness at MIDS, DWR and Reclamation proposed to investigate fish entrainment at the MIDS intake with regard to fishery populations in Goodyear Slough and to evaluate whether screening the diversion would provide substantial benefits to local populations of listed fish species. DWR staff monitored fish entrainment from September 2004 to June 2006 at the MIDS in Suisun Marsh to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations to provide data on the site-specific impact of the MIDS diversion with a focus on delta smelt and salmonids. Over 20 different species were identified during the sampling, yet only two fall-run sized Chinook salmon (south intake, 2006) and no delta smelt from entrained water were caught. Two species that associate with instream structures, threespine stickleback and prickly sculpin, comprised most of the entrained fish. DWR and Reclamation staff will continue coordination with the fishery agencies to address the screening requirement.

Reclamation and DWR continue to coordinate with the FWS, NMFS, and DFG regarding fish entrainment at this facility. The objective remains to provide the greatest benefit for aquatic species in Suisun Marsh. Studies suggest that GYS is a marginal, rarely used habitat for special-status fishes. Therefore, implementation and/or monitoring of a tidal restoration project elsewhere is emerging as the most beneficial and pratical approach (in lieu of installing and maintainging fish screens). Restoration of tidal wetland ecosystems is expected to aid in the recovery of several listed and special status species within the marsh and improve food availability for delta smelt and other pelagic organisms.

South Delta Improvements Project – Stage 1

Section 7 consultation on the hydrodynamic effects of implementing the South Delta Improvement Program Stage 1 are covered in this OCAP Biological Assessment, whereas the predation, passage and construction effects will be consulted on through a different process (see Chapter 2). The hydrodynamic effects are described below and the other effects (predation, passage and construction) are summarized below. For the full description and documentation of the background, methods of analysis and effects for all the impacts, refer to the *South Delta Improvements Program Action Specific Implementation Plan* (DWR and USBR 2006), and *South Delta Improvements Program EIS/EIR* (DWR and USBR 2006).

Spring-Run and Winter-Run Chinook

Gate operations would not likely adversely affect the rearing habitat. Operable gates would have beneficial impacts on movement of adult and juvenile Chinook. Gate operations would not affect water temperature, entrainment into diversions, or food production and availability of juvenile spring-run Chinook.

Central Valley Steelhead

The small loss of rearing habitat due to gate operations would not likely adversely affect rearing habitat for steelhead. Operable gates would have beneficial impacts on movement of adult and juvenile. Gate operations would not affect water temperature, entrainment into diversions, or food production and availability of steelhead. Contaminants associated with construction activities, including gate construction, placement of riprap, dredging, and maintenance dredging, could be introduced into the south Delta channels and could adversely affect steelhead during migration. However, environmental commitments, including an erosion and sediment control plan, SWPPP, hazardous materials management plan, spoils disposal plan, and environmental training, will be developed and implemented before and during construction activities. Construction of the gates would also include placement of sheetpiles and riprap and could directly injure fish present during the time of construction. Dredging could entrain and injure juvenile steelhead. Cofferdams, if used, could trap juvenile steelhead. Steelhead that become trapped inside the cofferdams could be killed during desiccation of the construction area and other construction activities. Direct injury associated with construction and maintenance activities, including dredging, would have a less-than-significant impact on steelhead. The addition of structure has the potential to increase the density of predator species and predation on steelhead moving around and past the structure. Predation associated with the addition of the operable gates and the agricultural intake extensions to the south Delta channels could cause a small and likely negligible (i.e., less-than-significant impact) increase in mortality of the juvenile steelhead moving past the structures. Closure of the head of Old River fish control gate would minimize the movement of juvenile steelhead into Old River. In comparison to the existing temporary barriers, an operable gate would provide increased opportunities for fish protection in response to new information on fish survival for variable flows and migration pathways. The increased flexibility is a beneficial impact. The head of Old River fish control gate may also provide benefits to adult steelhead during upstream migration in September through March. The benefits would be similar to those described for adult Chinook salmon relative to movement in the San Joaquin River past Stockton.

Green Sturgeon

Green sturgeon rear in the Delta and Suisun Bay, but there is no data indicating which areas are used by juvenile green sturgeon. Gate operations in the Delta have the potential to permanently modify channel bottom areas that may provide rearing habitat for juvenile green sturgeon. The flexible operation of the permanent flow control gates in Middle River, Grant Line Canal, and Old River at DMC will have a beneficial impact on green sturgeon movement relative to the existing temporary barriers. The design of the gate structures also will ensure successful passage of the agricultural gates by adult and juvenile sturgeon when the gates are down. Hydraulic conditions (e.g., water depth and flow velocity) at the permanent gates when the gates are down will be relatively unchanged, further ensuring that suitable passage conditions for adult and juvenile green sturgeon are maintained. Although the impacts of gate closure are similar for both baseline conditions and the SDIP, the operable gates will provide increased opportunities for green sturgeon to move about in Old River relative to existing conditions. Gate operations would not affect water temperature or entrainment into diversions. Contaminants associated with construction activities, including gate construction, placement of riprap, dredging, and maintenance dredging, could be introduced into the south Delta channels and could adversely affect adult green sturgeon during migration and juveniles rearing in the Delta. Construction of the gates would also include placement of sheet-piles and riprap and could directly injure fish present during the time of construction. Dredging could entrain and injure green sturgeon. Cofferdams, if used, could trap juvenile and adult green sturgeon. Direct injury associated with construction and maintenance activities, including dredging, would have a less than significant impact on green sturgeon. . If green sturgeon migrate through the South Delta, the gate closure could minimize the movement of green sturgeon into the Sacramento River and out to the Pacific Ocean. However, closure of the Old River fish control gate would not preclude juvenile and adult sturgeon movement between the San Joaquin River upstream of Old River and the Sacramento River or Pacific Ocean. Closure of the head of Old River fish control gate increases the San Joaquin River flow past Stockton and green sturgeon that may migrate through the South Delta would presumably use the route past Stockton to migrate into the Sacramento River and out to the Pacific Ocean.

Water Transfers

Water transfers would increase Delta exports from about 60,000 to 500,000 acre-feet (af) in the wettest 80 percent of years and potentially more in the driest 20 percent years, and up to 1,000,000 af in the most adverse Critical year water supply conditions. Most transfers will occur at Banks (SWP) because reliable capacity is not likely to be available at Jones (CVP) except in the driest 20 percent of years. Most of the transfers would occur during July through September. Juvenile salmonids are rarely present in the Delta in these months, so no increase in salvage due to water transfers during these months is anticipated. Water transfers could be beneficial if they shift the time of year that water is pumped from the Delta from the winter and spring period to the summer, avoiding periods of higher salmonid abundance in the vicinity of the pumps. Some adult salmon and steelhead are immigrating upstream through the Delta during July through September. Increased pumping is not likely to affect immigrating adults because they are moving in a general upstream direction against the current. For transfers that occur outside of the July through September period, all current water quality and pumping restrictions would still be in place to limit effects that could occur.

Post-processing of model data for Transfers

This section shows results from post-processed available pumping capacity at Banks and Jones for the Study 8.0 (Future Conditions - 2030). These results are used for illustration purposes. Results from the Existing Conditions CVP-OCAP study alternatives do not differ greatly from those of Study 8.0, and produce similar characteristics and tendencies regarding the opportunities for transfers over the range of study years. The assumptions for the calculations are:

- Capacities are for the Late-Summer period July through September total.
- The pumping capacity calculated is up to the allowable E/I ratio and is limited by either the total physical or permitted capacity, and does not include restrictions due to ANN salinity requirements with consideration of carriage water costs.
- The quantities displayed on the graph do not include the additional 500 cfs of pumping capacity at Banks (up to 7,180 cfs) that is permitted to offset reductions previously taken for fish protection. This may provide up to about 90 taf of additional capacity for the July-September period, although 60 taf is a better estimate of the practical maximum available from that 500 cfs of capacity, allowing for some operations contingencies.
- Figure 13-50 and Figure 13-51 show the available export capacity from Study 8.0 (Future Conditions-2030) at Banks and Jones, respectively, with the 40-30-30 water year type on the x-axis and the water year labeled on the bars. The SWP allocation or the CVP south of Delta Agriculture allocation is the allocation from CalSim II output from the water year.

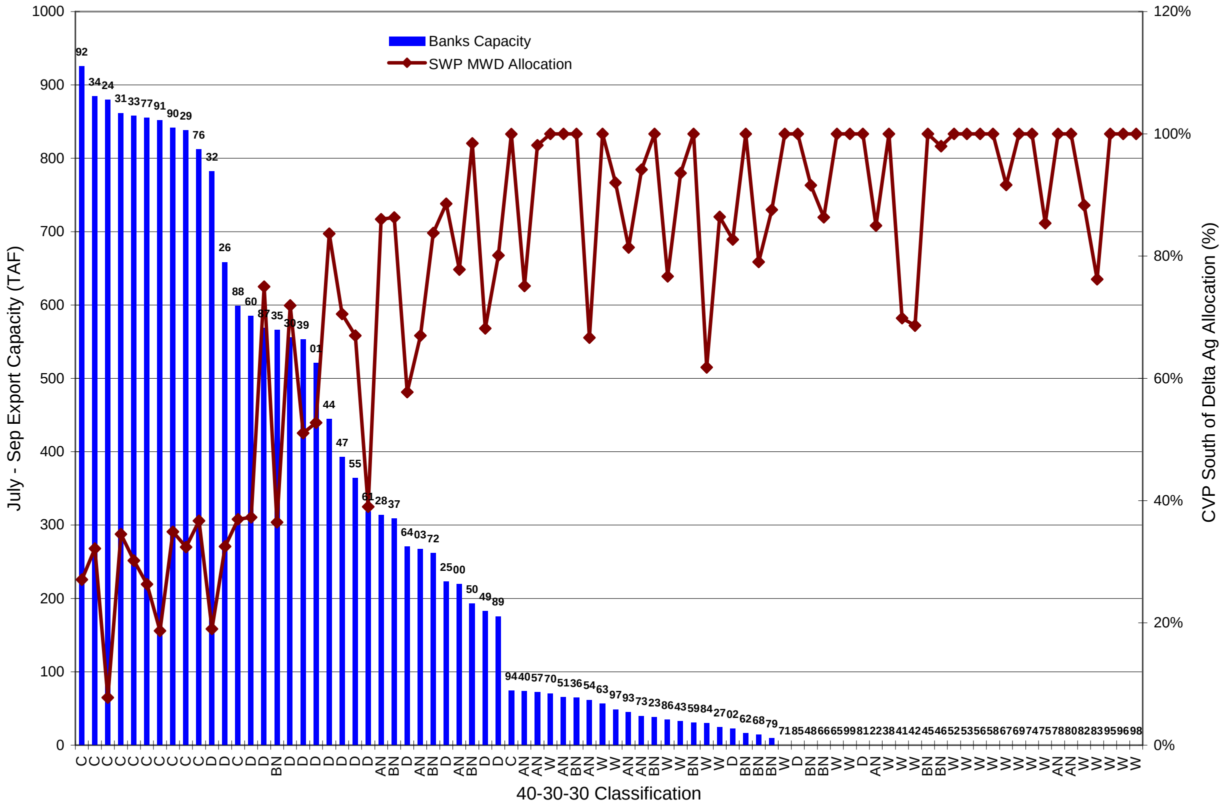

Figure 13-50 Available Export Capacity at Banks Pumping Plant

From Figure 13-50, the most capacity at Banks will be available in Critical and some Dry years (driest 20 percent of study years) which generally have the lowest water supply allocations, and reflect years when transfers may be higher to augment water supply to export contractors. For the other 80 percent of study years (generally the wettest 80 percent) the available capacity at Banks for transfer ranges from about 60 to 500 taf (if the additional 60 taf accruing from the proposed permitted increase of 500 cfs at Banks is included). Transfers at Jones (Figure 13-51) are probably most likely to occur in the driest 20 percent of years (Critical years and some Dry years) when there is available capacity and low allocations.

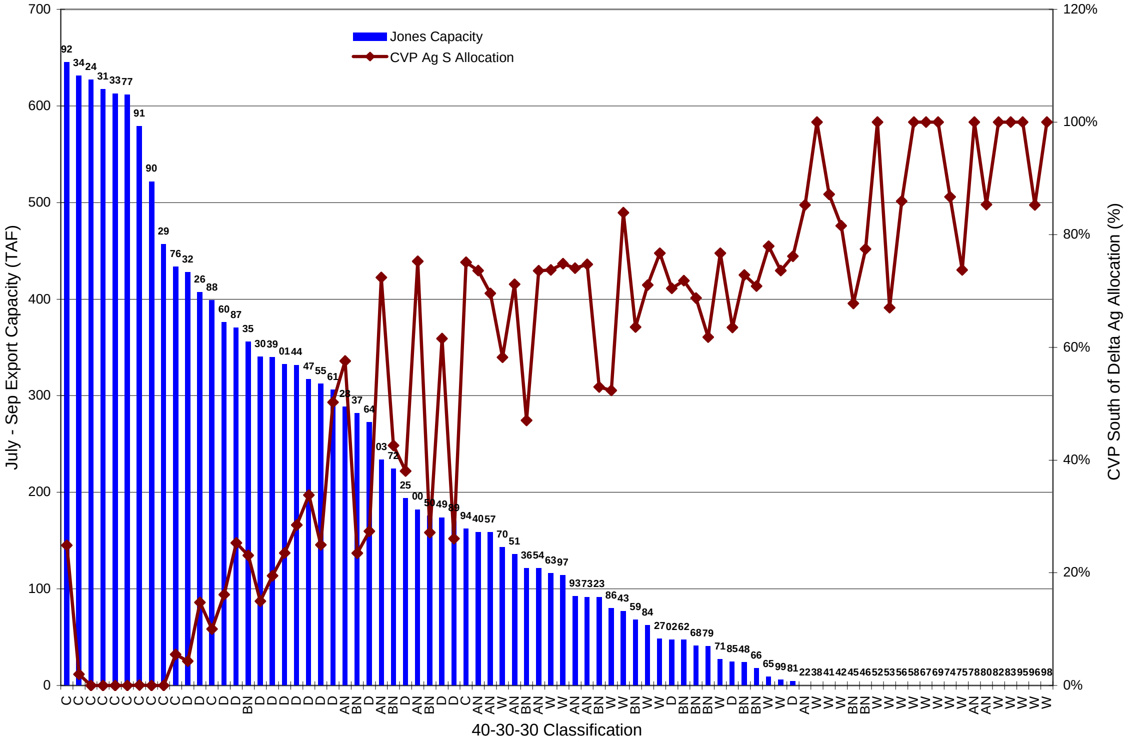

Figure 13-51 Available Export Capacity at Jones Pumping Plant

Limitations

The analysis of transfer capacity available derived from the CalSim IIstudy results shows the capacity at the export pumps and does not reflect the amount of water available from willing sellers or the ability to move through the Delta. The available capacity for transfer at Banks and Jones is a calculated quantity that should be viewed as an indicator, rather than a precise estimate. It is calculated by subtracting the respective project pumping each month from that project’s maximum pumping capacity. That quantity may be further reduced to ensure compliance with the Export/Inflow ratio required. In actual operations, other contingencies may further reduce or limit available capacity for transfers: for example, maintenance outages, changing Delta outflow requirements, limitations on upstream operations, water level protection criteria in the south Delta, and fishery protection criteria. For this reason, the available capacity should be treated as an indicator of the maximum available for use in transfers under the assumed study conditions.