affect flows. Thus, this factor is considered to have no influence on the current condition of PCE #4

Nonnative Species

A dramatic decline in primary production in the Estuary was documented following the introduction of the overbite clam into the lower Estuary in 1986 (Alpine and Cloern 1992; Jassby et al 2002).

In the Western Delta, the food web may be compromised by overgrazing by overbite clam that can suppress phytoplankton biomass, and the abundance of delta smelt's prey (Kimmerer and Orsi 1996, Jassby et al 2002). The chronic low outflow conditions during summer and fall may increase the reproductive success and upstream range of overbite clam.

Climate Change

There are currently no published analyses of how ongoing climate change has affected the current condition of any of the primary constituent elements of delta smelt critical habitat. Climate change could have caused shifts in the timing of flows and water temperatures in the Delta which could lead to a change in the timing of migration of adult and juvenile delta smelt.

Effects of the Proposed Action

Introduction

The Status of the Species/Environmental Baseline section of this document described the multitude of factors that affect delta smelt population dynamics including predation, contaminants, introduced species, entrainment, habitat suitability, food supply, aquatic macrophytes, and *microcystis*. The extent to which these factors adversely affect delta smelt is related to hydrodynamic conditions in the Delta, which in turn are controlled to a large extent by CVP and SWP operations. Other sources of water diversion (NBA, CCWD, local agricultural diversions, power plants) adversely affect delta smelt largely through entrainment (see following discussion), but when taken together do not control hydrodynamic conditions throughout the Delta to any degree that approaches the influence of the Banks and Jones export facilities. So while many of the other stressors that have been identified as adversely affecting delta smelt were not caused by CVP and SWP operations, the likelihood and extent to which they adversely affect delta smelt is highly influenced by how the CVP/SWP are operated in the context of annual and seasonal hydrologic conditions. While research indicates that there is no single primary driver of delta smelt population dynamics, hydrodynamic conditions driven or influenced by CVP/SWP operations in turn influence the dynamics of delta smelt interaction with these other stressors (Bennett and Moyle 1996).

The following analysis focuses on the subset of factors that is affected or controlled by CVP/SWP operations, and includes a discussion of other factors to the extent they modulate or otherwise affect the CVP/SWP-related factors affecting delta smelt. Although it is becoming increasingly clear that the long-term decline of delta smelt has been affected by ecosystem changes caused by non-indigenous species invasions and other non-CVP/SWP factors, the CVP and SWP have played an important direct role in that decline. The CVP and SWP have also played an indirect role in the delta smelt's decline by creating an altered environment in the Delta that has fostered the establishment of non-indigenous species and exacerbates these and other stressors that are adversely impacting delta smelt. This analysis and others show that every day the system is in balanced conditions, the CVP and SWP are a primary driver of delta smelt abiotic and biotic habitat suitability, health, and mortality. However, the Service is relying on the findings of Bennett and Moyle (1996) and Bennett (2005), and the consensus emerging from the POD investigation (Sommer et al. 2007, Baxter et al. 2008), by assuming that delta smelt abundance trends have been driven by multiple factors, some of which are affected or controlled by CVP/SWP operations and others that are not. The decline of delta smelt cannot be explained solely by the effects of CVP/SWP operations.

This analysis of the effects of proposed CVP/SWP operations on delta smelt differs from the 2005 biological opinion in that it analyzes CVP/SWP-related effects in the context of a life-cycle model for delta smelt (Table E-1). In the following discussion, the effects of proposed CVP/SWP operations on delta smelt are organized in a seasonal context from winter through fall over the course of the annual delta smelt life cycle. Although all types of effects are covered, there is a specific focus on three major seasonally-occurring categories of effects: entrainment of delta smelt, habitat restriction, and entrainment of *Pseudodiaptomus forbesi*, the primary prey of delta smelt during summer-fall.

The following analysis assumes that the proposed CVP/SWP operations affect delta smelt throughout the year either directly through entrainment or indirectly through influences on its food supply and habitat suitability. During December-June, when delta smelt are commonly entrained at Banks and Jones, their habitat and co-occurring food supply also are being entrained, so CVP/SWP-related effects on habitat and food supply are only examined explicitly during July-December when delta smelt entrainment is rare. Delta smelt entrainment is rare from about mid-July through mid-December each year mainly because environmental conditions in the San Joaquin River and its distributaries are not appropriate to support delta smelt. The water is too warm and clear, so delta smelt actively avoid the Central and South Delta during summer and fall (Feyrer et al. 2007; Nobriga et al. 2008).

Our analysis also assumes that any of these three major categories of effects described above will adversely affect delta smelt, either alone or in combinations. This approach is also consistent with Rose (2000), who used several different individual-based models to show how multiple interacting stressors can result in fish population declines that would not be readily discernable using linear regression-based approaches.

Table E-1. The distribution of three categories of effects caused by proposed CVP/SWP operations over the life cycle of delta smelt.

Season	Delta smelt entrainment	Pseudodiaptomus entrainment/retention	Habitat suitability
Winter	X (adults)[a]		
Spring	X (larvae/juveniles)[b]		
Summer		X[c]	
Fall			X[d]

[a] Historical hydrodynamic data are DAYFLOW 1967-2007; OMR was measured 1993-2007 and estimated using regression on DAYFLOW variables by Cathy Ruhl (USGS) for 1967-1992; historical delta smelt salvage data are 1993-2007, the period when the data are considered most reliable.

[b] Historical hydrodynamic data are DAYFLOW 1967-2007 (except OMR as noted in the previous footnote); direct estimates of larval-juvenile entrainment are 1995-2005. (Kimmerer 2008); Entrainment was estimated statistically for 1967-1994 and 2006-2007

[c] Historical hydrodynamic data (DAYFLOW; except OMR 1988-1992, see footnote a) and Pseudodiaptomus density data (IEP monitoring) are 1988-2006 because Pseudodiaptomus was introduced in 1988.

[d] Historical hydrodynamic data are DAYFLOW 1967-2007.

Data and Models used in the Analysis

This analysis of the effects of proposed CVP and SWP operations on the delta smelt and its critical habitat uses a combination of available tools and data, including the CALSIM II model outputs provided in the appendices of Reclamation's 2008 biological assessment, historical hydrologic data provided in the DAYFLOW database, statistical summaries derived from 936 unique 90-day particle tracking simulations published by Kimmerer and Nobriga (2008), and statistical summaries and derivative analyses of hydrodynamic and fisheries data published by Feyrer et al. (2007), Kimmerer (2008), and Grimaldo et al. (accepted manuscript).

The biological assessment suggested using CALSIM II study 7.0 as the current baseline, and 6.1 as the historical baseline but the CALSIM monthly simulation model does not capture a precise Delta operation. When Study 6.1 was modeled, changes were expected between Study 6.1 and Studies 7.0 and 7.1 but the results in the August 2008 biological assessment were nearly identical (which differed from the May 2008 biological assessment model outputs where there had been a difference between those study runs). On page 9-32 of the 2008 biological assessment there is discussion of the various studies, including study 6.1 taken from the text: "Study 6.1 – This study represents the previous

OCAP biological assessment 2004 assumptions also within the new CALSIM II model framework. Conditions for water demands, facilities, and water project-operational policy are duplicated, to the extent possible, to Study 3a, but this is simulated only through the CVPIA (b)(2) step. This study is identical to Study 6.0 in the OCAP biological assessment May 2008 issue and is included to emulate pre-POD conditions. Study 6.1 is an imperfect representation of the pre-POD and supplemental analysis should be evaluated to compensate for this modeling limitation (discussed in Chapter 13: CVP and SWP Delta Effects). " The modeling done in the 2004 OCAP biological assessment is shown in Table E-2.

Table E-2. Summary of assumptions in the 2004 OCAP CALSIM II runs.

	Level of Development	Article 21	Refuge Deliveries	Trinity Required Flows	D1485	Winter-Run B.O.	D1641	CVPIA 3406 (b)(2)	EWA
Study A D1485 (1991)	2001		Historical Level 2	340,000 af/yr	X				
Study B D1485 w/ Refuge Firm Level 2 (1992)	Same as above		Firm Level 2	Same as above	X				
Study C D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)	Same as above		Same as above	Same as above	X	X			
Study D D1641 (1994)	Same as above		Same as above	Same as above		X	X		
Study 1 D1641 w/ CVPIA 3406 (b)(2) (1997)	Same as above	X	Same as above	Same as above		X	X	X	
Study 3 Today CVPIA 3406 (b)(2) with EWA (2004)	Same as above	X	Same as above	369,000-453,000 af/yr		X	X	X	X

A number of CALSIM II model updates and changes in assumptions have been revised from the 2004 biological assessment to the 2008 biological assessment. A summary of these changes are provided the Table E-3.

Table E-3. Changes in CALSIM II model updates and assumptions from 2004 to 2008.

Major Model updates		
Area	**2004 BA**	**2008 BA**
Hydrology	73 years (1922-1994)	82 years (1922-2003)
San Joaquin River	Derived from older logic	Water Quality and hydrology Updated
Yuba	Timeseries from DWR's HEC-5 external model	Timeseries from updated, YCWA external model

Colusa Basin	Colusa Basin within Hydrology	Improved Hydrology and more explicit operation
Sacramento River Hydrology	No explicit rice decomposition, within hydrology	Included Rice Decomposition water
State Project	Assumed variable Table A demand and some Article 21	Updated 3 pattern with Article 56 and more accurate Table A and Article 21 split
ANN – Delta Salinity Estimate	2004 version of ANN	Training of ANN improved between DSM2 by including tidal energy and now using DSM2 trained X2
Level of Development	Current 2001 & Future 2020	Current 2005 & Future 2030
Major Assumptions	**2004 BA**	**2008 BA**
American River Demands	Future demands based on Water Forum assumptions	Future demands based on full contract amounts
State Demands	Future Table A 3.3-4.1 MAF and Article 21 demand 134 TAF/month (Dec-Mar)	Future Full Table A (4.2 MAF) and Article 21 demand 314 TAF/month (Dec-Mar)
EWA	Future with Full EWA and different logic for assets, debts, and actions	Future with Limited EWA with updated more explicit asset, debt, and action logic
Refuge	Firm Level 2	Recent Historic (existing), Firm Level 2 (future)
San Joaquin River	Fixed Annual demands	Updated land based demand
Trinity Note	Flows 340 TAF in current or 369-453 TAF and 369-815 in ROD for future	Trinity current level is 369-815 from the ROD

The inaccuracies in CALSIM lead us to use actual data to develop an empirical baseline. We also developed historical time series data for hydrologic variables used in this effects analysis based on the DAYFLOW database (http://iep.water.ca.gov/dayflow/index.html) and OMR data obtained from USGS. We calculated monthly or multiple month averages or medians based on these daily hydrology data sets. The historical time series are intended to show where changes in water project operations have caused or contributed to changed Delta hydrology and to serve as an empirical baseline of SWP and CVP operations for comparison to proposed futures modeled using CALSIM II. We used WYs 1967-2007 as the "historical" period for all hydrologic variables. Note that OMR has only been measured empirically since 1987. The OMR data for 1981-1986 were estimated by Ruhl et al. (2006). The OMR flows for 1967-1980 were estimated using DAYFLOW variables with the following equation: (-600) – (0.0065*EAST) – (0.851*EXPORT) + (0.506*SJR). The equation used by Ruhl et al. (2006) did not include the “EAST” term accounting for flows from the Delta’s east side tributaries. Note however that the r^2 between the Ruhl equation and the one including the “EAST” term is 0.99.

The CALSIM II model is a mathematical simulation model developed for statewide water planning. It has the ability to estimate water supply, streamflows, and Delta water export capability, keeping within “rules” such as water quality standards that limit model outputs to plausibly achievable system operations. CALSIM II is DWR’s and Reclamation’s official SWP and CVP planning tool. The CALSIM II model is applied to the SWP, the CVP, and the Sacramento and San Joaquin Delta. The model is used to evaluate the performance of the CVP and SWP systems for: existing or future levels of land development, potential future facilities, and current or alternative operational policies and regulatory environments. Key model output includes reservoir storage levels, instream river flow, water delivery, Delta exports and conditions, biological indicators such as X2, and operational and regulatory metrics.

CALSIM II simulates 82 years of hydrology for the Central Valley region spanning WYs 1922-2003. The model employs an optimization algorithm to find ways to move water through the SWP and CVP in order to meet assumed water demands on a monthly time step. The movement of water in the system is governed by an internal weighting structure that ensures regulatory and operational priorities are met. The Delta is also represented in CALSIM II by DWR’s Artificial Neural Network (ANN), which simulates flow and salinity relationships. Delta flow and electrical conductivity are output for key regulatory locations. Details of the level of land development (demands) and hydrology are discussed in Appendix D of the biological assessment (Reclamation 2008), as are details of how the model simulates flexible operations like (b)(2) and EWA allocations. Most of the model data used in this analysis were direct output from CALSIM II simulations for the biological assessment. However, certain Delta flow indicators, most notably OMR flows, were estimated by inputting CALSIM II outputs into the DSM-2 HYDRO model, which can predict OMR based on the hydrologic data output by CALSIM II.

This effects analysis analyzes outputs from the following subset of studies presented in the biological assessment: 7.0, 7.1, 8.0, and 9.0-9.5.

Study 7.0 was the model run that Reclamation and DWR thought best represented current operations, and was thus intended as a “current baseline.” However, due to limitations of CALSIM II to accurately model actual operations, we also used the 1967-2007 DAYFLOW summaries described above to compare against CALSIM II outputs. Study 7.0 modeled represents a 2005 level of development with (b)(2) allocations and a full EWA. The full EWA was represented in the CALSIM II framework as up to 50,000 acre-feet of water export reductions during December-February, the VAMP pulse flow, and export reductions following VAMP (mid-May into June) when CALSIM II predicted the EWA had surplus water (i.e., collateral exceeded debt).

Study 7.1 also represents a 2005 level of development with (b)(2) allocations, but with a limited EWA, which as described in the Project Description above consists mainly of water provided under the Yuba Accord. In the limited EWA, there were no export reductions in February and June, but export reductions were possible during December to January and late May. The VAMP pulse flow was modeled in the same way as in the full EWA.

Study 8.0 estimates SWP and CVP operations with a 2030 level of development, (b)(2) allocations and the limited EWA. Note that the 2030 level asked CALSIM II to try to provide 100 percent of the CVP's contract demand and 100 percent of the SWP's Table A contract demand, in all WY types but deliveries are shorted based on hydrology.

Study 9.0 represents a future condition to serve as a basis of comparison of the effects of climate change to sea level rise for the sensitivity evaluation. Neither (b)(2) actions or EWA were added to these steps.

Study 9.1 represents a future scenario in which sea level is assumed to be one foot higher than present, resulting in a four-inch higher tidal elevation at Martinez, California.

Studies 9.2-9.5 represent 'bookends' of climate change scenarios with the 2030 level of development. These bookends cannot be summarized simply except in qualitative terms. The bookends represent 10^{th} and 90^{th} percentiles of predicted changes in precipitation and temperature for the period 2010 to 2030 relative to 1971 to 2000 conditions. Generally, climate change models outputs indicate that the Central Valley will be warmer in the future, but are indeterminate as to whether precipitation will increase or decrease (e.g., Dettinger 2005). Thus, the climate change bookends include drier and wetter possibilities, but do not include cooler futures relative to current conditions. Thus, the temperature bookends can be called 'less warming' and 'more warming' or 'warmer' and 'warmer still'. Study 9.2 is a wetter and warmer simulation, 9.3 is a wetter and warmer still simulation, 9.4 is a drier and warmer simulation, and 9.5 is a drier and warmer still simulation. These climate change scenarios were not intended to be directly compared to studies 7.0-8.0. However, for simplicity all model output summaries were plotted together.

Study 9.5 represents the "worst-case scenario" among all simulations presented in the biological assessment because drier conditions are expected to result in more frequent conflicts over limited water resources. Further, springtime water temperatures influence the length of the spawning season for delta smelt (Bennett 2005) and summertime water temperature conditions already can be marginal for delta smelt (e.g., Nobriga et al. 2008). For those reasons, all warmer future scenarios are expected to further stress delta smelt, but the warmer still scenarios have the highest potential for detrimental effects.

Effects Analysis Methods

The effects analyses range from qualitative descriptions and conceptual models of project effects to quantitative analyses. The effects of Banks and Jones pumping on adult delta smelt entrainment, larval-juvenile delta smelt entrainment, and fall habitat suitability and its predicted effect on the summer townet survey abundance index are quantitatively analyzed. The remainder of proposed action elements and effects are not analyzed quantitatively because data are not available to do so or it is the opinion of the FWS that they have minor effects on delta smelt. For maximum clarity, analytical details are provided in the relevant sections.

Migrating and Spawning Adults (~ December through March)

Water Diversions and Reservoir Operations

Upstream Reservoirs and Diversions

The following CVP/SWP project elements are included in the modeling results and are not specifically discussed in this analysis, rather the effects of these project elements are included in the "Adult Entrainment Effects" and the "Habitat Suitability Effects" sections below: Trinity River Operations, Whiskeytown Operations, Clear Creek Operations, Shasta Lake and Keswick Dam Operations, Red Bluff Diversion Dam Operations, Oroville Dam and Feather River Operations, Folsom and Nimbus Dam Operations, New Melones Reservoir Operations, and Freeport Diversion Operations.

Banks and Jones Pumping Plants

Entrainment

The entrainment of delta smelt into the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. See Brown et al. (1996) for a description of fish salvage operations. Total entrainment is calculated based upon estimates of the number of fish salvaged (Kimmerer 2008). However, these estimates are indices - most entrained fish are not observed (Table E-4), so most of the fish are not salvaged and therefore do not survive. Many, if not most, of the entrained delta smelt likely die due (Bennett 2005). Recent studies also indicate that delta smelt predation and mortality across CCF may be high (Castillo et al. 2008). Additional studies will further explore this issue. The effects of NBA and CCWD operations on delta smelt are presented separately below.

Table E-4. Factors affecting delta smelt entrainment and salvage.

	Adults	Larvae < 20 mm	Larvae > 20 mm and juveniles
Predation prior to encountering fish salvage facilities	unquantified	unquantified	unquantified
Louver efficiency (based on Kimmerer 2008)	Limited data indicate an efficiency of about 13 percent for the CVP facility; no equivalent data are available for the SWP facility	~ 0 percent	Likely < 13 percent at any size; << 13 percent at less than 30 mm
Collection screens efficiency	~ 100 percent	~ 0 percent	< 100 percent until at least 30 mm
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates
Fish survival after Handling, trucking and release back into the Delta	Study in progress	0 percent	Study in progress

The population-level effects of delta smelt entrainment vary; delta smelt entrainment can best be characterized as a sporadically significant influence on population dynamics. Kimmerer (2008) estimated that annual entrainment of the delta smelt population (adults and their progeny combined) ranged from approximately 10 percent to 60 percent per year from 2002-2006. Major population declines during the early 1980s (Moyle et al. 1992) and during the recent POD years (Sommer et al. 2007) were both associated with hydrodynamic conditions that greatly increased delta smelt entrainment losses as indexed by numbers of fish salvaged. However, currently published analyses of long-term associations between delta smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008).

Adult Entrainment

Adult delta smelt have been salvaged at Banks and Jones as early in the WY as November and as late as June, but most of the recent historical salvage has occurred between mid-December and March (www.delta.dfg.ca.gov). Delta smelt salvage usually occurs in a prolonged event that has one major peak. This is evidence that the maturing population makes a spawning migration into the Delta. The migration is cued by pulses of freshwater flow into the estuary, otherwise known as "first flush" events (Grimaldo et al. accepted manuscript). The physiological mechanism that cues migration is unknown but salvage of adults typically begins when turbidities elevate over 12 NTU (Clifton Court Forebay Station) and total Delta inflow generally increases to over 25,000 cfs. During extreme flow events (total inflow > 100,000 cfs), delta smelt spawn downstream of the Delta and in critically dry years they often spawn in the North Delta.

Annual winter salvage is best explained by OMR flow, whereby salvage increases with reverse OMR flow (Figure E-1). Kimmerer (2008) calculated that entrainment losses of adult delta smelt in the winter removed 1 to 50 percent of the estimated population and were proportional to OMR flow, though the high entrainment case might overstate actual entrainment. Given there are demonstrated relationships between smelt entrainment and salvage with OMR flows (Kimmerer 2008; Grimaldo et al. accepted manuscript), this effects analysis evaluates the proposed action operations by comparing the long-term trends in OMR flows to OMR flows in the CALSIM II modeling presented in the biological assessment. For both approaches, predictions of salvage and total entrainment losses were made using OMR flow since it was the best explanatory variable of each. The effects of proposed operations were determined by comparing actual salvage and entrainment losses with predictions of these parameters under modeled OMR flows. As was done in the biological assessment (Reclamation 2008, Chapter 13), we have not attempted to separate the effects of SWP and CVP. The hydrodynamic effects of pumping that cause reverse OMR flow result from the combined action of both facilities.

The salvage and adult effects analysis was determined for each December to March period (i.e., winter period). We defined the December to March period to be consistent with recent analyses (Kimmerer 2008, Grimaldo et al. accepted manuscript) as this is the period when the majority of adults migrate upstream to spawn And therefore vulnerable to export operations. We compared salvage and population losses over the full winter period and not on a month-by-month basis to account for the cumulative effects of the proposed operations on the adult life stage of delta smelt.

OMR Flows

Overall, there has been a downward trend in average winter OMR flows in these years (Figure E-2a). In contrast, winter total inflows have remained constant (Figure E-2b). The increase in negative OMR flow is mostly driven by a steady increase in winter exports over the last four decades (Figure E-2c). The modeling results show OMR flows much more negative than historic years for all WY types except for critical dry years (Figure E-3).

Salvage and Entrainment Loss Predictions

Salvage loss estimates were derived from the linear model from Grimaldo et al. (accepted manuscript). In that paper, the authors identified that OMR flow was the best explanatory variable of salvage between 1993 and 2005. The equation from this relationship (salvage = 3757 – 0.4657*OMR flow; adjusted $R^2 = 0.31$) was used to generate salvage for the proposed action operations by WY type (Table E-5b). Predicted salvage numbers are not reported since it is unknown how the population size will vary in future years. Instead, the predicted percentage increase or decrease in salvage are reported as a more meaningful method to assess effects of proposed operations on salvage given an OMR value.

To quantitatively predict population losses of delta smelt, a suite of hydrodynamic variables were explored with adult entrainment loss estimates from Kimmerer (2008; Kimmerer (2008) calculated adult entrainment losses (Dec-Mar) using Kodiak trawl data for 2002-2005 and FMWT (November-December) for 1995-2005. For this analysis, the adult entrainment estimates from the FMWT estimates were used since they encompass a longer period by which to explore meaningful relationships. The model that explained adult entrainment losses (Dec-Mar) was the following: adult entrainment loss = 6.243 – 0.000957*OMR Flow (Dec-Mar). The adjusted R^2 for this model was 0.36. For comparative analyses, predictions of population losses from 1967-1994 were generated from this equation, (Figure E-4) whereby loss estimates from 1995-2006 were taken from Kimmerer (2008). Note much of the variability in both the salvage and population loss model is left unexplained but the predictions in the models do follow the trend that salvage and population losses increase as OMR flows decrease. In part, the variation is not captured because adult salvage and entrainment is not solely explained by OMR flows. Entrainment is also related to the number of adults that migrate into the vicinity of Banks and Jones. Although WY type may sometimes affect the spawning distribution (Sweetnam 1999), there is wide, apparently random variation in the use of the Central and South Delta by spawning delta smelt. For example, there are years when a greater proportion of the smelt population moves into the vicinity of the export facilities, which may lead to larger salvage and population loss. Leaving aside differences due to spawning migration variability, the approach used here provides expected salvage and entrainment losses given an OMR flow. The percent differences between historic winter salvage and predicted winter salvage from modeled studies were examined for each WY.

Predicted Salvage and Entrainment

The median OMR flows from the CALSIM II modeled scenarios were more negative than historic OMR flow for all WY types except critically dry years (Figure E-3; see Table E-5b for all differences). Overall, proposed OMR flows are likely to generate increases in population losses compared to historic years (Figure E-5 and Figure E-6). For example, the frequency of years when population losses are less than 10 percent from most modeled studies (except studies 7.0 and 8.0) is less than 24 percent compared to historic estimates that only exceed 10 percent in approximately half of the years.

The most pronounced differences occur during wet years, where median OMR flows are projected to be approximately 400 to 600 percent (-7100 to -3678 cfs) higher than historical wet years (-1032 cfs). Generally, wet years are marked by low salvage and population losses. However, the proposed operations during wet year are predicted to cause up to a 65 percent increase in smelt salvage and lower probability that population losses will be below 10 percent.

The proposed operation conditions likely to have the greatest impact on delta smelt are those modeled during above normal WYs. The modeled OMR flows for the above normal WYs ranged between -8155 and -6242 cfs, a 33 to 57 percent decrease from the historic median of -5178 cfs. Though the predicted salvage would only be about 15-20 percent higher than historic salvage during these years (Table E-5c), the modeled OMR flows in these years would increase population losses compared to historic years.

In below normal and dry WYs, proposed OMR flows are also modeled to decrease from historic medians. Predicted salvage levels are likely to increase between 2 and 44 percent. More importantly, the modeled median flows from all studies in these WY types range between -5747 and -7438 cfs. Modeled OMR flows at these levels are predicted to increase salvage and increase the population losses from historic levels as well.

During critically dry years, the median OMR flows for studies 7.0, 7.1, 8.0, 9.1, 9.4, and 9.5 are less than -5,000 cfs. These studies have predicted salvage lower than historic salvage and are not likely to generate larger population losses compared to historic years. The models might overestimate salvage during critical dry years when smelt are unlikely to migrate towards the Central Delta due to lack of turbidity or first flush. Thus, the effects of critical dry operations on delta smelt take are probably small and lower than estimated.

In summary, adult entrainment is likely to be higher than it has been in the past under most operating scenarios, resulting in lower potential production of early life history stages in the spring in some years. While the largest predicted effects occur in Wet and Above Normal WYs, there are also likely adverse effects in Below Normal and Dry WYs. Only Critically Dry WYs are generally predicted to have lower entrainment than what has occurred in the recent past.

Table E-5a. Historic and CALSIM II modeled median winter (Dec-Mar) OMR flows by water year type

Water year type	Historic	7	7.1	8	9	9.1	9.2	9.3	9.4	9.5
Wet	-1033	-5256	-5498	-5699	-5684	-5500	-3999	-3678	-7066	-6100
Above Normal	-5178	-7209	-7923	-8073	-8156	-7595	-6863	-6934	-7861	-7723
Below Normal	-2405	-6461	-7208	-7009	-6599	-6420	-5647	-6736	-6721	-6343
Dry	-5509	-6443	-6931	-6692	-6620	-6353	-6831	-7438	-5785	-5760
Critical	-5037	-4547	-4931	-4980	-5051	-4588	-5320	-5194	-4260	-3845

Table E-5b. Winter OMR Flow percent difference from historic median value to CALSIM II model median value

Water year type	7	7.1	8	9	9.1	9.2	9.3	9.4	9.5
Wet	408.92%	432.37%	451.84%	450.36%	432.50%	287.16%	256.13%	584.15%	490.63%
Above Normal	39.21%	53.01%	55.90%	57.49%	46.67%	32.53%	33.91%	51.80%	49.13%
Below Normal	168.62%	199.68%	191.41%	174.35%	166.90%	134.75%	180.05%	179.42%	163.72%
Dry	16.95%	25.81%	21.48%	20.17%	15.32%	24.01%	35.02%	5.01%	4.57%
Critical	-9.74%	-2.12%	-1.14%	0.27%	-8.92%	5.61%	3.11%	-15.44%	-23.68%

Table E-5c. Percent difference from historic median salvage to predicted salvage based on Dec-Mar OMR flows from CALSIM II studies

Water year type	Study 7	Study 7.1	Study 8	Study 9	Study 9.1	Study 9.2	Study 9.3	Study 9.4	Study 9.5
Wet	45.64%	48.26%	50.43%	50.26%	48.27%	32.05%	28.59%	65.20%	54.76%
Above Normal	15.15%	20.49%	21.60%	22.22%	18.04%	12.57%	13.10%	20.02%	18.99%
Below Normal	38.17%	45.20%	43.33%	39.46%	37.78%	30.50%	40.76%	40.61%	37.06%
Dry	6.80%	10.36%	8.62%	8.09%	6.15%	9.63%	14.05%	2.01%	1.83%
Critical	-3.70%	-0.81%	-0.43%	0.10%	-3.39%	2.13%	1.18%	-5.87%	-9.00%

Article 21

The analysis of Banks Article 21 pumping is qualitative because the CALSIM II modeling, as shown in the biological assessment, does not simulate two major South of the Delta storage facilities, the Kern Water Bank and Diamond Valley Lake. Both of these facilities have been used to store water moved under Article 21. As such, the full effects of Article 21 pumping is underestimated by the modeling. The modeling assumptions assume that Article 21 water demand would be 314 TAF for each month December through March and up to 214 TAF per month in all other months. As shown in Figure P-17 and Table P-12, there has been an increase in SWP pumping corresponding to an increase of the use of Article 21. This increased pumping at the SWP from the year 2000 to present corresponds to the recent declines in the delta smelt population, currently being studied by the IEP. This pumping is included in the exports at Banks, so Article 21 effects to delta smelt are included in the adult entrainment, larval-juvenile entrainment, and fall habitat effects sections. However, as described above, the modeling underestimates these effects and the amounts of water that would be moved to south of Delta storage facilities. The previous section showed that the proposed action would result in increased adult entrainment during winter. As shown below, Article 21 pumping in the fall contributes to habitat degradation and Article 21 pumping in the spring (if it occurred) would contribute to higher larval-juvenile entrainment than what occurred from 1995-2007.

The export of Article 21 appears to be one of the factors that increase entrainment in the months of December through March, demonstrated by the large increases of pumping at Banks. The highest amounts of Article 21 water are pumped in the months when adult delta smelt entrainment is also highest.

The Service is concerned with the WY type in which Article 21 water is pumped. In the 2004 OCAP biological assessment and the Service's 2005 biological opinion, Article 21 pumping was only assumed to occur during wet and above normal WYs. In the modeling for the 2004 biological assessment, Article 21 was assumed to be 50 TAF/month for MWDSC in December through March and up to 84 TAF/month for other water users for a total of 134 TAF/month from December through March. The 2005 biological opinion stated this would be an infrequent occurrence. However, from 2004 to 2007, Article 21 has been used in more than in the wet years. In 2004, a below normal WY when Article 21 should not have been pumped according to the 2005 biological opinion, 209 TAF (which was higher than the maximum assumed amount of 134 TAF) of Article 21 was pumped in March. The maximum assumed Article 21 pumping from the biological opinion was also exceeded in 2005 (167 TAF in February, 219 TAF in March and 147 TAF in April) and 2006 (260 TAF in February and 184 TAF in March).

The effects of pumping of Article 21 water to adult delta smelt would be most severe during below normal and dry years. Even though Article 21 may not be called often in these water types, San Luis Reservoir can be filled in dryer years (for example if the preceding year was wet). It is during these types of years that the increased pumping associated with Article 21 would have the most detrimental effects to delta smelt and significant adult entrainment may occur.

DMC-CA Intertie

As described in the Project Description, the DMC-CA Intertie would provide operational flexibility between the DMC and the CA. CALSIM II-modeling results show that the Jones pumping plant capacity increases from 4,200 cfs in Study 7.0 to 4,600 cfs in Study 8.0. While the specific effects of the intertie on delta smelt cannot be analytically distinguished, the increased capacity of the Jones pumping plant is included in the adult entrainment effects discussion above and can result in higher entrainment of adult, larval and juvenile delta smelt at Jones. In addition, increased pumping at Jones can have indirect effects to delta smelt by entraining their food source and reducing their available habitat, as discussed below in the habitat suitability section.

NBA Diversion

North Bay Aqueduct diversions have had no clear trend in most months since 2000 (Source: Dayflow), though annualized average NBA pumping was higher (83 cfs) in WY 2007 than in any previous year. Seasonal pumping rates during 2005-2007 were 109 cfs in Summer (Jun-Aug), 94 in Fall (Sep-Nov), 39 in Winter (Dec-Feb), and 36 in Spring (Mar-May). These recent historical numbers are substantially below values produced by CALSIMII Study 7.0 in the Winter and Spring months. For example, the 2005-2007 December pumping rate of 52 cfs is 44 percent of the Study 7.0 December pumping rate (116 cfs); the historical April pumping rate during the same period was 31 cfs, or 23 percent of the Study 7.0 rate of 133 cfs. Because some of these differences are large, the actual historical values are discussed in each seasonal subsection below.

Modeled North Bay Aqueduct diversions are highest during the winter months. The diversion rate for study 8 in December (142 cfs) was higher than diversion rate for studies 7.0 (116 cfs). The actual average December through February pumping in 2005-2007 was 39 cfs. The SCWA hydrodynamic modeling of NBA diversions indicates that the majority of water diverted under historical pumping rates originates from Campbell Lake and Calhoun Cut during the winter. As previously mentioned, delta smelt migrate up into the Delta during the winter months. Modeled diversion rates in Studies 7.0 and 8.0 for the winter months may create hydrodynamic conditions that entrain substantial numbers of delta smelt into Barker Slough if delta smelt are present in that region.

In some years, delta smelt will begin spawning in February when temperatures reach about 12 ^{o}C (Bennett 2005). In some years, delta smelt larvae may be entrained at the NBA diversions. However since the majority of water diverted originates from Campbell Lake during the winter under historical pumping conditions, these effects were likely minimal. During years when the Yolo Bypass floods, the entrainment risk of larvae into the NBA was also probably extremely localized under historical pumping conditions because of a hydrodynamic "plug" that forms between Barker and Lindsay sloughs with

Cache Slough. When this happens, hydrodynamic mixing between Cache Slough and Lindsay/Barker sloughs decreases, causing spikes in turbidity and organic carbon in Barker and Lindsay Sloughs (DWR, North Bay Aqueduct Water Quality Report). Entrainment vulnerability would be greatest during dry years when the NBA diversions entrain a large portion of water from Barker and Lindsay Sloughs and are often years when delta smelt will spawn in the North Delta (Sweetnam 1999). This vulnerability could be higher under pumping rates associated with Studies 7.0 and 8.0. The fish screen at the NBA diversion was designed to exclude delta smelt larger than 25 mm. However, a study of a fish screen in Horseshoe Bend built to delta smelt standards excluded 99.7 percent of fish from entrainment even though most of these were only 15-25 mm long (Nobriga et al. 2004). On that basis, the fish screen at NBA may protect many, if not most, of the delta smelt larvae that do hatch and rear in Barker Slough.

CCWD Diversions

As described in the Project Description, CCWD diverts water from three different intakes in the Delta. All CCWD facilities are subject to no-fill and no-diversion periods to protect delta smelt from entrainment. With implementation of proposed CVP/SWP operations, water demands of the CCWD are anticipated to increase from 135 TAF/year in study 7.0 to 195 TAF/year in study 8.0.

Old River intake

CCWD currently diverts water using the Old River intake for its supplies directly from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake. However, since this facility is fully screened to meet delta smelt fish screening criteria, adult entrainment is not a concern. Diversion from this facility may affect OMR flows.

Rock Slough

The Rock Slough Intake is presently unscreened. As described in the Project Description, Reclamation is required to screen this diversion and is seeking an extension for the completion of the fish screen.

Catches of delta smelt at the Rock Slough diversion are low based on sampling conducted using a sieve net three times per week from January through June and twice per week from July through December and using a plankton net at the headworks structure twice per week during times when larval delta smelt could be present in the area (generally March through June). The numbers of delta smelt entrained by the facility since 1998 have been extremely low based on this monitoring, with only a single fish taken in February 2005. Most water diversions at the Rock Slough intake now occur during the summer months, so adult delta smelt entrainment is not likely to be high. In addition, Rock Slough is a dead-end slough with poor habitat for delta smelt, so the numbers of delta smelt using Rock Slough are usually low.

Alternative Intake

Total entrainment at CCWD's facilities is likely to be reduced when the CCWD's Alternative Intake Project is completed. This diversion is going to be screened according to delta smelt fish screening criteria and will likely reduce diversions from the unscreened Rock Slough diversion. Because the Alternative Intake diversion is fully screened, adult delta smelt entrainment is not likely to be high. Diversion from this facility may affect OMR flows.

Suisun Marsh Salinity Control Gates

The SMSCG are generally operated, as needed, from September through May to meet State salinity standards in the marsh. The number of days the SMSCG are operated in any given year varies. Historically, the SMSCG were operated 60-120 days between October and May (for the period 1988-2004). With an increased understanding of the effectiveness of the SMSCG in lowering salinity in Montezuma Slough, salinity standards have been met with less frequent gate operations. In 2006 and 2007, the gates were operated periodically between 10-20 days annually. It is expected that this level of operational frequency (10-20 days per year) will continue in the future.

It is possible for delta smelt and other fishes to be entrained behind the SMSCG in Montezuma Slough and Suisun Marsh when the SMSCG is closed. Fish may enter Montezuma Slough from the Sacramento River when the gates are open to draw freshwater into the marsh and then may not be able to move back out when the gates are closed. It is not known whether this harms delta smelt in any way, but they could be exposed to predators hovering around the SMSCG or they could have an increased risk of exposure to water diversions in the marsh (Culberson et al. 2004). It is possible that if delta smelt are indeed entrained into Montezuma Slough and Suisun Marsh that they may be more vulnerable to water diversion such as DWR's MIDS. Entrainment into MIDS from the Sacramento River may be unlikely based on particle tracking studies that have demonstrated low entrainment vulnerability for particles released at random locations throughout Suisun Marsh (3.7 percent), and almost no vulnerability (<0.1 percent) to particles released at Rio Vista (Culberson et al. 2004). Moreover, fish entrainment monitoring at MIDS showed very low entrainment of delta smelt (one larva in 2.3 million m^3 of water sampled over a two-year period) because salinity in Suisun Slough was usually too high for delta smelt when the MIDS diversion needed to operate (Enos et al. 2007). The degree to which movement of delta smelt around the LSZ is constrained by opening and closing the SMSCG is also unknown.

Indirectly, operations of the SMSCG may influence delta smelt habitat suitability and entrainment vulnerability. When the SMSCG are opened, the draw of freshwater into the marsh effectively moves the Suisun Bay salinity field upstream. In some years, the salinity field indexed by X2 may be shifted as far as 3 km upstream. Thus, depending on the tidal conditions during and after gate operations, X2 may be transported upstream nominally about 20 days per year. The consequence of this shift decreases the extent of delta smelt habitat and moves the distribution of delta smelt upstream (Feyrer et al. 2007; see delta smelt habitat effects section below for further discussion). Because juvenile delta smelt production decreases when X2 moves upstream during the fall (Feyrer et al. 2007), any attributable shift in X2 between September to November (December during low outflow years) caused by operation of the SMSCG can be a concern. However, a 3-km shift in X2 happening 20 days per year is far less significant than the 10-20 km shifts that have occurred for up to 120 or more days per year during late summer through early winter due to South Delta diversions (see habitat effects section below).

During January through March, most delta smelt move into spawning areas in the Delta. Grimaldo et al (accepted manuscript) found that prior to spawning entrainment vulnerability of adult delta smelt increased at the SWP and CVP when X2 was upstream of 80 km. Thus, any upstream shift in X2 from SMSCG operations may influence entrainment of delta smelt at the CVP and SWP, especially during years of low outflow or periods of high CVP/SWP exports. However, between January and June the SWP and CVP operate to meet the X2 standards in SWRCB D-1641, thus the effects of the SMSCG on X2 during this period are negligible. Therefore, SMSCG operations from January to May are not likely to affect delta smelt entrainment vulnerability. In addition, because delta smelt move upstream between December and March, operations of the SMSCG are unlikely to adversely affect delta smelt habitat suitability during this period.

Larval and Juvenile Delta Smelt (~ March-June)

Water Diversions and Reservoir Operations

Banks and Jones

As stated previously, larval and juvenile delta smelt are free-swimming and pelagic; they do not associate strongly with structure or shorelines. Delta smelt use a variety of swimming behaviors to maintain position within suitable habitats – even in regions of strong tidal currents and net seaward flows (Bennett et al. 2002). Since the water exported during spring and early summer (mainly March-June) from the Central and South Delta is suitable habitat, young delta smelt do not have a cue to abandon areas where water is flowing toward Banks and Jones. Combinations of Delta inflows and export flows or variables like Delta outflow and OMR are good predictors of larval and young juvenile delta smelt entrainment (Kimmerer 2008). This effects analysis evaluates the proposed action operations by exploring long-term trends in Delta outflow, or X2, and OMR flows during March-June and comparing these to hydrodynamic conditions expected based on CALSIM II modeling presented in the biological assessment. The analysis uses the larval-juvenile entrainment estimates provided by Kimmerer (2008) and flow and export projections from the biological assessment to estimate the annual percentages of the larval/juvenile delta smelt population expected to be entrained.

This section examines the effects of entrainment on larval and juvenile delta smelt during the months of March-June. The analysis is based on comparison of historical (1967-2007) OMR and X2 to the proposed action's predictions of these variables provided in the biological assessment for studies 7.0, 7.1, 8.0, and 9.0-9.5. The hydrologic data are examined in light of recent estimates of larval/juvenile delta smelt entrainment (Kimmerer 2008) that are reproduced well by Delta outflow (or X2) and OMR (Figure E-7). All analyses examine two sets of spring months; March-June, which encompasses most of the spawning season and April-May, which encompasses the empirical hatch dates of most fish surviving to the fall in recent years (Hobbs and Bennett, 2008). The reason for using two spring averaging periods was to demonstrate that the conclusions are robust with regard to choice of averaging period; the predicted entrainment is very similar.

Kimmerer (2008) proposed a method for estimating the percentage of the larval-juvenile delta smelt population entrained at Banks and Jones each year. These estimates were based on a combination of larval distribution data from the 20-mm survey, estimates of net efficiency in this survey, estimates of larval mortality rates, estimates of spawn timing, particle tracking simulations from DWR's DSM-2 particle tracking model, and estimates of Banks and Jones salvage efficiency for larvae of various sizes. Kimmerer estimated larval-juvenile entrainment for 1995-2005. We used Kimmerer's entrainment estimates to develop multiple regression models to predict the proportion of the larval-juvenile delta smelt population entrained based on a combination of X2 and OMR. Using Kimmerer's method, larval-juvenile is predicted to be 0 during periods of very high outflow. For instance, Kimmerer predicted entrainment loss was 0 percent in 1995 and 1998. For simplicity, we estimated the relationship between X2, OMR, and larval-juvenile entrainment without 1995 and 1998 in the model because the relationship between these variables is linear when only years that had entrainment higher than 0 were modeled. As mentioned above, we developed two separate models, one for the March-June averaging period and one for the April-May averaging period. The reason for using two spring averaging periods was to demonstrate that the conclusions are robust with regard to choice of averaging period; the predicted entrainment is very similar. The equations are: March-June percent entrainment = (0.00933*March-June X2) - (0.0000207*March-June OMR) – 0.556 and April-May percent entrainment = (0.00839*April-May X2) - (0.000029*April-May OMR) – 0.487. The adjusted R^2 on these equations are 0.90 and 0.87, respectively. These equations were used to predict historical springtime entrainment (1967-1994 and 2006-2007). We also used the above-mentioned regression equations to predict larval-juvenile entrainment based on the hydrologic predictions provided in the biological assessment. We used these estimates to compare historical entrainment effects predicted from the CALSIM II studies. Because the equations were based only on data that had non-zero entrainment, they predict entrainment proportions are negative during periods of very high outflow. The negative entrainment predictions were changed to 0 percent before summary analysis.

Historical Data (1967-2007)

Combined Old and Middle River Flow

There has been no clear long term trend in OMR for either the March-June or April-May averaging periods (Figures E-8 and E-9). Since the early 1990s, minimum OMR flows during April-May have been higher (less negative) than 1967-1990 (Figure E-9).

Delta Outflow

Delta outflows generally declined from 1967-1990, but Delta outflows have generally been higher and comparable to 1970s levels since 1990. This is true for both the March-June and April-May averaging periods (Figures E-10 and E-11). Since the early 1990s, minimum Delta outflows flows during April-May have usually been slightly higher than 1967-1990. This is likely due to the combination of the X2 standard and the VAMP pulse flow.

Predicted entrainment

Predicted entrainment is a function of both X2 and OMR, therefore higher flows and lower exports translate into lower entrainment of delta smelt. Predicted larval-juvenile entrainment was often higher prior to the implementation of the X2 standard in 1995 than it has been since (Figure E-16). The predictions for entrainment range from 0 to about 40 percent for 1967-1994 and 0 to about 30 percent for 1995-2007. However, the upper confidence limits reach substantially higher levels, ranging from 0 to about 65 percent between 1967 and 1994 and 0 to about 40 percent during 1995-2007. The effect of the X2 standard on larval-juvenile entrainment can be seen in Figure E-17. The frequency of years in which 0 percent-10 percent of the larval-juvenile population was estimated to have been entrained was similar between 1967-1994 and 1995-2005 because very high spring outflows have always pushed X2 far downstream resulting in delta smelt distributions distant from the influence of Banks and Jones. However, there are substantial differences between the 1967-1994 and 1995-2005 time periods in terms of how frequently larger percentages of the larval-juvenile population were entrained. For instance, it is estimated that less than 20 percent of the larval-juvenile population was entrained in 67 percent of years from 1995-2005, but only 44 percent of years from 1967-1994 (Figure E-17). Further, predicted entrainment sometimes exceeded 30 percent during 1967-1994, but was never that high during 1995-2005. Note that we did not attempt to carry the confidence limits on entrainment estimates through these calculations. See Figure E-16 for estimates of the confidence intervals.

Proposed Action

Combined Old and Middle River Flow

The biological assessment proposes that Banks and Jones pumping will cause March-June OMR flows to be more negative than 1967-2007 in wet and above normal years and will cause April-May OMR flows to be more negative than 1967-2007 wet years (Figures E-12 and E-13). It is also anticipated there will be less variation in OMR during wet and above normal years than there was historically. The predicted OMR flows are predicted to be higher (hovering near 0 cfs on average) in dry and critical years. This is true for both averaging periods. These patterns do not change in the climate change scenarios (Studies 9.0-9.5).

X2

Most of the projected operations result in average March-June and average April-May X2 that are further downstream than 1967-2007 averages (Figures E-14 and E-15). As stated previously, this is likely due to the full implementation of the X2 standard and VAMP export reduction in projected operations. The exception is wet years. In wet years, projected X2 is generally very similar to historical in both averaging periods except that the boxplots indicate no occurrences of X2 further downstream than 50 km. This is probably due to the proposed decreases in wet year OMR flows (Figures E-8 and E-9). The climate change scenarios predict April and May X2 will be further downstream in dry and critical years, but the differences are modest (< 5 km) and again likely due primarily to the modeling assumptions of meeting the X2 standard and providing an export reduction during VAMP.

Effects of Forecasted Operations

Note that we did not attempt to carry the confidence limits on entrainment estimates through these calculations. See Figure E-16 for estimates of the uncertainty surrounding the following. The biological assessment's assumptions of a continued X2 standard and an EWA-related export reduction during April-May, keep the frequency of years with larval-juvenile entrainment higher than 20 percent consistent with 1995-2005 expectations regardless of operational assumptions (Figure E-18). However, the proposed action will decrease the frequency of years in which estimated entrainment is ≤ 15 percent. Thus, over a given span of years, the project as proposed will increase larval-juvenile entrainment relative to 1995-2005 levels. This will have an adverse effect on delta smelt based on their current low population levels.

Article 21

The effects from Article 21 on larval and juvenile delta smelt would be similar to those described for adult delta smelt (See previous effects discussion on Article 21 in the adult delta smelt section). While Article 21 pumping during March through June is usually lower than in the winter, larval and juvenile delta smelt could become entrained during March through June when Article 21 pumping is occurring.

VAMP

VAMP, as described in the Project Description and the Status of the Species and Environmental Baseline section, has beneficial effects to larval and juvenile delta smelt because it simultaneously provides a pulse flow on the San Joaquin River and an export reduction at Banks and Jones. This combination has provided 31 days of improved transport flows in the Central Delta since 2000. Also as discussed above in the Status of the Species/Environmental Baseline section, Bennett (unpublished analysis) found that most delta smelt that survived to be pre-adults in the FMWT hatched during VAMP. The Service considers this evidence that VAMP has selectively enhanced the survival of delta smelt larvae that emerge during the flow pulse and export reduction by reducing the entrainment of larvae from the Central Delta.

VAMP is an experiment, and it is only projected to continue until 2009. As described in the Project Description, after VAMP ends, Reclamation has committed to maintaining the export curtailment portion of VAMP. However, since VAMP also contains a San Joaquin River flow component, which would not be continued past 2009, maintaining only the export curtailment is not expected to provide the same benefits to larval and juvenile delta smelt as the complete VAMP experiment. In order for delta smelt spawned in the Central Delta during the VAMP period to survive to the fall, the export curtailments and the VAMP flows would be needed.

According to the Project Description, DWR proposes to continue the export reductions at Banks as long as there are assets available from the Yuba Accord Water Transfer to compensate the SWP for lost pumping. Because the export reductions may cost more than the Yuba Accord provides, the export curtailments at Banks may be smaller and therefore provide less benefit to larval and juvenile delta smelt. Also, as mentioned above, the export reductions at Jones and Banks are only part of VAMP, and the San Joaquin River (i.e., Vernalis) flow pulse is also important for protection of delta smelt from entrainment.

Therefore, the reduced protections during VAMP by only providing the export curtailment portion of VAMP and not the San Joaquin River flow component is likely to adversely effect delta smelt. Larval and juvenile delta smelt in the Central and South Delta would be protected from entrainment at Banks and Jones during this period, but the lack of San Joaquin River flow would not help them to move to the Western Delta and

Suisun Bay. Without the flow component, the larval and juvenile delta smelt would remain in the Central and South Delta, where they could be exposed to lethal water temperatures, entrainment at Banks and Jones after the VAMP export curtailment period, or succumb to predation or m*icrocystis* blooms.

Intertie

The effects from the intertie on larval and juvenile delta smelt would be similar to those described for adult delta smelt. See previous effects discussion on the intertie in the adult delta smelt section.

NBA Diversion

The differences in NBA diversions during the spring were as follows: For April, study 8.0 had a diversion rate of 145 cfs, which is approximately 10 percent higher than the April diversion rates in studies 7.0 (133 cfs) (Chapter 12). For May, study 8.0 also had a diversion rate of 145 cfs, which is approximately 25 percent higher than the May diversion rates in studies 7.0 (116 cfs). For June, study 8.0 assumed a diversion rate of 148 cfs, about 18 percent higher than the June diversion rates in studies 7.0 (126 cfs) The actual average March through May pumping in 2005-2007 was 36 cfs. Overall, spring represents the period of greatest entrainment risk for delta smelt larvae at the NBA, especially in dry years when delta smelt spawn in the North Delta (http://www.delta.dfg.ca.gov/data/NBA/). Entrainment risk at the pumping rates modeled in Studies 7.0 and 8.0 could be substantially higher than risks that existed under historical pumping rates. As described above, based on Nobriga et al. 2004, the fish screen at NBA may protect many, if not most of the delta smelt larvae that hatch and rear in Barker Slough. However, as the NBA diversions increase, as proposed in study 8.0, the small effect of the NBA diversion may become more significant.

CCWD Diversions

Old River Intake

In addition to the Old River diversion being screened to protect adult delta smelt, all CCWD diversions implement fishery protection measures to minimize larval delta smelt from becoming entrained at CCWD facilities. These measures consist of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir and a concurrent 30-day period during which CCWD halts all diversions from the Delta, provided that Los Vaqueros Reservoir storage is above emergency levels. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively; the Service, NMFS and DFG can change these dates to best protect the subject species. Larval fish may occur at this facility outside of the no-fill and no-diversion periods, and may be subject to entrainment. However, larval fish monitoring behind the screens has shown very few larval fish become entrained (Reclamation 2008) and, as stated above for the NBA, the fish screens at this facility may protect fish smaller than intended by the screens' designs. Diversion from this facility may affect OMR flows.

Rock Slough

Although most water diversions at the Rock Slough intake now occur during the summer months, the Rock Slough diversion is also subject to the no-fill and no-diversion periods that all CCWD diversions are operated under. Like the Old River diversion, larval delta smelt may occur at this facility outside of the no-fill and no-diversion periods, and may be subject to entrainment. Since the Rock Slough diversion is not screened, larval fish entrainment at this facility may be a concern. However, larval fish monitoring behind the headworks has not shown that large numbers of larval fish become entrained (Reclamation 2008).

Alternative Intake

Like the Old River diversion, the Alternative intake is screened to protect adult delta smelt from entrainment. Since larval smelt are not protected by these fish screens, the Alternative intake is also proposed to operate in accordance with the no-fill and no-diversion periods to minimize larval fish from entrainment. Like the other two CCWD diversions discussed above, larval delta smelt may occur at this facility outside of the no-fill and no-diversion periods, and may be subject to entrainment. Larval fish may also become entrained at this facility, but as stated above for the NBA, the fish screens at this facility may protect fish smaller than intended by the screens' designs. Diversion from this facility may affect OMR flows.

South Delta Temporary Barriers

Hydrodynamic Effects

The TBP does not alter total Delta outflow, or the position of X2. However, the TBP causes changes in the hydraulics of the Delta, which may affect delta smelt. The HORB blocks San Joaquin River flow, which prevents it from entering Old River at that point. This situation increases the flow toward Banks and Jones from Turner and Columbia cuts, which can increase the predicted entrainment risk for particles in the East and Central Delta by up to about 10 percent (Kimmerer and Nobriga 2008). In most instances, net flow is directed towards the Banks and Jones pumps and local agricultural diversions. Computer simulations have shown that placement of the barriers changes South Delta hydrodynamics, increasing Central Delta flows toward the export facilities (Reclamation 2008). In years with substantial numbers of adult delta smelt moving into the Central Delta, increases in negative OMR flow caused by installation of the SDTBs can increase entrainment. The directional flow towards the Banks and Jones increases the vulnerability of fish to entrainment. Larval and juvenile delta smelt are especially susceptible to these flows.

The varying proposed operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables limit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. 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 (Nobriga et al. 2000). This observation indicates that short-term salvage can significantly increase when the HORB is installed in such a manner that it causes a sharp change or reversal of positive net daily flow in the South and Central Delta. The physical presence of the TBP may attract piscivorous fishes and influence predation on delta smelt. However, past studies by the DFG TBP Fish Monitoring Program indicated that such predation is negligible (DWR 2000a).

Vulnerability to Local Agricultural Diversions

Fish that may become trapped upstream of the TBP agricultural barriers may suffer increased vulnerability to local agricultural diversions. However, the risk of entrainment (Kimmerer and Nobriga 2008) or death from unsuitable water quality (as inferred from lack of delta smelt occurrence in the South Delta during summer; see Nobriga et al. 2008) is so high for delta smelt trapped in the South Delta that loss to irrigation diversions in this region is likely to be negligible.

Effects to Potential Fish Prey Items

The extent to which the distribution and abundance of delta smelt prey organisms is influenced by the conditions created by the TBP is difficult to determine. Because the TBP does not influence X2, organisms that exhibit a strong abundance-X2 relationship (e.g., mysid shrimp) (Jassby et al.1995), are not likely to be affected. However, the barriers might influence the flux of *Pseudodiaptomus* from the Delta to the LSZ.

South Delta Permanent Operable Gates

Hydrodynamic Effects

As described in the Project Description, the South Delta Permanent Operable Gates (Operable Gates) are expected to be constructed in late 2012. The Operable Gates are expected to operate during similar time periods as the TBP, with the gate closing starting in April and operating thorough the winter. The Head of Old River Gate would operate in April and May and in the fall.

The effects of the Operable Gates on larval and juvenile delta smelt are expected to be similar to those caused by the TBP. The Operable Gates will open daily to maintain water levels at 0.0 foot mean sea level in Old River near the Jones pumping plant, and these daily openings would provide passage for delta smelt. Like the TBP, the operations of the Operable Gates are not expected to decrease Delta outflows, but the risk of larval and juvenile delta smelt entrainment at Banks and Jones is expected to remain about the same as with the TBP. Also, OMR flows would be affected by the Operable Gates and may result in more negative OMR flows which could increase the risk of larval and juvenile delta smelt entrainment.

If the Operable Gates are operated during periods when the TBP have not been installed, additional effects to delta smelt could occur. For example, if the Operable Gates are closed during the winter (December through March), flow cues from the San Joaquin River may be disrupted and may affect adult delta smelt migration into the Delta. Also, if the Operable Gates are closed during this period, the available habitat for delta smelt would be reduced. The South Delta can be suitable habitat for delta smelt in some years; if this habitat is inaccessible to the delta smelt due to the Operable Gates being closed, adverse effects to the delta smelt and their habitat would occur.

Vulnerability to Local Agricultural Diversions

Under the proposed operations of the Operable Gates, delta smelt are likely to be affected in a manner similar to that caused by operation of the TBP, although delta smelt may be less susceptible to entrainment at local agricultural diversion since the Operable Gates are likely to be opened more often. As discussed above, the risk of entrainment or death from unsuitable water quality is so high for delta smelt trapped in the South Delta that loss to irrigation diversions in this region is likely to be negligible.

Effects to Potential Fish Prey Items

Under the proposed operations of the Operable Gates, delta smelt are likely to be affected in a manner similar to that caused by operation of the TBP, although delta smelt may be less affected because the Operable Gates will be open more than the TBP.

Suisun Marsh Salinity Control Gates

The effects from the SMSCG on larval and juvenile delta smelt would be similar to those described for adult delta smelt. See previous effects discussion on the SMSCG in the adult delta smelt section.

American River Demands

Based on CALSIM II model study 8.0 results, total American River Division annual demands on the American and Sacramento rivers are estimated to increase from about 324,000 acre-feet in 2005 to 605,000 acre-feet in 2030, without the Freeport Regional Water Project maximum of 133,000 acre-feet during drier years. These increases in demands and diversions are included in the modeling results. The effects of these demands on delta smelt are discussed below in the section dealing with the effects of CVP/SWP operation on habitat suitability.

Delta Cross Channel

The DCC will be closed for fishery protection as described in the Project Description. This action is not expected to change in the future. The effects of the DCC on Delta hydrodynamics are included in the CALSIM II modeling results and are discussed below in the section dealing with the effects of CVP/SWP operation on habitat suitability.

Juveniles and Adults (~ July-December)

Entrainment of *Pseudodiaptomus forbesi* (June-September)

Historically, the diet of juvenile delta smelt during summer was dominated by the copepod *Eurytemora affinis* and the mysid shrimp *Neomysis mercedis* (Moyle et al. 1992; Feyrer et al. 2003). These prey bloomed from within the estuary's LSZ and were decimated by the overbite clam *Corbula amurensis* (Kimmerer and Orsi 1996), so delta smelt switched their diet to other prey. *Pseudodiaptomus forbesi* has been the dominant summertime prey for delta smelt since it was introduced into the estuary in 1988 (Lott 1998; Nobriga 2002; Hobbs et al. 2006). Unlike *Eurytemora* and *Neomysis*, *Pseudodiaptomus* blooms originate in the freshwater Delta (John Durand San Francisco State University, oral presentation at 2006 CALFED Science Conference). This freshwater reproductive strategy provides a refuge from overbite clam grazing, but *Pseudodiaptomus* has to be transported to the LSZ during summer to co-occur with most of the delta smelt population. This might make *Pseudodiaptomus* more vulnerable to pumping effects from the export facilities than *Eurytemora* and *Neomysis* were. By extension, the projects might have more effect on the food supply available to delta smelt than they did before the overbite clam changed the LSZ food web. As evidence for this hypothesis, the IEP Environmental Monitoring Program zooplankton data show the summertime density of *Pseudodiaptomus* is generally higher in the South Delta than in Suisun Bay. The ratio of South Delta *Pseudodiaptomus* density to Suisun Bay *Pseudodiaptomus* density was greater than one in 73 percent of the collections from June-September 1988-2006. The average value of this ratio is 22, meaning that on average summer *Pseudodiaptomus* density has been 22 times higher in the South Delta than Suisun Bay. Densities in the two regions are not correlated ($P > 0.30$). This demonstrates that the presence of high copepod densities in the South Delta which delta smelt do not occupy during summer months, do not necessarily occur simultaneously in the LSZ where delta smelt rear.

There is statistical evidence suggesting that the co-occurrence of delta smelt and *Pseudodiaptomus forbesi* has a strong statistical influence on the survival of young delta smelt from summer to fall (Miller 2007). In addition, recent histopathological evaluations of delta smelt have shown possible evidence of food limitation in delta smelt during the summer (Bennett 2005; Bennett et al. 2008). However, the glycogen depletion of the delta smelt livers reported in these studies can also arise from thermal stress due to high summer water temperatures (Bennett et al. 2008).

Water Transfers

Water transfers would increase Delta exports by 0 to 360,000 acre-feet (af) in most years (the wettest 80 percent of years) and by up to 600,000 AF in Critical and some Dry years (approximately the driest 20 percent years). Most transfers will occur at Banks (SWP) because reliable capacity is not likely to be available at Jones except in the driest 20 percent of years. Although transfers can occur at any time of year, the exports for transfers described in this assessment would occur only in the months July-September. Delta smelt are rarely present in the Delta in these months, so no increase in salvage due to water transfers during these months is anticipated, but as described above, these transfers might affect delta smelt prey availability.

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 . 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 proposed to offset reductions previously taken for fish protection. This could provide up to a maximum 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 13-59 and Figure 13-60 in the biological assessment show the available export capacity from Study 8.0 (Future Conditions-2030) at Banks and Jones, respectively, with the 40-30-30 WY type on the x-axis and the WY labeled on the bars. The SWP allocation or the CVP south of Delta Agriculture allocation is the allocation from CALSIM II output from the WY.

From Figure 13-59 of the biological assessment, Banks will have the most ability to move water for transfers in Critical and certain 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 all other study years (generally the wettest 80 percent) the available capacity at Banks for transfer ranges from about 0 to 500 TAF (not including the additional 60 TAF accruing from the proposed permitted increase of 500 cfs at Banks. But, over the course of the three months July-September other operations constraints on pumping and occasional contingencies would tend to reduce capacity for transfers. In consideration of those factors, proposed transfers would be up to 360 TAF in most years when capacity is limiting. In Critical and some Dry years, when capacity would not be a limiting factor, exports for transfers could be up to 600 TAF (at Banks and Jones combined). Transfers at Jones (Figure 13-60 of the biological assessment) are probably most likely to occur only in the driest of years (Critical years and some Dry years) when there is available capacity and low allocations.

Limitations

The analysis of transfer capacity available derived from the CALSIM II study 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.

Proposed Exports for Transfers

In consideration of the estimated available capacity for transfers, and in recognition of the many other operations contingencies and constraints that might limit actual use of available capacity, for this assessment proposed exports for transfers (months July-September only) are as follows:

Water Year Type	Maximum Amount of Transfer
Critical	up to 600 kaf
Consecutive Dry	up to 600 kaf
Dry after Critical	up to 600 kaf
All other Years	up to 360 kaf

Therefore, effects of water transfers are not expected to have direct entrainment effects to adult delta smelt since the proposed transfer window is a time when delta smelt are distributed the western Delta. However, water transfers could have adverse effects to delta smelt habitat or food items by increased pumping during the summer or fall. These habitat effects are captured in CALSIM II modeling and the Habitat Suitability Section.

JPOD

JPOD, as described in the Project Description and included in the SWRCB's D-1641, gives Reclamation and DWR the ability to use/exchange each Project's diversion capacity capabilities to enhance the beneficial uses of both Projects. There are a number of requirements outlined in D-1641 that restrict JPOD to protect Delta water quality and fisheries resources. The effects of JPOD are included in the CALSIM II modeling results and in the habitat suitability section.

500 cfs at Banks

Under the 500 cfs increased diversion, the maximum allowable daily diversion rate into CCF during the months of July, August, and September would increase from 13,870 AF up to 14,860 AF and three-day average diversions would increase from 13,250 AF up to 14,240 AF. This increased diversion over the three-month period would result in an amount not to exceed 90,000 AF each year. Maximum average monthly SWP exports during the three-month period from Banks Pumping Plant would increase to 7,180 cfs. Variations to hydrologic conditions coupled with regulatory requirements may limit the ability of the SWP to fully utilize the proposed increased diversion rate. Also, facility capabilities may limit the ability of the SWP to fully utilize the proposed increased diversion rate. This increased pumping may reduce the suitable habitat available for delta smelt and may result in entrainment of *Pseudodiaptomus* as described above.

NBA Diversion

The summer pumping rates of NBA diversions in study 7.0 (average rate was 115 cfs) was 18 percent lower than study 8.0 (average 135 cfs) (Chapter 12). The actual average June-August pumping in 2005-2007 was 109 cfs. Hydrodynamic modeling results from the Solano County Water Agency (SCWA) indicate that at recent (post-2004) actual pumping rates, the major water source pumped by the NBA during normal water years is Campbell Lake, a small non-tidal lake north of Barker Slough that receives local drainage. Thus under most summer-time conditions the entrainment effects are likely to have been low, especially since delta smelt move downstream by July (Nobriga et al. 2008). In dry seasons and at higher pumping rates described in Study 7 and the future Studies, the NBA entrains water from Barker and Lindsay sloughs (SCWA), indicating a potential entrainment risk for delta smelt. Historically, delta smelt densities have been low in Barker and Lindsay sloughs, but the modeling data suggest that delta smelt could exhibit some level of entrainment vulnerability. North Bay aqueduct diversions are lowest in the fall (Chapter 12), averaging 101 cfs in study 7.0, and 123 in study 8.0. The actual average September through November pumping in 2005-2007 was 94 cfs. As discussed previously, delta smelt reside in the Suisun Bay to Sherman Island region during the fall months and are not likely to be entrained. Thus, there are no expected direct effects of the NBA on delta during this period. Because pumping rates are low and the hydrodynamic models indicate only a small percentage of water entrained enters from Barker Slough, it is unlikely the NBA has any measurable indirect effects during this period.

CCWD Diversions

The effects of CCWD diversions on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on effects of CCWD diversions in the larval and juvenile delta smelt section.

Temporary Agricultural Barriers

The effects of the TBP on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on effects of the TBP in the larval and juvenile delta smelt section.

Permanent Operable Gates

The effects of the permanent gates on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on the effects of the permanent operable gates in the larval and juvenile delta smelt section.

American River Demands

The effects of increased American River demands on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on increased American River demands in the larval and juvenile delta smelt section.

Delta Cross Channel

The effects DCC operations on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on the effects of the DCC in the larval and juvenile delta smelt section.

Entrainment Effects

Water Diversions and Reservoir Operations

Banks and Jones

Entrainment effects during July through November are not expected to be significant. Delta smelt are not present during this time of year, so direct entrainment during this time of year is not likely a concern.

Intertie

The effects the intertie on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on the effects of the intertie in the larval and juvenile delta smelt section.

Suisun Marsh Salinity Control Gates

The effects of the SMSCG on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on the effects of the SMSCG in the larval and juvenile delta smelt section.

Habitat Suitability (Sept-Dec)

All fishes depend on healthy suitable habitats to survive and reproduce. Because the upper San Francisco Estuary constitutes the sole habitat for delta smelt, a healthy suitable estuary and delta are critical to the long-term health and persistence of the species. The biological assessment and the Baseline section of this biological opinion provide details on the habitat requirements for the different life stages of delta smelt. This element of the Effects Analysis covers the effects of habitat for delta smelt during the fall months of September through December. During this time period, delta smelt are maturing pre-adults that rely heavily on suitable habitat conditions in the low salinity portion of the estuary. Suitable habitat for delta smelt during this time period can be briefly defined as the abiotic and biotic components of habitat that allow delta smelt to survive and grow to adulthood. Biotic components of habitat include suitable amounts of food resources and sufficiently low predation pressures. Abiotic components of habitat include the physical characteristics of water quality parameters, especially salinity and turbidity.

Interactions between the amount or area of suitable abiotic habitat available for delta smelt and the biotic components of habitat can have great consequences on density-dependent effects on population dynamics. Density-dependence is a fundamental concept in fish population dynamics. Compensatory density-dependence is a negative feedback on population size and therefore tends to stabilize the population (Rose et al. 2001). Depensatory density-dependence is a positive feedback on the population and therefore tends to destabilize the population (Liermann and Hilborn 2001). Both of these mechanisms are important in delta smelt population dynamics. Compensatory density-dependence has been statistically detected in delta smelt at high population levels (Bennett 2005). However, the current record low levels of abundance of delta smelt make the species extremely vulnerable to the effects of depensatory density-dependence (Baxter et al. 2008).

Depensatory density-dependence can manifest in four ways: decreased probability of fertilization, impaired group dynamics, conditioning of the environment, and predator saturation (Liermann and Hilborn 2001). Patterns in the stock-recruit relationship since 2000 suggest that impaired group dynamics and the probability of fertilization are likely to be currently affecting the delta smelt population (Allee effects; Baxter et al. 2008). As discussed below, there is substantial evidence to suggest that delta smelt is vulnerable to environmental conditioning and predator saturation because the amount of suitable abiotic habitat for maturing pre-adult delta smelt has been seriously depleted and stabilized by CVP/SWP operations. The fact that delta smelt are subject to the effects of all four elements of depensatory density-dependence creates a situation where it might be extremely difficult for the population to recover under the present environmental conditions in the Estuary.

The Service's examination of habitat suitability during fall is derived from published literature and unpublished information linking X2 to the amount of suitable abiotic habitat for delta smelt (Feyrer et al 2007, 2008). Under balanced conditions, CVP/SWP operations control the position of X2 and therefore are a primary driver of delta smelt habitat suitability. As a result, this analysis relies on the effects of proposed CVP/SWP operations on fall X2, how that affects the surface area of suitable abiotic habitat for delta smelt, and finally how that affects delta smelt abundance given current delta smelt population dynamics. Supporting background material on the effect of fall X2 on the amount of suitable abiotic habitat and delta smelt abundance is available in Feyrer et al. (2007, 2008).

During the fall, when delta smelt are nearing adulthood, the amount of suitable abiotic habitat for delta smelt is positively associated with X2. This results from the effects of Delta outflow on salinity distribution throughout the Estuary. Fall X2 also has a measurable effect on recruitment of juveniles the following summer in that it has been a significant covariate in delta smelt's stock-recruit relationship since the invasion of the overbite clam. Potential mechanisms for the observed effect are two-fold. First, positioning X2 seaward during fall provides a larger habitat area which presumably lessens the likelihood of density-dependent effects (e.g., food availability) on the delta smelt population. Second, a more confined distribution may increase the impact of stochastic events that increase mortality rates of delta smelt. For delta smelt, this includes predation and anthropogenic effects such as contaminants and entrainment (Sommer et al. 2007).

This evaluation of habitat suitability considered three specific elements: X2, total area of suitable abiotic habitat, and the predicted effect on delta smelt abundance the following summer. Effects of proposed CVP/SWP operations were determined by comparing X2, the area of suitable abiotic habitat, and the effect of these two variables on delta smelt abundance across the operational scenarios characterized by the CALSIM II model runs, and also as they compare to actual historic values from 1967 to the present. The modeled scenarios include: Study 7.0, Study 7.1, Study 8.0, and Studies 9.0-9.5. This section concludes with additional observations of the historic and modeled data with a discussion of the potential underlying mechanisms.

X2

The first step of the evaluation examined the effect of proposed CVP/SWP operations on X2 (km) during fall, as determined by the CALSIM II model results. These model results are presented in a monthly time step and are provided in the appendices to the biological assessment. In order to be consistent with previous analyses (Feyrer 2007, 2008), X2 during the fall was calculated as the average of the monthly X2 values from September through December obtained from the CALSIM II model results. The data were also differentiated by WY type according to that of the previous spring.

The median X2 across the CALSIM II modeled scenarios were 10-15 percent further upstream than actual historic X2 (Figure E-19). Median historic fall X2 was 79km, while median values for the CALSIM II modeled scenarios ranged from 87 to 91km. The CALSIM II modeled scenarios all had an upper range of X2 at about 90km. The consistent upper cap on X2 shows that water quality requirements for the Delta ultimately constrain the upper limit of X2 in the simulations. These results were also consistent across WY types (Figure E-19) with the differences becoming much more pronounced as years became drier. Thus, the proposed action operations will affect X2 by shifting it upstream in all years, and the effect is exacerbated in drier years.

Area of Suitable Abiotic Habitat

The second step of the evaluation used the modeled X2 to estimate the total surface area of suitable abiotic habitat available for delta smelt. Feyrer et al. (2008) examined three different definitions of habitat suitability for delta smelt that were subsequently used to generate the hectares (ha) of suitable abiotic habitat. The three habitat criteria examined by Feyrer et al. (2008) were based on the statistical probability of delta smelt occurring in a sample due to water salinity and clarity characteristics at the time of sampling. The probabilities of occurrence they examined and compared were ≥ 10 percent, ≥ 25 percent, and ≥ 40 percent. This evaluation applied their intermediate definition of 25 percent to avoid potentially over- or under-estimating the effect. The quantitative model relating X2 to area of suitable abiotic habitat is presented in Figure E-20.

The median amounts of suitable abiotic habitat based upon X2 values generated across the CALSIM II modeled scenarios were 49-57 percent smaller than that predicted by actual historic X2 (Figure E-21). The median historic amount of suitable abiotic habitat was 9,164 ha, while median values for the CALSIM II modeled scenarios ranged from 3,995 to 4,631 ha. These results were also consistent across WY types (Figure E-21), with the differences becoming much more pronounced in drier years. Thus, the proposed action operations affect the amount of suitable abiotic habitat by decreasing it as a result of moving X2 upstream, and the effect is exacerbated in drier years.

Effect on Delta Smelt Abundance

The third step of the evaluation was to use the modeled X2 to estimate the effect on delta smelt abundance. The model relating X2 to delta smelt abundance was updated from that developed by Feyrer et al. (2008) by adding the most recent year of available data (Figure E-22). This model incorporates X2 as a covariate in the standard stock-recruit (FMWT index-TNS index the following year; Bennett (2005)) relationship for delta smelt. The model is based on data available since 1987 and therefore represents current delta smelt population dynamics (Feyrer et al. 2007). Note that although the regression model is highly significant and explains 56 percent of the variability in the data set, the residuals are not normally distributed. The pattern of the residuals suggests that some type of transformation of the data would help to define a better fitting model (Figure E-22). This analysis did not explore different data transformations. For generating predictions, the FMWT values in the model were held constant at 280, the median value over which the model was built. This was done for all iterations in order to make the results comparable across the scenarios examined. In plots that show “historic” TNS categories, the values are those predicted with the model using actual historic X2 values from 1967 to the present. This approach was necessary in order to examine the likely effects of the different scenarios on present-day delta smelt population dynamics.

The median values for the predicted TNS index based upon X2 values generated across the CALSIM II modeled scenarios were 60-80 percent smaller than those predicted from actual historic X2 (Figure E-23). The median value for the TNS index predicted based upon historic X2 was 5, while median values predicted from X2 values generated from the CALSIM II modeled scenarios ranged from 1 to 2. These results were also consistent across WY types (Figure E-23) with the differences becoming much more pronounced as years became drier. Thus, the proposed action operations are likely to negatively affect the abundance of delta smelt.

Additional Long-term Trends and Potential Mechanisms

There has been a long-term shift upstream for actual X2 during fall that is associated with a similar upstream shift in the E:I ratio (Figure E-24). X2 is largely determined by Delta outflow, which in turn is largely determined by the difference between total delta inflow and the total amount of water exported, commonly referred to as the E:I ratio. During fall, the E:I ratio directly affects X2, slightly less so when the E:I ratio reaches approximately 0.45 (Figure E-24). The leveling off is due to the need to meet D-1641 salinity standards. Thus, the long-term positive trend in X2 and the associated negative affects on area of suitable abiotic habitat and predicted delta smelt abundance appear to be related to the long-term positive trend in E:I ratio. X2 in the time series for each of the

CALSIM II model runs is even greater than the peak of the actual historic values (Figure E-25). Based on the proposed operations, the upstream X2 shift will persist.

While the above results demonstrate the likely effects of project operations on X2 averaged over the fall period, the modeling scenarios indicate that X2 in individual months will vary by WY type classification and by the specific modeling scenario (Figure E-26). In wetter years of Studies 7.0, 7.1, and 8.0 (wet and above average WY types), X2 tends to diverge from historic conditions in that it shifts upstream in September, October, and November, and shifts downstream in December. This pattern is much less pronounced in the climate change scenarios, Studies 9.0-9.5. In all model studies there is also a general decrease in interannual variability across all of the months. In drier years (below normal to critical WY types), the model scenarios indicate that for all months X2 will generally be shifted upstream and that much of the interannual historic variability will be lost.

The effects of project operations outlined above on X2 during the fall months have considerably altered the hydrodynamics of the estuary in two important ways other than which have already been described. First, the long-term upstream shift in fall X2 has created a situation where all fall seasons regardless of WY type now resemble dry or critical years (Figure E-27). In other words, all fall seasons have now been converted into uniform, low flow periods. Second, the effects have also manifested in a divergence between X2 during fall and X2 during the previous spring (April-July spring averaging period), and the modeling studies indicate this condition will persist in the future (Figure E-28).

Combined, these effects of project operations on X2 will have significant adverse direct and indirect effects on delta smelt. Directly, these changes will substantially decrease the amount of suitable abiotic habitat for delta smelt, which in turn has the possibility of affecting delta smelt abundance through the depensatory density-dependant mechanisms outlined above. Because current abundance estimates are at such historic low levels, depensatory density-dependence can be a serious threat to delta smelt despite the fact that the population may not be perceived to be habitat limited. It is clear from published research that delta smelt has become increasingly habitat limited over time and that this has contributed to the population declining to record-low abundance levels (Bennett 2005; Baxter et al. 2008; Feyrer et al. 2007, 2008; Nobriga et al. 2008). Therefore, the continued loss and constriction of habitat proposed under future project operations significantly threatens the ability of a self-sustaining delta smelt population to recover and persist in the Estuary at abundance levels higher than the current record-lows.

Indirectly, changes such as the extremely stable low outflow conditions resembling dry or critical years proposed for the fall across all WY types will likely a) contribute to higher water toxicity (Werner et al. 2008) because the proposed flows are always low in all WY types, b) contribute to the potential suppression of phytoplankton production by ammonia entering the system from wastewater treatment plants (Wilkerson et al. 2006; Dugdale et al. 2007) because diluting flows are minimal, c) increase the reproductive success of overbite clams allowing them to establish year-round populations further east because salinity is consistently high with low variability (Jan Thompson, USGS, unpublished data), d) correspond with high E:I ratios resulting in elevated entrainment of lower trophic levels, e) increase the frequency with which delta smelt encounter unscreened agricultural irrigation diversions in the Delta (Kimmerer and Nobriga 2008) because the eastward movement of X2 will shift the distribution of delta smelt upstream, and provide environmental conditions for nonnative fishes that thrive in stable conditions (Nobriga et al. 2005). Although there is no single driver of delta smelt population dynamics (Baxter et al. 2008), these indirect effects will exacerbate any direct effects on delta smelt and hinder the ability of the population to recover and maintain higher levels of abundance in the future (Bennett and Moyle 1996; Bennett 2005; Feyrer et al. 2007).

American River Demands

The effects of increased American River demands on delta smelt during the summer and fall would be similar to those described for larval and juvenile delta smelt. See previous effects discussion on the effects of increased American River demands in the larval and juvenile delta smelt section.

Komeen Treatment

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 effects 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." 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, 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) or delta smelt.

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 delta smelt in the Forebay at the time of application are taken. The daily loss values vary greatly within treatments, between months and between years. Figure E-29 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. However, since the treatments will only be during July and August, delta smelt are not expected to be present in the Forebay during this time, so adverse effects to delta smelt are unlikely.

Effects to Delta Smelt Critical Habitat

Primary Constituent Elements

Due to the interrelationship between the PCEs and the intended conservation role they serve for different delta smelt life stages, some effects are similar and overlap across the PCEs. For instance, Delta outflow determines the extent and location of the LSZ and the areas of physical habitat delta smelt are able to utilize at all times of the year. Therefore, many of the effects described below for the PCEs are difficult to separate so some effects are repeated for multiple PCEs.

Spawning Habitat

PCE 1 – Physical Habitat

Delta smelt require physical habitat only during spawning. The major impact to spawning habitat from the CVP/SWP projects would be from dredging proposed as part of construction of the South Delta Improvements Program Stage 1. However, any dredging activities will be covered through a separate section 7 consultation. Upstream reservoirs such as Shasta, Folsom and Oroville Dams reduce gravel and sediment recruitment into the rivers and estuary. However, this impact is expected to remain relatively unchanged for delta smelt. The TBP will impact the physical habitat during the construction of the barriers which again is not covered within this biological opinion.

PCE 2 – Water

As described in the Effects Section, the CVP/SWP alter the hydrologic conditions within spawning habitat throughout the spawning period for delta smelt by impacting various abiotic factors including the distributions of turbidity, food, and contaminants. Article 21, DMC-CA Intertie, NBA, and CCWD Diversions effects are included within the affects of the CVP/SWP. The TBP and the SMSCG modify circulation within the Delta and Suisun Marsh which may have a small impact on delta smelt spawning habitat. The South Delta Permanent Operable Gates should have less of an impact than the TBP if operated only within the time period, as described in the Project Description.

PCE 3 – River Flow

The CVP and SWP, as analyzed in the Effects Section, directly influence the location and the amount of suitable spawning habitat, especially in drier WYs . Further, through upstream depletions and alteration of river flows, the CVP/SWP has played a role in altering the environment of the Delta. This has resulted in adverse effects to delta smelt spawning habitat availability and may mobilize contaminants. The contaminant effects may be generated or diluted by flow depending on the amount of flow, the type of contaminant, the time of the year, and relative concentrations.

Article 21 has increased in total volume recently (see Baseline section). This increase of pumping for Article 21 has occurred in December through March which coincides with the spawning of delta smelt. The DMC-CA Intertie, NBA, and CCWD Diversions are smaller diversions that are captured within the effects of the CVP/SWP. As described in the Project Description, CCWD operations are managed for fishery concerns during the spawning and rearing period for delta smelt through the no-fill and no-diversion requirements.

PCE 4 – Salinity

The LSZ expands and moves downstream when river flows are high. By capturing river flows, reservoirs can contribute to upstream movement of the LSZ which reduces habitat quality and quantity. Banks and Jones pumping likewise can result in upstream movement of the LSZ. Model results in the biological assessment show that in the future the location of the LSZ will generally be further upstream than occurred historically. This will result in a reduction in the amount and quality of spawning habitat available to delta smelt. These changes are primarily due to proposed future increases in upstream depletions and changes to reservoir operations and export pumping from the CVP/SWP.

Habitat quality will continue to be adversely affected by contaminants and increasing numbers of non-native invasive species.

Larval and Juvenile Transport

PCE 1 – Physical Habitat

Physical habitat is needed only during the spawning season and is not associated with larval and juvenile transport.

PCE 2 – Water

As described in the Effects Section, the CVP/SWP alter the hydrologic conditions within spawning habitat throughout the spawning period for delta smelt by impacting various abiotic factors including distributions of turbidity, food, and contaminants. Article 21, DMC-CA Intertie, NBA, and CCWD Diversions effects are included within the effects of the CVP/SWP. The TBP and the SMSCG modify circulation within the Delta and Suisun Marsh which may have a small impact on delta smelt spawning habitat. The South Delta Permanent Operable Gates should have less of an impact than the TBP if operated only within the time period, as described in the Project Description.

PCE 3 – River Flows

The CVP/SWP, as analyzed in the Effects Section, directly influence river flows especially in years when releases from CVP/SWP reservoirs make up a higher percentage flows into the Delta from the Sacramento River.

In addition, pumping at Banks and Jones can alter flows within the Delta. This results in a corresponding alteration of larval and juvenile transport. Instead of tidal and downstream transport within suitable rearing areas, operations result in upstream transport that entrains delta smelt. Since the water exported during the spring and early summer (mainly March-June) from the Central and South Delta is suitable habitat, the effect of the action results in loss of suitable habitat. Unfortunately, young delta smelt do not have a cue to abandon areas where water is flowing toward Banks and Jones.

Reservoir releases and export reductions during VAMP have resulted in enhanced survival of delta smelt. However, the future of VAMP is uncertain.

The TBP increases the flux of delta smelt into the zone of entrainment. As described in the Effects Section, significant entrainment of delta smelt has occurred when the TBP operates coincident with high export levels. The South Delta Permanent Operable Gates should have less impact than the TBP if operated only within the time period specified in the Project Description (April 15-May 15 for the HOR Gate and April 15-November 30 for the flow control gates). The SMSCG can alter flows that interrupt the transport of larval and juvenile delta smelt in Montezuma Slough and Suisun Marsh when the SMSCG is closed.

PCE 4 – Salinity

As described previously, the CVP/SWP alters the location of the LSZ by modifying both the Sacramento and San Joaquin river flows which reduces habitat quality and quantity. Model results in the biological assessment show the location of the LSZ will be further upstream in the future than occurred historically. This will result in less suitable habitat for larval and juvenile delta smelt. These changes are primarily due to proposed future increases in upstream depletions and changes to reservoir operations. In addition, habitat quality will continue to be adversely affected by many associated factors like non-native invasive species and contaminants. The SMSCG, when in operation, modifies the salinity within Suisun Marsh and when in operation, there can be upstream movement of X2.

However, the SMSCG have been operated less frequently in recent years.

Rearing Habitat

PCE 1 – Physical Habitat

Physical habitat is needed only during the spawning season and is not associated with rearing habitat.

PCE 2 – Water

As described in the Effects Section, the CVP/SWP alter the hydrologic conditions within rearing habitat throughout the spawning period for delta smelt by impacting various abiotic factors including distributions of turbidity, food, and contaminants. Article 21, DMC-CA Intertie, NBA, and CCWD Diversions effects are included within the effects of the CVP/SWP. As described in the Project Description, CCWD operations are managed during the spawning and rearing period for delta smelt through the no-fill and no-diversion requirements. The TBP and the Suisun Marsh Salinity Control Gates modify circulation within the Delta and Suisun Marsh which may have a small adverse impact on delta smelt rearing habitat. The South Delta Permanent Operable Gates should have less of an adverse impact than the TBP if operated only within the time period (April 15-May 15 for the HOR Gate and April 15-November 30 for the flow control gates), as described in the Project Description.

PCE 3 – River Flows

The CVP and SWP, as analyzed in the Effects Section, directly influence river flows.

Pumping at Banks and Jones alters flows within the Delta. As described in the Effects Section, negative flows can result in an increase risk of entrainment when rearing habitat includes the South Delta. In addition, when rearing habitat includes the Central and South Delta, as temperatures increase in May and June, altered river flows can further degrade rearing habitat suitability. Rearing habitat in the South Delta may also be impacted indirectly through increases in contaminant concentrations and entrainment of zooplankton.

The TBP alter flows within rivers and channels which can increase the risk of entrainment. As described in the Effects Section, in the past with operation of the TBP and with high export levels, significant spikes in delta smelt entrainment have occurred at Jones and Banks. The South Delta Permanent Operable Gates should have less impact than the TBP if operated only within the time period (April15-May 15 for the HOR Gate and April 15-November 30 for the flow control gates), as described in the Project Description. The SMSCG can alter flows that interrupt and alter flows in Montezuma

Slough and Suisun Marsh when the SMSCG is closed.

PCE 4 – Salinity

As stated previously, the CVP/SWP alters the extent and location of the LSZ by modifying both the Sacramento and San Joaquin river flows which reduces habitat quality and quantity. Model results in the biological assessment show that in the future the location of the LSZ will be further upstream in the future than occurred historically. This will result in less suitable habitat for larval and juvenile delta smelt. These changes are primarily due to proposed future increases in upstream depletions and changes to reservoir operations and exports at Banks and Jones. In addition, habitat quality will continue to be adversely affected by mobilizing and concentrating contaminants within the Delta and creating hydrologic conditions that favor non-native invasive species over native species. The SMSCG, when in operation, modifies the salinity within Suisun Marsh and when the SMSCG is in operation there can be upstream movement of X2. However, the Gates have been operated less frequently in recent years.

Adult Migration

PCE 1 – Physical Habitat

Physical habitat is needed only during the spawning season and is not associated with adult migration per se.

PCE 2 – Water

As described previously, the CVP/SWP alters Delta hydrodynamics in ways that adversely affect delta smelt migration. Article 21, DMC-CA Intertie, NBA, and CCWD Diversions effects are included within the affects of the CVP/SWP. The TBP and the SMSCG modify circulation within the Delta and Suisun Marsh which may have a small impact on delta smelt migration. The South Delta Permanent Operable Gates should have less of an impact than the TBP if operated only within the time period, as described in the Project Description.

PCE 3 – River Flows

The CVP and SWP, as analyzed in the Effects Section, directly influence river flows especially during low flow periods when releases from CVP and SWP reservoirs make up a higher percentage of river flows into the Delta from the Sacramento River.

River flows in combination with an increase in turbidity cues the upstream migration of delta smelt for spawning.

In addition, Banks and Jones can alter flows within rivers and channels within the Delta. These alterations can interrupt the migration of pre-spawning and spawning adult delta smelt resulting in entrainment of delta smelt. As described in the Effects Section, adult entrainment is likely to be higher than it has been in the past under most operating scenarios, resulting in lower potential production of larval and juvenile delta smelt.

The South Delta Permanent Operable Gates would only have adverse effect to adult migration if they are operated during the winter months. The SMSCG can alter flows that interrupt movements of adult delta smelt in Montezuma Slough and Suisun Marsh when the gate is closed.

PCE 4 – Salinity

The CVP/SWP alters the location of the LSZ by modifying both the Sacramento and San Joaquin river flows which reduces habitat quality and quantity. Model results in the biological assessment show that in the future the location of the LSZ will be further upstream than occurred historically. This will result in less suitable habitat for pre-spawning and spawning delta smelt. These changes are primarily due to the proposed future increases in upstream depletions and changes to reservoir operations. The SMSCG, when in operation, modifies the salinity within Suisun Marsh and when the Gates is in operation there can be upstream movement of X2. However, the Gates have been operated less frequently in recent years.

Summary of Effects of the Action on Delta Smelt Critical Habitat

Implementation of the proposed action, primarily the volume of diversions at Banks and Jones relative to proposed Delta inflows, will prevent critical habitat from serving its intended conservation role. It is imperative that suitable habitat conditions, as defined by the co-occurring PCEs, immediately be provided over the designated critical habitat. This is based on the extremely low numbers of delta smelt; their annual life cycle, and the fact that delta smelt spend their entire life within the influence of the CVP/SWP. The proposed actions only provide as conservation measures VAMP and flows from the Yuba Water Accord (identified in the Project Description as "limited EWA"). In the past, VAMP has benefited delta smelt. However, equivalent flows may not be provided in all WYs.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act.

On-going non-Federal diversions of water within the action area (e.g., municipal and industrial uses, as well as diversions through intakes serving numerous small, private agricultural lands) are not likely to entrain very many delta smelt based on the results of a study by Nobriga et al. (2004). Nobriga et al. reasoned that the littoral location and low-flow operational characteristics of these diversions reduced their risk of entraining delta smelt. A study of the Morrow Island Distribution System by DWR produced similar results, with one demersal species and one species that associates with structural environmental features together accounting for 97-98 percent of entrainment; only one delta smelt was observed to be entrained during the two years of the study (DWR 2007).

State or local levee maintenance may also destroy or adversely affect delta smelt spawning or rearing habitat and interfere with natural, long term spawning habitat-maintaining processes. Operation of flow-through cooling systems on the Mirant electrical power generating plants that draw water from and discharge into the action area may also adversely affect delta smelt in the form of entrainment and locally increased water temperatures.

Adverse effects to delta smelt and its critical habitat may result from point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into Delta waterways from shipping and boating activities and from urban activities and runoff. Implicated as potential stressors of delta smelt, these contaminants may adversely affect fish reproductive success and survival rates.

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of their discharge of ammonia. The Sacramento Regional County Sanitation District (SRCSD) wastewater treatment facility near Freeport discharges more than 500,000 cubic meters of treated wastewater containing more than 10 tons of ammonia into the Sacramento River each day (http://www.sacbee.com/378/story/979721.html). Preliminary studies commissioned by the IEP POD investigation and the Central Valley Regional Water Quality Control Board are evaluating the potential for elevated levels of Sacramento River ammonia associated with the discharge to adversely affect delta smelt and the Delta ecosystem. The Freeport location of the SRCSD discharge places it upstream of the confluence of Cache Slough and the mainstem Sacramento River, a location just upstream of where delta smelt have been observed to congregate in recent years during the spawning season. The potential for exposure of a substantial fraction of delta smelt spawners to elevated ammonia levels has heightened the importance of this investigation. Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the Estuary frequented by delta smelt and its recent upgrades suggest that it is more a potential issue for migrating salmonids than for delta smelt.

Other future, non-Federal actions within the action area that are likely to occur and may adversely affect delta smelt and its critical habitat include: the dumping of domestic and industrial garbage that decreases water quality; construction and maintenance of golf courses that reduce habitat and introduce pesticides and herbicides into the aquatic environment; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; agricultural activities, including burning or removal of vegetation on levees that reduce riparian and wetland habitats that contribute to the quality of habitat used by delta smelt; and livestock grazing activities that may degrade or reduce riparian and wetland habitats that contribute to the quantity and quality of habitat used by delta smelt.

Future actions that implement planning efforts such as the Bay-Delta Conservation Plan or the Governor's Delta Vision may have adverse effects to delta smelt or its critical habitat, but these projects would have a federal nexus and would be the subject of future ESA consultations, as appropriate.

Figures referenced in the Effects Section

Figure E-1. Relationship between average December-March flow in Old and Middle rivers and the salvage of delta smelt in the same averaging period.

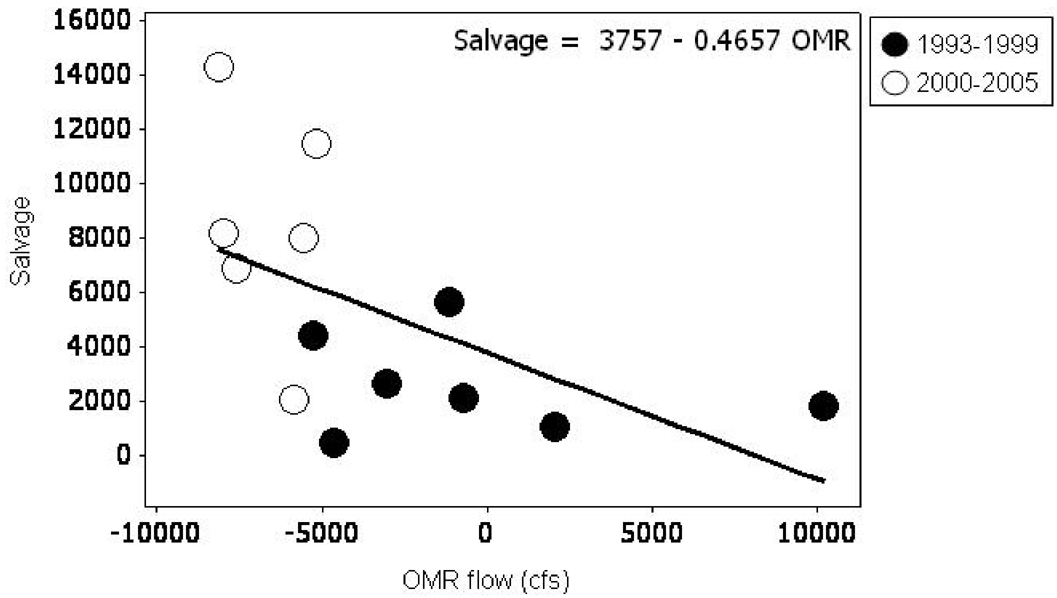


Figure E-2. Average winter (Dec-Mar) OMR flow (A), total Delta inflow (B), and combined SWP/CVP exports (C) by year. The data were fitted with lowess splines to show trends.

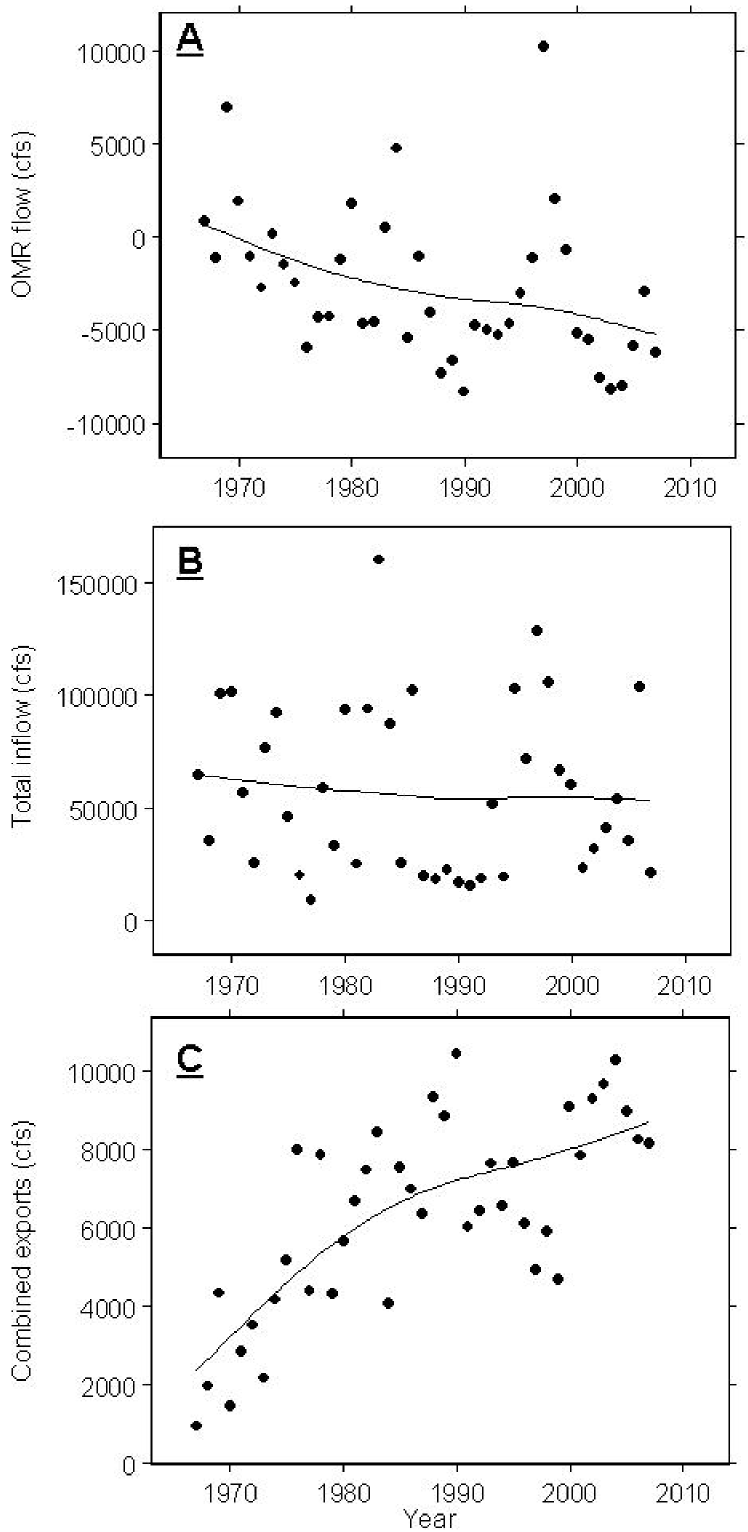


Figure E-3. Boxplot summary of CALSIM II operations study outputs of average winter (Dec-Mar) OMR flow for five water year types and the actual historic data (1967-2007). The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles.

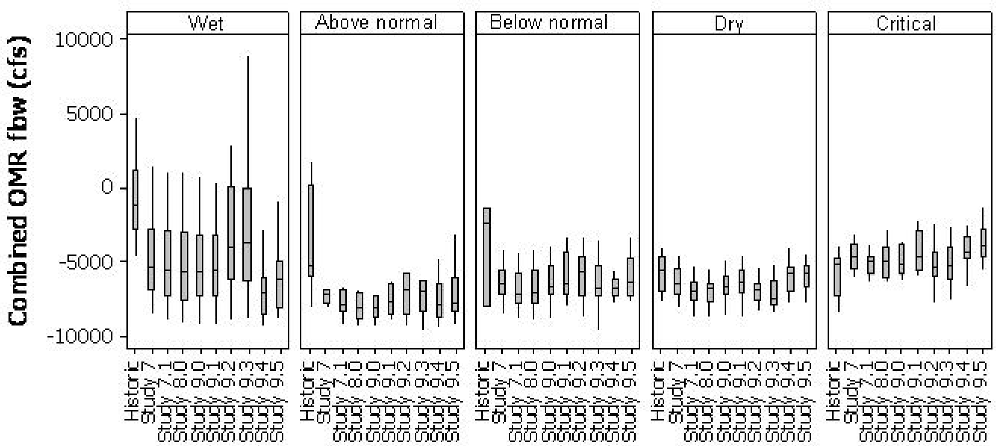


Figure E-4. Time series of estimated percentages (with 95 percent error bars) of the adult delta smelt population entrained in the SWP and CVP South Delta water export diversion facilities estimated from Kimmerer (2008). OMR flow is plotted on the secondary y-axis.

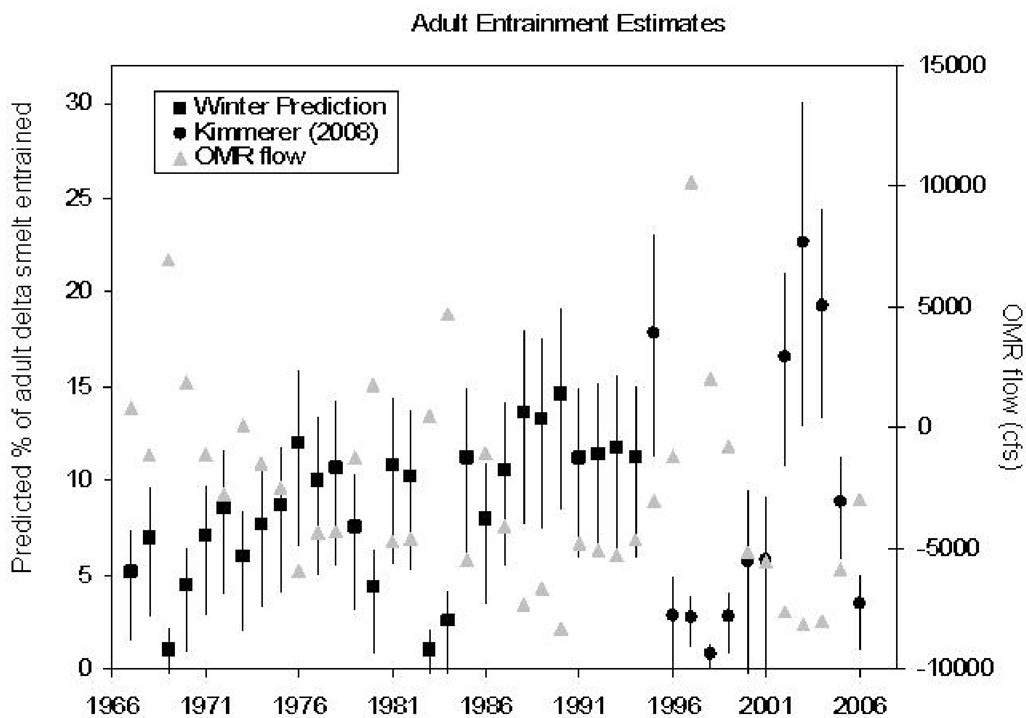


Figure E-5. Frequency distribution of predicted adult delta smelt entrained at Banks and Jones for predicted estimates from historic data (1967-1994), actual estimates from Kimmerer (2008) for years 1995-2006, and those estimated from CALSIM II model data by study.

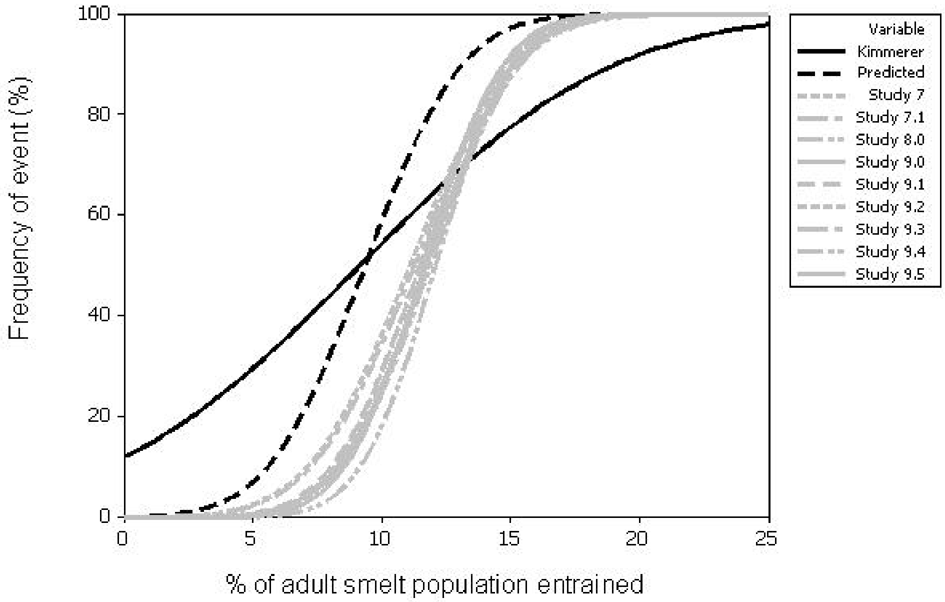


Figure E-6. Same as E-5 but by water year type. Kimmerer (2008) estimates did not include below normal or critical dry water year types.

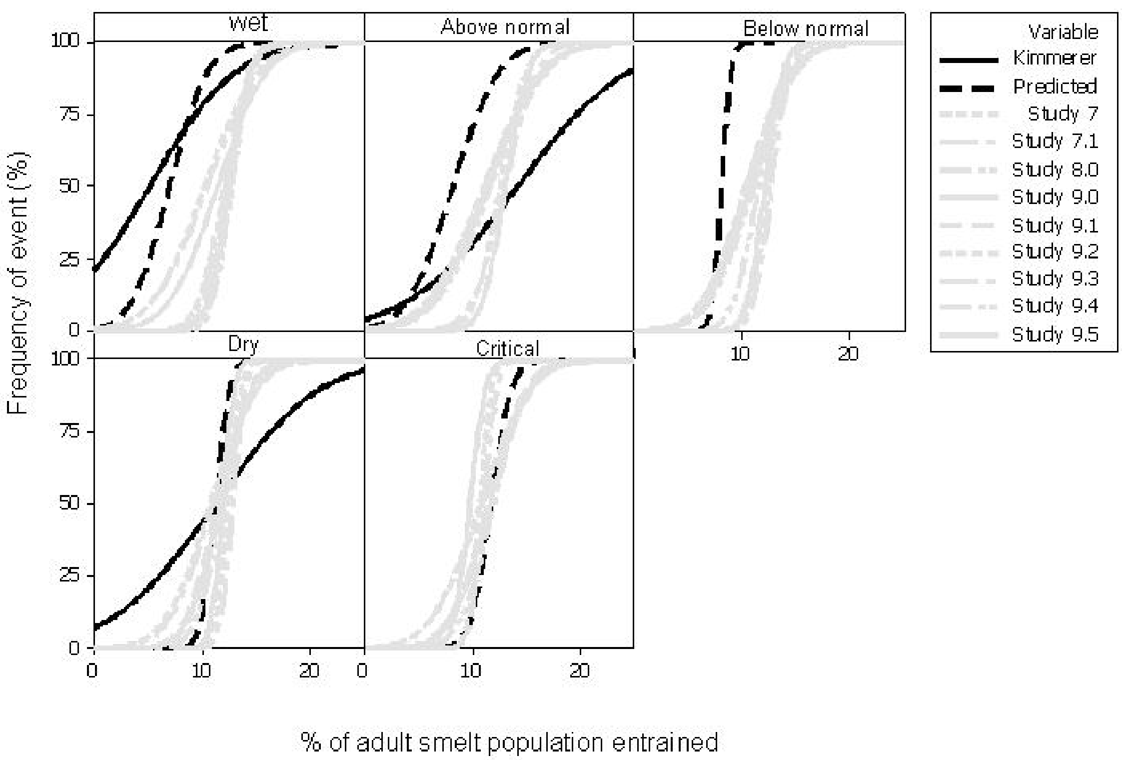


Figure E-7. Scatterplot of average flow in Old and Middle rivers (upper panel = March – June; lower panel = April – May) and the percentage of the larval and juvenile delta smelt population entrained in the SWP and CVP export pumps. The entrainment estimates were taken from Kimmerer (2008). The bubble sizes are scaled to the average Delta outflow for the same averaging periods as the OMR flows.

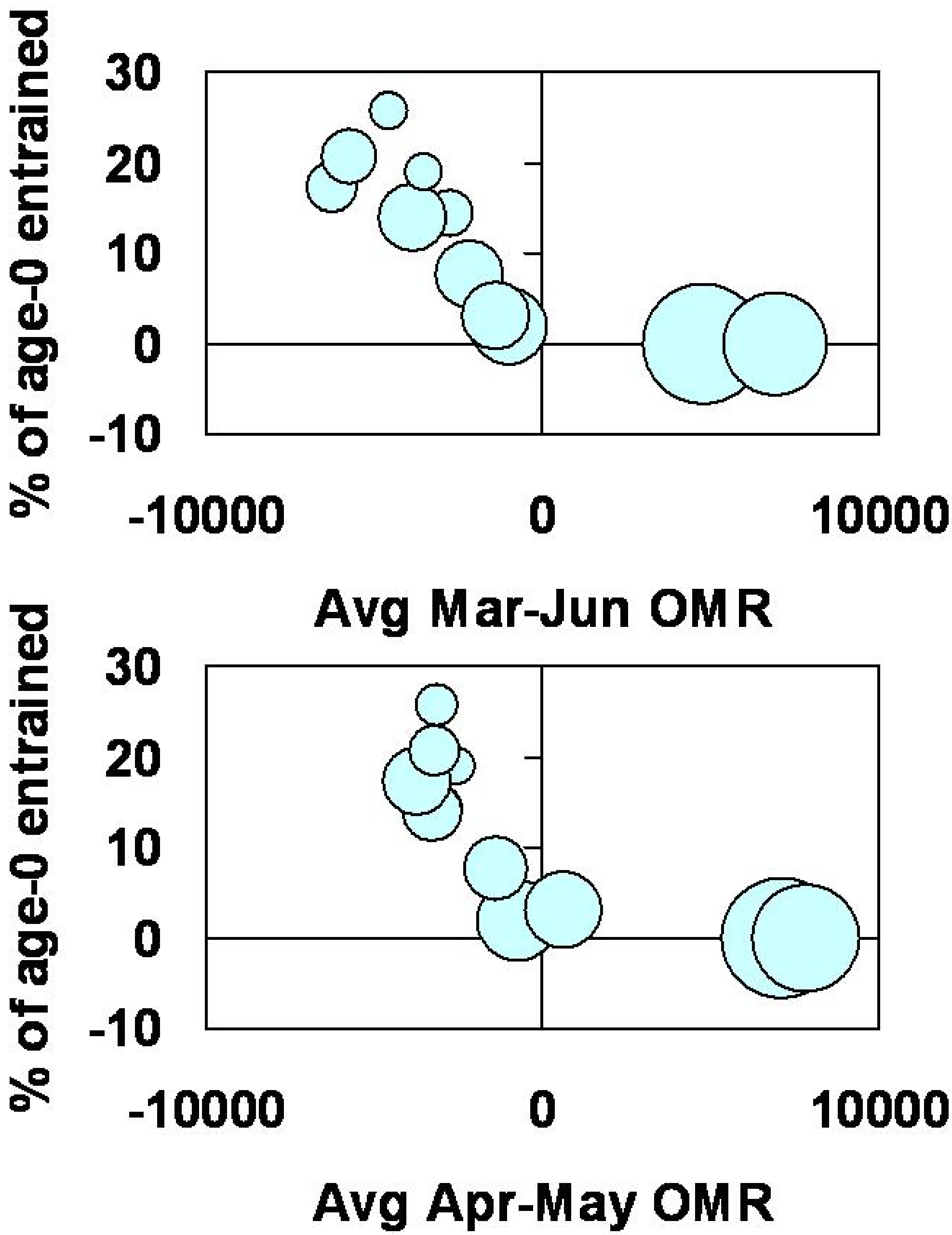


Figure E-8. Time trend in average March – June flow Old and Middle river flow, 1967-2007. Data for 1980-2006 are empirical data based on ADCP measurements. Data for 1967-1979 and 2007 are estimated as described in the text. The spline is a LOWESS regression
line.

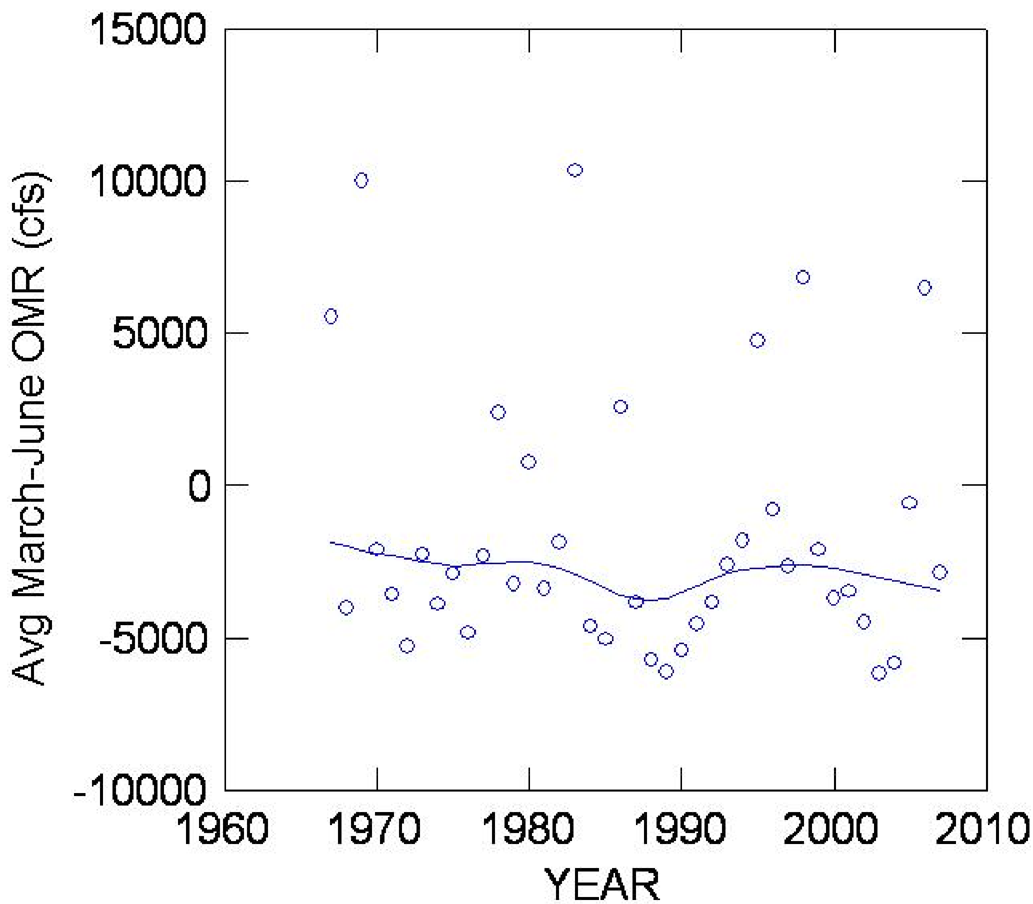


Figure E-9. Time trend in average April-May OMR flow, 1967-2007. Data for 1980-2006 are empirical data based on ADCP measurements. Data for 1967-1979 and 2007 are estimated as described in the text. The spline is a LOWESS regression line.

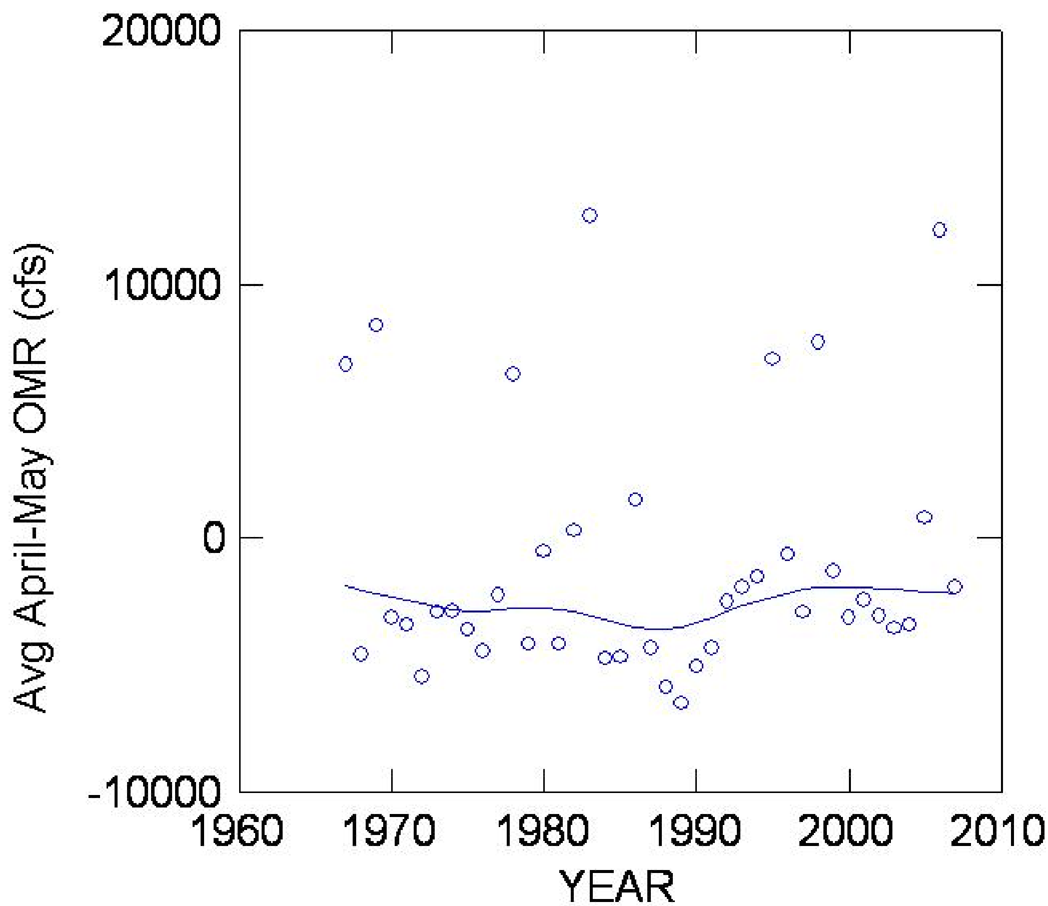


Figure E-10. Time trend in average March – June Delta outflow, 1967-2007. The spline is a LOWESS regression line.

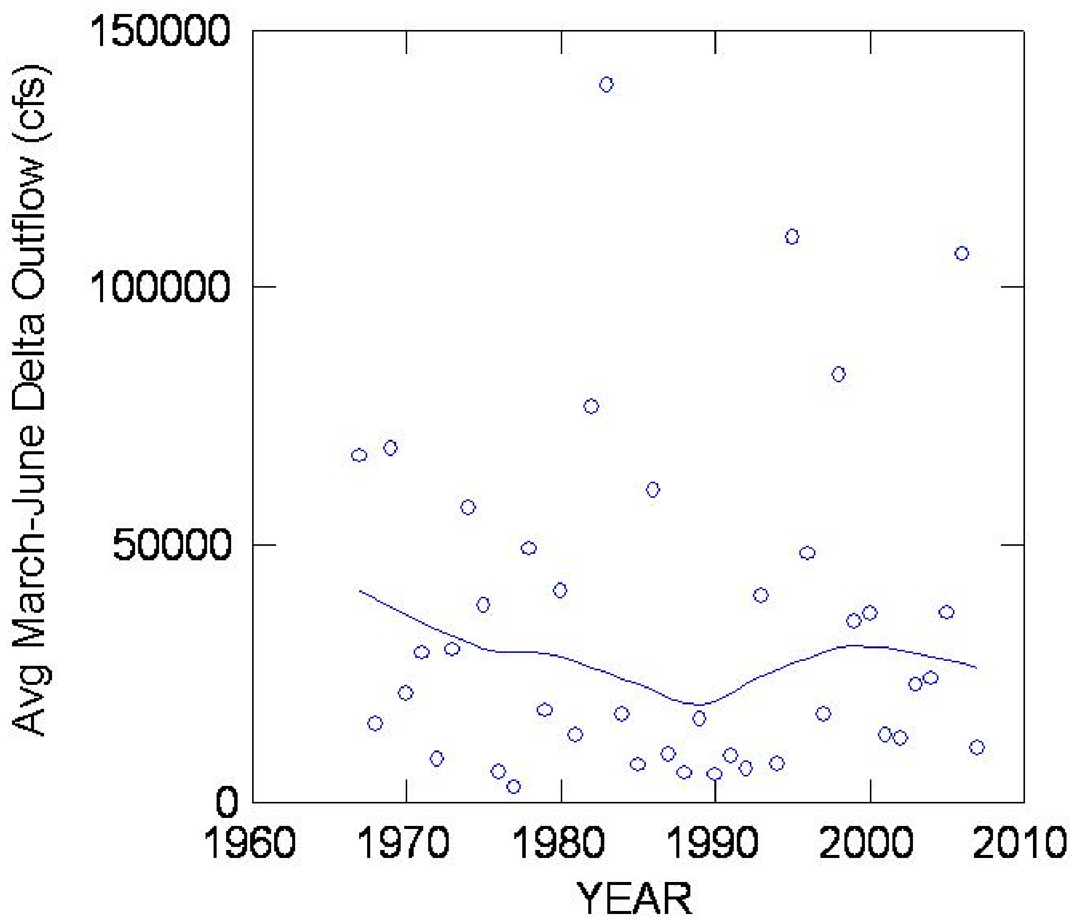


Figure E-11. Time trend in average April - May Delta outflow, 1967-2007. The spline is a LOWESS regression line.

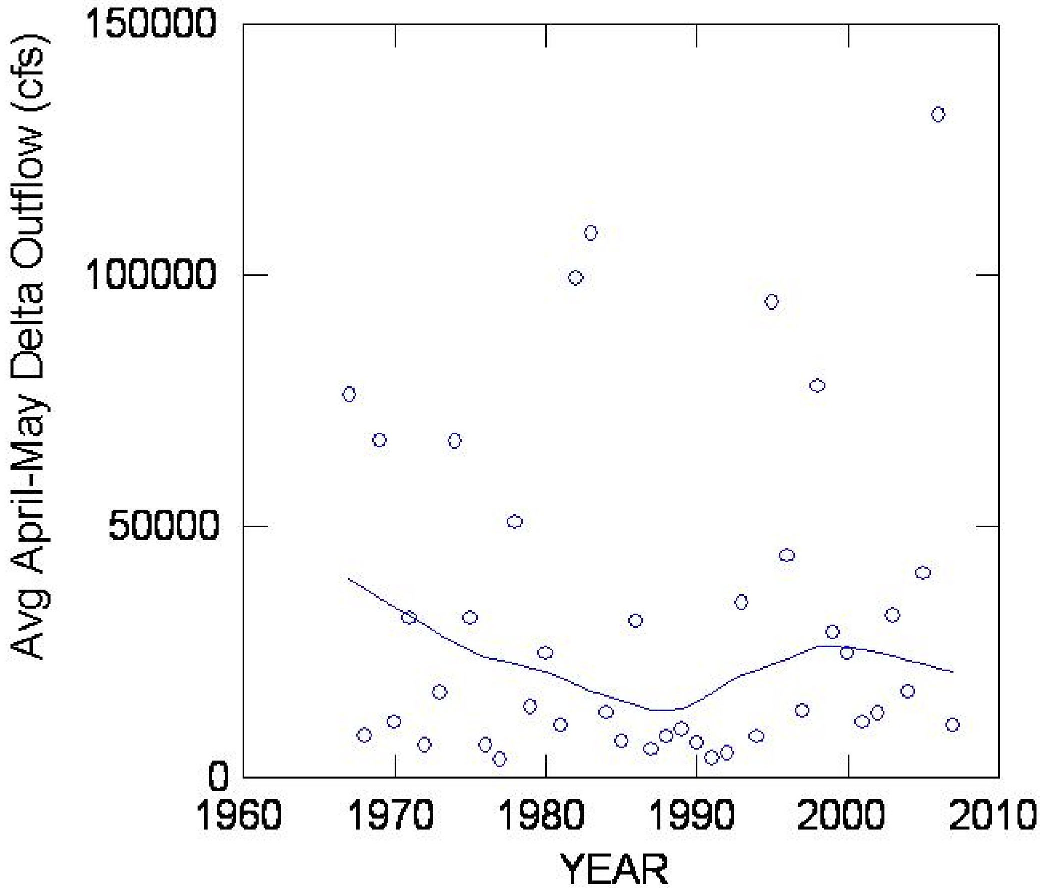


Figure E-12. Boxplot summary of CALSIM II operations study outputs of average March – June flows in Old and Middle rivers for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by the lines and asterisks. “Actual” is estimated and measured OMR flows from 1967-2007.

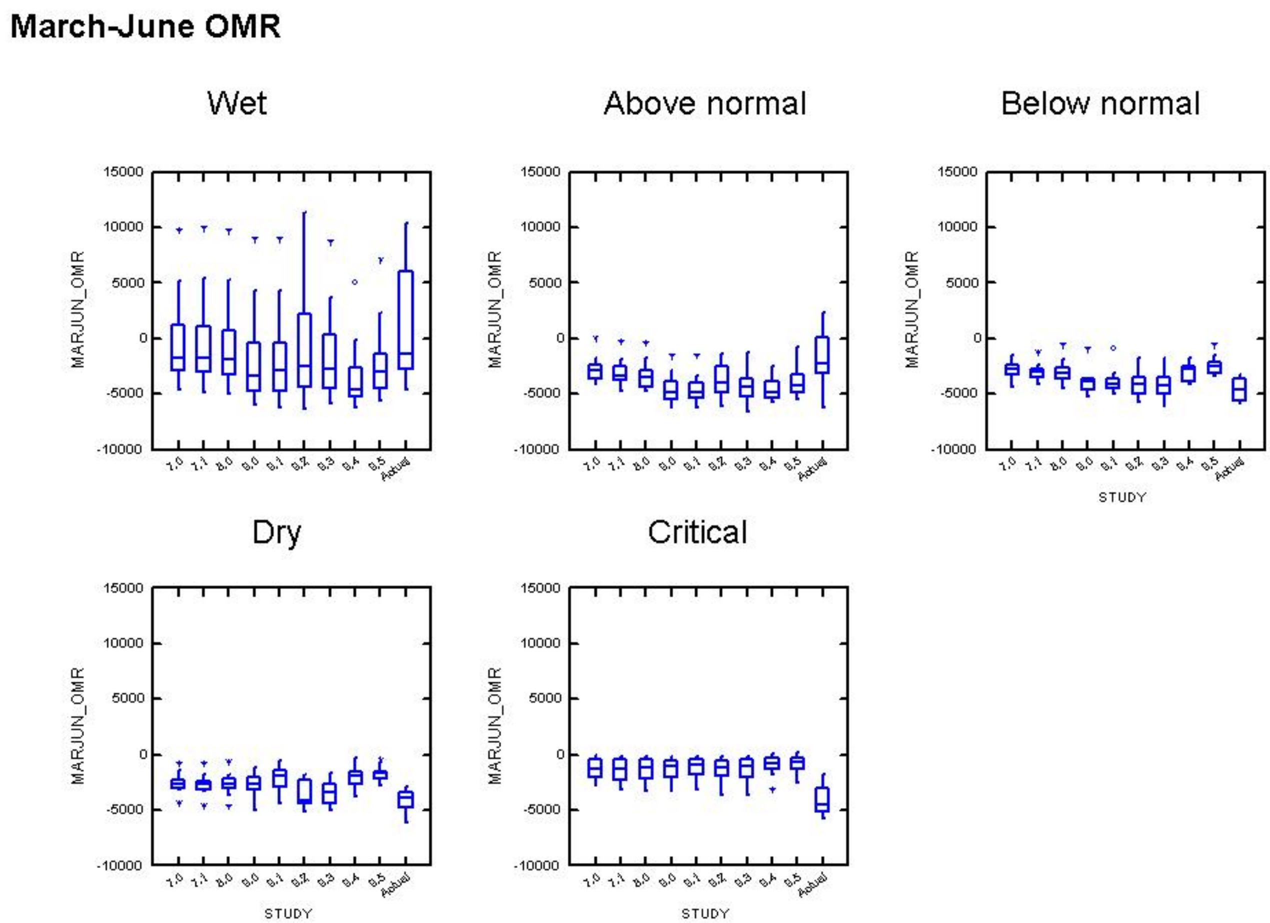


Figure E-13. Boxplot summary of CALSIM II operations study outputs of average April – May flows in Old and Middle rivers for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by the lines and asterisks. “Actual” is estimated and measured OMR flows from 1967-2007.

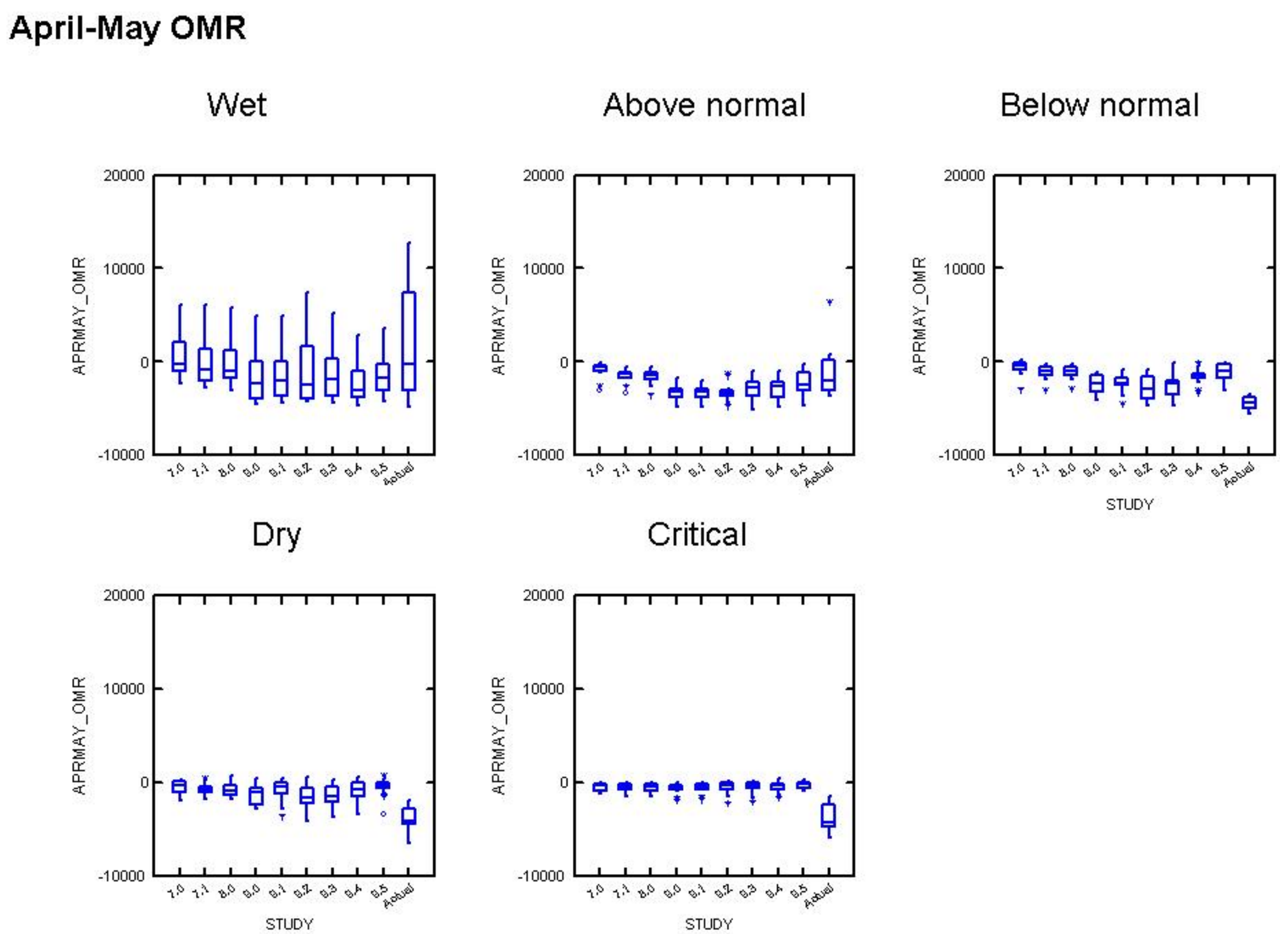


Figure E-14. Boxplot summary of CALSIM II operations study outputs of average March – June X2 positions for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by the lines and asterisks. “Actual” is X2 from 1967-2007.

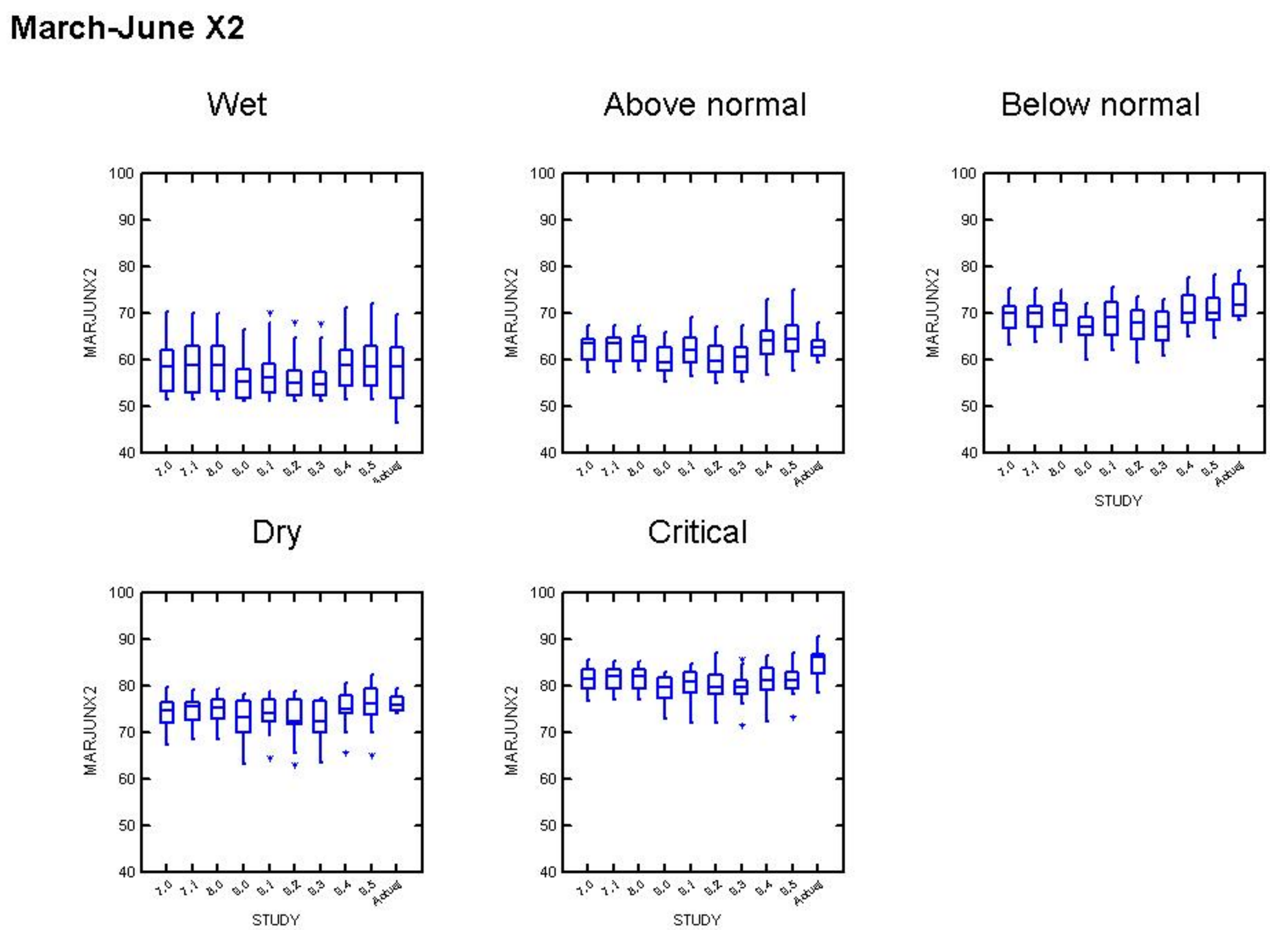


Figure E-15. Boxplot summary of CALSIM II operations study outputs of average April – May X2 positions for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by the lines and asterisks. “Actual” is X2 from 1967-2007.

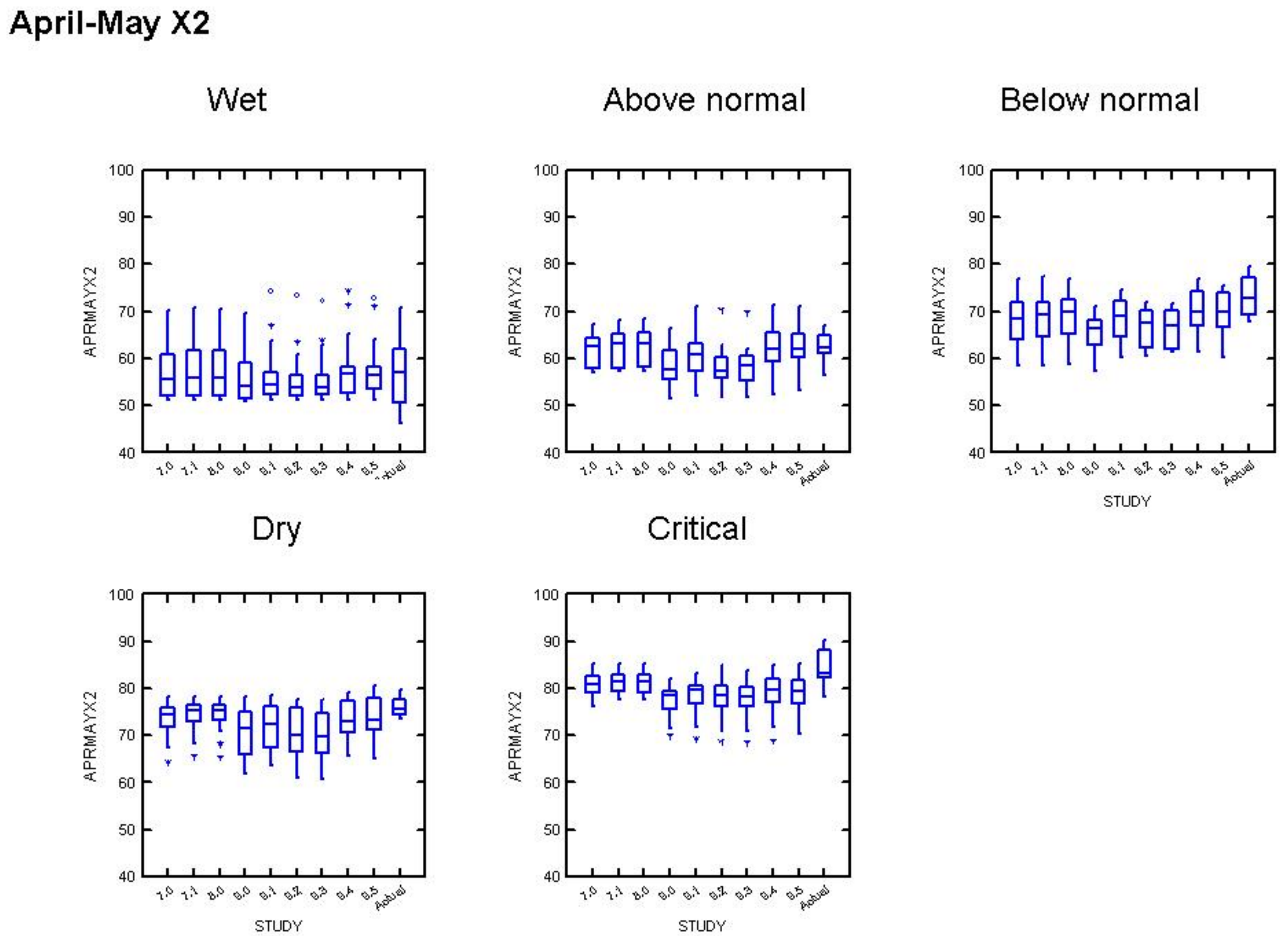


Figure E-16. Time series of estimated percentages of the larval-juvenile delta smelt population entrained in the SWP and CVP South Delta water export diversion facilities. Error bars were estimated by linear regression of Kimmerer's (2008) entrainment estimates versus the upper and lower 95 percent confidence intervals of the estimates.

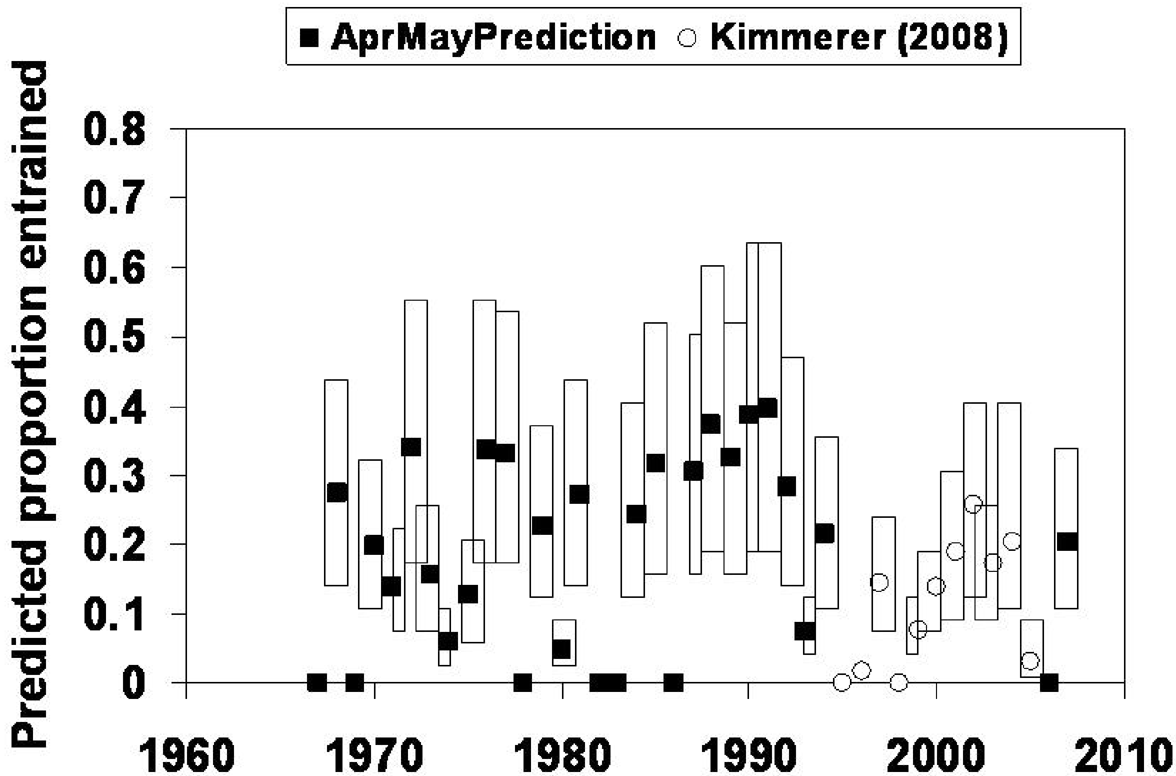


Figure E-17. Frequency distribution of estimated proportions of larval-juvenile delta smelt entrained at Banks and Jones for 1967-1994 and 1995-2007. The data were extrapolated to an 82-year period to make them comparable to the CALSIM II outputs in the biological assessment.

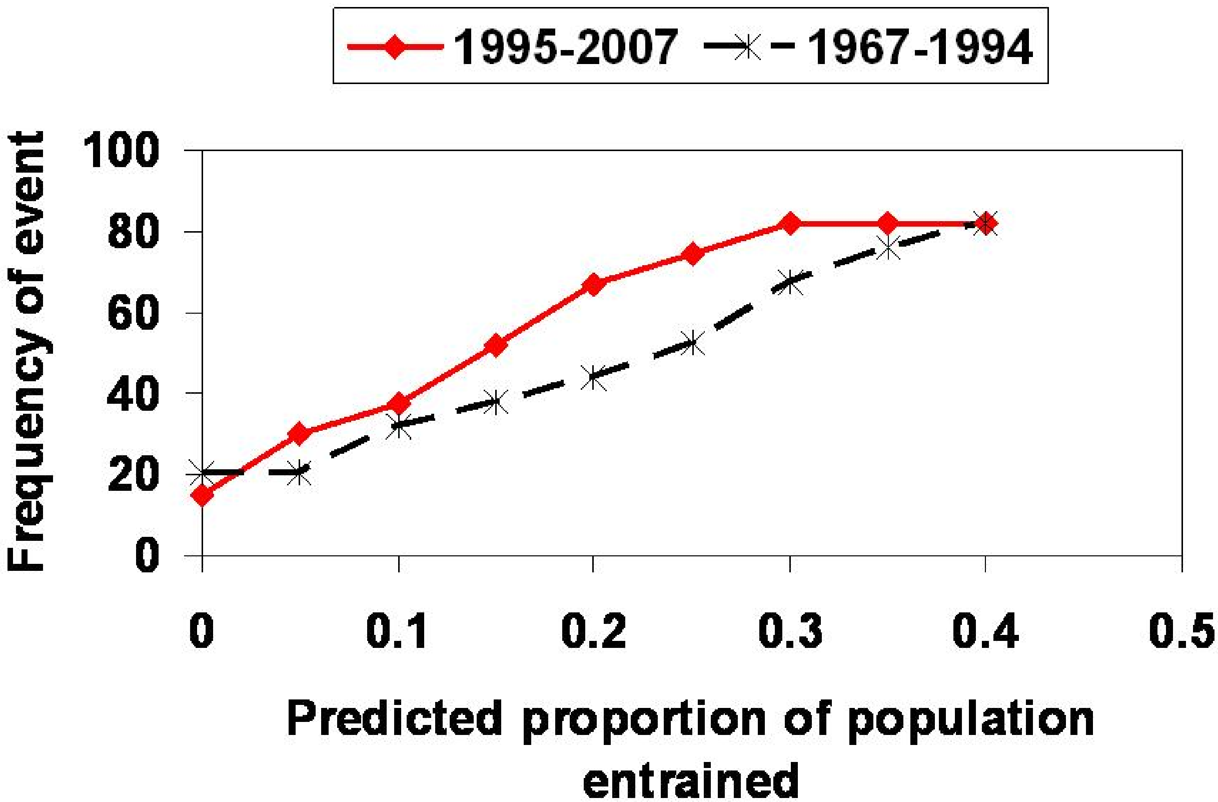


Figure E-18. Same as Figure 17, but including estimates based on X2 and OMR summaries from studies 7.0, 7.1, 8.0, 9.0-9.5 from the biological assessment.

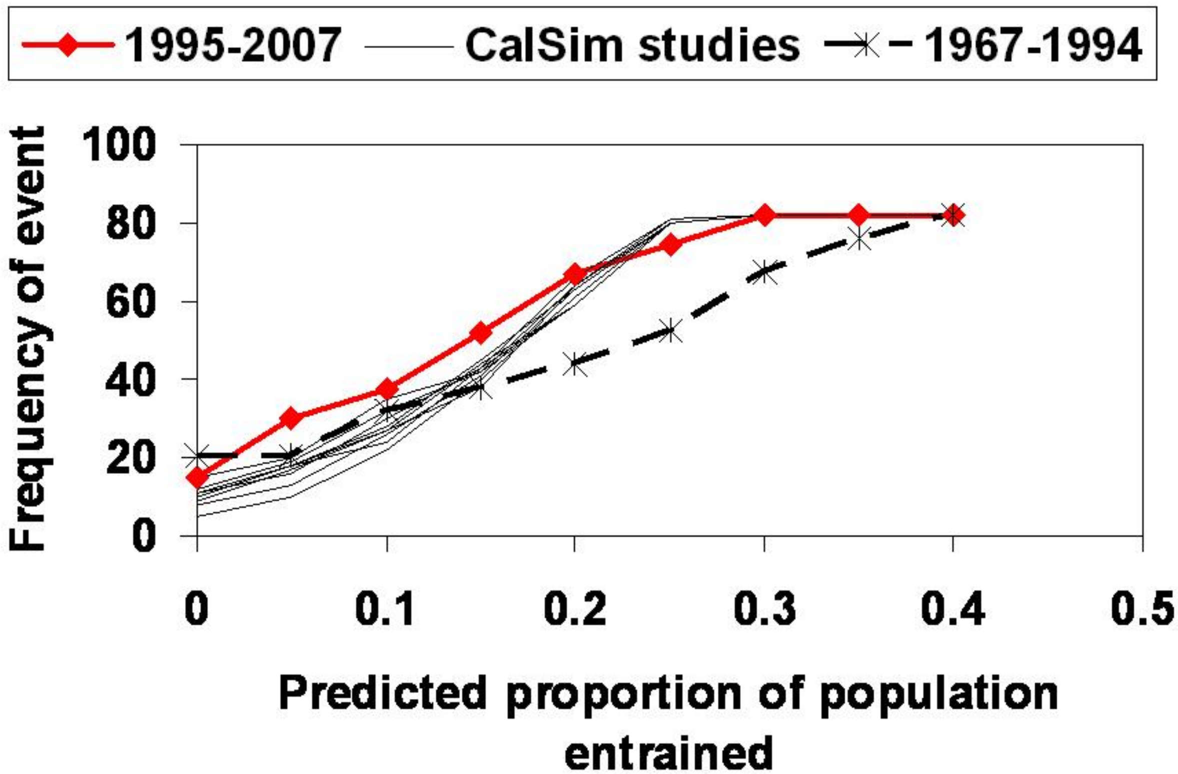


Figure E-19. X2 (km) during September to December based on historic data and CALSIM II model results. The center line in the box is the median and the outer box boundaries are the first and third quartiles.

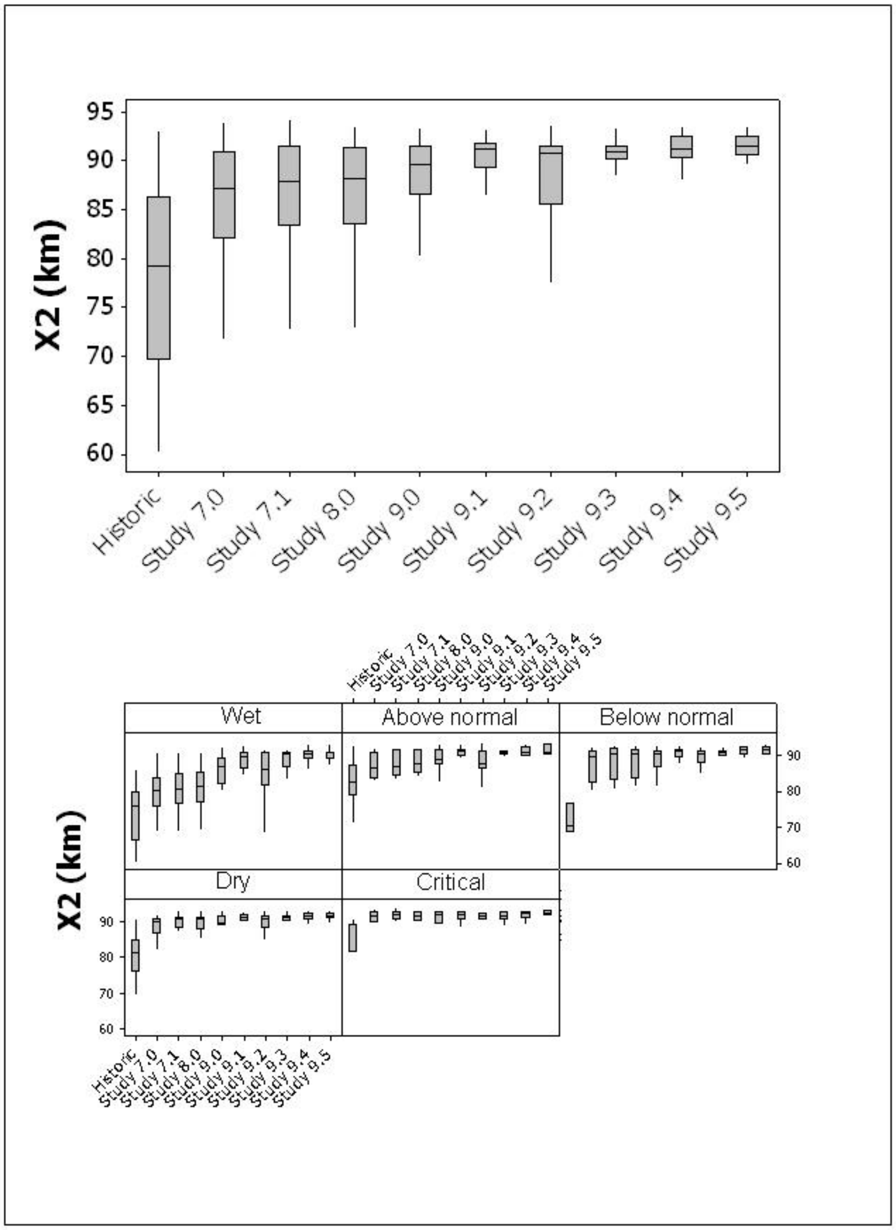
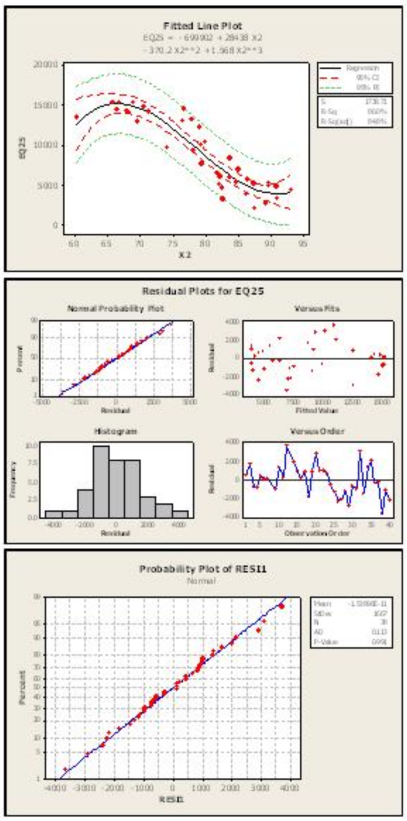


Figure E-20. Summary statistics for the model relating the effect of X2 on the area of suitable abiotic habitat (ha) for delta smelt during September to December.



The regression equation is
EQ25 = - 699902 + 28438 X2 - 370.2 X2**2 + 1.568 X2**3

S = 1738.71 R-Sq = 86.0% R-Sq(adj) = 84.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	630739911	210246637	69.55	0.000
Error	34	102786267	3023126		
Total	37	733526178			

Sequential Analysis of Variance

Source	DF	SS	F	P
Linear	1	582964214	139.39	0.000
Quadratic	1	6071691	1.47	0.233
Cubic	1	41704006	13.79	0.001

Figure E-21. Area of suitable abiotic habitat (ha) during September to December) based on historic data and CALSIM II model results for X2. The center line in the box is the median and the outer box boundaries are the first and third quartiles..

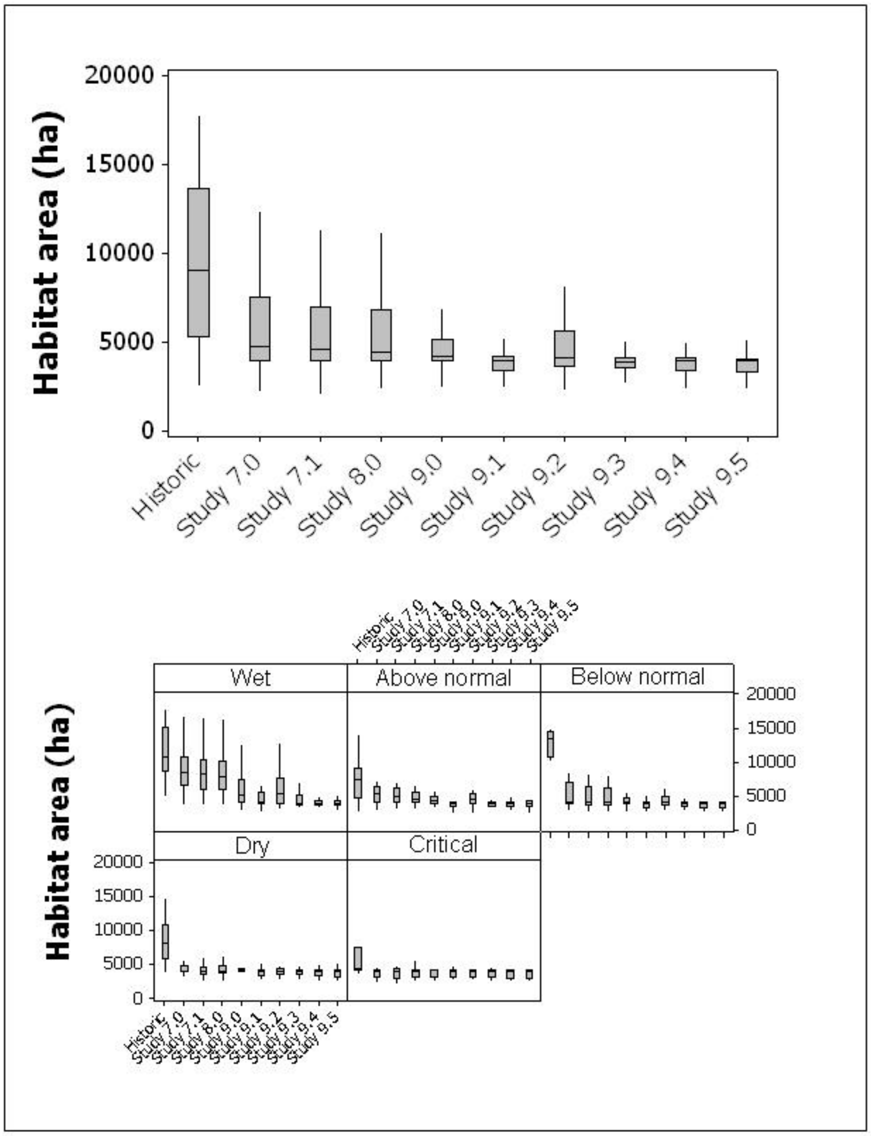
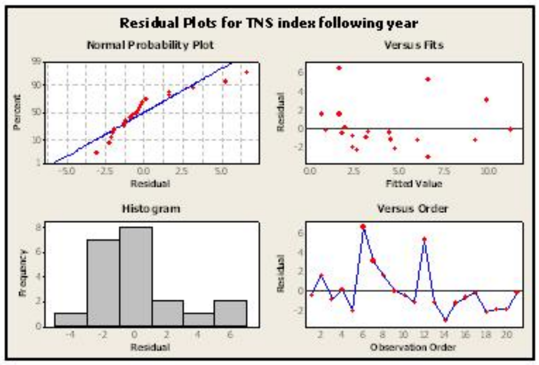
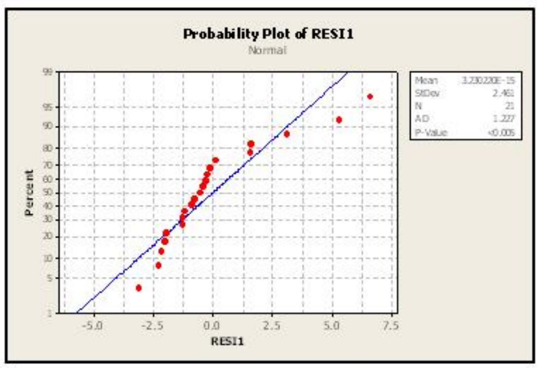


Figure E-22. Summary statistics for the stock-recruit model for delta smelt that incorporates X2 position during September to December as a covariate.





The regression equation is
TNS index following year = 29.1 + 0.00708 FMT index - 0.328 X2

Predictor	Coef	SE Coef	T	P
Constant	29.12	11.63	2.50	0.022
FMT index	0.007078	0.001886	3.75	0.001
X2	-0.3277	0.1354	-2.42	0.026

S = 2.59377   R-Sq = 60.6%   R-Sq(adj) = 56.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	186.134	93.067	13.83	0.000
Residual Error	18	121.097	6.728		
Total	20	307.231			

Source	DF	Seq SS
FMT index	1	146.751
X2	1	39.383

Figure E-23. Predicted Summer Townet Index for delta smelt based on historic and CALSIM II-modeled values of X2 position. The center line in the box is the median and the outer box boundaries are the first and third quartiles.

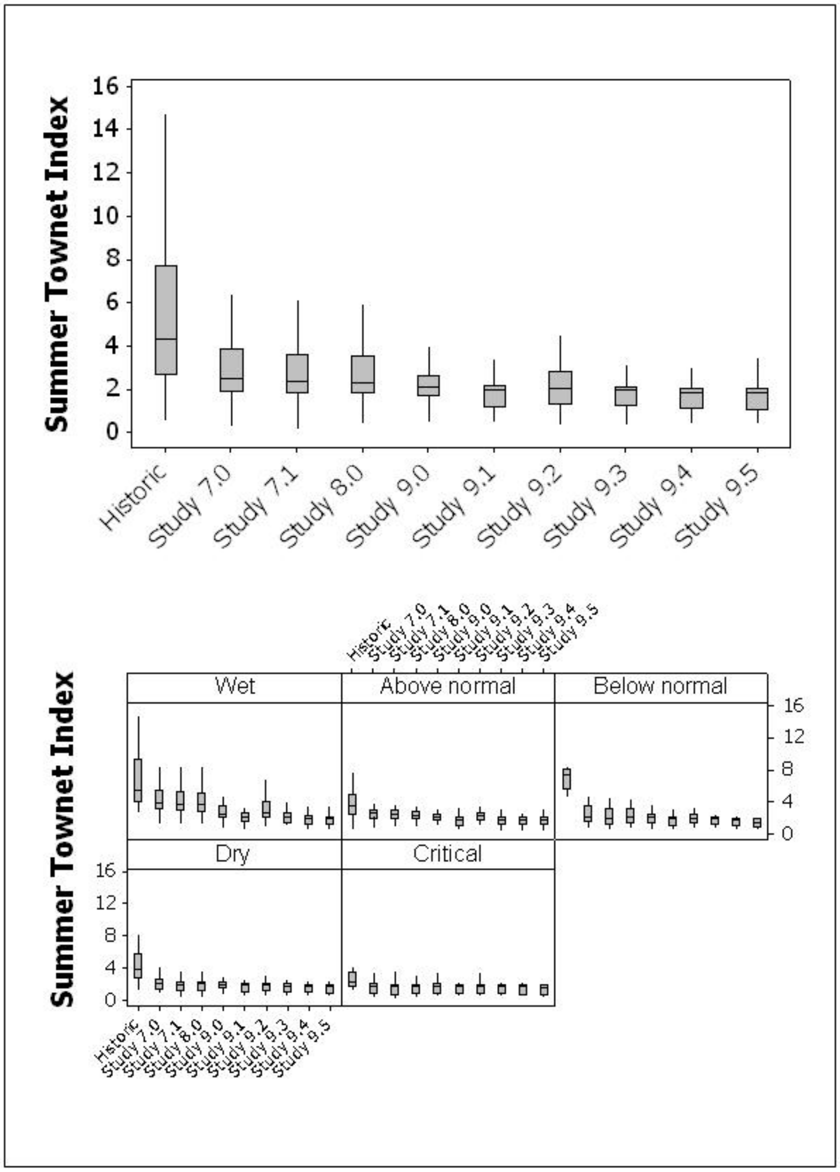


Figure E-24. Time series of historic X2 and E:I ratio for fall (September-December) in the upper panels and their relationship in the lower panel.

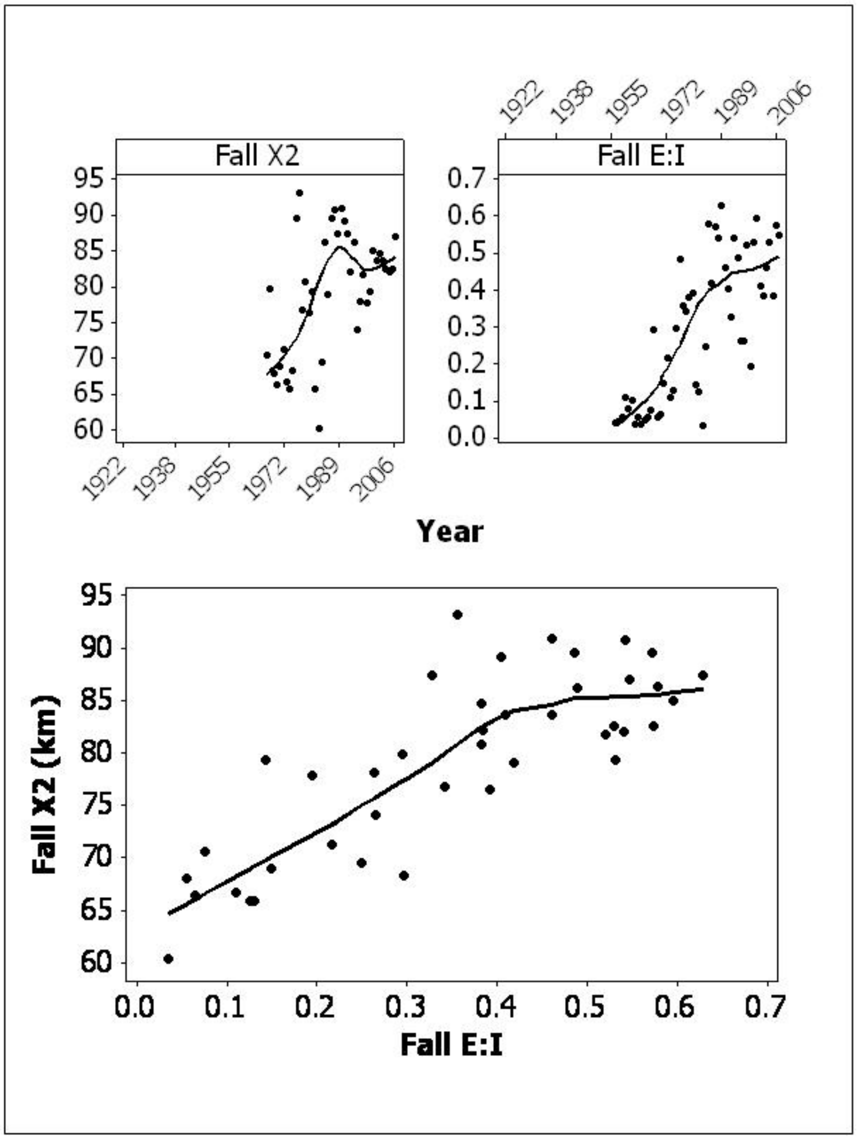


Figure E-25. Smoothed trend lines for the time series of historic and CALSIM II-modeled fall X2.

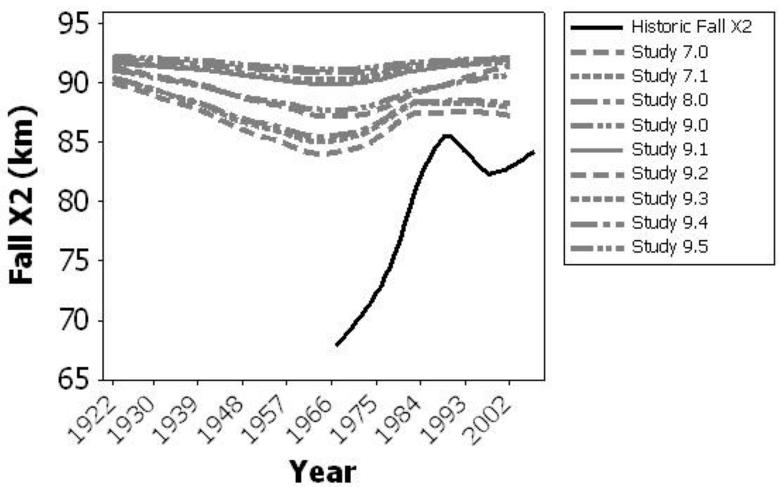


Figure E-26. X2 (km) during individual fall months for historic data and CALSIM II model results. The center line in the box is the median and the outer box boundaries are the first and third quartiles.

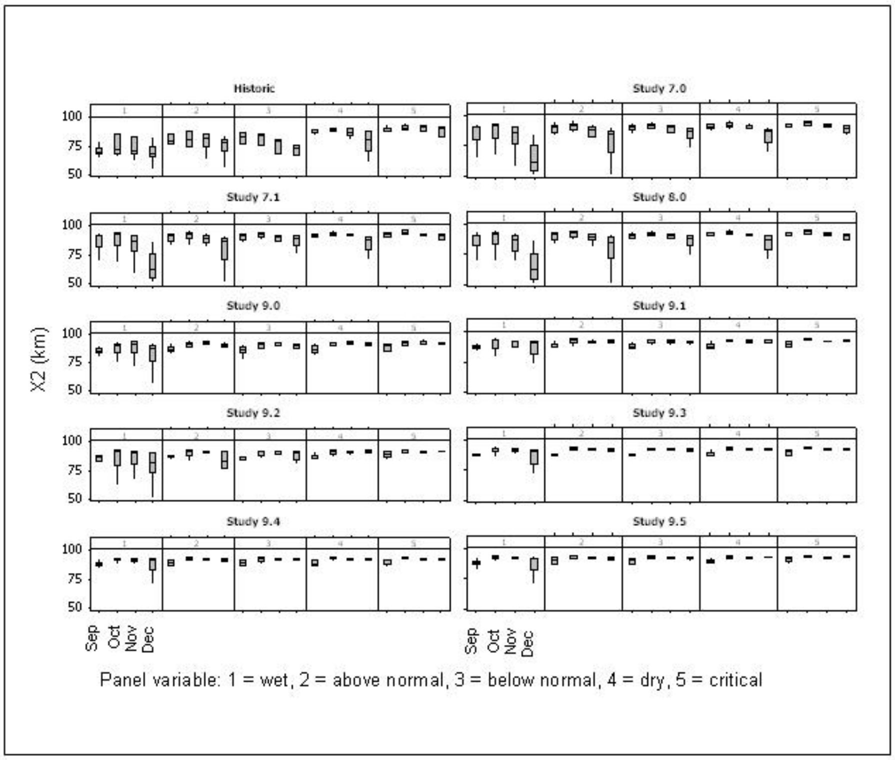


Figure E-27. Time series of fall X2 (September-December) with years noted by WY type for the previous spring.

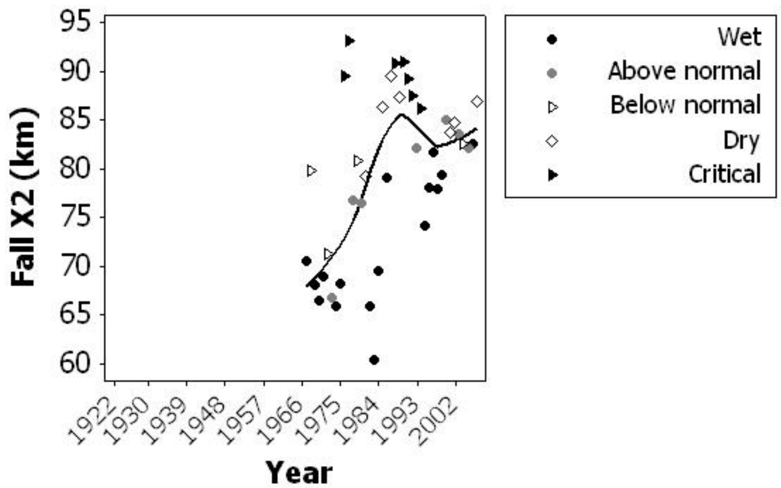


Figure E-28. Top panel: Time series of fall (September-December) and spring (April-July) X2. Lower panel: Smoothed time series of the difference between fall and spring X2 based on historic data and the CALSIM II model results.

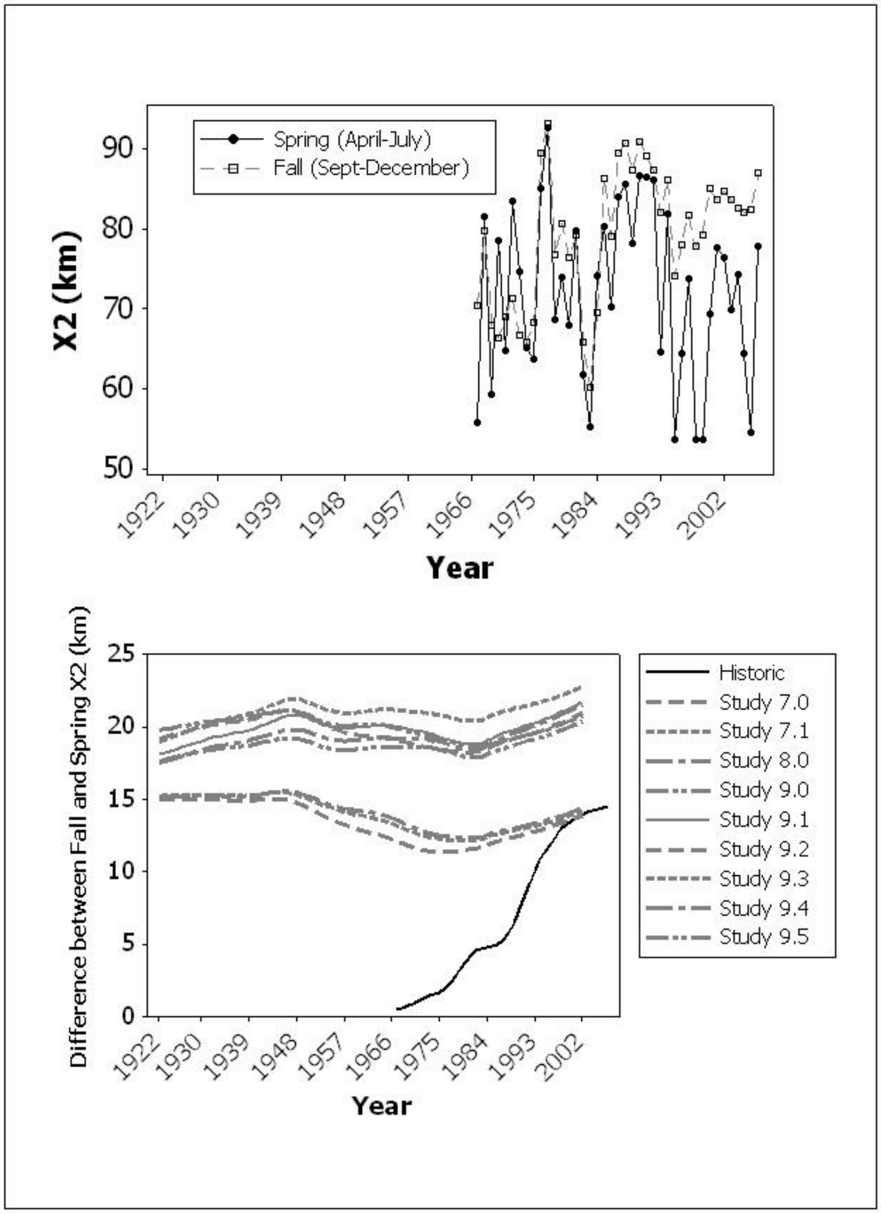
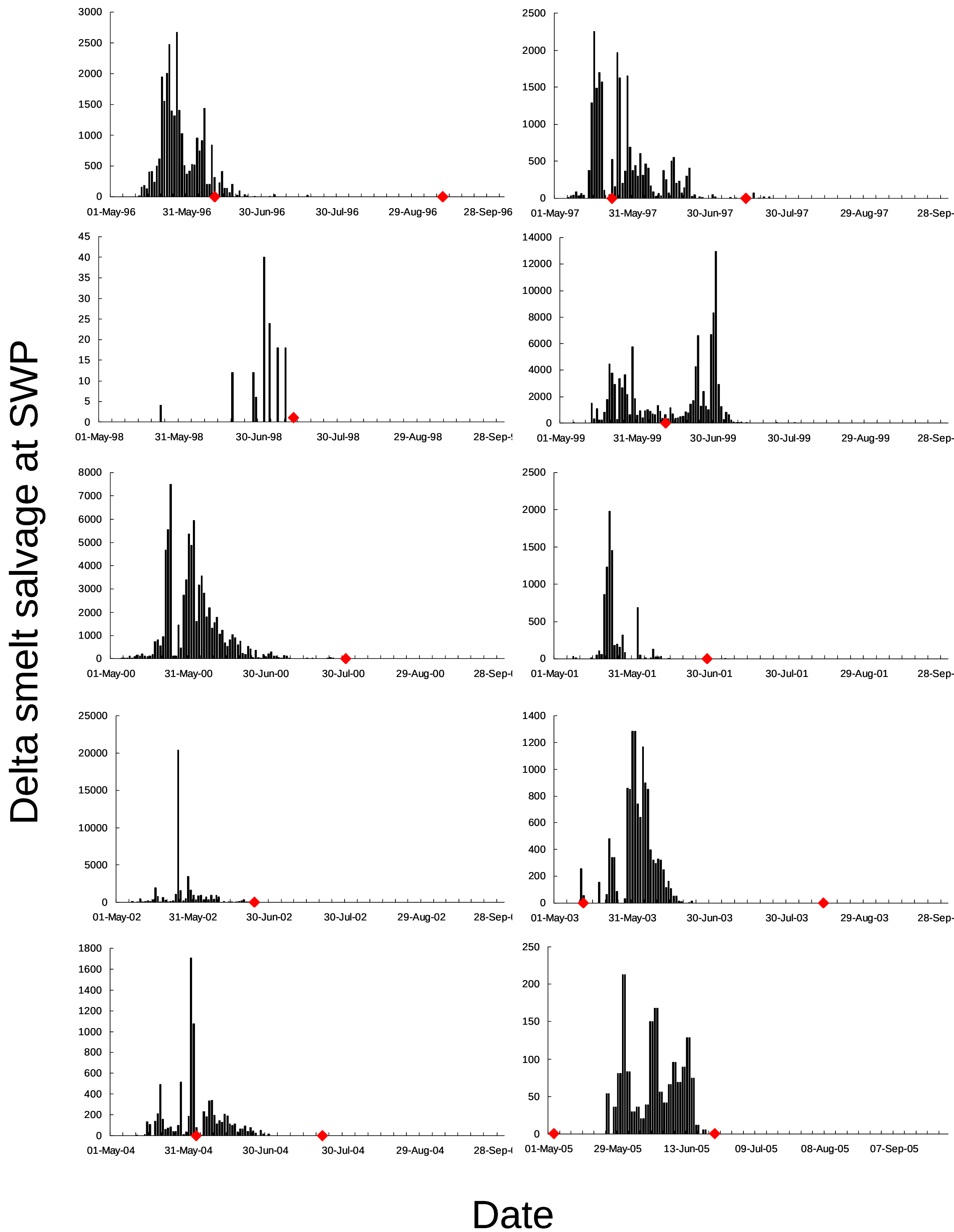


Figure E-29. May-September delta smelt salvage at the SWP Banks Pumping Plant, 1996-2005, with the start and end dates of Komeen or Nautique aquatic weed treatment indicated by the red diamonds.



Conclusion

Delta Smelt

After reviewing the current status of the delta smelt, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the coordinated operations of the CVP and SWP, as proposed, are likely to jeopardize the continued existence of the delta smelt. The Service reached this conclusion based on the following findings, the basis for which is presented in the preceding *Status of the Species/Environmental Baseline*, *Effects of the Action*, and *Cumulative Effects* sections of this document.

1. Diversions of water from the Delta have increased since 1967 when the SWP began operation in conjunction with the CVP. Past and present CVP/SWP operations have significantly altered hydro-dynamics throughout the Bay-Delta ecosystem. This alteration has resulted in numerous direct and indirect adverse effects on the delta smelt, including: (a) entrainment of migrating adults, larvae, and juveniles caused by pumping at the Banks and Jones water export facilities; (b) a reduction in the extent of available rearing and foraging habitat caused by CVP/SWP export of high proportions of Delta inflows that causes net negative flows in the South and Central Delta; and (c) a reduction in the frequency, duration and magnitude of high Delta outflows that has altered the location of the LSZ, which is a crucial component of the delta smelt's habitat, and may have facilitated the invasion of dense populations of exotic species that have significantly changed delta smelt prey dynamics. Increased pumping at the Banks and Jones export facilities (see Table P-12 and Figure P-17 in the biological assessment) corresponds to the decline of the delta smelt population during the period both prior to and following its listing under the Act.

2. The delta smelt is currently at its lowest level of abundance since monitoring began in 1967. A significant decline in the abundance of the delta smelt and other pelagic fish species began in about the year 2000 in conjunction with the POD. Since 2004, the FMWT index has varied from 26 to 74, but at such low levels that true differences in population abundance cannot be determined. On that basis, the Service concludes that resilience of the delta smelt population is currently at or near its lowest level since abundance monitoring began in 1967.

3. Under the proposed CVP/SWP operations, inflows to the Delta are likely to be further reduced, as water demands upstream of the Delta increase, most notably on the American River. Additionally, in Modeling Study 8.0, exports at the Banks and Jones export facilities are projected to increase over Study 7.0. These effects are likely to cause increased relative entrainment of adult delta smelt in the winter and spring, and of larval and juvenile delta smelt in the spring. OMR flows are expected to become more negative as a result of the proposed action. This is expected to result in higher entrainment of delta smelt, as well as affect the transport of larval and juvenile delta smelt into essential

rearing habitat in the Central and South Delta. The full suite of proposed operations will reduce Delta outflows, resulting in chronically lower suitability of delta smelt habitat.

4. Other baseline stressors will continue to adversely affect the delta smelt, such as contaminants, microcystis, aquatic macrophytes, and invasive species. Available information is inconclusive regarding the extent, magnitude and pathways by which delta smelt may be affected by these stressors independent of CVP/SWP operations. However, the operation of the CVP/SWP, as proposed, is likely to reduce or preclude seasonal flushing flows, substantially reduce the natural frequency of upstream and downstream movement of the LSZ, and lengthen upstream shifts of the LSZ to an extent that may increase the magnitude and frequency of adverse effects to the delta smelt from these stressors.

5. To survive and recover, delta smelt need:

(a) a substantially more abundant adult population;

(b) an increase in the quality and quantity of its spawning, rearing, and migratory habitat with respect to turbidity, temperature, salinity, escape cover, freshwater flow, and prey availability as a result of active or passive management of water and sediment processes in the San Francisco Bay-Delta ecosystem that mimics more natural (i.e., pre-water development) conditions. Improved habitat quality within the Bay-Delta should enhance the reproduction of adult delta smelt and increase the survival of both adults and juveniles;

(c) a reduction in the levels of contaminants and other pollutants within its habitat to increase survival of adults, larvae and juveniles;

(d) a reduction in exposure to disease and toxic algal blooms to increase survival of adults, larvae, and juveniles; a reduction in entrainment of adult and juvenile delta smelt at CVP/SWP pumping facilities, over and above reductions achieved under the VAMP and the EWA, to increase the abundance of the spawning adult population and the potential for recruitment of juveniles into the adult population;

(e) a reduction in entrainment at other water diversion-related structures within the Bay-Delta where delta smelt adults, larvae, or juveniles are known or are likely to be entrained to increase the adult population and the potential for recruitment of juveniles into the adult population;

(f) restoration of the structure of the food web in the Bay-Delta to a condition that more closely mimics the natural environment to increase survival of adults and juveniles; and

(g) to maximize its population resilience in the face of the potential adverse effects of ongoing climate change that are occurring in Bay-Delta ecosystem.

Relative to these survival and recovery needs, the effects of the proposed action are likely to: decrease the abundance of delta smelt; decrease the quality and quantity of its habitat; maintain or increase high levels of entrainment; contribute to a degraded food web in the Delta; and reduce the population resilience of delta smelt.

6. On the basis of findings (1)-(5) above, the Service concludes that the effects of the proposed action, taken together with cumulative effects, are likely to appreciably reduce the likelihood of both the survival and recovery of delta smelt in the wild by reducing its reproduction, abundance, and distribution.

Delta Smelt Critical Habitat

After reviewing the current status of delta smelt critical habitat, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the coordinated operations of the CVP and SWP, as proposed, are likely to adversely modify delta smelt critical habitat. The Service reached this conclusion based on the following findings, the basis for which is presented in the preceding *Status of Critical Habitat/Environmental Baseline, Effects of the Action, and Cumulative Effects* sections of this document.

1. The conservation role of delta smelt critical habitat is to provide migration, spawning and rearing habitat conditions necessary for successful delta smelt recruitment at levels that will provide for the conservation of the species. Appropriate physical habitat (PCE 1), water (PCE 2), river flows (PCE 3), and salinity (PCE 4) are essential for successful delta smelt spawning and survival.

2. The past and present operations of the CVP/SWP have degraded these habitat elements (particularly PCEs 2-4) to the extent that their co-occurrence at the appropriate places and times is insufficient to support successful delta smelt recruitment at levels that will provide for the species' conservation.

3. Implementation of the proposed action is expected to perpetuate the very limited co-occurrence of PCEs at appropriate places and times by: (a) altering hydrologic conditions in a manner that adversely affects the distribution of abiotic factors such as turbidity and contaminants; (b) altering river flows to an extent that increases delta smelt entrainment at Banks and Jones, as well as reduces habitat suitability in the Central and South Delta; and (c) altering the natural pattern of seasonal upstream movement of the LSZ to an extent that is likely to reduce available habitat for the delta smelt within areas designated as critical habitat.

The proposed action does include a provision for VAMP to address augmentation of river flow but future implementation of this provision is not well defined, making its beneficial effects on the PCEs of delta smelt critical habitat uncertain.

4. On the basis of findings (1)-(3) above, the Service concludes that implementation of the proposed action is likely to prevent delta smelt critical habitat from serving its intended conservation role.

Reasonable and Prudent Alternative

The regulations (50 CFR 402.02) implementing section 7 of the Act define reasonable and prudent alternatives (RPA) as alternative actions, identified during formal consultation, that: 1) can be implemented in a manner consistent with the intended purpose of the action; 2) can be implemented consistent with the scope of the action agency's (i.e.Reclamation's) legal authority and jurisdiction; 3) are economically and technologically feasible; and, 4) would, the Service believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

The Service has developed the following RPA that includes four components to be implemented using an adaptive approach within specific constraints. The fifth component includes monitoring and reporting requirements. The components presented below are based on the best available scientific information regarding what is necessary to adequately provide for successful delta smelt migration and spawning, and larval and juvenile survival, growth, rearing, and recruitment within the Bay-Delta.

The specific flow requirements, action triggers and monitoring stations prescribed in the RPA will be continuously monitored and evaluated consistent with the adaptive process. As new information becomes available, these action triggers may be modified without necessarily requiring re-consultation on the overall proposed action.

The following actions are necessary to ensure that implementation of the long term operations of the CVP/SWP does not appreciably reduce the likelihood of both the survival and recovery of the delta smelt and does not preclude the intended conservation role of its critical habitat through: 1) preventing/reducing entrainment of delta smelt at Jones and Banks; 2) providing adequate habitat conditions that will allow the adult delta smelt to successfully migrate and spawn in the Bay-Delta; 3) providing adequate habitat conditions that will allow larvae and juvenile delta smelt to rear; and 4) providing suitable habitat conditions that will allow successful recruitment of juvenile delta smelt to adulthood. In addition, it is essential to monitor delta smelt abundance and distribution through continued sampling programs through the IEP.

Detailed descriptions of the adaptive process, its framework, and the rationale for each of the RPA components are presented in Attachment B of this biological opinion.

Process for Determining Specific Actions within Components 1 and 2

1. Within one day after the SWG recommends an action should be initiated, changed, suspended or terminated, the SWG shall provide to the Service a written recommendation and a biological justification. The SWG shall use the process described in Attachments A and B to provide a framework for their recommendations. The Service shall determine whether the proposed action should be implemented, modified, or terminated; and the OMR flow needed to achieve the protection. The Service shall present this information to the WOMT.

2. The WOMT shall either concur with the recommendation or provide a written alternative to the recommendation to the Service within one calendar day. The Service shall then make a final determination on the proposed action to be implemented, which shall be documented and posted on the Sacramento Fish and Wildlife Service's webpage.

3. Once the Service makes a final determination to initiate a new action, it shall be implemented within two calendar days by Reclamation and DWR, and shall remain in effect until the need for the action ends or the OMR flow is changed, as determined by the Service, consistent with the RPA and described within Attachment B. Data demonstrating the implementation of the action shall be provided by Reclamation to the Service on a weekly basis.

4. If the Service determines that an OMR flow change is required while an action is ongoing, Reclamation and DWR shall adjust operations to manage to the new OMR flow within two days of receipt of the Service's determination. This new OMR flow shall be used until it is adjusted or the action is changed or terminated based on new information, as described in the RPA and Attachment B.

RPA Component 1: Protection of the Adult Delta Smelt Life Stage

Delta smelt are entrained at the fish facilities each year. These actions are designed to reduce the delta smelt entrainment losses. The objective of Component 1 (Actions 1 and 2 in Attachment B) is to reduce entrainment of pre-spawning adult delta smelt during December to March by controlling OMR flows during vulnerable periods. Action 1 is designed to protect upmigrating delta smelt. Action 2 is designed to protect adult delta smelt that have migrated upstream and are residing in the Delta prior to spawning. Overall, RPA Component 1 will increase the suitability of spawning habitat for delta smelt by decreasing the amount of Delta habitat affected by the projects' export pumping plants' operations prior to, and during, the critical spawning period.

Beginning in December of each year, the Service shall review data on flow, turbidity, salvage, and other parameters that have historically predicted the timing of delta smelt migration into the Delta. On an ongoing basis, and consistent with the parameters outlined below and in Attachment B, the SWG shall recommend to the Service OMR flows that are expected to minimize entrainment of adult delta smelt. Throughout the implementation of RPA Component 1, the Service will make the final determination as to OMR flows required to protect delta smelt.

OMR flow requirements given below are based on the following understanding: Where a 14-day running average is established, the average daily OMR flow must be no more negative than the required OMR flow. Where a 5-day running average is given, the daily average shall be no more than 25 percent more negative than the requirement. The daily OMR flows used to compute both the 14-day and the 5-day averages shall be the "tidally filtered" values reported by USGS.

Low-entrainment risk period: delta smelt salvage has historically been low between December 1 and December 19, even during periods when first flush conditions (i.e., elevated river inflow and turbidity) occurred. During the low-entrainment risk period, the SWG shall determine if the information generated by physical (i.e. turbidity and river inflow) and biological (e.g., salvage, DFG trawls) monitoring indicates that delta smelt are vulnerable to entrainment or are likely to migrate into a region where future entrainment events may occur. If this occurs, the Service shall require initiation of Action 1 as described in Attachment B. Action 1 shall require the Projects to maintain OMR flows no more negative than -2,000 cfs (14-day average) with a simultaneous 5-day running average flow no more negative than -2,500 cfs to protect adult delta smelt for 14 days.

High-entrainment risk period: delta smelt have historically been entrained when first flush conditions occur in late December. In order to prevent or minimize such entrainment, Action 1 shall be initiated on or after December 20 if the 3 day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 NTU, or if there are three days of delta smelt salvage at either facility or if the cumulative daily salvage count is above the risk threshold based upon the "daily salvage index" approach described in Attachment B. Action 1 shall require the Projects to maintain OMR flows no more negative than -2,000 cfs (14-day running average) with a simultaneous 5-day running average flow no more negative than -2,500 cfs to protect adult delta smelt for 14 days. However, the SWG can recommend a delayed start or interruption based on other conditions such as delta inflow that may affect vulnerability to entrainment.

Winter protection period: recent analyses indicate that cumulative adult entrainment and salvage are lower when OMR flows are no more negative than -5,000 cfs in the December through March period. Action 2 shall commence immediately after Action 1 ends. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt. OMR flows under Action 2 shall be in the range of -3,500 to -5,000 when turbidity and salvage are low. Based on historic conditions, OMR flow would generally be expected to be in the range of -2,000 cfs to -3,500 cfs given recent salvage events. However, at times when turbidity and flow conditions in the Delta may result in increased salvage, the range may be between -1,250 to -2,000 cfs. During the implementation of Action, the maximum negative flow for OMR shall be determined based on the criteria outlined in Attachment B. The OMR flow shall be based on a 14-day running average with simultaneous 5-day running average within 25 percent of the required OMR flow. The action may be suspended temporarily if the three day flow average is greater than or equal to 90,000 cfs at the Sacramento River at Rio Vista and 10,000 cfs at the San Joaquin River at Vernalis, because there is low likelihood that delta smelt will be entrained during such high inflow conditions. Suspension of this action due to high flow will end when flow drops below the 90,000 cfs and 10,000 cfs threshold. Action 2 ends when spawning begins as defined for Action 3 implementation (Component 2).

RPA Component 2: Protection of Larval and Juvenile Delta Smelt

Delta smelt larvae and juveniles are susceptible to direct mortality by entrainment. Hydrologic conditions resulting from CVP/SWP operations increase the risk of that entrainment. The objective of this RPA component (which corresponds to Action 3 in Attachment B), is to improve flow conditions in the Central and South Delta so that larval and juvenile delta smelt can successfully rear in the Central Delta and move downstream when appropriate.

Upon completion of RPA Component 1 or when Delta water temperatures reach 12˚C (based on a 3-station average of daily average water temperature at Mossdale, Antioch, and Rio Vista) or when a spent female delta smelt is detected in the trawls or at the salvage facilities, the projects shall operate to maintain OMR flows no more negative than -1,250 to -5000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable 14-day OMR flow requirement. Depending on the extant conditions, the SWG shall make recommendations for the specific OMR flows within this range from the onset of implementing RPA Component 2 through its termination. The Service shall make the final determination regarding specific OMR flows. This action shall end June 30 or when the 3-day mean water temperature at Clifton Court Forebay reaches 25° C, whichever occurs earlier.

The Spring HORB shall be installed only if the Service determines delta smelt entrainment is not a concern (Action 5 from Attachment B).

RPA Component 3: Improve Habitat for Delta Smelt Growth and Rearing

The objective of this component is to improve fall habitat for delta smelt through increasing Delta outflow during fall. Increase in fall habitat quality and quantity will both benefit delta smelt.

Subject to adaptive management as described below and in Action 4 in Attachment B, during September and October in years when the preceeding precipitation and runoff period was wet or above normal as defined by the Sacramento Basin 40-30-30 index, Reclamation and DWR shall provide sufficient Delta outflow to maintain monthly average X2 no greater (more eastward) than 74 km (from the Golden Gate) in Wet WYs and 81 km in Above Normal WYs. The monthly X2 target will be separately achieved for the months of September and October. During any November when the preceding water year was wet or above normal as defined by the Sacramento Basin 40-30-30 index, all inflow into CVP/SWP reservoirs in the Sacramento Basin shall be added to reservoir releases in November to provide an additional increment of outflow from the Delta to augment Delta outflow up to the fall X2 of 74 km for Wet WYs or 81 km for Above Normal WYs, respectively. In the event there is an increase in storage during any November this action applies, the increase in reservoir storage shall be released in December to augment the December outflow requirements in SWRCB D-1641.

Given the nature of this Action and to align its management more closely with the general plan described by the independent review team and developed by Walters (1997), the Service shall oversee and direct the implementation of a formal adaptive management process. The adaptive management process shall include the elements as described in Attachment B. This adaptive management program shall be reviewed and approved by the Service in addition to other studies that are required for delta smelt. In accordance with the adaptive management plan, the Service will review new scientific information when provided and may make changes to the action when the best available scientific information warrants. For example, there may be other ways to achieve the biological goals of this action, such as a Delta outflow target, that will be evaluated as part of the study. This action may be modified by the Service consistent with the intention of this action based on information provided by the adaptive management program in consideration of the needs of other listed species. Other CVP/SWP obligations may also be considered.

The adaptive management program shall have specific implementation deadlines. The creation of the delta smelt habitat study group, initial habitat conceptual model review, formulation of performance measures, implementation of performance evaluation, and peer review of the performance measures and evaluation that are described in steps (1) through (3) of Attachment B shall be completed before September 2009. Additional studies addressing elements of the habitat conceptual model shall be formulated as soon as possible, promptly implemented, and reported as soon as complete.

The Service shall conduct a comprehensive review of the outcomes of the Action and the effectiveness of the adaptive management program ten years from the signing of the biological opinion, or sooner if circumstances warrant. This review shall entail an independent peer review of the Action. The purposes of the review shall be to evaluate the overall benefits of the Action and to evaluate the effectiveness of the adaptive management program. At the end of 10 years or sooner, this action, based on the peer review and Service determination as to its efficacy shall either be continued, modified or terminated.

RPA Component 4: Habitat Restoration

This component of the RPA (Action 6 of Attachment B) is intended to provide benefits to delta smelt habitat to supplement the benefits resulting from the flow actions described above. DWR shall implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. These actions may require separate ESA consultations for their effects on federally listed species. The restoration efforts shall begin within 12 months of signature of this biological opinion and be completed by DWR (the applicant) within 10 years. The restoration sites and plans shall be reviewed and approved by the Service and be appropriate to improve habitat conditions for delta smelt. Management plans shall be developed for each restoration site with an endowment or other secure financial assurance and easement in place held by a third-party or DFG and approved by the Service. The endowment or other secure financial assurance shall be sufficient to fund the monitoring effort and operation and maintenance of the restoration site.

An overall monitoring program shall be developed to focus on the effectiveness of the restoration actions and provided to the Service for review within six months of signature of this biological opinion. The applicant shall finalize the establishment of the funding for the restoration plan within 120 days of final approval of the restoration program by the Service. There is a separate planning effort in Suisun Marsh where the Service is a co-lead with Reclamation on preparation of an Environmental Impact Statement. Restoration actions in Suisun Marsh shall be based on the Suisun Marsh Plan that is currently under development.

RPA Component 5: Monitoring and Reporting

Reclamation and DWR shall ensure that information is gathered and reported to ensure:
1) proper implementation of these actions,
2) that the physical results of these actions are achieved, and
3) that information is gathered to evaluate the effectiveness of these actions on the targeted life stages of delta smelt so that the actions can be refined, if needed.

Essential information to evaluate these actions (and the Incidental Take Statement) includes sampling of the FMWT, Spring Kodiak Trawl, 20-mm Survey, TNS and the Environmental Monitoring Program of the IEP. This information shall be provided to the Service within 14 days of collection. Additional monitoring and research will likely be required, as defined by the adaptive management process.

Information on salvage at Banks and Jones is both an essential trigger for some of these actions and an important performance measure of their effectiveness. In addition, information on OMR flows and concurrent measures of delta smelt distribution and salvage are essential to ensure that actions are implemented effectively. Such information shall be included in an annual report for the WY (October 1 to September 30) to the Service, provided no later than October 15 of each year, starting in 2010.

Reclamation shall implement the RPA based on performance standards, monitoring and evaluation of results from the actions undertaken and adaptive management as described in RPA component 3. RPA component 3 has a robust adaptive management component that requires a separate analysis apart from those required under this component. Some of the data needed for these performance measures are already being collected such as the FMWT abundances and salvage patterns. However, more information on the effect of these actions on smelt survival and the interactions of project operations with other stressors on delta smelt health, fecundity and survival is needed. This information may provide justificationfor refining these actions to better address the needs of delta smelt. Studies like those of the IEP's POD workteam have provided much useful information on the needs of delta smelt and the stressors affecting them that was integral in the development of these actions.

Avoidance of Jeopardy and Adverse Modification

The conservation needs of the delta smelt at this time are primarily associated with: (1) protective measures for pre-spawning adult delta smelt; (2) improvement of flow conditions in the Central and South Delta so that larval and juvenile delta smelt can successfully rear and move downstream with a minimum entrainment risk; and (3) restoration and enhancement of habitat availability and quality that improves growth and survival of delta smelt.

The RPA components described above and in Attachment B specifically address the above factors to the extent provided by the regulatory criteria that define a RPA. Implementation of this RPA will increase the likelihood that delta smelt habitat conditions and attributes for migration, spawning, recruitment, growth, and survival will be provided during the term of the proposed action. For these reasons, the Service finds that implementation of the RPA described above is likely to avoid jeopardy to the delta smelt and adverse modification of its critical habitat.

Incidental Take Statement

Introduction

Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary and must be implemented by Reclamation, working with DWR under the COA and other interagency agreements, in order for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activities that are covered by this Incidental Take Statement for the life of the proposed action. If Reclamation fails to assume and implement the RPA and terms and conditions or is unable to ensure that DWR adheres to the RPA and terms and conditions of this Incidental Take Statement while jointly operating under the COA and other interagency agreements, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impacts of incidental take, Reclamation must report the progress of the action and its impacts on the delta smelt to the Service as specified in this Incidental Take Statement. [50 CFR §402.14(i)(3)]

The Service developed the following Incidental Take Statement based on the premise that the RPA will be implemented. A detailed description of the rational for the development of the incidental take statement is in Attachment C. This Incidental Take Statement assumes full implementation of the RPA.

Form of Take Anticipated

The Service anticipates that take of the delta smelt is likely to occur in the form of kill, capture (via salvage), wound, harm, and harass as a result of CVP/SWP operations within the action area, inclusive of activities at the NBA and at CCWD facilities, and in conjunction with studies to determine screening criteria and to improve delta smelt handling and survival in the salvage process. The above forms of take will result in the injury or death of delta smelt. This Incidental Take Statement addresses all of the above.

Amount or Extent of Take

Take of Delta Smelt at the NBA and CCWD Facilities

The Service anticipates that incidental take of delta smelt at the NBA and at the CCWD diversions will be difficult to detect since no monitoring program samples for entrainment at these facilities on a regular basis. Incidental take is not expected to be high since the other diversions have fish screens and the unscreened Rock Slough diversion is at a dead end slough where delta smelt are not usually present. Due to the difficulty in quantifying the number of delta smelt that will be taken as a result of the proposed action, the Service is quantifying incidental take for the NBA and the CCWD diversion to be all delta smelt inhabiting the water diverted at these facilities under the conditions of 71 TAF per year at the NBA and 195 TAF at the CCWD diversions.

Take of Adult Delta Smelt

The Service anticipates that take of adult delta smelt via entrainment will be minimized when OMR flows are limited to -2,000 cfs during the first winter flush when adult smelt move within the zone of entrainment. OMR flows held between -1,250 and -5,000 cfs following the first flush until the onset of spawning will protect later delta smelt migrants and spawners. During frequent intervals within the timeframe for RPA Component 1, the SWG shall provide specific OMR flow recommendations to the Service; and the Service shall then determine flow requirements using the adaptive process as described in the RPA.

To estimate take with implementation of the RPA, the Service scaled projected salvage to abundance using the estimates provided by the prior year's FMWT Index (further details on the methods used in developing the Incidental Take Statement can be found in Attachment C). The segregation of year types is based upon descriptive statistics comprising quartiles, as expressed in Figure C-1 of Attachment C, and quantified following the approach described below.

The Cumulative Salvage Index (CSI) is calculated as the total year's adult salvage (the aggregate number for expanded salvage at both the Banks and Jones export facilities for the period December through March) divided by the previous year's FMWT Index. Water years 2006 to 2008 were years in which salvage, negative OMR flows, and delta smelt abundance were all lower relative to the historic values. The Service therefore believes these years within the historic dataset best approximate expected salvage under RPA Component 1.

The average CSI value for WYs 2006 to 2008 was 7.25. Projecting this average rate of salvage to the years in which CVP/SWP operations will be conducted within the sideboards established by the RPA would yield estimates of salvage at 7.25 times the prior year's FMWT Index. The Service used this estimator to predict incidental take levels of adult delta smelt during each year that the RPA's will be in effect. This value, which can be calculated upon release of the final FMWT Index within the current water year, is regarded as the incidental take for adult delta smelt under the RPA.

Incidental Take: Cumulative Expanded Salvage = 7.25 * Prior Year's FMWT Index

Delta smelt abundance is critically low, and without habitat quality conditions to appreciably improve juvenile growth and rearing from recent historic levels, is expected to remain so for the foreseeable future. The current population cannot tolerate direct mortality through adult entrainment at levels approaching even "moderate" take as observed through the historic record of recent decades. The method utilized herein to calculate take contains uncertainty within the estimates, and this fact translates into population-level risk. Further, there is a recognized need to provide a quantitative framework so that the Service and CVP/SWP operators have a common analytical methodology for reference and to further guide the adaptive process.

Therefore, the Service is also providing a Concern Level estimate, meant to indicate salvage levels approaching the take threshold, and help guide implementation of the RPA. Reaching this expanded salvage figure within a given season may require that OMR flows be set to a more restrictive level, unless available data indicate some greater level of exports is possible without increasing entrainment (e.g., there is strong reason to presume the pre-spawning migration has passed). Throughout the water year, as the SWG convenes and reviews daily salvage data, reaching the Concern Level for adult salvage requires an immediate specific recommendation to the Service.

The Service believes this Concern Level value should trigger at 75 percent of the calculated adult incidental take, as an indicator that operations may need to be more constrained to avoid exceeding the incidental take.

Concern Level: Cumulative Expanded Salvage = 5.43 * Prior Year's FMWT Index

Table IT-1 lists threshold levels of concern and incidental take for a range of potential FMWT indices. This table is intended to be used as a reference to discern levels of salvage reflecting the range of expected adult delta smelt mortality with implementation of the RPA, and as an indicator of adult delta smelt salvage levels that constitutes an increasing adverse effect to the delta smelt population due to CVP/SWP operations.

Table IT-1: Incidental Take Expanded Salvage Numbers by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	11	15	66	359	479	220	1197	1596	550	2992	3989
4	22	29	72	392	522	240	1305	1741	560	3046	4061
6	33	44	78	424	566	260	1414	1886	570	3100	4134
8	44	58	84	457	609	280	1523	2031	580	3155	4206
10	54	73	90	490	653	300	1632	2176	590	3209	4279
12	65	87	96	522	696	320	1741	2321	600	3264	4351
14	76	102	100	544	725	340	1849	2466	620	3372	4496
16	87	116	102	555	740	360	1958	2611	640	3481	4642
18	98	131	104	566	754	380	2067	2756	660	3590	4787
20	109	145	106	577	769	400	2176	2901	680	3699	4932
22	120	160	108	587	783	420	2285	3046	700	3808	5077
24	131	174	110	598	798	460	2502	3336	720	3916	5222
26	141	189	120	653	870	480	2611	3481	740	4025	5367
28	152	203	130	707	943	500	2720	3626	760	4134	5512
30	163	218	140	762	1015	502	2731	3641	780	4243	5657
34	185	247	150	816	1088	504	2741	3655	800	4351	5802
38	207	276	160	870	1160	506	2752	3670	840	4569	6092
42	228	305	170	925	1233	510	2774	3699	880	4787	6382
48	261	348	180	979	1305	520	2828	3771	920	5004	6672
54	294	392	190	1033	1378	530	2883	3844	960	5222	6962
60	326	435	200	1088	1450	540	2937	3916	1000	5439	7252

Take of Larval and Juvenile Delta Smelt

The Service has largely followed the methodology for estimating incidental take of larval delta smelt similar to that utilized for adults. Specifically, an average of the last four years (2005-2008) cumulative larval/juvenile salvage by month (April through July) was calculated. This can be summarizes as a Juvenile Salvage Index (JSI), calculated as:

Monthly Juvenile Salvage Index = cumulative seasonal ≥ 20 mm salvage by month end divided by current WY FMWT Index

The mean values from 2005-2008 were used as an estimate of take under the RPA. The reason for selecting this span of years is that the apparent abundance of delta smelt since 2005 as indexed by the 20-mm Survey and the TNS is the lowest on record. It was necessary to separate out this abundance variable, but also to account for other poorly understood factors relating salvage to OMR, distribution, and the extant conditions. On a monthly basis (cumulative salvage across the spring), this estimate represents a concern level where entrainment has reached high enough numbers to indicate the need for more protective OMR restrictions. The cumulative salvage figures in the Incidental Take Statement reflect totals beginning with the first seasonal juvenile salvage through the end of the current month (i.e., prior month totals are added to the succeeding month's values). The tables provided cover the full month to the final day of the applicable calendar month.

Concern Level = Monthly JSI 2005-2008 mean * Current WY FMWT

The last four years average monthly cumulative salvage was used to calculate the concern level for larval/juvenile smelt, as opposed to the incidental take under the RPA. It is acknowledged that salvage across years will be variable, as distribution, spawning success, prior entrainment of adults, enhanced survival of <20mm larval delta smelt under the RPA, and extant natural conditions determine. As mentioned above, this constrains predictability of take using this methodology, and is less reliable overall as the method used for adults. Also, it is believed that individuals of the larval/juvenile lifestage are less demographically significant than adults. Given these considerations, the incidental take estimate for ≥ 20 mm larval/juvenile delta smelt under the RPA will be above the four year average by 50 percent.

Larval/Juvenile Incidental Take = 1.5 * Concern Level

Lookup tables relating (current WY) FMWT to concern level and incidental take for cumulative salvage by month appears in Table IT-2 through IT-5, below.

Table IT-2: April Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take
2	1	1
4	1	2
6	2	3
8	2	4
10	3	4
12	4	5
14	4	6
16	5	7
18	5	8
20	6	9
22	6	10
24	7	11
26	8	11
28	8	12
30	9	13
34	10	15
38	11	17
42	12	18
48	14	21
54	16	24
60	18	26
66	19	29
72	21	32
78	23	34
84	25	37
90	26	40
96	28	42
100	29	44

FMWT Index	Concern Level	Incidental Take
102	30	45
104	30	46
106	31	47
108	32	47
110	32	48
120	35	53
130	38	57
140	41	62
150	44	66
160	47	70
170	50	75
180	53	79
190	56	84
200	59	88
220	64	97
240	70	106
260	76	114
280	82	123
300	88	132
320	94	141
340	100	150
360	106	158
380	111	167
400	117	176
420	123	185
460	135	202
480	141	211
500	147	220

FMWT Index	Concern Level	Incidental Take
502	147	221
504	148	222
506	148	223
510	150	224
520	152	229
530	155	233
540	158	237
550	161	242
560	164	246
570	167	251
580	170	255
590	173	259
600	176	264
620	182	273
640	188	281
660	193	290
680	199	299
700	205	308
720	211	317
740	217	325
760	223	334
780	229	343
800	235	352
840	246	369
880	258	387
920	270	405
960	281	422
1000	293	440

Table IT-3: May Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	26	39	102	1329	1994	502	6543	9815
4	52	78	104	1356	2033	504	6569	9854
6	78	117	106	1382	2072	506	6595	9893
8	104	156	108	1408	2112	510	6647	9971
10	130	196	110	1434	2151	520	6778	10167
12	156	235	120	1564	2346	530	6908	10362
14	182	274	130	1694	2542	540	7038	10558
16	209	313	140	1825	2737	550	7169	10753
18	235	352	150	1955	2933	560	7299	10949
20	261	391	160	2085	3128	570	7429	11144
22	287	430	170	2216	3324	580	7560	11340
24	313	469	180	2346	3519	590	7690	11535
26	339	508	190	2476	3715	600	7821	11731
28	365	547	200	2607	3910	620	8081	12122
30	391	587	220	2868	4301	640	8342	12513
34	443	665	240	3128	4692	660	8603	12904
38	495	743	260	3389	5083	680	8863	13295
42	547	821	280	3650	5474	700	9124	13686
48	626	938	300	3910	5865	720	9385	14077
54	704	1056	320	4171	6256	740	9645	14468
60	782	1173	340	4432	6647	760	9906	14859
66	860	1290	360	4692	7038	780	10167	15250
72	938	1408	380	4953	7429	800	10427	15641
78	1017	1525	400	5214	7821	840	10949	16423
84	1095	1642	420	5474	8212	880	11470	17205
90	1173	1760	460	5996	8994	920	11991	17987
96	1251	1877	480	6256	9385	960	12513	18769
100	1303	1955	500	6517	9776	1000	13034	19551

Table IT-4: June Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take
2	66	99
4	132	198
6	198	297
8	264	396
10	330	495
12	396	594
14	462	694
16	528	793
18	594	892
20	660	991
22	727	1090
24	793	1189
26	859	1288
28	925	1387
30	991	1486
34	1123	1684
38	1255	1882
42	1387	2081
48	1585	2378
54	1783	2675
60	1981	2972
66	2180	3269
72	2378	3567
78	2576	3864
84	2774	4161
90	2972	4458
96	3170	4756
100	3302	4954

FMWT Index	Concern Level	Incidental Take
102	3369	5053
104	3435	5152
106	3501	5251
108	3567	5350
110	3633	5449
120	3963	5944
130	4293	6440
140	4623	6935
150	4954	7431
160	5284	7926
170	5614	8421
180	5944	8917
190	6275	9412
200	6605	9907
220	7265	10898
240	7926	11889
260	8586	12880
280	9247	13870
300	9907	14861
320	10568	15852
340	11228	16843
360	11889	17833
380	12549	18824
400	13210	19815
420	13870	20806
460	15191	22787
480	15852	23778
500	16512	24769

FMWT Index	Concern Level	Incidental Take
502	16578	24868
504	16644	24967
506	16711	25066
510	16843	25264
520	17173	25759
530	17503	26255
540	17833	26750
550	18164	27245
560	18494	27741
570	18824	28236
580	19154	28732
590	19485	29227
600	19815	29722
620	20475	30713
640	21136	31704
660	21796	32695
680	22457	33685
700	23117	34676
720	23778	35667
740	24438	36657
760	25099	37648
780	25759	38639
800	26420	39630
840	27741	41611
880	29062	43593
920	30383	45574
960	31704	47556
1000	33025	49537

Table IT-5: July Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	75	112	102	3822	5732	502	18808	28213
4	150	225	104	3897	5845	504	18883	28325
6	225	337	106	3971	5957	506	18958	28437
8	300	450	108	4046	6070	510	19108	28662
10	375	562	110	4121	6182	520	19483	29224
12	450	674	120	4496	6744	530	19857	29786
14	525	787	130	4871	7306	540	20232	30348
16	599	899	140	5245	7868	550	20607	30910
18	674	1012	150	5620	8430	560	20981	31472
20	749	1124	160	5995	8992	570	21356	32034
22	824	1236	170	6369	9554	580	21731	32596
24	899	1349	180	6744	10116	590	22105	33158
26	974	1461	190	7119	10678	600	22480	33720
28	1049	1574	200	7493	11240	620	23229	34844
30	1124	1686	220	8243	12364	640	23979	35968
34	1274	1911	240	8992	13488	660	24728	37092
38	1424	2136	260	9741	14612	680	25477	38216
42	1574	2360	280	10491	15736	700	26227	39340
48	1798	2698	300	11240	16860	720	26976	40464
54	2023	3035	320	11989	17984	740	27725	41588
60	2248	3372	340	12739	19108	760	28475	42712
66	2473	3709	360	13488	20232	780	29224	43836
72	2698	4046	380	14237	21356	800	29973	44960
78	2922	4384	400	14987	22480	840	31472	47208
84	3147	4721	420	15736	23604	880	32971	49456
90	3372	5058	460	17235	25852	920	34469	51704
96	3597	5395	480	17984	26976	960	35968	53952
100	3747	5620	500	18733	28100	1000	37467	56200

Effect of the Take

The Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat when the RPA is implemented.

Reasonable and Prudent Measures

The following reasonable and prudent measures are necessary and appropriate to minimize the effect of the proposed action on the delta smelt:

1. Minimize adverse effects of the operations of the Permanent Operable Gates.

2. Minimize adverse effects of operations of the NBA.

3. Obtain real time data on the abundance and distribution of delta smelt in the Bay-Delta.

4. Minimize adverse effects of Banks and Jones on delta smelt.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, Reclamation shall ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

The following Term and Condition implements Reasonable and Prudent Measures one (1):

1. The Service shall have the final decision on the operations of the Permanent Gates. The members of the GORT can provide suggestions to operate the gates, but the ultimate decision on how to operate the gates to protect delta smelt will be made by the Service.

The following Term and Condition implements Reasonable and Prudent Measures two (2):

1. Annual evaluations shall be conducted for the fish screens at the NBA diversion during January through June. A proposed evaluation study shall be submitted to the Service for approval within 3 months of the issuance of this biological opinion. The evaluation shall monitor fish entrained and impinged on the fish screen, the screen approach velocities, cleanliness of the screen and any other pertinent criteria needed to determine the effectiveness of the fish screen.

The following Terms and Conditions implement Reasonable and Prudent Measures three (3):

1. During the months of December through July, when water is being diverted, Reclamation and DWR shall ensure that the frequency of sampling for delta smelt at Banks and Jones will be at least 25 percent of the time.

2. Reclamation and DWR shall develop a methodology for quantitative larval monitoring at Banks and Jones to help refine the triggers for the Actions in the RPA. An interim plan shall be submitted to the Service for approval within 30 days of the issuance of this biological opinion so the monitoring can be implemented this year. A more detailed plan shall be developed and approved by the Service within one year.

The following Term and Condition implements Reasonable and Prudent Measures four (4):

1. Reclamation will develop within 30 days a methodology for dealing with transitions in operations after changes in OMR flow requirements.

Monitoring Requirements

Monitoring requirements in accordance with section 402.14(i)(3) of the implementing regulations for section 7 of the Act have been included as part of the RPA and must be implemented by Reclamation and DWR.

Reporting Requirements

Reclamation or DWR shall immediately report to the Service any information about take or suspected take of federally-listed species not authorized in this biological opinion. Reclamation or DWR must notify the Service within 24 hours of receiving such information. Notification must include the date, time, and location of the incident or of the finding of a dead or injured delta smelt. Any killed delta smelt that have been taken should be properly preserved in accordance with Natural History Museum of Los Angeles County policy of accessioning (10 percent formalin in quart jar or freezing). Information concerning how the fish was taken, length of the interval between death and preservation, the water temperature and outflow/tide conditions, and any other relevant information should be written on 100 percent rag content paper with permanent ink and included in the container with the specimen. The Service contact persons are Chris Nagano, Deputy Assistant Field Supervisor, at telephone (916) 414-6600, and Dan Crum, Resident Agent-in-Charge of the Service's Law Enforcement Division at telephone (916) 414-6660.

Conservation Recommendations

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities that can be implemented to further the purposes of the Act, such as preservation of endangered species habitat, implementation of recovery actions, or development of information and data bases.

The Service requests notification of the implementation of any conservation recommendations in order to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats. We propose the following conservation recommendations:

1. The Service recommends that Reclamation and DWR develop and implement restoration measures consistent with the current Delta Native Species Recovery Plan.

2. The Service recommends that Reclamation and DWR develop procedures that minimize the effects of all other in-water activities that it conducts within the action area on delta smelt.

3. The Service recommends Reclamation work with willing partners to establish and maintain a diverse population of delta smelt for refuge and research purposes, managed to ensure adequate genetic diversity.

To be kept informed of actions minimizing or avoiding adverse effects or benefiting listed and proposed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

Reinitiation-Closing Statement

If the Sacramento Valley Water Year Type Index (40-30-30) February 1 50 percent exceedence forecast indicates that the water year will be a second consecutive (or more) dry or critically dry year, Reclamation shall reinitiate consultation with the Service. In order to allow the CVP/SWP to provide health and safety needs, critical refuge supplies, and obligation to senior water rights holders, the combined CVP/SWP export rates will not be required to drop below 1,500 cfs in these circumstances. However, in the unlikely event that salvage approaches the incidental take limit at these low export levels, the Service shall assess the on-going risk to delta smelt and will determine if additional reductions in pumping or other actions are necessary to further minimize effects.

If the subsequent 40-30-30 March 1 50 percent forecast indicates that the water year will no longer be a second consecutive (or more) dry or critically dry year, project operations may resume as described in the RPA. However, if subsequent April or May 75 percent exceedence forecasts move back to a critically dry year, reinitiation will again commence. Forecasts wetter than dry shall result in implementation of actions as described in the RPA.

This concludes formal consultation on the proposed coordinated operations of the CVP and SWP in California. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Reclamation involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the CVP/SWP that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the CVP/SWP is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the CVP/SWP. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease, pending reinitiation.

If you have questions concerning this biological opinion, please contact Ryan Olah, Steven Detwiler, or Cay C. Goude or Susan Moore of our Sacramento Fish and Wildlife Office at the letterhead address or at telephone (916) 414-6600.

Cc: California Department of Water Resources, Sacramento, CA

California Department of Fish and Game, Sacramento and Yountville, CA

National Marine Fisheries Service, Sacramento, CA