United States Department of the Interior

FISH AND WILDLIFE SERVICE
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In reply refer to:
81410-2011-F-0043

Memorandum

To: Area Manager, Bay-Delta Office, Bureau of Reclamation, Sacramento, California

From: Field Supervisor, Bay-Delta Fish and Wildlife Office, Fish and Wildlife Service, Sacramento, California Mike Chotkowski

Subject: First Draft 2011 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project

On March 28, 2011, the United States District Court for the Eastern District of California ordered the Fish and Wildlife Service (Service) to prepare a new, draft biological opinion on the effects of the proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP) in California, on delta smelt (*Hypomesus transpacificus*) and its designated critical habitat. The Bureau of Reclamation (Reclamation) is the lead Federal agency and the California Department of Water Resources (DWR) is the Applicant for this consultation. This document represents the Service's first draft of a biological opinion on the effects of the subject action to the threatened delta smelt and its designated critical habitat. The Service understands that Reclamation expects to develop a new project description, including actions intended to protect listed species, through a National Environmental Policy Act (NEPA) process that is responsive to the District Court Amended Final Judgment in the Delta Smelt Consolidated Cases (1:09-cv-00407-OWW-DLB issued on May 4, 2011). The Service expects to complete an effects analysis and make a determination on the proposed action once that process is complete and a final biological assessment is received. This first draft document is provided in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The Sacramento Fish and Wildlife Office (SFWO) conducted the previous Section 7 consultation for the subject action, issuing the December 15, 2008, Long-Term Operation and Criteria Plan for the CVP and SWP biological opinion (OCAP; Service File No. 81420-2008-F-1481-5). In 2008, Reclamation also requested consultation with SFWO on the effects of the proposed coordinated operations of the CVP and SWP on the endangered riparian brush rabbit (*Sylvilagus bachmani riparius*), endangered riparian woodrat (*Neotoma fuscipes riparia*), endangered salt marsh harvest mouse (*Reithrodontomys raviventris*), endangered California clapper rail (*Rallus longirostris obsoletus*), threatened giant garter snake (*Thamnophis gigas*), threatened California red-legged frog (*Rana aurora draytonii*), threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), endangered soft bird's-beak (*Cordylanthus mollis ssp.*

mollis), and the endangered Suisun thistle (*Cirsium hydrophilum var. hydrophilum*). Reclamation determined that the proposed continued operations of the CVP and SWP are not likely to adversely affect these listed species. The Service concurred with Reclamation's determination that the coordinated operations of the CVP and SWP are not likely to adversely affect these species.

This first draft biological opinion has been prepared in response to Judge Wanger's May 4, 2011, amended Final Judgement. A complete administrative record is on file at the San Francisco Bay-Delta Fish and Wildlife Office (BDFWO).

Consultation History

July 30, 2004	The Service issued a biological opinion addressing *Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operations Criteria and Plan to Address Potential Critical Habitat Issues* (Service File No. 1-1-04-F-0140).
February 15, 2005	The Department of the Interior is sued on the July 30, 2004 biological opinion.
February 16, 2005	The Service issued its *Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues* (Service File No. 1-1-05-F-0055).
May 20, 2005	The Department of the Interior is sued on the February 16, 2005 biological opinion.
February 2006 through September 2008	Staff from the California Department of Fish and Game (DFG), DWR, National Marine Fisheries Service (NMFS), Reclamation, and the Service (OCAP Working Team) met monthly to bi-weekly to discuss the development of the biological assessment.
July 6, 2006	Reclamation requested informal consultation on coordinated operations of the CVP and SWP and their effects to delta smelt.
May 25, 2007	Judge Wanger issued a summary judgment that invalidated the 2005 biological opinion and ordered a new biological opinion be developed by September 15, 2008.
May 31, 2007	The Service provided Reclamation with guidance and recommendations concerning the project description used in the 2004 biological opinion.
August 20, 2007	The Service provided a memorandum to Reclamation containing a species list for the proposed action and clarification of the formal consultation timeline.
October 29, 2007	The Service received an electronic version of the draft project description for the biological assessment (Chapter 2) dated August 2007.
December 4, 2007	DFG, NMFS, and the Service received a draft project description dated December 4, 2007.

December 6, 2007	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for part of the draft project description of CVP operations received on December 4, 2007.
December 14, 2007	Judge Wanger issued an interim order to direct actions at the export facilities to protect delta smelt until a new biological opinion is completed.
December 20, 2007	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for parts of the draft project description of SWP operations received on December 4, 2007.
January 17, 2008	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for the remaining portion of the draft project description received on December 4, 2007.
January 21, 2008	The Service sent to Reclamation an electronic version of the entire draft project description with guidance and recommendations developed jointly by DFG, NMFS, and the Service.
January 22, 2008	Reclamation provided DFG, NMFS and the Service with an electronic version of the description of operations of the Suisun Marsh Salinity Control Gates (SMSCG) dated August 2007.
January 23, 2008	DFG, NMFS, and the Service provided DWR with joint preliminary guidance and recommendations on the December 4, 2007, draft project description.
March 4, 2008	The Service provided DWR with joint DFG and Service guidance and recommendations for the August 2007 version of the proposed Suisun Marsh Salinity Control Gate (SMSCG) operations description.
March 6, 2008	DWR provided the Service with an updated description of proposed operations of the SMSCG.
March 10, 2008	The Service received a draft description and effects analysis of aquatic weed management in Clifton Court Forebay.
March 24, 2008	DFG, NMFS, and the Service provided Reclamation with guidance and recommendations on the aquatic weed management section of the biological assessment.
April 21, 2008	Reclamation provided the Service with a revised draft project description

	for the biological assessment.
April 28 through May 2, 2008	Reclamation conducted an external technical review of their draft biological assessment.
May 2008 through December 2008	Numerous meeting between the Service, Reclamation, DWR, DFG and NMFS on the development of the biological assessment and the biological opinion.
May 8, 2008	The fisheries agencies provided Reclamation and DWR with guidance and recommendations on the draft project description dated April 21, 2008.
May 16, 2008	The Service received a letter from Reclamation dated May 16, 2008, requesting formal consultation on the proposed action. A biological assessment also dated May 16, 2008, was enclosed with the letter.
May 17, 2008	Reclamation provided the Service with a number of revisions and addenda to the May 16, 2008 biological assessment.
May 28, 2008	Reclamation and DWR provided the Service with additional revisions to the May 16, 2008 biological assessment.
May 29, 2008	The Service sent a memo to Reclamation stating that with the revisions provided on May 28, 2008, the Service had received enough information to start the 30-day review period.
June 27, 2008	The Service provided Reclamation with a memo requesting additional information.
July 2, 2008	The Service received a memorandum from Reclamation informing the Service that Reclamation is committed to providing a response to the Services' June 27, 2008, request for additional information by early August, 2008.
August 11, 2008	The Service received Reclamation's August 8, 2008, letter transmitting the revised biological assessment.
August 20, 2008	The Service received the revised biological assessment on electronically from Reclamation.
August 29, 2008	Judge Wanger extended the completion date for the coordination of the CVP and SWP biological opinion to December 15, 2008.
September 25, 2008	The Service received a letter dated September 24, 2008 from the San Luis

	& Delta-Mendota Water Authority and the State Water Contractors, which provided comments on the biological assessment.
October 17, 2008	The Service received DWR's October 16, 2008 draft conservation actions.
October 17 through 24, 2008	Review of the draft Effects section of the biological opinion by the Service's Internal Peer Review Team (IPRT).
October 17 through 24, 2008	Independent Review of the draft Effects section of the biological opinion conducted by PBS&J (consultants).
October 23, 2008	The Service received a letter dated October 20, 2008 from the San Luis & Delta-Mendota Water Authority and the State Water Contractors, which provided comments on fall X2.
October 24, 2008	The Service received comments from Reclamation and DWR on the draft Effects section.
October 24 through November 19, 2008	Review of entire preliminary draft biological opinion by IPRT.
October 24 through November 19, 2008	Independent Review of the Service's draft conservation actions and DWR's draft conservation actions conducted by PBS&J. The Service's draft actions were also submitted to Reclamation.
November 21, 2008	The Service transmitted the draft biological opinion to Reclamation.
November 24, 2008	The Service received a letter dated November 19, 2008 from the San Luis & Delta-Mendota Water Authority and the State Water Contractors, which provided comments on the Effects section and the review conducted by PBS&J.
December 2, 2008	The Service received comments from Reclamation and DWR on the draft biological opinion.
December 15, 2008	The Service issued the OCAP biological opinion (Service File No. 81420-2008-F-1481-5) on the Proposed Coordinated Operations of the Central Valley Project and State Water Project.

March 3, 2009	The first of several complaints is filed by the Westlands Water District, San Luis and Delta Mendota Water Authority, DWR, Metropolitan Water District of Southern California ("Met"), Kern County Water Agency, and a number of other water agencies and other entities, seeking to have the court set aside the 2008 OCAP biological opinion.
December 14, 2010	Judge Wanger issued a summary judgment, finding the 2008 OCAP biological opinion unlawful and remanding it to the Service for further consideration per the findings in his Memorandum Decision.
May 4, 2011	Judge Wanger issued an amended Final Judgment, ordering the Service to complete a draft revised OCAP biological opinion by October 1, 2011, and a final revised OCAP biological opinion by December 1, 2013.
August 22 through September 2, 2011	Reclamation provided the Service with updated project description information.
August 31, 2011	Judge Wanger issued an order partially enjoining the fall X2 action, prohibiting the federal and state projects from operating to set X2 further downstream than 79 km for the purpose of meeting the requirements of the 2008 OCAP biological opinion.
September 20, 2011	Judge Wanger issued a Memorandum Decision on the merits in the challenge to the NMFS OCAP biological opinion.
December 13, 2011	Reclamation transmited a memorandum to the Service outlining a process by which they intend to develop a new project description, including actions intended to protect listed species, through a NEPA process.

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List of Abbreviations and Acronyms

°F	degrees Fahrenheit
°C	degrees Celsius
1995 Bay-Delta Plan	San Francisco Bay/Sacramento-San Joaquin Delta Estuary
8500 Banks	Banks Pumping Plant
ACID	Anderson-Cottonwood Irrigation District
AF	acre-feet
af/yr	acre-feet per year
AFRP	Anadromous Fish Restoration Program
ALPI	aleutian low pressure index
ANN	Artificial Neural Network
ARG	American River Group
ASIP	Action Specific Implementation Plan
Authority	San Luis and Delta Mendota Water Authority
B2IT	CVPIA Section 3406 (b)(2) Implementation Team
BA	biological assessment
Banks	Banks Pumping Plant
BDCP	Bay Delta Conservation Plan
BDFWO	San Francisco Bay-Delta Fish and Wildlife Office
BO	biological opinions
BR	breached
BY	brood year
CA	California Aqueduct
Cal EPA	California Environmental Protection Agency
CALFED	CALFED Bay-Delta Program
CalSim II	California Simulation computer model
CAMP	Comprehensive Assessment and Monitoring Program
CCC	Contra Costa Canal

CCF	Clifton Court Forebay
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFC	California Fish Commission
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHO	Constant Head Orifice
City	City of Sacramento
cm	centimeters
CMARP	Comprehensive Monitoring Assessment and Research Program
COA	Coordinated Operation Agreement
Conjunctive Use Agreements	Principles of Agreement for Proposed Conjunctive Use Agreements
Corps	U.S. Army Corps of Engineers
cpm	catch per minute
CPUE	catch per unit effort
CRR	Cohort Replacement Rate
CRWQ CB-NCR	California Regional Water Quality Control Board-North Coast Region
CSI	Cumulative Salvage Index
CVOO	Bureau of Reclamation's Central Valley Operations Office
CVP	Central Valley Project
CVPA	Central Valley Project Act
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
CWT	coded-wire-tag
D-1485	SWRCB Decision 1485

DAT	CVPIA Section 3406 (b)(2) Data Assessment Team
DBEEP	Delta-Bay Enhanced Enforcement Program
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DPS	Distinct Population Segment
DSM2	Delta Simulation Model 2
DSDT	delta smelt decision tree
DW	dewatered (at some point throughout the year)
DWR	California Department of Water Resources
E/I	export/inflow
EBMUD	East Bay Municipal Utility District
EC	electroconductivity
EFH	essential fish habitat
E/I	Export/Inflow Ratio
EID	El Dorado Irrigation District
EIR	Environmental Impact Report
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERP	Ecosystem Restoration Program
ESA	(Federal) Endangered Species Act
ESU	Evolutionarily Significant Unit
EWA	Environmental Water Account
EWAT	Environmental Water Account Team
FB	flashboards removed during winter

FERC	Federal Energy Regulatory Commission
Fisheries Agreement	Principles of Agreement for Proposed Lower Yuba River Fisheries Agreement
FL	Fork length
FLD	fish ladder
FMWT	Fall Midwater Trawl Survey
FPA	Federal Power Act
FR	Federal Register
FRH	Feather River Hatchery
FRWA	Freeport Regional Water Authority
FRWP	Freeport Regional Water Project
ft/s	foot/feet per second
FWS	U.S. Fish and Wildlife Service
GCID	Glenn-Colusa Irrigation District
GIS	geographic information system
GLM	Generalized Linear Models
GORT	Gate Operations Review Team
GS	Georgiana Slough
GSI	Genetic Stock Identification
HFC	high-flow channel
HGMP	Hatchery Genetics Management Plan
HORB	Head of Old River Barrier
IEP	Interagency Ecological Program
ID	Irrigation District
IFIM	Instream Flow Incremental Methodology
IHN	Infectious Hematopoietic Necrosis
Interior	U.S. Department of the Interior
IOS	Interactive Object-Oriented Salmon Simulation

IPO	Interim Plan of Operation
IWOFF	Integrated Water Operations Fisheries Forum
Jones	C.W. “Bill” Jones Pumping Plant. Formerly known as Tracy Pumping Plant
JPE	Juvenile Production Estimate
JPOD	joint point of diversion
KCWA	Kern County Water Agency
KFE	Kern Fan Element
km	kilometer
LCM	life-cycle model
LFC	low-flow channel
LOD	Level of Development
LP	linear programming
LSZ	low-salinity zone
LWD	large woody debris
M&I	municipal and industrial
maf	million acre-feet
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MAs	Management Agencies (FWS, NOAA Fisheries, and DFG for EWA)
mg/L	milligrams per liter
mgd	millions of gallons per day
MIB	methylisoborneol
MIDS	Morrow Island Distribution System
MILP	mixed integer linear programming
MLR	multiple linear regression
mm	millimeters
mmhos/cm	millimhos per centimeter
MOA	Memorandum of Agreement

MOU	Memorandum of Understanding
mS/cm	milliSiemens per centimeter
msl	mean sea level
MWDSC	Metropolitan Water District of Southern California
NBA	North Bay Aquaduct
NCCPA	Natural Community Conservation Planning Act
NCWA	Northern California Water Association
NDO	Net Delta Outflow
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMIPO	New Melones Interim Plan of Operation
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries (also know as National Marine Fisheries Service [NMFS])
NOD	North of Delta
NRC	National Research Council
NTU	Nephelometric Turbidity Unit
OCAP	Operations Criteria and Plan
OFF	Operations and Fishery Forum
OID	Oakdale Irrigation District
ONCC	Oregon/Northern California Coast
Ops Group	CALFED Operations Coordination Group
PAs	Project Agencies (DWR and Reclamation)
PCBs	Polychlorinated biphenyls
PCEs	Primary Constituent Elements
PCWA	Placer County Water Agency
PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council

PG&E	Pacific Gas and Electric
PHABSIM	Physical Habitat Simulation
PIT	passive integrated transponder
POD	Pelagic Organic Decline
POP	Persistent organic pollutants
ppm	parts per million
ppt	parts per trillion
Project	CVP and SWP (as in CVP and SWP water rights)
PSL	Pre-screen loss
psu	Practical Salinity Units
PTM	Particle Tracking Model
QSA	Quantification Settlement Agreement
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Bureau of Reclamation
RM	River Marker (similar to mile marker)
RMS	Residual Mean Square
RMIS	Regional Mark Information System
ROD	Record of Decision
RPA	reasonable and prudent alternative
RRDS	Roaring River Distribution System
RST	rotary screw (fish) trap
RWQCB	Regional Water Quality Control Board
SA	Settlement Agreement
SAFCA	Sacramento Area Flood Control Agency
Salmod model	A computer model that simulates the dynamics of freshwater salmonid populations
SCDD	Spring Creek Debris Dam
SCE	Southern California Edison

SCWA	Sacramento County Water Agency
SDFF	South Delta Fish Facility Forum
SDIP	South Delta Improvement Project
sdl	standard length
SDP	Station Development Plan
SDTB	South Delta Temporary Barriers
SFWO	Sacramento Fish and Wildlife Office
SJRA	San Joaquin River Agreement
SJRTC	San Joaquin River Technical Committee
SJRWR	San Joaquin River water rights
SKT	Spring Kodiak Trawl
SL	sloped dam
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SMWC	Sutter Mutual Water Company
SOD	South of Delta
SOD	Safety of Dams
SONCC	Southern Oregon/Northern California Coast
SPME	Solid Phase Micro-extraction
SRCD	Suisun Resource Conservation District
SRPP	Spring-run Chinook Salmon Protection Plan
SRTTG	Sacramento River Temperature Task Group
SRWQM	Sacramento River Water Quality Management
SSJID	South San Joaquin Irrigation District
SWP	State Water Project
SVWMP	Sacramento Valley Water Management Program (Phase 8)
SWRCB	(California) State Water Resources Control Board
SWRI	Surface Water Resources, Inc.

T&E	Threatened and Endangered
taf	thousand acre-feet
TAO	Thermalito Afterbay Outlet
TCCA	Tehama-Colusa Canal Authority
TCD	temperature control device
TDS	total dissolved solids
TFCF	Tracy Fish Collection Facility
TFFIP	Tracy Fish Facility Improvement Program
TFPL	Trust for Public Lands
TNS	Townet Survey
TU	temperature units
U.S.C.	United States Code
UN	unscreened diversion
USFC	U.S. Commission of Fish and Fisheries
USGS	U.S. Geological Survey
USRFRHAC	Upper Sacramento River Fisheries and Riparian Habitat Advisory Council
VAMP	Vernalis Adaptive Management Plan
VSP	Viable Salmonid Population
Water Purchase Agreement	Principles of Agreement for Proposed Long-term Transfer Agreement
WDSC	(Metropolitan) Water District of Southern California
Western	Western Area Power Administration
Westlands	Westlands Water District
WOMT	Water Operations Management Team
Working Group	Delta Smelt Working Group
WQCP	Water Quality Control Plan
WRESL	Water Resources Engineering Simulation Language

WTP	Water Treatment Plant
WUA	weighted usable (spawning) area
WY	water year
X2	2 parts per thousand isohaline
YCWA	Yuba County Water Agency
YOY	young-of-the-year

Draft Project Description

The following proposed action described existing operations of the the CVP and SWP absent any additional actions to avoid jeopardy to delta smelt and adverse modification of the smelt's critical habitat. This project description is expected to change following Reclamation's National Environmental Policy Act process on proposed operations.

The proposed action is the continued operations of the CVP and SWP The proposed action includes the operation of the temporary barriers project in the south Delta and the 500 cfs increase in SWP Delta export limit July through September. In addition to recent historic operations, several other recent actions are included in this consultation. In addition to recent historic operations, several other actions are included in this consultation. These actions are: (1) an intertie between the California Aqueduct (CA) and the Delta-Mendota Canal (DMC), (2) Freeport Regional Water Project (FRWP), (3) changes in the operation of the Red Bluff Diversion Dam (RBDD), (4) Middle River Intake Project for CCWD, and (5) minor operational changes. Table 1 summarizes the differences between current operational actions and future operational actions to be covered by this consultation. A detailed summary of all operational components and associated modeling assumptions are included in Table 2.

Table 1. Major Proposed Future Operational Actions for Consultation

Area of Project	Today 2011	Future 2030
Trinity & Whiskeytown	Trinity Restoration Flows 368,600-815,000 af	Same
Shasta/Sacramento River	Red Bluff Diversion Dam (RBDD) 8 months gates out	New RBDD Operation 10 months gates out with pumping plant
Oroville and Feather River	Old FERC License and NMFS 2004 BO	Expect New FERC License
Folsom and American River	Current Demands	Build out of demands, New American River Flow Management, and Freeport Regional Water Project
New Melones and Stanislaus River	Interim Plan of Operations Guidance	Interim Plan of Operations Guidance
Friant Division	Historic Operations	Same
Sacramento-San Joaquin Delta	Current Demands	2030 Demands
Suisun Marsh	Same	Expect to Implement New Charter
WQCP	D-1641	Same
COA	1986 Guidance	Same

CVPIA	May 9, 2003 Decision	Same
Banks Pumping Plant	6680* cfs and Temporary Barriers	6680* cfs and Temporary Barriers
Jones Pumping Plant	Max of 4600 cfs with Flexibility of Intertie	Max 4600 cfs with Flexibility of Intertie

This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to Clifton Court Forebay, although between December 15 and March 15, when the San Joaquin River is above 1,000 cfs, one-third of the San Joaquin River flow at Vernalis may be pumped in addition. Furthermore, the SWP is permitted to pump an additional 500 cfs between July 1 and September 30 to offset water costs associated with fisheries actions making the summer limit effectively 7,180 cfs.

Table 2. Assumptions for the Base and Future Studies

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	OCAP BA 2004 Today CVPIA 3406 (b)(2) with EWA	**Today-OCAP BA 2004 Assumptions in Revised CalSim-II Model - EWA**	**Today-OCAP BA 2004 Assumptions in Revised CalSim-II Model - CVPIA (b)(2) - CONV**	**Today-Existing Conditions, (b)(2), EWA**	**Near Future-Existing Conditions and OCAP BA 2004 Consulted Projects, (b)(2), Yuba Accord C1/500 cfs Fish Protection Offset**	**Future - (b)(2), Yuba Accord C1/500 cfs Fish Protection Offset**	**Future Climate Change-D1641**	**Model Revisions since OCAP BA 2004**
OCAP Base model: Common Assumptions: Common Model Package (Version 8D) *"Same" indicates an assumption from a column to the left*								
Planning horizon	2001	2005[a]	Same	Same	2019	2030[a]	Same	
Period of Simulation	73 years (1922-1994)	82 years (1922-2003)	Same	Same	Same	Same	Same	Extended hydrology timeseries
HYDROLOGY							Inflows are modified based on alternative climate inputs [b]	Revised level of detail in the Yuba and Colusa Basin including rice decomposition operations
Level of development (Land Use)	2001 Level	2005 level	Same	Same	Same	2030 level[c]	Same	
Sacramento Valley (excluding American R.)								

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	CVP	Land-use based, limited by contract amounts[d]	Same	Same	Same	Same	CVP Land-use based, Full build out of CVP contract amounts[d]	Same	
	SWP (FRSA)	Land-use based, limited by contract amounts[e]	Same	Same	Same	Same	Same	Same	
	Non-project	Land-use based	Same	Same	Same	Same	Same	Same	
	Federal refuges	Firm Level 2	Same	Same	Recent Historical Firm Level 2 water needs[f]	Same	Firm Level 2 water needs[f]	Same	
American River									
	Water rights	2001[g]	Same	Same	2005[g]	Same	2025[g]	Same	
	CVP (PCWA American River Pump Station)	No project	Same	Same	CVP (PCWA modified)[g]	Same	Same	Same	
San Joaquin River[h]									
	Friant Unit	Regression of Historical Demands	Limited by contract amounts, based on current allocation policy	Same	Same	Same	Same	Same	Developed land-use based demands, water quality calculations, and revised accretions/depletions in the East-Side San Joaquin Valley
	Lower Basin	Fixed Annual Demands	Land-use based, based on district level operations and constraints	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Stanislaus River	New Melones Interim Operations Plan	Same	Same	Same	Same	Same	Same	Initial storage conditions for New Melones Reservoir were increased.
South of Delta	(CVP/SWP project facilities)	CVP Demand based on contracts amounts[d]	Same	Same	Same	Same	Same	Same	
	Contra Costa Water District	124 TAF/yr annual average	135 TAF/yr annual average CVP contract supply and water rights[i]	Same	Same	Same	195 TAF/yr annual average CVP contract supply and water rights[i]	Same	
	SWP Demand - Table A	Variable 3.1-4.1 MAF/Yr	Same	Same	Variable 3.1-4.2 MAF/Yr[e,j]	Same	Full Table A	Same	Revised SWP delivery logic. Three patterns with Art 56 and more accurately defined Table A / Article 21 split modeled
	SWP Demand - North Bay Aqueduct (Table A)	48 TAF/Yr	Same	Same	71 TAF/Yr[u]	Same	Same	Same	
	SWP Demand - Article 21 demand	Up to 134 TAF/month December to March, total of other demands up to 84 TAF/month in	Same	Same	Up to 314 TAF/month from December to March, total of demands up to 214	Same	Up to 414 TAF/month from December to March, total of demands up to 214 TAF/month in all other months[e,jw]	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
		all months			TAF/month in all other months[e,jw]				
	Federal refuges	Firm Level 2	Same	Same	Recent Historical Firm Level 2 water needs[f]	Same	Firm Level 2 water needs[f]	Same	
FACILITIES									
Systemwide		Existing facilities[a]	Same	Same	Same	Same	Same	Same	
Sacramento Valley									
	Red Bluff Diversion Dam	No diversion constraint	Same	Same	Diversion Dam operated May 15 - Sept 15 (diversion constraint)	Same	Diversion Dam operated July - August (diversion constraint)	Same	
	Colusa Basin	Existing conveyance and storage facilities	Same	Same	Same	Same	Same	Same	
	Upper American River	No project	Same	Same	PCWA American River pump station[k]	Same	Same	Same	
	Sacramento River Water Reliability	No project	Same	Same	Same	Same	American/Sacramento River Diversions[t]	Same	
	Lower Sacramento River	No project	Same	Same	Same	Freeport Regional Water Project (Full Demand)[l]	Same	Same	
Delta Region									
	SWP Banks Pumping Plant	South Delta Improvements Program Temporary Barriers, 6,680 cfs	Same	Same	Same	Temporary Barriers. 6,680 cfs capacity in Oct – Jun, 7180 cfs in Jul	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
		capacity in all months and an additional 1/3 of Vernalis flow from Dec 15 through Mar 15[a]				– Sep and an additional 1/3 of Vernalis flow from Dec 15 through Mar 15 [a]			
	CVP C.W. Bill Jones (Tracy) Pumping Plant	4,200 cfs + deliveries upstream of DMC constriction	Same	Same	Same	4,600 cfs capacity in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)	Same	Same	
	City of Stockton Delta Water Supply Project (DWSP)	No project	Same	Same	DWSP WTP 0 mgd	Same	DWSP WTP 30 mgd	Same	
	Contra Costa Water District	Existing pump locations	Same	Same	Same	Same	Same[m]	Same	
South of Delta (CVP/SWP project facilities)									
	South Bay Aqueduct (SBA)	Existing capacity 300 cfs	Same	Same	SBA Rehabilitation: 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 diversion point	Same	Same	Same	
REGULATORY STANDARDS									
Trinity River									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/year)	Same	Same	Same	Same	Same	Same	
	Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same	Same	Same	Same	Same	Same	
Clear Creek									
	Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
Upper Sacramento River									
	Shasta Lake	NMFS 2004 BO: 1.9 MAF end of Sep. storage target in non-critical years	Same	Same	Same	Same	Same	Same	
	Minimum flow below Keswick Dam	Flows for SWRCB WR 90-5 temperature control, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
Feather River									
	Minimum flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 cfs)	Same	Same	Same	2006 Settlement Agreement (700 / 800 cfs)	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	Same	Same	Same	Same	Same	Same	
Yuba River									
	Minimum flow below Daguerre Point Dam	Available Yuba River Data[p]	D-1644 Interim Operations[p]	Same	Yuba Accord Adjusted Data[p]	Same	Lower Yuba River Accord	Same	
American River									
	Minimum flow below Nimbus Dam	SWRCB D-893 (see Operations Criteria), and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	(b)(2) Minimum Instream Flow management[s]	Same	Same	Same	
	Minimum Flow at H Street Bridge	SWRCB D-893	Same	Same	Same	Same	Same	Same	
Lower Sacramento River									
	Minimum flow near Rio Vista	SWRCB D-1641	Same	Same	Same	Same	Same	Same	
Mokelumne River									
	Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 cfs)	Same	Same	Same	Same	Same	Same	
	Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same	Same	Same	Same	Same	Same	
Stanislaus River									
	Minimum flow below Goodwin Dam	1987 USBR, DFG agreement, and USFWS discretionary	Same	Same	Same	New Melones Interim Operations Plan	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
		use of CVPIA 3406(b)(2)							
	San Joaquin River Restoration Program	N/A	N/A	N/A	N/A	Full Restoration Flows	Same	Same	
	Minimum dissolved oxygen	SWRCB D-1422	Same	Same	Same	Same	Same	Same	
Merced River									
	Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180-220 cfs, Nov-Mar), Cowell Agreement	Same	Same	Same	Same	Same	Same	
	Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same	Same	Same	Same	Same	Same	
Tuolumne River									
	Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/year)	Same	Same	Same	Same	Same	Same	
San Joaquin River									
	Maximum salinity near Vernalis	SWRCB D-1641	Same	Same	Same	Same	Same	Same	
	Minimum flow near Vernalis	SWRCB D-1641, and Vernalis Adaptive Management Plan per San Joaquin River Agreement	Same	Same	Same	Same	Same	Same	
Sacramento River–San Joaquin River Delta									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	Same	Same	Same	Same	Same	Same	Revised Delta ANN (salinity estimation)[v]
	Delta Cross Channel gate operation	SWRCB D-1641	Same	Same	Same	Same	Same	Same	
	Delta exports	SWRCB D-1641, USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
OPERATIONS CRITERIA: RIVER-SPECIFIC									
Upper Sacramento River									
	Flow objective for navigation (Wilkins Slough)	3,250 - 5,000 cfs based on CVP water supply condition	Same	Same	Same	Same	Same	Same	
American River									
	Folsom Dam flood control	Variable 400/670 flood control diagram (without outlet modifications)	Same	Same	Same	Same	Same	Same	
	Flow below Nimbus Dam	Discretionary operations criteria corresponding to SWRCB D-893 required minimum flow	Same	Same	(b)(2) Minimum Instream Flow management[s]	Same	American River Flow Management [s]	Same	
	Sacramento Area Water Forum "Replacement" Water	"Replacement" water is not implemented	Same	Same	Same	Same	Same	Same	
Stanislaus River									
	Flow below Goodwin Dam	1997 New Melones Interim Operations	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
		Plan							
San Joaquin River									
	Flow at Vernalis	D1641	Same	Same	Same	Same	Same[q]	Same	
OPERATIONS CRITERIA: SYSTEMWIDE									
CVP water allocation									
	CVP Settlement and Exchange	100% (75% in Shasta critical years)	Same	Same	Same	Same	Same	Same	
	CVP refuges	100% (75% in Shasta critical years)	Same	Same	Same	Same	Same	Same	
	CVP agriculture	100%-0% based on supply (South-of-Delta allocations are reduced due to D-1641 and 3406(b)(2) allocation-related export restrictions)	Same	Same	Same	Same	Same	Same	
	CVP municipal & industrial	100%-50% based on supply (South-of-Delta allocations are reduced due to D-1641 and 3406(b)(2) allocation-related export restrictions)	Same	Same	Same	Same	Same	Same	
SWP water allocation									
	North of Delta (FRSA)	Contract specific	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement	Same	Same	Same	Same	Same	Same	
CVP-SWP coordinated operations									
	Sharing of responsibility for in-basin-use	1986 Coordinated Operations Agreement (FRWP EBMUD and 2/3 of the North Bay Aqueduct diversions are considered as Delta Export, 1/3 of the North Bay Aqueduct diversion is considered as in-basin-use)	Same	Same	Same	Same	Same	Same	
	Sharing of surplus flows	1986 Coordinated Operations Agreement	Same	Same	Same	Same	Same	Same	
	Sharing of Export/Inflow Ratio	Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) restricts only CVP and/or SWP exports	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Sharing of export capacity for lesser priority and wheeling related pumping	Cross Valley Canal wheeling (max of 128 TAF/year), SWRCB D-1641 defined Joint Point of Diversion (JPOD)	Same	Same	Same	Same	Same	Same	
Study assumptions from above apply			**Study 6a**	**Study 7a**	**Study 7a**	**Study 7.1a**	**Study 8a**	**NA**	
CVPIA 3406(b)(2): Per May 2003 Dept. of Interior Decision									
	Allocation	800 TAF, 700 TAF in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years[n]	Same	Same	Same	Same	Same	NA	
Post Processing Assumptions									
WATER MANAGEMENT ACTIONS (CALFED)									
Water Transfers									
	Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users	Same	NA	Same	Same	Same	NA	
	Phase 8[o]	Evaluate available capacity	Same	NA	Same	Same	Same		
	Refuge Level 4 water	Evaluate available capacity	Same	NA	Same	Same	Same		

Notes:

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II

[a] The BA project description is presented in Chapter 2.

[b]Climate change sensitivity analysis assumptions and documentation are presented in Appendix R.

[c] The Sacramento Valley hydrology used in the CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of 2030 land-use assumptions are being coordinated with the California Water Plan Update for future models.

[d] CVP contract amounts have been reviewed and updated according to existing and amended contracts as appropriate. Assumptions regarding CVP agricultural and M&I service contracts and Settlement Contract amounts are documented in Table 3A (North of Delta) and 5A (South of Delta) of Appendix D: Delivery Specifications section of the Technical Appendix.

[e] SWP contract amounts have been reviewed and updated as appropriate. Assumptions regarding SWP agricultural and M&I contract amounts are documented in Table 1A (North of Delta) and Table 2A (South of Delta) of Appendix D: Delivery Specifications section.

[f] Water needs for federal refuges have been reviewed and updated as appropriate. Assumptions regarding firm Level 2 refuge water needs are documented in Table 3A (North of Delta) and 5A (South of Delta) of Appendix D:Delivery Specifications. Incremental Level 4 refuge water needs have been documented as part of the assumptions of future water transfers.

[g] PCWA demand in the foreseeable existing condition is 8.5 TAF/yr of CVP contract supply diverted at the new American River PCWA Pump Station. In the future scenario, PCWA is allowed 35 TAF/yr. Assumptions regarding American River water rights and CVP contracts are documented in Table 5 of Appendix D: Delivery Specifications section.

[h] The new CalSim-II representation of the San Joaquin River has been included in this model package (CalSim-II San Joaquin River Model, Reclamation, 2005). Updates to the San Joaquin River have been included since the preliminary model release in August 2005. The model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to on-going groundwater overdraft problems. In addition, a dynamic groundwater simulation is not yet developed for San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

[i] Study 6.0 demands for CCWD are assumed equal to Study 7.0 due to data availability with the revised CalSim-II model framework. For all Studies, Los Vaqueros Reservoir storage capacity is 100 TAF.

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1.1 ANALYTICAL	Study 8.0.1 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II

[j] Table A deliveries into the San Francisco Bay Area Region for existing cases are based on a variable demand and a full Table A for future cases. The variable demand is dependent on the availability of other water during wet years resulting in less demand for Table A. In the future cases it is assumed that the demand for full Table A will be independent of other water sources. Article 21 demand assumes MWD demand of 100 TAF/mon (Dec-Mar), Kern demand of 180 TAF/mon (Jan-Dec), and other contractor demand of 34 TAF/mon (Jan-Dec).

[k] PCWA American River pumping facility upstream of Folsom Lake is under construction.

[l] Mokelumne River flows reflect EBMUD supplies associated with the Freeport Regional Water Project.

[m] The CCWD Middle River Intake Project, an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir is not included in these CalSim II model runs.

[n] The allocation representation in CalSim-II replicates key processes, shortage changes are checked by post-processing.

[o] This Phase 8 requirement is assumed to be met through Sacramento Valley Water Management Agreement Implementation.

[p] OCAP BA 2004 modeling used available hydrology at the time which was data developed based on 1965 Yuba County Water Agency -Department of Fish of Game Agreement. Since the OCAP BA 2004 modeling, Yuba River hydrology was revised. Interim D-1644 is assumed to be fully implemented with or without the implementation of the Lower Yuba River Accord. This is consistent with the future no-action condition being assumed by the Lower Yuba River Accord EIS/EIR study team. For studies with the Lower Yuba River Accord, an adjusted hydrology is used.

[q] It is assumed that either VAMP, a functional equivalent, or D-1641 requirements would be in place in 2030.

[r] The Draft Transitional Operations Plan assumptions are discussed in Chapter 2.

[s] For Studies 7.0, 7.1, and 8.0 the flow components of the proposed American River Flow Management are included and applied using the CVPIA 3406(b)(2

[t] This BA assumes the flexibility of diversion location but does not assume the Sacramento Area Water Forum Water Forum "replacement water" in drier water year types.

[u] Aqueduct improvements that would allow an increase in South Bay Aqueduct demand at the time of model development were expected to be operational within 6 months. However, a delay in the construction has postponed the completion.

[V] The Artificial Neural Network (ANN) was updated for both salinity and X2 calculations. Study 3a does not include an updated ANN, Study 6.1 has an updated salinity but not X2, and all remaining Studies include both the updated salinity and X2.

[w] North Bay Article 21 deliveries are dependent on excess conditions rather than being dependent on San Luis storage.

Figure 1. Map of California CVP and SWP Service Areas

Coordinated Operations of the CVP and SWP

Coordinated Operations Agreement

The CVP and SWP use a common water supply in the Central Valley of California (Figure 1). The DWR and Reclamation (collectively referred to as Project Agencies) have built water conservation and water delivery facilities in the Central Valley in order to deliver water supplies to affected water rights holders as well as project contractors. The Project Agencies' water rights are conditioned by the State Water Resources Control Board (SWRCB) to protect the beneficial uses of water within each respective project and jointly for the protection of beneficial uses in the Sacramento Valley and the Sacramento-San Joaquin Delta Estuary. The Project Agencies coordinate and operate the CVP and SWP to meet the joint water right requirements in the Delta.

The Coordinated Operations Agreement (COA), signed in 1986, defines the project facilities and their water supplies, sets forth procedures for coordination of operations, identifies formulas for sharing joint responsibilities for meeting Delta standards, as the standards existed in SWRCB Decision 1485 (D-1485) and other legal uses of water, identifies how unstored flow will be shared, sets up a framework for exchange of water and services between the CVP/SWP, and provides for periodic review of the agreement.

Implementing the COA

Obligations for In-Basin Uses

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the SWRCB D-1485 Delta standards (D-1485 ordered the CVP and SWP to guarantee certain conditions for water quality protection for agricultural, municipal and industrial [M&I], and fish and wildlife use). The Project Agencies are obligated to ensure water is available for these uses, but the degree of obligation is dependent on several factors and changes throughout the year, as described below.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equals the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation's Central Valley Operations Office (CVOO) and DWR's SWP Operations Control Office jointly decide when balanced or excess water conditions exist.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under Article 6(g) of the COA, Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical, legal and contractual limits. In excess water conditions, water accounting is not required. However, during balanced water conditions, the Projects share the responsibility in meeting in-basin uses.

When water must be withdrawn from reservoir storage to meet in-basin uses, 75 percent of the responsibility is borne by the CVP and 25 percent is borne by the SWP[1]. When unstored water is available for export (i.e., Delta exports exceed storage withdrawals while balanced water conditions exist), the sum of CVP stored water, SWP stored water, and the unstored water for export is allocated 55/45 to the CVP and SWP, respectively.

Accounting and Coordination of Operations

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other's facilities for pumping and wheeling.

During balanced water conditions, daily water accounting is maintained of the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days travel time from the Delta. It also means adjustments can be made "after the fact" using actual data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses.

The accounting language of the COA provides the mechanism for determining the responsibility of each project for Delta outflow-influenced standards; however, real time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow required to maintain joint standards. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response will likely be to increase Folsom releases first. Lake Oroville water releases require about three days to reach the Delta, while water released from Lake Shasta requires five days to travel from Keswick to the Delta. As water from the other reservoirs arrives in the Delta, Folsom releases can be adjusted downward. Any imbalance in meeting each project's designed shared obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. Increasing or decreasing project exports can immediately achieve changes to Delta outflow. As with changes in reservoir releases, imbalances in meeting each project's designed shared obligations are captured by the COA accounting.

During periods of balanced water conditions, when real-time operations dictate project actions, an accounting procedure tracks the designed sharing water obligations of the CVP and SWP. The Projects produce daily and accumulated accounting balances. The account represents the imbalance resulting from actual coordinated operations compared to the COA-designed sharing of obligations and supply. The project that is "owed" water (i.e., the project that provided more or exported less than its COA-defined share) may request the other project adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one

[1] These percentages were derived from negotiations between Reclamation and DWR for SWRCB D-1485 standards

balanced water condition through the excess water condition and into the next balanced water condition. When the project that is owed water enters into flood control operations, at Shasta or Oroville, the accounting is zeroed out for that respective project. The biological assessment provides a detailed description of the changes in the COA.

State Water Resources Control Board Water Rights

1995 Water Quality Control Plan

The SWRCB adopted the 1995 Bay-Delta Water Quality Control Plan (WQCP) on May 22, 1995, which became the basis of SWRCB Decision-1641. The SWRCB continues to hold workshops and receive information regarding processes on specific areas of the 1995 WQCP. The SWRCB amended the WQCP in 2006, but to date, the SWRCB has made no significant changes to the 1995 WQCP framework.

Decision 1641

The SWRCB imposes a myriad of constraints upon the operations of the CVP and SWP in the Delta. With Water Rights Decision 1641, the SWRCB implements the objectives set forth in the SWRCB 1995 Bay-Delta WQCP and imposes flow and water quality objectives upon the Projects to assure protection of beneficial uses in the Delta. The SWRCB also grants conditional changes to points of diversion for the Projects with D-1641.

The various flow objectives and export restraints are designed to protect fisheries. These objectives include specific outflow requirements throughout the year, specific export restraints in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and they vary throughout the year and by the wetness of the year.

Figure 2 and Figure 3 summarize the flow and quality objectives in the Delta and Suisun Marsh for the Projects from D-1641. These objectives will remain in place until such time that the SWRCB revisits them per petition or as a consequence to revisions to the SWRCB Water Quality Plan for the Bay-Delta (which is to be revisited periodically).

On December 29, 1999, SWRCB adopted and then revised (on March 15, 2000) Decision 1641, amending certain terms and conditions of the water rights of the SWP and CVP. Decision 1641 substituted certain objectives adopted in the 1995 Bay-Delta Plan for water quality objectives that had to be met under the water rights of the SWP and CVP. In effect, D-1641 obligates the SWP and CVP to comply with the objectives in the 1995 Bay-Delta Plan. The requirements in D-1641 address the standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. SWRCB D-1641 also authorizes SWP and CVP to jointly use each other’s points of diversion in the southern Delta, with conditional limitations and required response coordination plans. SWRCB D-1641 modified the Vernalis salinity standard under SWRCB Decision 1422 to the corresponding Vernalis salinity objective in the 1995 Bay-Delta Plan. The criteria imposed upon the CVP and SWP are summarized in Figure 2 (Summary Bay-Delta Standards), Figure 3 (Footnotes for Summary Bay-Delta Standards), and Figure 4 (CVP/SWP Delta Map).

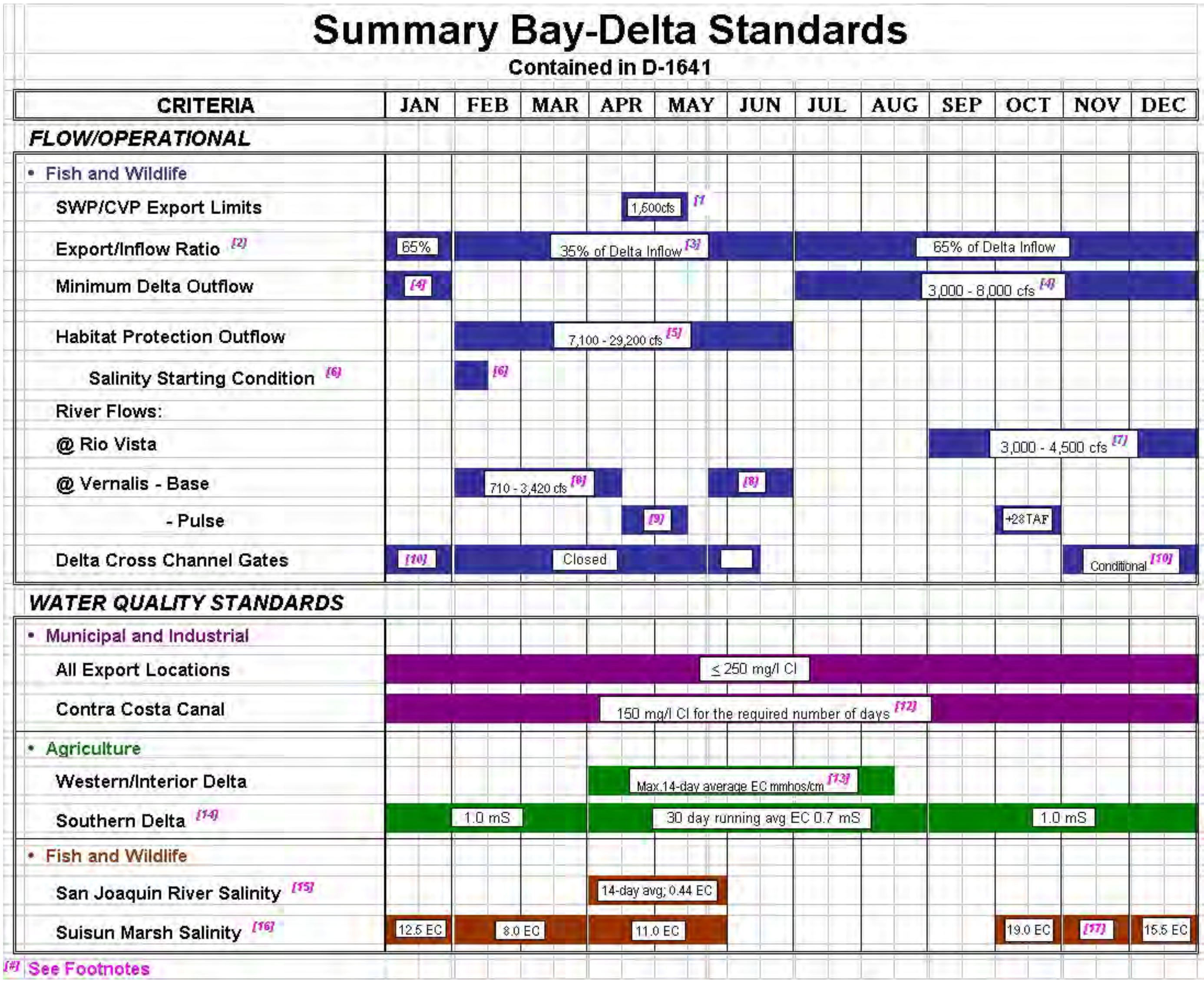

Figure 2. Summary Bay Delta Standards (See footnotes on page 16)

Footnotes

[1] Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Year Type	All
Apr15 - May15*	The greater of 1,500 or 100% of 3-day avg. Vernalis flow

* This time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CalFed Op's group.

[2] The maximum percentage of average Delta inflow (use 3-day average for balanced conditions with storage withdrawal, otherwise use 14-day average) diverted at Clifton Court Forebay (excluding Byron-Bethany pumping) and Tracy Pumping Plant using a 3-day average. (These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water cost.)

[3] The maximum percent Delta inflow diverted for Feb may vary depending on the January 8RI.

Jan 8RI	Feb exp. limit
≤ 1.0 MAF	45%
between 1.0 & 1.5 MAF	35%-45%
> 1.5 MAF	35%

[4] Minimum monthly average Delta outflow (cfs). If monthly standard ≤ 5,000 cfs, then the 7-day average must be within 1,000 cfs of standard; if monthly standard > 5,000 cfs, then the 7-day average must be ≥ 80% of standard.

Year Type	All	W	AN	BN	D	C
Jan	4,500*					
Jul		8,000	8,000	6,500	5,000	4,000
Aug		4,000	4,000	4,000	3,500	3,000
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

* Increase to 6,000 if the Dec 8RI is greater than 800 TAF

[5] Minimum 3-day running average of daily Delta outflow of 7,100 cfs OR: either the daily average or 14-day running average EC at Collinsville is less than 2.64 mmhos/cm (This standard for March may be relaxed if the Feb 8RI is less than 500 TAF. The standard does not apply in May and June if the May estimate of the SRI IS < 8.1 MAF at the 90% exceedence level in which case a minimum 14-day running average flow of 4,000 cfs is required.) For additional Delta outflow objectives, see **TABLE A**.

[6] February starting salinity: If Jan 8RI > 900 TAF, then the daily or 14-day running average EC @ Collinsville must be ≤ 2.64 mmhos/cm for at least one day between Feb 1-14. If Jan 8RI is between 650 TAF and 900 TAF, then the CalFed Op's group will determine if this requirement must be met.

[7] Rio Vista minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 1,000 below the monthly objective).

Year Type	All	W	AN	BN	D	C
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

[8] BASE Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Feb-Apr14 and May16-Jun		2,130 or 3,420	2,130 or 3,420	1,420 or 2,280	1,420 or 2,280	710 or 1,140

[9] PULSE Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Apr15 - May15		7,330 or 8,620	5,730 or 7,020	4,620 or 5,480	4,020 or 4,880	3,110 or 3,540
Oct	1,000*					

* Up to an additional 28 TAF pulse/attraction flow to bring flows up to a monthly average of 2,000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op's group.

[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[11] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days per CALFED Op's group. During the period the Delta cross channel gates may close 4 consecutive days each week, excluding weekends.

[12] Minimum # of days that the mean daily chlorides ≤ 150 mg/l must be provided in intervals of not less than 2 weeks duration. Standard applies at Contra Costa Canal Intake or Antioch Water Works Intake.

Year Type	W	AN	BN	D	C
# Days	240	190	175	165	155

Figure 3. Footnotes for Summary Bay Delta Standards (continued on next page)

[13] The maximum14-day running average of mean daily EC (mmhos/cm) depends on water year type.

Year Type	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *
W	Aug 15		Aug 15		Aug 15		Aug 15	
AN	Jul 1	0.63	Aug 15		Aug 15		Aug 15	
BN	Jun 20	1.14	Jun 20	0.74	Aug 15		Aug 15	
D	Jun 15	1.67	Jun 15	1.35	Aug 15		Jun 25	0.58
C		2.78		2.20		0.54		0.87

* When no date is shown, EC limit continues from April 1.

[14] As per D-1641, for San Joaquin River at Vernalis: however, the April through August maximum 30- day running average EC for San Joaquin River at Brandt Bridge,Old River near Middle River, and Old River at Tracy Road Bridge shall be 1.0 EC until April 1, 2005 when the value will be 0.7 EC.

[15] Compliance will be determined between Jersey Point & Prisoners Point.
Does not apply in critical years or in May when the May 90% forecast of SRI $\leq$ 8.1 MAF.

[16] During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations as per SMPA is:

Month	mhtEC
Oct	19.0
Nov	16.5
Dec-Mar	15.6
Apr	14.0
May	12.5

[17] In November, maximum monthly average mhtEC = 16.5 for Western Marsh stations and maximum monthly average mhtEC = 15.5 for Eastern Marsh stations in all periods types.

TABLE A

Number of Days When Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained. (This can also be met with a maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago Standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mmhos/cm or less. PMI is previous month's 8RI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of day's for values of the PMI between those specified below shall be determined by linear interpolation.

PMI (TAF)	Chipps Island (Chipps Island Station D10)				
	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0
750	0	0	0	0	0
1000	28*	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥ 5500	28	31	30	31	30

*When 800 TAF < PMI < 1000 TAF, the number of days is determined by linear interpolation between 0 and 28 days.

PMI (TAF)	Port Chicago (continuous recorder at Port Chicago)				
	FEB	MAR	APR	MAY	JUN
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
> 10000	28	31	30	31	30

Figure 3. Footnotes for Summary Bay Delta Standards

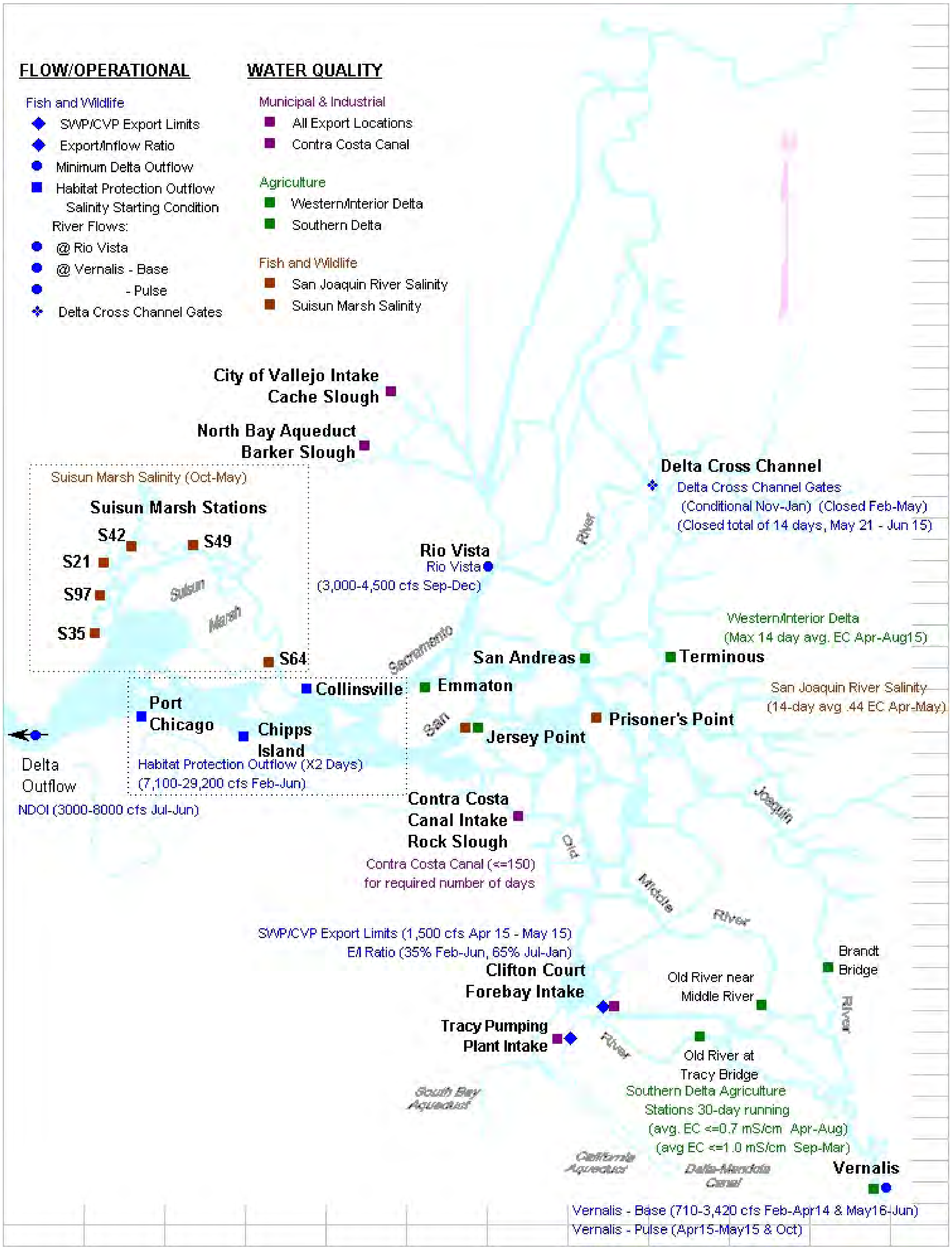

Figure 4. CVP/SWP Delta Map

Joint Points of Diversion

SWRCB D-1641 granted Reclamation and DWR the ability to use/exchange each Project's diversion capacity capabilities to enhance the beneficial uses of both Projects. The SWRCB conditioned the use of Joint Point of Diversion (JPOD) capabilities based on a staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1 – for water service to Cross Valley Canal contractors, Tracy Veterans Cemetery and Musco Olive, and to recover export reductions taken to benefit fish.
- Stage 2 – for any purpose authorized under the current project water right permits.
- Stage 3 – for any purpose authorized up to the physical capacity of the diversion facilities. Stage 3 is not part of the project description.

Each stage of JPOD has regulatory terms and conditions which must be satisfied in order to implement JPOD.

All stages require a response plan to ensure water levels in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan). All stages require a response plan to ensure the water quality in the southern and Central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and Central Delta.

All JPOD diversion under excess conditions in the Delta is junior to Contra Costa Water District (CCWD) water right permits for the Los Vaqueros Project, and must have an X2 (the two parts per thousand (ppt) isohaline location in kilometers from the Golden Gate Bridge) located west of certain compliance locations consistent with the 1993 Los Vaqueros biological opinion for delta smelt.

Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water. This is commonly known as the Fisheries Response Plan. A Fisheries Response Plan was approved by the SWRCB in February 2007, but relies in part on the 2004 and 2005 Biological Opinions. Once this consultation is complete, the Fisheries Response Plan will be re-examined. If modifications are required, the plan will be revised and re-submitted to the SWRCB at a future date.

Stage 3 has an additional requirement to protect water levels in the southern Delta under the operational conditions of Phase II of the South Delta Improvements Program, along with an updated companion Fisheries Response Plan.

Reclamation and DWR intend to apply all response plan criteria consistently for JPOD uses as well as water transfer uses.

In general, JPOD capabilities will be used to accomplish four basic CVP-SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP-SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to use JPOD capabilities.

- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies.
- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer.
- During certain coordinated CVP-SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP-SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Revised WQCP (2006)

The SWRCB undertook a proceeding under its water quality authority to amend the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) adopted in 1978 and amended in 1991 and in 1995. Prior to commencing this proceeding, the SWRCB conducted a series of workshops in 2004 and 2005 to receive information on specific topics addressed in the Bay-Delta Plan.

The SWRCB adopted a revised Bay-Delta Plan on December 13, 2006. There were no changes to the Beneficial Uses from the 1995 Plan to the 2006 Plan, nor were any new water quality objectives adopted in the 2006 Plan. A number of changes were made simply for readability. Consistency changes were also made to assure that sections of the 2006 Plan reflected the current physical condition or current regulation. The SWRCB continues to hold workshops and receive information regarding Pelagic Organism Decline (POD), Climate Change, and San Joaquin salinity and flows, and will coordinate updates of the Bay-Delta Plan with on-going development of the comprehensive Salinity Management Plan.

Real Time Decision-Making to Assist Fishery Management

Introduction

Real time decision-making to assist fishery management is a process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. For the proposed action high uncertainty exists for how to best manage water operations while protecting listed species. Sources of uncertainty relative to the proposed action include:

- Hydrologic conditions
- Ocean conditions
- Listed species biology

Under the proposed action the goals for real time decision-making to assist fishery management are:

- Meet contractual obligations for water delivery
- Minimize adverse effects for listed species

Framework for Actions

Reclamation and DWR work closely with the Service, NMFS, and DFG to coordinate the operation of the CVP and SWP with fishery needs. This coordination is facilitated through several forums in a cooperative management process that allows for modifying operations based on real-time data that includes current fish surveys, flow and temperature information, and salvage or loss at the project facilities, (hereinafter "triggering event").

Water Operations Management Team

The Water Operations Management Team (WOMT) is comprised of representatives from Reclamation, DWR, the Service, NMFS, and DFG. This management-level team was established to facilitate timely decision-support and decision-making at the appropriate level. The WOMT first met in 1999, and will continue to meet to make management decisions as part of the proposed action. Routinely, it also uses the CALFED Ops Group to communicate with stakeholders about its decisions. Although the goal of WOMT is to achieve consensus on decisions, the participating agencies retain their authorized roles and responsibilities.

Process for Real Time Decision- Making to Assist Fishery Management

Decisions regarding CVP and SWP operations to avoid and minimize adverse effects on listed species must consider factors that include public health, safety, water supply reliability, and water quality. To facilitate such decisions, the Project Agencies and the Service, NMFS, and DFG have developed and refined a set of processes for various fish species to collect data, disseminate information, develop recommendations, make decisions, and provide transparency. This process consists of three types of groups that meet on a recurring basis. Management teams are made up of management staff from Reclamation, DWR, the Service, NMFS, and DFG. Information teams are teams whose role is to disseminate and coordinate information among agencies and stakeholders. Fisheries and Operations Technical Teams are made up of technical staff from state and Federal agencies. These teams review the most up-to-date data and information on fish status and Delta conditions, and develop recommendations that fishery agencies' management can use in identifying actions to protect listed species.

The process to identify actions for protection of listed species varies to some degree among species but follows this general outline: A Fisheries or Operations Technical Team compiles and assesses current information regarding species, such as stages of reproductive development, geographic distribution, relative abundance, and physical habitat conditions; it then provides a recommendation to the agency with statutory obligation to enforce protection of the species in question. The agency's staff and management will review the recommendation and use it as a basis for developing, in cooperation with Reclamation and DWR, a modification of water operations that will minimize adverse effects to listed species by the Projects. If the Project Agencies do not agree with the action, then the fishery agency with the statutory authority will make a final decision on an action that they deem necessary to protect the species.

The outcomes of protective actions that are implemented will be monitored and documented, and this information will inform future recommended actions.

Groups Involved in Real Time Decision-Making to Assist Fishery Management and Information Sharing

Information Teams

CALFED Ops and Subgroups

The CALFED Ops Group consists of the Project agencies, the fishery agencies, SWRCB staff, and the U.S. Environmental Protection Agency (EPA). The CALFED Ops Group generally meets eight times a year in a public setting so that the agencies can inform each other and stakeholders about current operations of the CVP and SWP, implementation of the CVPIA and State and Federal endangered species acts, and additional actions to contribute to the conservation and protection of State- and Federally-listed species. The CALFED Ops Group held its first public meeting in January 1995, and during the next six years the group developed and refined its process. The CALFED Ops Group has been recognized within SWRCB D-1641, and elsewhere, as one forum for coordination on decisions to exercise certain flexibility that has been incorporated into the Delta standards for protection of beneficial uses (e.g., E/I ratios, and some DCC closures). Several teams were established through the Ops Group process. These teams are described below:

Data Assessment Team (DAT)

The DAT consists of technical staff members from the Project and fishery agencies as well as stakeholders. The DAT meets frequently[2] during the fall, winter, and spring. The purpose of the meetings is to coordinate and disseminate information and data among agencies and stakeholders that is related to water project operations, hydrology, and fish surveys in the Delta.

B2 Interagency Team (B2IT)

The B2IT was established in 1999 and consists of technical staff members from the Project and fisheries agencies. The B2IT meets weekly to discuss implementation of section 3406 (b)(2) of the CVPIA, which mandates the dedication of CVP water supply for environmental purposes. B2IT communicates with WOMT to ensure coordination with the other operational programs or resource-related aspects of project operations, including flow and temperature issues.

Technical Teams

Fisheries Technical Teams

Several fisheries specific teams have been established to provide guidance and recommendations on resource management issues. These teams include:

The Sacramento River Temperature Task Group (SRTTG)

The SRTTG is a multiagency group formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1, to assist with improving and stabilizing Chinook population in the Sacramento River. Annually, Reclamation develops temperature operation plans for the Shasta and Trinity Divisions of the CVP. These plans consider impacts on winter-run and other races of Chinook salmon, and associated Project operations. The SRTTG meets initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control. Once the SRTTG has recommended an operation plan for temperature

[2] The DAT holds weekly conference calls and may have additional discussions during other times as needed.

control, Reclamation then submits a report to the SWRCB, generally on or before June 1st each year.

After implementation of the operation plan, the SRTTG may perform additional studies and commonly holds meetings as needed, typically monthly through the summer and into fall, to develop revisions based on updated biological data, reservoir temperature profiles, and operations data. Updated plans may be needed for summer operations protecting winter-run, or in fall for fall-run spawning season. If there are any changes in the plan, Reclamation submits a supplemental report to SWRCB.

Smelt Working Group (SWG)

The SWG evaluates biological and technical issues regarding delta smelt and develops recommendations for consideration by the Service. Since the longfin smelt (*Spirinchus thaleichthys*) became a state candidate species in 2008, the SWG has also developed for DFG recommendations to minimize adverse effects to longfin smelt. The SWG consists of representatives from the Service, DFG, DWR, EPA, and Reclamation. The Service chairs the group, and members are assigned by each agency.

The SWG compiles and interprets the latest near real-time information regarding state- and federally-listed smelt, such as stages of development, distribution, and salvage. After evaluating available information and if they agree that a protection action is warranted, the SWG will submit their recommendations in writing to the Service and DFG.

The SWG may meet at any time at the request of the Service, but generally meets weekly during the months of December through June, when smelt salvage at Jones and Banks has occurred historically. However, the Delta Smelt Risk Assessment Matrix (see below) outlines the conditions when the SWG will convene to evaluate the necessity of protective actions and provide the Service with a recommendation. Further, with the State listing of longfin smelt, the group will also convene based on longfin salvage history at the request of DFG.

Delta Smelt Risk Assessment Matrix (DSRAM)

The SWG will employ a delta smelt risk assessment matrix to assist in evaluating the need for operational modifications of SWP and CVP to protect delta smelt. This document will be a product and tool of the SWG and will be modified by the SWG with the approval of the Service, in consultation with Reclamation, DWR and DFG, as new knowledge becomes available. The currently approved DSRAM is Attachment A.

If an action is taken, the SWG will follow up on the action to attempt to ascertain its effectiveness. The ultimate decision-making authority rests with the Service. An assessment of effectiveness will be attached to the notes from the SWG's discussion concerning the action.

Delta Operations Salmonid and Sturgeon (DOSS) Group

The DOSS workgroup is a technical team with relevant expertise from Reclamation, DWR, DFG, FWS, SWRCB, USGS, EPA, and NMFS that provides advice to WOMT and to NMFS on issues related to fisheries and water resources in the Delta and recommendations on measures to reduce adverse effects of Delta operations of the CVP and SWP to salmonids and green sturgeon. The purpose of DOSS is to provide recommendations for real-time management of operations to WOMT and NMFS; review annually project operations in the Delta and the collected data from the different ongoing monitoring programs; and coordinate with the SWG to maximize benefits to all listed species.

American River Group

In 1996, Reclamation established a working group for the Lower American River, known as American River Group (ARG). Although open to the public, the ARG meetings generally include representatives from several agencies and organizations with on-going concerns and interests regarding management of the Lower American River. The formal members of the group are Reclamation, the Service, NMFS, and DFG.

The ARG convenes monthly or more frequently if needed, with the purpose of providing fishery updates and reports to Reclamation to help manage Folsom Reservoir for fish resources in the Lower American River.

Operations Technical Teams

An operations specific team is established to provide guidance and recommendations on operational issues and one is proposed for the South Delta Improvement Program (SDIP) operable gates. These teams are:

Delta Cross Channel (DCC) Project Work Team:

The DCC Project Work Team is a multiagency group under CALFED. Its purpose is to determine and evaluate the affects of DCC gate operations on Delta hydrodynamics, water quality, and fish migration.

Gate Operations Review Team

When the gates proposed under SDIP Stage 1 are in place and operational, a federal and state interagency team will be convened to discuss constraints and provide input to the existing WOMT. The Gate Operations Review Team (GORT) will make recommendations for the operations of the fish control and flow control gates to minimize impacts on resident threatened and endangered species and to meet water level and water quality requirements for South Delta water users. The interagency team will include representatives of DWR, Reclamation, the Service, NMFS, and DFG. DWR will be responsible for providing predictive modeling, and SWP Operations Control Office will provide operations forecasts. Reclamation will be responsible for providing CVP operations forecasts, including San Joaquin River flow, and data on current water quality conditions. Other members will provide the team with the latest information related to South Delta fish species and conditions for crop irrigation. Operations plans would be developed using the Delta Simulation Model 2 (DSM2), forecasted tides, and proposed diversion rates of the projects to prepare operating schedules for the existing CCF gates and the four proposed operable gates. The Service will use the SWG for recommendations regarding gate operations. The FWS will generally rely on the SWG for recommendations regarding gate operations.

Uses of Environmental Water Accounts

CVPIA Section 3406 (b)(2)

On May 9, 2003, the Department of the Interior issued its Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Dedication of (b)(2) water occurs when Reclamation takes a fish, wildlife, or habitat restoration action based on recommendations of the Service (and in consultation with NMFS and DFG), pursuant to Section 3406 (b)(2). Dedication and management of (b)(2) water may also assist in meeting WQCP fishery objectives and help meet the needs of fish listed under the ESA as threatened or endangered since the enactment of the CVPIA.

The May 9, 2003, decision describes the means by which the amount of dedicated (b)(2) water is determined. Planning and accounting for (b)(2) action is done cooperatively and occurs primarily through weekly meetings of the B2IT. Actions usually take one of two forms: in-stream flow augmentation below CVP reservoirs or CVP Jones pumping reductions in the Delta. Chapter 9 of the biological assessment contains a more detailed description of (b)(2) operations, as characterized in the CALSIM II modeling assumptions and results of the modeling are summarized.

CVPIA 3406 (b)(2) Operations on Clear Creek

Dedication of (b)(2) water on Clear Creek provides actual in-stream flows below Whiskeytown Dam greater than those that would have occurred under pre-CVPIA regulations, e.g., the fish and wildlife minimum flows specified in the 1963 proposed release schedule. In-stream flow objectives are usually taken from the AFRP's plan, in consideration of spawning and incubation of fall-run Chinook salmon. Augmentation in the summer months is usually in consideration of water temperature objectives for steelhead and in late summer for spring-run Chinook salmon.

CVPIA 3406 (b)(2) Operations on the Upper Sacramento River

Dedication of (b)(2) water on the Sacramento River provides actual in-stream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA regulations, e.g., the fish and wildlife requirements specified in WR 90-5 and the temperature criteria formalized in the 1993 NMFS Winter-run biological opinion as the base. In-stream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, rearing, and migration.

CVPIA 3406 (b)(2) Operations on the Lower American River

Dedication of (b)(2) water on the American River provides actual in-stream flows below Nimbus Dam greater than those that would have occurred under pre-CVPIA regulations, (e.g. the fish and wildlife requirements previously mentioned in the American River Division). In-stream flow objectives from October through May generally aim to provide suitable habitat for salmon and steelhead spawning, incubation, and rearing, while considering impacts to American River operations the rest of the year. In-stream flow objectives for June to September endeavor to provide suitable flows and water temperatures for juvenile steelhead rearing while balancing the effects on temperature operations into October and November.

- Flow Fluctuation and Stability Concerns:

  Through CVPIA, Reclamation has funded studies by DFG to better define the relationships of Nimbus release rates and rates of change criteria in the Lower American River to minimize the negative effects of necessary Nimbus release changes on sensitive fishery objectives. Reclamation is presently using draft criteria developed by DFG. The draft criteria have helped reduce the incidence of anadromous fish stranding relative to past historic operations. The primary operational coordination for potentially sensitive Nimbus Dam release changes is conducted through the B2IT process.

CVPIA 3406 (b)(2) Operations on the Stanislaus River

Dedication of (b)(2) water on the Stanislaus River provides actual in-stream flows below Goodwin Dam greater than the fish and wildlife requirements discussed below in the East Side Division, and in the past has been generally consistent with the Interim Plan of Operation (IPO) for New Melones. In-stream fishery management flow volumes on the Stanislaus River, as part of the IPO, are based on the New Melones end-of-February storage plus forecasted March to September inflow. The volume determined by the IPO is a combination of fishery flows pursuant to the 1987 DFG Agreement and the Service AFRP in-stream flow goals. The fishery volume is then initially distributed based on modeled fish distributions and patterns used in the IPO.

Actual in-stream fishery management flows below Goodwin Dam will be determined in accordance with the Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Reclamation has begun a process to develop a long-term operations plan for New Melones. The ultimate long-term plan will be coordinated with B2IT members, along with the stakeholders and the public before it is finalized.

CVPIA 3406 (b)(2) Operations in the Delta

Export curtailments at the CVP Jones Pumping Plant and increased CVP reservoir releases required to meet SWRCB D-1641's Objectives for Fish and Wildlife Beneficial Uses, as well as direct export reductions for fishery management using dedicated (b)(2) water at the CVP Jones Pumping Plant, will be determined in accordance with the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Direct Jones Pumping Plant export curtailments for fishery management protection will be based on coordination with the weekly B2IT meetings and vetted through WOMT, as necessary.

Yuba Accord - Component 1 Water

Component 1 Water under the Yuba Accord can provide up to approximately 48,000 AF of replaced supply to cover the water costs of various fishery protection actions taken by the SWP and CVP. Component 1 water comprises the release of 60,000 AF annually from the Yuba River and ultimately to the Delta. After accounting for reasonable carriage water costs, an estimate of 48,000 AF of increased diversion in the Delta would occur during July, August, and September of each year.

In years where capacity to pump the Yuba Accord Component 1 Water is not available under the normal 6680 cfs maximum diversion capacity into Clifron Court Forebay (CCF), the maximum allowable daily diversion rate into CCF during the months of July, August, and September will be increased from 13,870 AF to 14,860 AF and three-day average diversions from 13,250 AF to 14,240 AF (500 cfs per day equals 990 AF). The increase in diversions has been permitted and in place since 2000. The current permit expires on September 30, 2012, but is expected to be renewed into the future. The purpose of this diversion increase into CCF for use by the SWP is to recover export reductions made due to the ESA or other actions taken to benefit fisheries resources. The increased diversion rate will not result in any increase in water supply deliveries than would occur in the absence of the increased diversion rate. This increased diversion over the three-month period would result in an amount not to exceed 90 TAF each year. Increased diversions above the 48 TAF discussed previously could occur for a number of reasons including:

1) Actual carriage water loss on the 60 TAF of current year's Yuba Accord Component 1 Water is less than the assumed 20 percent.
2) Diversion of Yuba Accord Component 1 Water exceeds the current year's 60 TAF allotment to make up for a Yuba Accord Component 1 deficit from a previous year.
3) In very wet years, the diversion of excess Delta outflow goes above and beyond the Yuba Accord Component 1 Water allotment.

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 increased diversion rate.

In years where the accumulated export under the 500 cfs increased diversion exceeds 48 taf, the additional assets will be applied to earlier export reductions made due to the ESA or other actions taken to benefit fisheries resourcees that exceeded 48 TAF or held in the SWP share of San Luis Reservoir, as long as space is available, to be applied to subsequent export reductions made due to the ESA or other actions taken to benefit fisheries resources.
As the winter and spring progress, the SWP share of San Luis Reservoir may fill and the space will no longer be available to store the asset. If this happens, the asset will be converted to SWP supply stored in San Luis Reservoir and the SWP exports from the Delta will be reduced at that time by the same volume as the asset. Any reductions in exports resulting from this situation are expected to occur in the December-March period.

Implementation of the proposed action is contingent on meeting the following conditions:

1. The increased diversion rate will not result in an increase in annual SWP water supply allocations other than would occur in the absence of the increased diversion rate. Water pumped due to the increased capacity will only be used to offset reduced diversions that occurred or will occur because of ESA or other actions taken to benefit fisheries.

2. Use of the increased diversion rate will be in accordance with all terms and conditions of existing biological opinions governing SWP operations.

3. All three temporary agricultural barriers (Middle River, Old River near Tracy and Grant Line Canal) must be in place and operating when SWP diversions are increased.

4. Between July 1 and September 30, if the combined salvage of listed fish species reaches a level of concern, the relevant fish regulatory agency will determine whether the 500 cfs increased diversion is or continues to be implemented.

Central Valley Project

Central Valley Project Improvement Act

On October 30, 1992, Public Law 102-575, (Reclamation Projects Authorization and Adjustment Act of 1992) was passed. Included in the law was Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement having an equal priority with power generation. Changes mandated by the CVPIA include:

- Dedicating 800,000 AF annually to fish, wildlife, and habitat restoration
- Authorizing water transfers outside the CVP service area
- Implementing an anadromous fish restoration program
- Creating a restoration fund financed by water and power users
- Providing for the Shasta Temperature Control Device
- Implementing fish passage measures at Red Bluff Diversion Dam (RBDD)
- Calling for planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges
- Improving the Tracy Fish Collection Facility (TFCF)
- Meeting Federal trust responsibility to protect fishery resources (Trinity River)

The CVPIA is being implemented as authorized. The Final Programmatic Environmental Impact Statement (PEIS) for the CVPIA analyzed projected conditions in 2022, 30 years from the CVPIA's adoption in 1992. The Final PEIS was released in October 1999 and the CVPIA Record of Decision (ROD) was signed on January 9, 2001. The biological opinions were issued on November 21, 2000.

Water Service Contracts, Allocations and Deliveries

Water Needs Assessment

Water needs assessments have been performed for each CVP water contractor eligible to participate in the CVP long-term contract renewal process. Water needs assessments confirm a contractor's past beneficial use and determine future CVP water supplies needed to meet the contractor's anticipated future demands. The assessments are based on a common methodology used to determine the amount of CVP water needed to balance a contractor's water demands with available surface and groundwater supplies. All of the contractor assessments have been finalized.

Future American River Operations - Water Service Contracts and Deliveries

Surface water deliveries from the American River are made to various water rights entities and CVP contractors. Total American River Division annual demands on the American and Sacramento Rivers are estimated to increase from about 324,000 acre-feet in 2005 and 605,000 acre-feet in 2030 without the Freeport Regional Water Project maximum of 133,000 acre-feet during drier years. Reclamation is negotiating the renewal of 13 long-term water service contracts, four Warren Act contracts, and has a role in six infrastructure or Folsom Reservoir operations actions influencing the management of American River Division facilities and water use.

Water Allocation – CVP

The water allocation process for CVP begins in the fall when preliminary assessments are made of the next year's water supply possibilities, given current storage conditions combined with a range of hydrologic conditions. These preliminary assessments may be refined as the WY progresses. Beginning February 1, forecasts of WY runoff are prepared using precipitation to date, snow water content accumulation, and runoff to date. All of CVP's Sacramento River Settlement water rights contracts and San Joaquin River Exchange contracts require that contractors be informed no later than February 15 of any possible deficiency in their supplies. In recent years, February 20th has been the target date for the first announcement of all CVP contractors' forecasted water allocations for the upcoming contract year. Forecasts of runoff and operations plans are updated at least monthly between February and May.

Reclamation uses the 90 percent probability of exceedance forecast as the basis of water allocations. Furthermore, NMFS reviews the operations plans devised to support the initial water allocation, and any subsequent updates to them, for sufficiency with respect to the criteria for Sacramento River temperature control.

CVP M&I Water Shortage Operational Assumptions

The CVP has 253 water service contracts (including Sacramento River Settlement Contracts). These water service contracts have had varying water shortage provisions (e.g., in some contracts, municipal and industrial (M&I) and agricultural uses have shared shortages equally; in most of the larger M&I contracts, agricultural water has been shorted 25 percent of its contract entitlement before M&I water was shorted, after which both shared shortages equally).

The M&I minimum shortage allocation does not apply to contracts for the (1) Friant Division, (2) New Melones interim supply, (3) Hidden and Buchanan Units, (4) Cross Valley contractors, (5) San Joaquin River Exchange settlement contractors, and (6) Sacramento River settlement contractors. Any separate shortage-related contractual provisions will prevail.

There will be a minimum shortage allocation for M&I water supplies of 75 percent of a contractor's historical use (i.e., the last three years of water deliveries unconstrained by the availability of CVP water). Historical use can be adjusted for growth, extraordinary water conservation measures, and use of non-CVP water as those terms are defined in the proposed policy. Before the M&I water allocation is reduced, the irrigation water allocation would be reduced below 75 percent of contract entitlement.

When the allocation of irrigation water is reduced below 25 percent of contract entitlement, Reclamation will reassess the availability of CVP water and CVP water demand; however, due to limited water supplies during these times, M&I water allocation may be reduced below 75 percent of adjusted historical use during extraordinary and rare times such as prolonged and severe drought. Under these extraordinary conditions allocation percentages for both South of Delta and North of Delta irrigation and M&I contractors are the same.

Reclamation will deliver CVP water to all M&I contractors at not less than a public health and safety level if CVP water is available, if an emergency situation exists, but not exceeding 75 percent on contract total (and taking into consideration water supplies available to the M&I contractors from other sources). This is in recognition, however, that the M&I allocation may, nevertheless, fall to 50 percent as the irrigation allocation drops below 25 percent and approaches zero due to limited CVP supplies.

Allocation Modeling Assumptions:

Ag 100% to 75% then M&I is at 100%	
Ag 70%	M&I 95%
Ag 65%	M&I 90%
Ag 60%	M&I 85%
Ag 55%	M&I 80%
Ag 50% to 25%	M&I 75%
Dry and Critical Years:	
Ag 20%	M&I 70%
Ag 15%	M&I 65%
Ag 10%	M&I 60%
Ag 5%	M&I 55%
Ag 0%	M&I 50%

Project Facilities

Trinity River Division Operations

The Trinity River Division, completed in 1964, includes facilities to store and regulate water in the Trinity River, as well as facilities to divert water to the Sacramento River Basin. Trinity Dam is located on the Trinity River and regulates the flow from a drainage area of approximately 720 square miles. The dam was completed in 1962, forming Trinity Lake, which has a maximum storage capacity of approximately 2.4 million acre-feet (maf; see map in Figure 5).

The mean annual inflow to Trinity Lake from the Trinity River is about 1.2 maf per year. Historically, an average of about two-thirds of the annual inflow has been diverted to the Sacramento River Basin (1991-2003). Trinity Lake stores water for release to the Trinity River and for diversion to the Sacramento River via Lewiston Reservoir, Clear Creek Tunnel, Whiskeytown Reservoir, and Spring Creek Tunnel where it commingles in Keswick Reservoir with Sacramento River water released from both the Shasta Dam and Spring Creek Debris Dam.

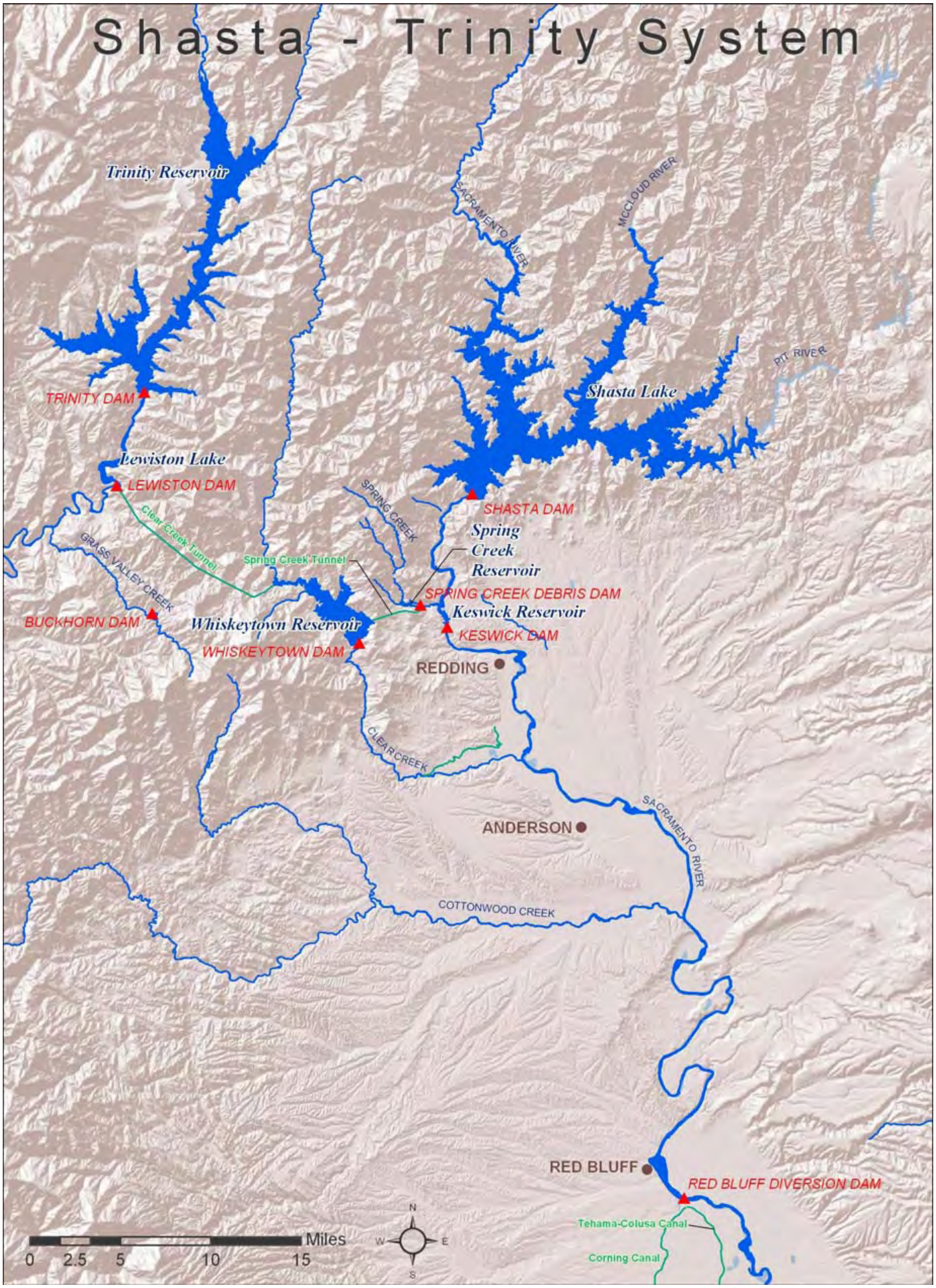

Figure 5. Shasta-Trinity System

Safety of Dams at Trinity Reservoir

Periodically, increased water releases are made from Trinity Dam consistent with Reclamation Safety of Dams criteria intended to prevent overtopping of Trinity Dam. Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations.

The Safety of Dams release criteria specifies that Carr Powerplant capacity should be used as a first preference destination for Safety of Dams releases made at Trinity Dam. Trinity River releases are made as a second preference destination. During significant Northern California high water flood events, the Sacramento River water stages are also often at concern levels. Under such high water conditions, the water that would otherwise move through Carr Powerplant is routed to the Trinity River. Total river release can reach up to 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high water concerns in the flood plain and local bridge flow capacities. The Safety of Dam criteria provides seasonal storage targets and recommended releases November 1 to March 31. During May 2006 the river flows were over 10,000 cfs for several days.

Fish and Wildlife Requirements on Trinity River

Based on the Trinity River Mainstem Fishery Restoration ROD, dated December 19, 2000, from 368,600AF to 815,000 AF is allocated annually for Trinity River flows. This amount is scheduled in coordination with the Service to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Temperature objectives for the Trinity River are set forth in SWRCB order WR 90-5 (Table 3 below). These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River. Reclamation consults with the Service in establishing a schedule of releases from Lewiston Dam that can best achieve these objectives.

For the purpose of determining the Trinity Basin WY type, forecasts using the 50 percent exceedance as of April 1st are used. There are no make-up/or increases for flows forgone if the WY type changes up or down from an earlier 50 percent forecast. In the modeling, actual historic Trinity inflows were used rather than a forecast. There is a temperature curtain in Lewiston Reservoir that provides for temperature management for the diversions to Clear Creek Tunnel.

Table 3. Water temperature objectives for the Trinity River during the summer, fall, and winter as established by the CRWQCB-NCR (California Regional Water Quality Control Board North Coast Region)

Date	Temperature Objective (°F)	
	Douglas City (RM 93.8)	North Fork Trinity River (RM 72.4)
July 1 through Sept 14	60	-
Sept 15 through Sept 30	56	-
Oct 1 through Dec 31	-	56

Transbasin Diversions

Diversion of Trinity water to the Sacramento Basin provides limited water supply and hydroelectric power generation for the CVP and assists in water temperature control in the Trinity River and upper Sacramento River. The amounts and timing of the Trinity exports are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity water supply.

The seasonal timing of Trinity exports is a result of determining how to make best use of a limited volume of Trinity export (in concert with releases from Shasta) to help conserve cold water pools and meet temperature objectives on the upper Sacramento and Trinity rivers, as well as power production economics. A key consideration in the export timing determination is the thermal degradation that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake.

To minimize the thermal degradation effects, transbasin export patterns are typically scheduled by an operator to provide an approximate 120,000 AF volume to occur in late spring to create a thermal connection to the Spring Creek Powerhouse before larger transbasin volumes are scheduled to occur during the hot summer months (Figure 6). Typically, the water flowing from the Trinity Basin through Whiskeytown Lake must be sustained at fairly high rates to avoid warming and to function most efficiently for temperature control. The time period for which effective temperature control releases can be made from Whiskeytown Lake may be compressed when the total volume of Trinity water available for export is limited.

Export volumes from Trinity are made in coordination with the operation of Shasta Reservoir. Other important considerations affecting the timing of Trinity exports are based on the utility of power generation and allowances for normal maintenance of the diversion works and generation facilities.

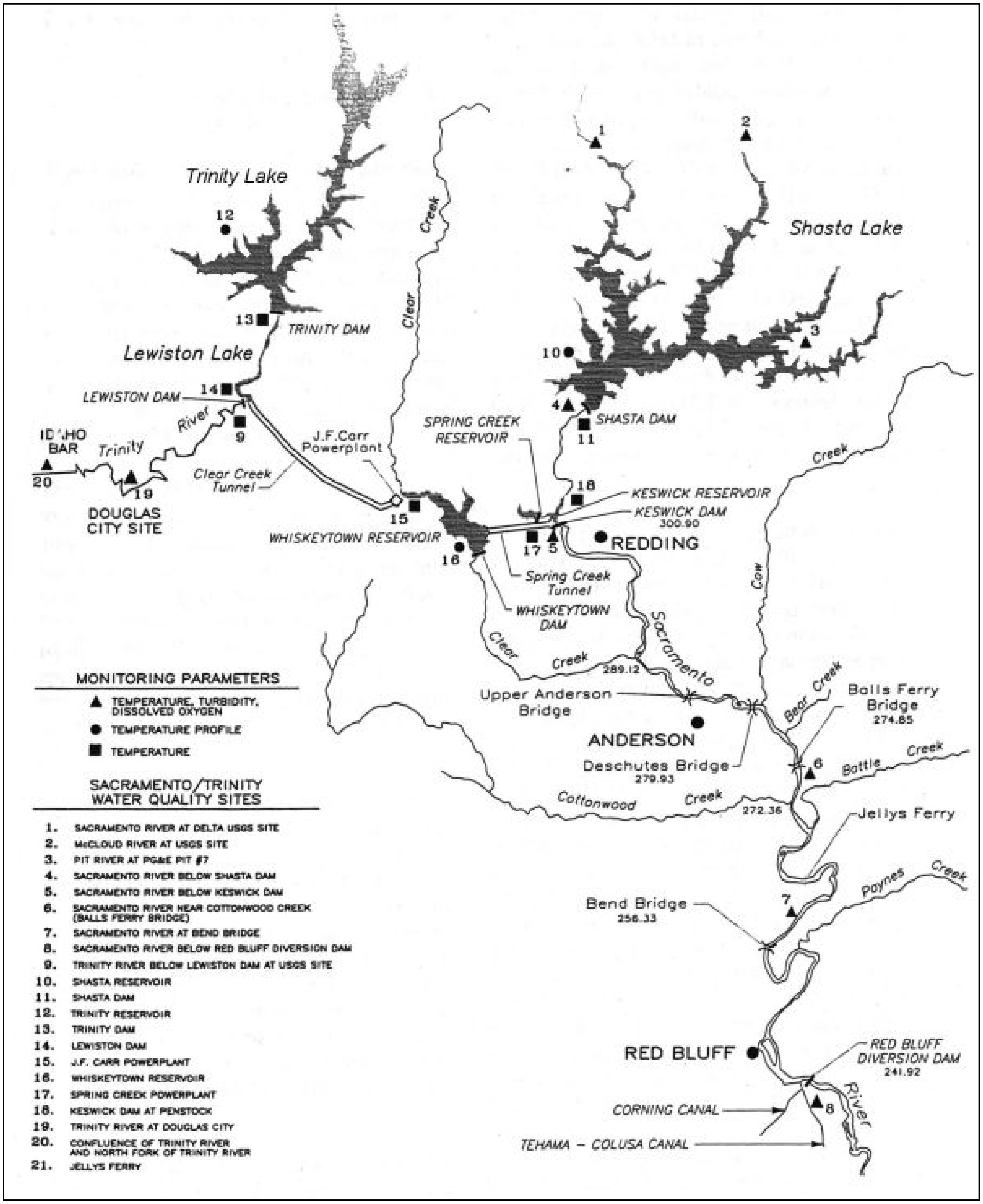

Figure 6. Sacramento-Trinity Water Quality Network (with river miles [RM])

Trinity Lake historically reached its greatest storage level at the end of May. With the present pattern of prescribed Trinity releases, maximum storage may occur by the end of April or in early May.

Reclamation maintains at least 600,000 AF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Reservoir is also drawn down. Reclamation will address end of WY carryover on a case-by-case basis in dry and critically dry WY types with the Service and NMFS through the WOMT and B2IT processes.

Whiskeytown Reservoir Operations

Since 1964, a portion of the flow from the Trinity River Basin has been exported to the Sacramento River Basin through the CVP facilities. Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Powerplant and into Keswick Reservoir. All of the water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir.

Spring Creek also flows into the Sacramento River and enters at Keswick Reservoir. Flows on Spring Creek are partially regulated by the Spring Creek Debris Dam. Historically (1964-1992), an average annual quantity of 1,269,000 AF of water has been diverted from Whiskeytown Lake to Keswick Reservoir. This annual quantity is approximately 17 percent of the flow measured in the Sacramento River at Keswick.

Whiskeytown is normally operated to (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek consistent with the CVPIA Anadromous Fish Restoration Program (AFRP) objectives. Although it stores up to 241,000 AF, this storage is not normally used as a source of water supply. There are two temperature curtains in Whiskeytown Reservoir.

Spillway Flows below Whiskeytown Lake

Whiskeytown Lake is annually drawn down approximately 35,000 AF per year of storage space during November through April to regulate flows for power generation. Heavy rainfall events occasionally result in spillway discharges to Clear Creek, as shown in Table 4 below.

Table 4. Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2005, WY Types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critical

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D
1986	17	W

Water Year	Days of Spilling	40-30-30 Index
1987	0	D
1988	0	C
1989	0	D
1990	8	C
1991	0	C
1992	0	C
1993	10	AN
1994	0	C
1995	14	W
1996	0	W
1997	5	W
1998	8	W
1999	0	W
2000	0	AN
2001	0	D
2002	0	D
2003	8	AN
2004	0	BN
2005	0	AN
2006	4	W
2007	0	D
2008	0	C
2009	0	D
2010	6	BN

Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin.

Fish and Wildlife Requirements on Clear Creek

Water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. Two agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with the DFG established minimum flows to be released to Clear Creek at Whiskeytown Dam (Table 5).
- A 1963 release schedule for Whiskeytown Dam was developed with the Service and implemented, but never finalized. Although this release schedule was never formalized, Reclamation has operated according to this proposed schedule since May 1963.

Table 5. Minimum flows at Whiskeytown Dam from 1960 MOA with the DFG

Period	Minimum flow (cfs)
1960 MOA with the DFG	
January 1 - February 28(29)	50
March 1 - May 31	30
June 1 - September 30	0
October 1 - October 15	10
October 16 - October 31	30
November 1 - December 31	100
1963 FWS Proposed Normal year flow (cfs)	
January 1 - October 31	50
November 1 - December 31	100
1963 FWS Proposed Critical year flow (cfs)	
January 1 - October 31	30
November 1 - December 31	70

Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5,800 AF of water. Operation of SCDD and Shasta Dam has allowed some control of the toxic wastes with dilution criteria. In January 1980, Reclamation, the DFG, and the SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds. Given improved water quality in Spring Creek and at the SCDD site, a modified MOU is under consideration that could modify and update several monitoring requirements and would slightly modify operations of the SCDD.

The MOU identifies agency actions and responsibilities, and establishes release criteria based on allowable concentrations of total copper and zinc in the Sacramento River below Keswick Dam. The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to these criteria and schedules provided) and that such operation will not cause flood control parameters on the Sacramento River to be exceeded and will not unreasonably interfere with other project requirements as determined by Reclamation. The MOU also specifies a minimum schedule for monitoring copper and zinc concentrations at SCDD and in the Sacramento River below Keswick Dam. Reclamation has primary responsibility for the monitoring; however, the DFG and the RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analyses techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD targeting the more stringent Central Valley Region Water Quality Control Plan (Basin Plan) criteria in addition to the MOU goals. Instead of the total copper and total zinc criteria contained in the MOU, Reclamation operates SCDD releases and Keswick dilution flows to not exceed the Basin Plan standards of 0.0056 mg/L dissolved copper and 0.016 mg/L dissolved zinc. Release rates are estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Powerplant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of SCDD is complicated during major heavy rainfall events. SCDD reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at SCDD can occur during major flood events on the upper Sacramento River and also during localized rainfall events in the Spring Creek watershed. During flood control events, Keswick releases may be reduced to meet flood control objectives at Bend Bridge when storage and inflow at Spring Creek Reservoir are high.

Because SCDD releases are maintained as a dilution ratio of Keswick releases to maintain the required dilution of copper and zinc, uncontrolled spills can and have occurred from SCDD. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, SCDD releases are also increased in an effort to reduce spill potential.

In the operational situation when heavy rainfall events will fill SCDD and Shasta Reservoir will not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Reclamation has voluntarily released additional water from CVP storage to maintain release ratios for toxic metals below Keswick Dam. Reclamation has typically attempted to meet the Basin Plan standards but these releases have no established criteria and are dealt with on a case-by-case basis. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

Shasta Division and Sacramento River Division

The CVP’s Shasta Division includes facilities that conserve water in the Sacramento River for (1) flood control, (2) navigation maintenance, (3) agricultural water supplies, (4) M&I water supplies (5) hydroelectric power generation, (6) conservation of fish in the Sacramento River, and (7) protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water. The Shasta Division includes Shasta Dam, Lake, and Powerplant; Keswick Dam, Reservoir, and Powerplant, and the Shasta Temperature Control Device.

The Sacramento River Division was authorized after completion of the Shasta Division. Total authorized diversions for the Sacramento River Division are approximately 2.8 MAF. Historically the total diversion has varied from 1.8 MAF in a critically dry year to the full 2.8 MAF in wet year. It includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the RBDD, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals.

The unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the U.S. Army Corps of Engineers (Corps), also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4,552,000 AF. Water in Shasta Lake is released through or around the Shasta Powerplant to the Sacramento River where it is re-regulated downstream by Keswick Dam. A small amount of water is diverted directly from Shasta Lake for M&I uses by local communities.

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23,800 AF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Powerplant. All releases from Keswick Reservoir are made to the Sacramento River at Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek.

Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that will not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs. Flood control operations are based on regulating criteria developed by the Corps pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 MAF, with variable storage space requirements based on an inflow parameter.

Flood control operation at Shasta Lake requires the forecasting of runoff conditions into Shasta Lake, as well as runoff conditions of unregulated creek systems downstream from Keswick Dam, as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce large rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately 8 to 10 hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any 2-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

Fish and Wildlife Requirements in the Sacramento River

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05. If Reclamation cannot meet the SWRCB order an exception will be requested. An April 5, 1960, MOA between Reclamation and the DFG originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years (Table 6). Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and DFG. This release schedule was included in Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and RBDD from September through the end of February in all water years, except critically dry years.

Table 6. Current Minimum Flow Requirements and Objectives (cfs) on the Sacramento River below Keswick Dam

Water Year Type	MOA	WR 90-5	MOA and WR 90-5	Proposed Flow Objectives below Keswick
Period	**Normal**	**Normal**	**Critically Dry**	**All**
January 1 - February 28(29)	2600	3250	2000	3250
March 1 - March 31	2300	2300	2300	3250
April 1 - April 30	2300	2300	2300	---*
May 1 - August 31	2300	2300	2300	---*
September 1 - September 30	3900	3250	2800	---*
October 1 - November 30	3900	3250	2800	3250
December 1 - December 31	2600	3250	2000	3250
Note: * No regulation.				

The 1960 MOA between Reclamation and the DFG provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon to the extent compatible with other operational requirements. Releases from Shasta and Keswick Dams are gradually reduced in September and early October during the transition from meeting Delta export and water quality demands to operating the system for flood control and fishery concerns from October through December.

Reclamation proposes a minimum flow of 3,250 cfs from October 1 through March 31 and ramping constraints for Keswick release reductions from July 1 through March 31 as follows:

- Releases must be reduced between sunset and sunrise.
- When Keswick releases are 6,000 cfs or greater, decreases may not exceed 15 percent per night. Decreases also may not exceed 2.5 percent in one hour.
- For Keswick releases between 4,000 and 5,999 cfs, decreases may not exceed 200 cfs per night. Decreases also may not exceed 100 cfs per hour.
- For Keswick releases between 3,250 and 3,999 cfs, decreases may not exceed 100 cfs per night.
- Variances to these release requirements are allowed under flood control operations.

Reclamation usually reduces releases from Keswick Dam to the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet unexpected downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

A recent change in agricultural water diversion practices has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Historically, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning has been phased out due to air quality concerns and has been replaced by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

The changes in agricultural practice over the last decade related to the Rice Straw Decomposition and Waterfowl Habitat Program have been incorporated into the systematic modeling of agricultural use and hydrology effects as described in the biological assessment.

Minimum Flow for Navigation – Wilkins Slough

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation. Currently, there is no commercial traffic between Sacramento and Chico Landing, and the Corps has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough, (gauging station on the Sacramento River), under all but the most critical water supply conditions, to facilitate pumping and use of screened diversions.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough, but using the 3,500 cfs rate as a target level for an extended period would have major impacts on diverters.

No criteria have been established specifying when the navigation minimum flow should be relaxed. However, the basis for Reclamation's decision to operate at less than 5,000 cfs is the increased importance of conserving water in storage when water supplies are not sufficient to meet full contractual deliveries and other operational requirements.

Water Temperature Operations in the Upper Sacramento River

Water temperature in the upper Sacramento River is governed by current water right permit requirements. Water temperature on the Sacramento River system is influenced by several factors, including the relative water temperatures and ratios of releases from Shasta Dam and from the Spring Creek Powerplant. The temperature of water released from Shasta Dam and the Spring Creek Powerplant is a function of the reservoir temperature profiles at the discharge points at Shasta and Whiskeytown, the depths from which releases are made, the seasonal management of the deep cold water reserves, ambient seasonal air temperatures and other climatic conditions, tributary accretions and water temperatures, and residence time in Keswick, Whiskeytown and Lewiston Reservoirs, and in the Sacramento River.

SWRCB Water Rights Order 90-05 and Water Rights Order 91-01

In 1990 and 1991, the SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights on the Sacramento River. The orders stated Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to fisheries. The optimal control point is the RBDD.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at RBDD. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. The SWRCB orders also required Reclamation to establish the Sacramento River Temperature Task Group (SRTTG) to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers. This group consists of representatives from Reclamation, SWRCB, NMFS, the Service, DFG, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold water resources and competing demands usually an issue, the SRTTG will devise operation plans with the flexibility to provide the best protection consistent with the CVP's temperature control capabilities and considering the annual needs and seasonal spawning distribution monitoring information for winter-run and fall-run Chinook salmon. In every year since the SWRCB issued the orders, those plans have included modifying the RBDD compliance point to make best use of the cold water resources based on the location of spawning Chinook salmon. Reports are submitted periodically to the SWRCB over the temperature control season defining our temperature operation plans. The SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

Shasta Temperature Control Device

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook stock. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Powerplant. The release of water through the low-level river outlets was a major facet of Reclamation's efforts to control upper Sacramento River temperatures from 1987 through 1996.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest elevation gates possible are utilized to draw from the upper portions of the lake to conserve deeper colder resources (see Table 7). During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource below the Shasta Powerplant elevation in Shasta Lake.

Table 7. Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of Submergence	Shasta Storage
Upper Gates	1035	~3.65 MAF
Middle Gates	935	~2.50 MAF
Pressure Relief Gates	840	~0.67 MAF
Side Gates	720*	~0.01 MAF

* Low Level intake bottom.

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold water resources deep in Shasta Lake, until the time the resource is of greatest management value to fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design.

Reclamation's Proposed Upper Sacramento River Temperature Objectives

Reclamation will continue a policy of developing annual operations plans and water allocations based on a conservative 90 percent exceedance forecast. Reclamation is not proposing a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir.

In continuing compliance with Water Rights Orders 90-05 and 91-01 requirements, Reclamation will implement operations to provide year round temperature protection in the upper Sacramento River, consistent with the intent of Order 90-05 that protection be provided to the extent controllable. Among factors that affect the extent to which river temperatures will be controllable include Shasta TCD performance, the availability of cold water, the balancing of habitat needs for different species in spring, summer, and fall, and the constraints on operations created by the combined effect of the projects and demands assumed to be in place in the future.

Under all but the most adverse drought and low Shasta Reservoir storage conditions, Reclamation proposes to continue operating CVP facilities to provide water temperature control at Ball's Ferry or at locations further downstream (as far as Bend Bridge) based on annual plans. Reclamation and the SRTTG will take into account projections of cold water resources, numbers of expected spawning salmon, and spawning distribution (as monitoring information becomes available) to make the decisions on allocation of the cold water resources.

Locating the target temperature compliance at Ball's Ferry (1) reduces the need to compensate for the warming effects of Cottonwood Creek and Battle Creek during the spring runoff months with deeper cold water releases and (2) improves the reliability of cold water resources through the fall months. Reclamation proposes Sacramento River temperature control point to be consistent with the capability of the CVP to manage cold water resources and to use the process of annual planning in coordination with the SRTTG to arrive at the best use of that capability.

Anderson-Cottonwood Irrigation District (ACID) Diversion Dam

ACID holds senior water rights and has diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood since 1916. The United States and ACID signed a contract providing for the project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about five miles downstream from Keswick Dam.

Close coordination is required between Reclamation and ACID for regulation of river flows to ensure safe operation of ACIDs diversion dam during the irrigation season. The irrigation season for ACID runs from April through October.

Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID diversion dam.

Red Bluff Diversion Dam Operations

Since 1986, the RBDD gates have been raised during winter months to improve passage conditions for winter-run Chinook salmon and spring-run Chinook salmon. As documented in the 2004 NMFS biological opinion addressing the long-term CVP and SWP operations and in the recent past, the gates are raised from approximately September 15 through May 14, each year. Future gate operations are further modified by the Red Bluff Fish Passage Improvement Project as detailed below.

Red Bluff Fish Passage Improvement Project and Red Bluff Diversion Dam Pumping Plant

Reclamation signed a ROD on July 16, 2008 for the Red Bluff Fish Passage Improvement Project. The project includes reoperation of the RBDD to allow future unrestricted fish passage and features construction of a new pumping plant to enhance pumping capacity while the RBDD gates are open. Reclamation completed ESA section 7 consultations with FWS and the NMFS to address construction and operation of the new pumping plant at a maximum capacity of 2,500 cfs.

The new pumping plant is currently under construction, and is scheduled to be operational by May 2012. In 2009 Reclamation agreed to only operate the RBDD with the gates in from June 15 to August 31 during the construction of the new pumping plant. In the absence of any unforeseen or unavoidable pumping plant construction delays, the RBDD will be operated with gates out permanently after May 15, 2012.

American River Division

Reclamation's Folsom Lake, the largest reservoir in the watershed, has a capacity of 977,000 af. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated as a major component of the CVP. The American River Division includes facilities that provide conservation of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Powerplant; Nimbus Dam and Powerplant, and Lake Natoma. See map in Figure 7.

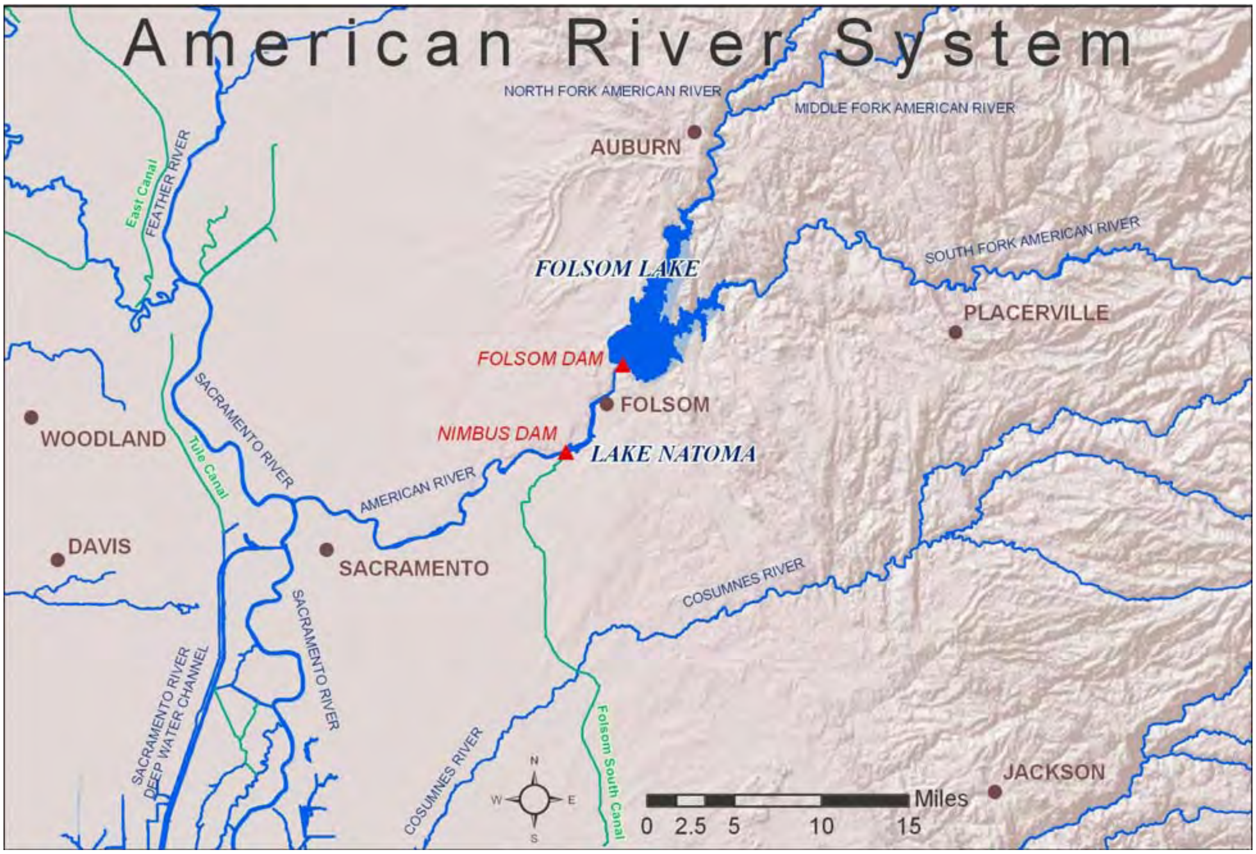

Figure 7. American River System

Error! Reference source not found. Table 8 provides Reclamation's annual water deliveries for the period 2000 through 2010 in the American River Division. The totals reveal an increasing trend in water deliveries over that period. For this Biological Assessment, present level of American River Division water demands are modeled at about 325 taf per year. Future level (2030) water demands are modeled at near 800 taf per year. The modeled deliveries vary depending on modeled annual water allocations.

Table 8. Annual Water Delivery - American River Division

Year	Water Delivery (taf)[3]
2000	174
2001	223
2002	221
2003	270
2004	266
2005	297
2006	280
2007	113
2008	233
2009	260
2010	125

Annual Water Delivery data has been enhanced and the annual totals include CVP contracts, water rights and other deliveries.

Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. This facility is also operated by Reclamation as part of the CVP. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. This CVP facility serves water to M&I users in Sacramento County. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant, or, at flows in excess of 5,000 cfs, the spillway gates.

Although Folsom Lake is the main storage and flood control reservoir on the American River, numerous other small reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs have any specific flood control responsibilities. The total upstream reservoir storage above Folsom Lake is approximately 820,000 af. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136,000 af); Hell Hole (208,000 af); Loon Lake (76,000 af); Union Valley (271,000 af); and Ice House (46,000 af). Reclamation has agreements with the operators of some of these reservoirs to coordinate operations for releases.

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by the Placer County Water Agency (PCWA). The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, PCWA operates water treatment plants and sells wholesale treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from PCWA. Loon Lake (also on the Middle Fork), and Union Valley and Ice House reservoirs on the South Fork, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

Flood Control

Flood control requirements and regulating criteria are specified by the Corps and described in the Folsom Dam and Lake, American River, California Water Control Manual (Corps 1987). Flood control objectives for the Folsom unit require the dam and lake are operated to:

- Protect the City of Sacramento and other areas within the Lower American River floodplain against reasonable probable rain floods.
- Control flows in the American River downstream from Folsom Dam to existing channel capacities, insofar as practicable, and to reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP projects.
- Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir.
- Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

From June 1 through September 30, no flood control storage restrictions exist. From October 1 through November 16 and from April 20 through May 31, reserving storage space for flood control is a function of the date only, with full flood reservation space required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation space is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the storage to encroach into the space reserved for flood control, releases from Nimbus Dam are increased. Flood control regulations prescribe the following releases when water is stored within the flood control reservation space:

- Maximum inflow (after the storage entered into the flood control reservation space) of as much as 115,000 cfs, but not less than 20,000 cfs, when inflows are increasing.
- Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, changes in river releases of short duration may occur.

In February 1986, the American River Basin experienced a significant flood event. Folsom Dam and Reservoir moderated the flood event and performed the flood control objectives, but with serious operational strains and concerns in the Lower American River and the overall protection of the communities in the floodplain areas. A similar flood event occurred in January 1997. Since then, significant review and enhancement of Lower American River flooding issues has occurred and continues to occur. A major element of those efforts has been the Sacramento Area Flood Control Agency (SAFCA) sponsored flood control plan diagram for Folsom Reservoir.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 thousand af of flood control space in Folsom and in a combination of three upstream reservoirs. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and the SAFCA. The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom.

The SAFCA release criteria are generally equivalent to the Corps plan, except the SAFCA diagram may prescribe flood releases earlier than the Corps plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing Corps plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram will begin to decrease on March 1. Between March 1 and April 20, the rate of filling is a function of the date and available upstream space. As of April 21, the required flood reservation is about 225,000 af. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom Reservoir storage permitted to fill completely on June 1.

Reclamation and the Corps are jointly working on construction of an auxiliary spillway that will assist in meeting the established flood damage reduction objectives for the Sacramento area (at least 1-in-200-year flood protection) while continuing to preserve and expedite safely passing the Probable Maximum Flood. This project is commonly referred as the Joint Federal Project. Other partners in this project include the Department of Water Resources and SAFCA.

The Corps is also undertaking a Folsom Dam Reoperation Study to develop, evaluate, and recommend changes to the flood control operations of the Folsom Dam project that will further the goal of reduced flood risk for the Sacramento area. Operational changes may be necessary to fully realize the flood risk reduction benefits of the additional operational capabilities created by completion of the Joint Federal Project, and the increased system capabilities provided by the implemented and authorized features of the Common Features Project (a project being carried by the Corps designed to strengthen the American River levees so they can safely pass a flow of 160,000 cfs), and those anticipated to be provided by completion of the authorized Folsom Dam Mini-Raise Project. The Folsom Dam Reoperation Study will also consider improved forecasts from the National Weather Service. Once a modified flood operation plan is complete, the Corps, in cooperation with Reclamation, will consult with FWS and NMFS relative to any changes to American River and/or system-wide CVP operations that may result.

Fish and Wildlife Requirements in the Lower American River

The minimum allowable flows in the Lower American River are defined by SWRCB Decision 893 (D-893) which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream Sacramento-San Joaquin Delta WQCP requirements and CVP water supply objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions.

In July 2006, Reclamation, the Sacramento Area Water Forum and other stakeholders completed a draft technical report establishing a flow regime intended to improve conditions for fish in the lower American River (i.e., the Lower American River Flow Management Standard [FMS]). Reclamation began operating to the FMS immediately thereafter. Reclamation continues to operate to this flow regime and the modeling assumptions herein include the operational components of the recommended Lower American River flows consistent with the proposed FMS (Appendix __). Until this action is adopted by the SWRCB, The minimum legally required flows will be defined by D-893. However, Reclamation intends to operate to the proposed flow management standard using releases of additional water pursuant to Section 3406 (b)(2) of the CVPIA, if necessary.

Use of additional (b)(2) flows above the proposed flow standard is envisioned only on a case-by-case basis. Such additional use of (b)(2) flows would be subject to available resources and such use would be coupled with plans to not intentionally cause significantly lower river flows later in a water year. This case-by-case use of additional (b)(2) for minimum flows is not included in the modeling results.

Water temperature control operations in the Lower American River are affected by many factors and operational tradeoffs. These include available cold water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply TCD management, and Nimbus Hatchery considerations. Shutter and TCD management provide the majority of operational flexibility used to control downstream temperatures.

During the late 1960s, Reclamation designed a modification to the trashrack structures to provide selective withdrawal capability at Folsom Dam. Folsom Powerplant is located at the foot of Folsom Dam on the right abutment. Three 15-foot-diameter steel penstocks for delivering water to the turbines are embedded in the concrete section of the dam. The centerline of each penstock intake is at elevation 307.0 feet and the minimum power pool elevation is 328.5 feet. A reinforced concrete trashrack structure with steel trashracks protects each penstock intake.

The steel trashracks, located in five bays around each intake, extend the full height of the trashrack structure (between 281 and 428 feet). Steel guides were attached to the upstream side of the trashrack panels between elevation 281 and 401 feet. Forty-five 13-foot steel shutter panels (nine per bay) and operated by the gantry crane, were installed in these guides to select the level of withdrawal from the reservoir. The shutter panels are attached to one another, in a configuration starting with the top shutter, in groups of three, two, and four.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline became operational in 2003. The centerline to the 84-inch-diameter Urban Water Supply intake is at elevation 317 feet. An enclosure structure extending from just below the water supply intake to an elevation of 442 feet was attached to the upstream face of Folsom Dam. A telescoping control gate allows for selective withdrawal of water anywhere between 331 and 401 feet elevation under normal operations.

The current objectives for water temperatures in the Lower American River address the needs for steelhead incubation and rearing during the late spring and summer, and for fall–run Chinook spawning and incubation starting in late October or early November.

A major challenge is determining the starting date at which time the objective is met. Establishing the start date requires a balancing between forecasted release rates, the volume of available cold water, and the estimated date at which time Folsom Reservoir turns over and becomes isothermic. Reclamation will work to provide suitable spawning temperatures as early as possible (after November 1) to help avoid temperature related pre-spawning mortality of adults and reduced egg viability. Operations will be balanced against the possibility of running out of cold water and increasing downstream temperatures after spawning is initiated and creating temperature related effects to eggs already in the gravel.

The cold water resources available in any given year at Folsom Lake needed to meet the stated water temperature goals are often insufficient. Only in wetter hydrologic conditions is the volume of cold water resources available sufficient to meet all the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are considered part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold water resources available. Reclamation's coordination on the planning and management of cold water resources is done through the B2IT and ARG groups as discussed earlier in this Chapter.

The management process begins in the spring as Folsom Reservoir fills. All penstock shutters are put in the down position to isolate the colder water in the reservoir below an elevation of 401 feet. The reservoir water surface elevation must be at least 25 feet higher than the sill of the upper shutter (426 feet) to avoid cavitation of the power turbines. The earliest this can occur is in the month of March, due to the need to maintain flood control space in the reservoir during the winter. The pattern of spring run-off is then a significant factor in determining the availability of cold water for later use. Folsom inflow temperatures begin to increase and the lake starts to stratify as early as April. By the time the reservoir is filled or reaches peak storage (sometime in the May through June period), the reservoir is highly stratified with surface waters too warm to meet downstream temperature objectives. There are, however, times during the filling process when use of the spillway gates can be used to conserve cold water.

In the spring of 2003, high inflows and encroachment into the allowable storage space for flood control required releases that exceeded the available capacity of the power plant. Under these conditions Folsom Dam standard operations involve the use of the river outlets that would draw upon the cold water pool. Instead, Reclamation reviewed the release requirements, Safety of Dams issues, reservoir water temperature conditions, and the benefits to the cold water pool and determined that the spillway gates should be used to make the incremental releases above powerplant capacity, thereby conserving cold water for later use. The ability and necessity to take similar actions will be evaluated on a case-by-case basis.

The annual temperature management strategy and challenge is to balance conservation of cold water for later use in the fall, with the more immediate needs of steelhead during the summer. The planning and forecasting process for the use of the cold water pool begins in the spring as Folsom Reservoir fills. Actual Folsom Reservoir cold water resource availability becomes significantly more defined through the assessment of reservoir water temperature profiles and more definite projections of inflows and storage. Technical modeling analysis begins in the spring for the projected Lower American River water temperature management plan. The significant variables and key assumptions in the analysis include:

- Starting reservoir temperature conditions
- Forecasted inflow and outflow quantities
- Assumed meteorological conditions
- Assumed inflow temperatures
- Assumed Water Supply Intake TCD operations

A series of shutter management scenarios are then incorporated into the model to gain a better understanding of the potential for meeting water temperature needs for both over-summer rearing steelhead and spawning Chinook salmon in the fall. Most annual strategies contain significant tradeoffs and risks for water temperature management for steelhead and fall–run Chinook salmon goals and needs due to the frequently limited coldwater resource. The planning process continues throughout the summer. New temperature forecasts and operational strategies are updated as more information on actual operations and ambient conditions is gained. This process is shared with the American River Group (ARG).

Meeting both the summer steelhead and fall salmon temperature objectives without negatively impacting other CVP project purposes requires the final shutter pull be reserved for use in the fall to provide suitable fall-run Chinook salmon spawning temperatures. In most years, the volume of cold water is not sufficient to support strict compliance with the summer water temperature target at the downstream end of the compliance reach (i.e.,Watt Avenue Bridge) while at the same time reserving the final shutter pull for fall-run Chinook salmon, or in some cases, continue to meet steelhead over-summer rearing objectives later in the summer. A strategy that is used under these conditions is to allow the annual compliance location water temperatures to warm towards the upper end of the annual water temperature design value before making a shutter pull. This management flexibility is essential to the annual management strategy to extend the effectiveness of cold water management through the summer and fall months.

The Folsom Water Supply Intake TCD has provided additional flexibility to conserve cold water for later use. As anticipated, the TCD has been operated during the summer months and delivers water that is slightly warmer than that which could be used to meet downstream temperatures (60°F to 62°F), but not so warm as to cause significant treatment issues.

Water temperatures feeding the Nimbus Fish Hatchery were historically too high for hatchery operations during some dry or critical years. Water temperatures in the Nimbus Hatchery are generally in the desirable range of 42°F to 55°F, except for the months of June, July, August, and September. When temperatures get above 60°F during these months, the hatchery must begin to treat the fish with chemicals to prevent disease. When temperatures reach the 60°F to 70°F range, treatment becomes difficult and conditions become increasingly dangerous for the fish. In years when mean daily water temperatures are forecast to approach 70°F, a significant number of steelhead may be released early in the summer. Stocked fish have the opportunity to find suitable rearing habitat within the river and reduced densities result in lower mortality in the group of fish that remain in the hatchery.

Reclamation operates Nimbus Dam to maintain the health of the hatchery fish while minimizing the loss of the coldwater pool for fish spawning in the river during fall. Evaluation of Nimbus

Dam operations is done on a case-by-case basis and is different in various months and year types. Water temperatures above 70°F in the hatchery usually mean the fish need to be moved to another hatchery or released to the river. The real time implementation of CVPIA AFRP objective flows and meeting SWRCB D-1641 Delta standards with the limited water resources of the Lower American River requires a significant coordination effort to manage the cold water resources at Folsom Lake. Reclamation consults with the FWS, NMFS, and DFG through B2IT when these types of difficult decisions are needed. In addition, Reclamation communicates with the American River Group (ARG) on real time data and operational tradeoffs.

A fish diversion weir at the hatcheries blocks Chinook salmon from continuing upstream and guides them to the hatchery fish ladder entrance. The fish diversion weir consists of eight piers on 30-foot spacing, including two riverbank abutments. Fish rack support frames and walkways are installed each fall via an overhead cable system. A pipe rack is then put in place to support the pipe pickets (¾-inch steel rods spaced on 2½-inch centers). The pipe rack rests on a submerged steel I-beam support frame that extends between the piers and forms the upper support structure for a rock filled crib foundation. The rock foundation has deteriorated with age and is subject to annual scour which can leave holes in the foundation that allow fish to pass if left unattended. Reclamation released the final environmental documentation in August 2011 that selected an alternative to extend the existing fishway up to Nimbus Dam as the solution to the issues associated with the weir. Construction of the new fishway is expected to begin in 2014.

Fish rack supports and pickets are installed around September 15, of each year and correspond with the beginning of the fall-run Chinook salmon spawning season. A release equal to or less than 1,500 cfs from Nimbus Dam is required for safety and to provide full access to the fish rack supports. It takes six people approximately three days to install the fish rack supports and pickets. In years after high winter flows have caused active scour of the rock foundation, a short period (less than eight hours) of lower flow (approximately 500 cfs) is needed to remove debris from the I-beam support frames, seat the pipe racks, and fill holes in the rock foundation. Compete installation can take up to seven days, but is generally completed in less time. The fish rack supports and pickets are usually removed at the end of fall-run Chinook salmon spawning season (mid-January) when flows are less than 2,000 cfs. If Nimbus Dam releases are expected to exceed 5,000 cfs during the operational period, the pipe pickets are removed until flows decrease.

Delta Division and West San Joaquin Division

CVP Facilities

The CVP's Delta Division includes the Delta Cross Channel (DCC), the Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, the Jones Pumping Plant, the Tracy Fish Collection Facility (TFCF), and the Delta Mendota Canal (DMC). The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The Contra Costa Water District (CCWD) diversion facilities use CVP water resources to serve district customers directly and to operate CCWD's Los Vaqueros Project. The Jones Pumping Plant diverts water from the Delta to the head of the DMC. See map in Figure 8.

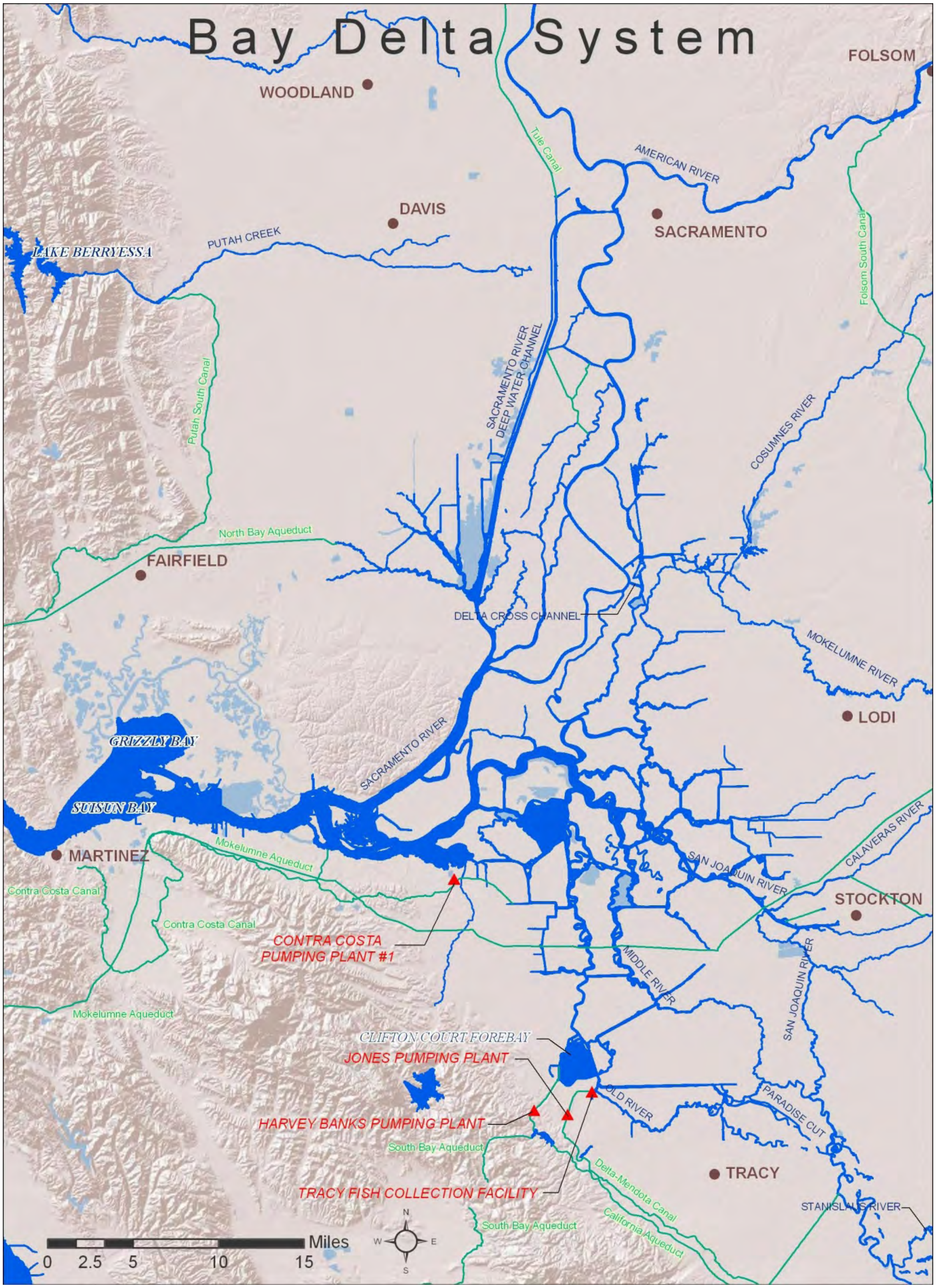

Figure 8. Bay Delta System

Delta Cross Channel Operations

The DCC is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. Flows into the DCC from the Sacramento River are controlled by two 60-foot by 30-foot radial gates. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the South Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small craft, and is used extensively by recreational boaters and fishermen whenever it is open.

SWRCB D-1641 DCC standards provide for closure of the DCC gates for fisheries protection at certain times of the year. From November through January, the DCC may be closed for up to 45 days for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 time period. Reclamation determines the timing and duration of the closures after discussion with the Service, DFG, and NMFS. These discussions will occur through WOMT.

WOMT typically relies on monitoring for fish presence and movement in the Sacramento River and Delta, the salvage of salmon at the Tracy and Skinner facilities, and hydrologic cues when considering the timing of DCC closures. However, the overriding factors are current water quality conditions in the interior and western Delta. From mid-June to November, Reclamation usually keeps the gates open on a continuous basis. The DCC is also usually opened for the busy recreational Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

The Salmon Decision Process (as provided in the biological assessment) includes "Indicators of Sensitive Periods for Salmon" such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the Salmon Decision Process.

The Salmon Decision Process is used by NMFS, DFG, the Service and Reclamation to facilitate the often complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish lifestage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions.

Jones Pumping Plant

The CVP and SWP use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the South Delta. The CVP's Jones Pumping Plant, about five miles north of Tracy, consists of six available pumps. The Jones Pumping Plant is located at the end of an earth-lined intake channel about 2.5 miles in length. At the head of the intake channel, louver screens (that are part of the Tracy Fish Collection Facility) intercept fish, which are then collected, held, and transported by tanker truck to release sites far away from the pumping plants.

Jones Pumping Plant has a permitted diversion capacity of 4,600 cfs with maximum pumping rates typically ranging from 4500 to 4300 cfs during the peak of the irrigation season and approximately 4,200 cfs during the winter non-irrigation season until construction and full operation of the proposed DMC/California Aqueduct Intertie, described later in the project description.

The winter-time constraints at the Jones Pumping Plant are the result of a DMC freeboard constriction between Jones Pumping Plant and O'Neill Forebay, O'Neill Pumping Plant capacity, and the current water demand in the upper sections of the DMC.

Tracy Fish Collection Facility

The Tracy Fish Collection Facility (TFCF) is located in the south-west portion of the Sacramento-San Joaquin Delta and uses behavioral barriers consisting of primary and secondary louvers as illustrated in Figure 9, to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The original design of the TFCF focused on smaller fish (<200 mm) that would have difficulty fighting the strong pumping plant induced flows since the intake is essentially open to the Delta and also impacted by tidal action.

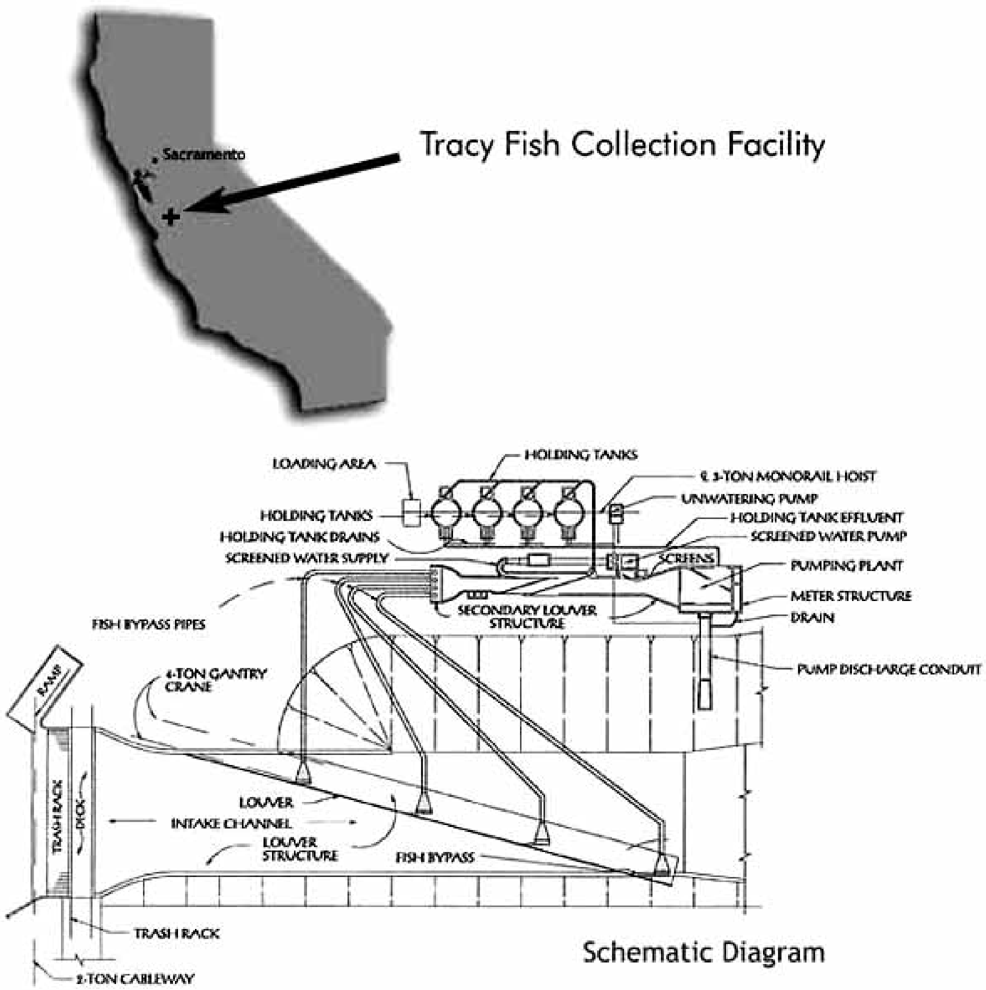

Figure 9. Tracy Fish Collection Facility Diagram

The primary louvers are located in the primary channel just downstream of the trashrack structure. The secondary louvers are located in the secondary channel just downstream of the traveling water screen. The louvers allow water to pass through onto the pumping plant but the openings between the slats are tight enough and angled against the flow of water such a way as to prevent most fish from passing between them and instead enter one of four bypass entrances along the louver arrays.

There are approximately 52 different species of fish entrained into the TFCF per year; however, the total numbers are significantly different for the various species salvaged. Also, it is difficult if not impossible to determine exactly how many safely make it all the way to the collection tanks awaiting transport back to the Delta. Hauling trucks used to transport salvaged fish to release sites inject oxygen in the tanks and contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge. During a facility inspection a few years ago, TFCF personnel noticed significant decay of the transition boxes and conduits between the primary and secondary louvers. The temporary rehabilitation of these transition boxes and conduits was performed during the fall and winter of

2002. Extensive rehabilitation of the transition boxes and conduits was completed during the San Joaquin pulse period of 2004.

When South Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated with the D-1485 and the following water velocities: for striped bass of approximately 1 foot per second (ft/s) from May 15 through October 31, and for salmon of approximately 3 ft/s from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility. Due to changes in South Delta hydrology over the past fifty years, the present-day TFCF is able to meet these conditions approximately 55 percent of the time.

Fish passing through the facility will be sampled at intervals of no less than 20 minutes every 2 hours when listed fish are present, generally December through June. When fish are not present, sampling intervals will be 10 minutes every 2 hours. Fish observed during sampling intervals are identified to species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the North Delta away from the pumps. In addition, Reclamation will monitor for the presence of spent female delta smelt in anticipation of expanding the salvage operations to include sub 20 mm larval delta smelt detection.

Contra Costa Water District Diversion Facilities

Contra Costa Water District (CCWD) diverts water from the Delta for irrigation and M&I uses under its CVP contract and under its own water right permits and license, issued by the State Water Resources Control Board (SWRCB). CCWD’s water system includes intake facilities on Mallard Slough, Rock Slough, Old River, and Victoria Canal; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough intake facilities, the Contra Costa Canal, and the shortcut pipeline are owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Construction of the fish screen at the Rock Slough intake was completed by Reclamation in 2011. Mallard Slough Intake, Old River Intake and Los Vaqueros Reservoir are owned and operated by CCWD.

The Mallard Slough Intake is located at the southern end of a 3,000-foot-long channel running south from Suisun Bay, near Mallard Slough (across from Chipps Island). The Mallard Slough Pump Station was refurbished in 2002, which included constructing a positive barrier fish screen at this intake. The Mallard Slough Intake can pump up to 39.3 cfs. CCWD’s d water rights (License No. 10514 and Permit No. 19856) authorize diversions of up to 26,780 acre-feet per year at Mallard Slough. However, this intake is rarely used due to the generally high salinity at this location. Pumping at the Mallard Slough Intake since 1993 has on average accounted for about 3 percent of CCWD’s total diversions. When CCWD diverts water at the Mallard Slough Intake, CCWD reduces pumping of CVP water at its other intakes.

The Rock Slough Intake is located about four miles southeast of Oakley, where water flows through a positive barrier fish screen into the earth-lined portion of the Contra Costa Canal. The fish screen at this intake was constructed by Reclamation in accordance with the CVPIA and the 1993 FWS Biological Opinion for the Los Vaqueros Project. Completed in 2011, this new fish screen is expected to reduce take of fish through entrainment at the Rock Slough Intake. The Canal connects the fish screen at Rock Slough to Pumping Plant 1, approximately four miles to the west. The earth-lined portion of the Canal is open to tidal influence for approximately 3.7 miles from the Rock Slough fish screen. Approximately 0.3 miles of the Canal immediately east (upstream) of Pumping Plant 1 have been encased in concrete pipe, the first portion of the Contra Costa Canal Encasement Project to be completed. When completed, the Canal Encasement Project will eliminate tidal flows into the Canal. Pumping Plant 1 has capacity to pump up to 350 cfs into the concrete-lined portion of the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract. With completion of the Rock Slough fish screen, CCWD may divert approximately 30 to 50 percent of its total supply through the Rock Slough Intake.

Construction of the Old River Intake was completed in 1997 as a part of the Los Vaqueros Project. The Old River Intake is located on Old River near State Route 4. The intake has a positive-barrier fish screen and a pumping capacity of 250 cfs, and can pump water via pipeline either to the Contra Costa Canal or to Los Vaqueros Reservoir. Diversions at Old River to the Contra Costa Canal are typically taken under CVP contract or under the District's Los Vaqueros water right (Permit 20749). Pumping to storage in Los Vaqueros Reservoir is limited to 200 cfs by the terms of the Los Vaqueros Project biological opinions and by SWRCB Decision 1629, the SWRCB water right decision for the Los Vaqueros Project. From 1998 through 2009, CCWD has diverted about 80 percent of its total supply through the Old River Intake; with the completion of the Rock Slough fish screen and Middle River Intake, the average percentage of CCWD supply diverted at Old River will decrease. The CCWD's water diversions that are not made at Rock Slough will now be split between the Middle River and Old River intakes, contingent primarily by the CCWD water quality goals, as described below.

In 2010, CCWD completed construction of the Middle River Intake (formerly referred to as Alternative Intake Project,) on Victoria Canal. The Middle River Intake consist of a new 250 cfs capacity intake on Victoria Canal, with positive-barrier fish screens, and a conveyance pipeline to CCWD's existing conveyance facilities. Similar to the Old River Intake, the Middle River Intake can be used to either pump to the Contra Costa Canal or to fill the Los Vaqueros Reservoir. Diversions to the Contra Costa Canal are typically taken under CVP contract, while diversions to storage in the Los Vaqueros Reservoir can be taken either under CVP contract or under CCWD's Los Vaqueros water right (Permit 20749). The effects of the Middle River Intake on delta smelt are covered by the April 27, 2007 FWS biological opinion (amended on May 16, 2007). Effects on salmonids and green sturgeon are covered by the July 13, 2007 NMFS biological opinion for this intake project.

CCWD operates the Middle River Intake together with its other intake facilities to better meet its delivered water quality goals and to better protect listed species. The choice of which intake to use at any given time is based in large part upon salinity, consistent with fish protection requirements in the biological opinions for the Middle River Intake and the Los Vaqueros Project. The Middle River Intake was built as a project to improve the water quality delivered to the CCWD service area, and does not increase CCWD's average annual diversions from the Delta. However, it can alter the timing and pattern of CCWD's diversions, because Middle River Intake salinity tends to be lower in the late summer and fall than salinity at CCWD's other intakes. This could allow CCWD to decrease winter and spring diversions while still meeting water quality goals in the summer and fall through use of the new intake.

Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. Originally constructed as a 100,000 acre foot reservoir in 1997 as part of the Los Vaqueros Project, the facility is used to improve delivered water quality and emergency storage reliability for CCWD's customers. Los Vaqueros Reservoir is filled with Delta water from either the Old River Intake or the Middle River Intake, when salinity in the Delta is low. In the late summer and fall months, CCWD releases water from Los Vaqueros Reservoir to blend with higher-salinity direct diversions from the Delta to meet CCWD water quality goals. Releases from Los Vaqueros Reservoir are conveyed to the Contra Costa Canal via a pipeline.

Construction of expanded storage capacity at Los Vaqueros Reservoir is ongoing in 2011, with completion scheduled in 2012. This expansion, to 160,000 acre feet, will provide additional water quality and water supply reliability benefits, and will maintain the existing functions of the reservoir. With the expanded reservoir, CCWD's average annual diversions from the Delta will remain the same as they have been with the 100 TAF reservoir. A Feasibility Study is ongoing to evaluate whether an additional expansion of this reservoir is in the federal interest; a draft Feasibility Report is scheduled for completion by 2013.

CCWD diverts approximately 127 TAF per year in total, and will continue to divert the same amount with the expanded reservoir. Approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion 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 and Middle River Intake. The biological opinions for the Los Vaqueros Project, CCWD's Incidental Take Permit issued by DFG, and SWRCB D-1629 of the State Water Resources Control Board include fisheries protection measures consisting 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 FWS, NMFS and DFG can change these dates to best protect the subject species. CCWD coordinates the filling of Los Vaqueros Reservoir with Reclamation and DWR to avoid water supply impacts to the CVP and SWP. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir.

In addition to the existing 75-day no-fill period (March 15-May 31) and the concurrent no-diversion 30-day period, CCWD operates to an additional term in the Incidental Take Permit issued by DFG. Under this term, CCWD shall not divert water to store in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90 TAF on February 1. If reservoir storage is at or above 80 TAF on February 1, but below 90 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28. If reservoir storage is at or above 70 TAF on February 1, but below 80 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 5 days from February 24 through February 28. These dates can be changed to better protect Delta fish species, at the direction of DFG.

Water Demands—Delta Mendota Canal (DMC) and San Luis Unit

Water demands for the DMC and San Luis Unit are primarily composed of three separate types: CVP water service contractors, exchange contractors, and wildlife refuge contractors. A significantly different relationship exists between Reclamation and each of these three groups. Exchange contractors "exchanged" their senior rights to water in the San Joaquin River for a

CVP water supply from the Delta. Reclamation thus guaranteed the exchange contractors a firm water supply of 840,000 AF per annum, with a maximum reduction under the Shasta critical year criteria to an annual water supply of 650,000 AF.

Conversely, water service contractors did not have water rights. Agricultural water service contractors also receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed and reductions in contractual supply can exceed 25 percent. Wildlife refuge contractors provide water supplies to specific managed lands for wildlife purposes and the CVP contract water supply can be reduced under critically dry conditions up to 25 percent.

To achieve the best operation of the CVP, it is necessary to combine the contractual demands of these three types of contractors to achieve an overall pattern of requests for water. In most years sufficient supplies are not available to meet all water demands because of reductions in CVP water supplies which are due to restricted Delta pumping capability. In some dry or critically dry years, water deliveries are limited because there is insufficient storage in northern CVP reservoirs to meet all in-stream fishery objectives including water temperatures, and to make additional water deliveries via the Jones Pumping Plant. The scheduling of water demands, together with the scheduling of the releases of water supplies from the northern CVP to meet those demands, is a CVP operational objective that is intertwined with the Trinity, Sacramento, and American River operations.

East Side Division

New Melones Operations

The Stanislaus River originates in the western slopes of the Sierra Nevada and drains a watershed of approximately 900 square miles. The average unimpaired runoff in the basin is approximately 1.2 MAF per year; the median historical unimpaired runoff is 1.1 MAF per year. Snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June. See map in Figure 10.

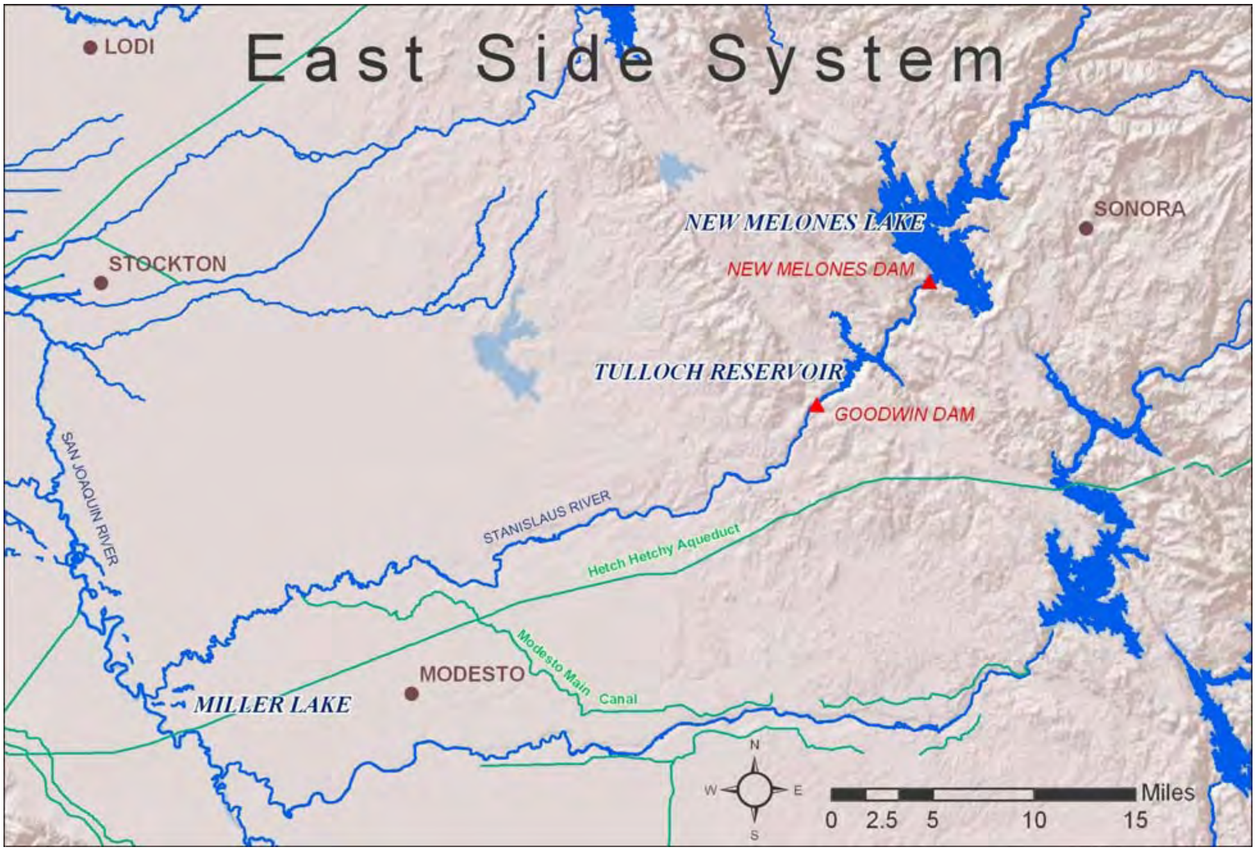

Figure 10. East Side System

Currently, the flow in the lower Stanislaus River is primarily controlled by New Melones Reservoir, which has a storage capacity of about 2.4 MAF. The reservoir was completed by the Corps in 1978 and approved for filling in 1983. New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus River and the San Joaquin River and is operated by Reclamation. Congressional authorization for New Melones integrates New Melones Reservoir as a financial component of the CVP, but it is authorized to provide water supply benefits within the defined Stanislaus Basin per the 1980 ROD before additional water supplies can be used out of the defined Stanislaus Basin.

New Melones Reservoir is operated primarily for purposes of water supply, flood control, power generation, fishery enhancement, and water quality improvement in the lower San Joaquin River. The reservoir and river also provide recreation benefits. Flood control operations are conducted in conformance with the Corps' operational guidelines.

Another major water storage project in the Stanislaus River watershed is the Tri-Dam Project, a power generation project that consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately 6 miles downstream of New Melones Dam on the main stem Stanislaus River. New Spicer Reservoir on the north fork of the Stanislaus River has a storage capacity of 189,000 AF and is used for power generation.

Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. Under contractual agreements between Reclamation, the Oakdale Irrigation District (OID), and South

San Joaquin Irrigation District (SSJID), Tulloch Reservoir provides afterbay storage to re-regulate power releases from New Melones Powerplant. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 1.9 miles downstream of Tulloch Dam.

Goodwin Dam, constructed by OID and SSJID in 1912, creates a re-regulating reservoir for releases from Tulloch Powerplant and provides for diversions to canals north and south of the Stanislaus River for delivery to OID and SSJID. Water impounded behind Goodwin Dam may be pumped into the Goodwin Tunnel for deliveries to the Central San Joaquin Water Conservation District and the Stockton East Water District.

Twenty ungaged tributaries contribute flow to the lower portion of the Stanislaus River, below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions.

Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in downstream flows in excess of 1,250 cfs to 1,500 cfs because of seepage problems in agricultural lands adjoining the river associated with flows above this level. Up to 450,000 AF of the 2.4 MAF storage volume in New Melones Reservoir is dedicated for flood control and 10,000 AF of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by the Corps, part or all of the dedicated flood control storage may be used for conservation storage, depending on the time of year and the current flood hazard.

Requirements for New Melones Operations

The operating criteria for New Melones Reservoir are affected by (1) water rights, (2) in-stream fish and wildlife flow requirements (3) SWRCB D-1641 Vernalis water quality requirements, (4) dissolved oxygen (DO) requirements on the Stanislaus River, (5) SWRCB D-1641 Vernalis flow requirements, (6) CVP contracts, and (7) flood control considerations. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

Flows in the lower Stanislaus River serve multiple purposes concurrently. The purposes include water supply for riparian water right holders, fishery management objectives, and DO requirements per SWRCB D-1422. In addition, water from the Stanislaus River enters the San Joaquin River where it contributes to flow and helps improve water quality conditions at Vernalis. Requirement D-1422, issued in 1973, provided the primary operational criteria for New Melones Reservoir and permitted Reclamation to appropriate water from the Stanislaus River for irrigation and M&I uses. D-1422 requires the operation of New Melones Reservoir include releases for existing water rights, fish and wildlife enhancement, and the maintenance of water quality conditions on the Stanislaus and San Joaquin Rivers.

Water Rights Obligations

When Reclamation began operations of New Melones Reservoir in 1980, the obligations for releases (to meet downstream water rights) were defined in a 1972 Agreement and Stipulation among Reclamation, OID, and SSJID. The 1972 Agreement and Stipulation required Reclamation release annual inflows to New Melones Reservoir of up to 654,000 AF per year for diversion at Goodwin Dam by OID and SSJID, in recognition of their prior water rights. Actual historical diversions prior to 1972 varied considerably, depending upon hydrologic conditions. In addition to releases for diversion by OID and SSJID, water is released from New Melones Reservoir to satisfy riparian water rights totaling approximately 48,000 AF annually downstream of Goodwin Dam.

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was superseded by an agreement that provided for conservation storage by OID and SSJID. The new agreement required Reclamation to release New Melones Reservoir inflows of up to 600,000 AF each year for diversion at Goodwin Dam by OID and SSJID.

In years when annual inflows to New Melones Reservoir are less than 600,000 AF, Reclamation provides all inflows plus one-third the difference between the inflow for that year and 600,000 AF per year. The 1988 Agreement and Stipulation created a conservation account in which the difference between the entitled quantity and the actual quantity diverted by OID and SSJID in a year may be stored in New Melones Reservoir for use in subsequent years. This conservation account has a maximum storage limit of 200,000 AF, and withdrawals are constrained by criteria in the agreement.

In-stream Flow Requirements

Under D-1422, Reclamation is required to release 98,000 AF of water per year, with a reduction to 69,000 AF in critical years, from New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by DFG for fish and wildlife purposes. In 1987, an agreement between Reclamation and DFG provided for increased releases from New Melones to enhance fishery resources for an interim period, during which habitat requirements were to be better defined and a study of Chinook salmon fisheries on the Stanislaus River would be completed.

During the study period, releases for in-stream flows would range from 98,300 to 302,100 AF per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. The Service published the results of a 1993 study, which recommended a minimum in-stream flow on the Stanislaus River of 155,700 AF per year for spawning and rearing.

Dissolved Oxygen Requirements

SWRCB D-1422 requires that water be released from New Melones Reservoir to maintain DO standards in the Stanislaus River. The 1995 revision to the WQCP established a minimum DO concentration of 7 milligrams per liter (mg/L), as measured on the Stanislaus River near Ripon. .

Vernalis Water Quality Requirement

SWRCB D-1422 also specifies that New Melones Reservoir must operate to maintain average monthly level total dissolved solids (TDS), commonly measured as a conversion from electrical conductivity, in the San Joaquin River at Vernalis as it enters the Delta. SWRCB D-1422 specifies an average monthly concentration of 500 parts per million (ppm) TDS for all months. Historically, releases were made from New Melones Reservoir for this standard, but due to shortages in water supply and high concentrations of TDS upstream of the confluence of the Stanislaus River, the D-1422 standard was not always met during the 1987-1992 drought. Reclamation has always met the D-1641 standard since 1995.

In the past, when sufficient supplies were not available to meet the water quality standards for the entire year, the emphasis for use of the available water was during the irrigation season, generally from April through September. SWRCB D-1641 modified the water quality objectives at Vernalis to include the irrigation and non-irrigation season objectives contained in the 1995 Bay-Delta WQCP. The revised standard is an average monthly electric conductivity 0.7 milliSiemens per centimeter (mS/cm) (approximately 455 ppm TDS) during the months of April through August, and 1.0 mS/cm (approximately 650 ppm TDS) during the months of September through March.

Bay-Delta Vernalis Base Flow Requirements

SWRCB D-1641 sets flow requirements on the San Joaquin River at Vernalis from February to June. These flows are commonly known as San Joaquin River base flows (Table 9).

Table 9. San Joaquin base flows-Vernalis

Water Year Class	February-June Flow (cfs)*
Critical	710-1140
Dry	1420-2280
Below Normal	1420-2280
Above Normal	2130-3420
Wet	2130-3420
*the higher flow required when X2 is required to be at or west of Chipps Island	

Since D-1641 has been in place, the San Joaquin base flow requirements have at times, been an additional demand on the New Melones water supply beyond what is identified in the Interim Plan of Operation (IPO) described below.

CVP Contracts

Reclamation entered into water service contracts for the delivery of water from New Melones Reservoir, based on a 1980 hydrologic evaluation of the long-term availability of water in the Stanislaus River Basin. Based on this study, Reclamation entered into a long-term water service contract for up to 49,000 AF per year of water annually (based on a firm water supply), and two long-term water service contracts totaling 106,000 AF per year (based on an interim water supply). Water deliveries under these contracts were not immediately available prior to 1992 for two reasons: 1) new diversion facilities were required to be constructed and prior to 1992 were not yet fully operational; and 2) water supplies were severely limited during the 1987 to 1992 drought.

New Melones Operations

Since 1997, the New Melones IPO has guided, to varying degrees, CVP operations on the Stanislaus River and at New Melones Reservoir.The IPO was developed as a joint effort between Reclamation and the Service, in conjunction with the Stanislaus River Basin Stakeholders (SRBS). The process of developing the plan began in 1995 with a goal to develop a long-term management plan with clear operating criteria, given a fundamental recognition by all parties that New Melones Reservoir water supplies are over-committed on a long-term basis, and consequently, unable to meet all the potential beneficial uses designated as purposes. Reclamation will continue to use the interim plan.

The IPO suggests available quantities for various categories of water supply based on storage and projected inflow. The annual water categories are for in-stream fishery enhancement (1987 DFG Agreement and CVPIA Section 3406(b)(2) management), SWRCB D-1641 San Joaquin River water quality requirements (Water Quality), SWRCB D-1641 Vernalis flow requirements (Bay-Delta), and use by CVP contractors (Table 10, Table 11).

Table 10. Inflow/Storage characterization for the New Melones IPO

Annual water supply category	March-September forecasted inflow plus end of February storage (TAF)
Low	0 – 1400
Medium-low	1400 – 2000
Medium	2000 – 2500
Medium-high	2500 – 3000
High	3000 – 6000

Table 11. New Melones Modified IPO flow objectives (in thousand AF)

Storage plus inflow		Fishery		Vernalis water quality		Bay-Delta		CVP contractors	
From	To	From	To	From	To	From	To	From	To
1400	2000	98	125	70	80	0	0	0	0
2000	2500	125	345	80	175	0	0	0	155*
2500	3000	345	467	175	250	75	75	155*	155*
3000	6000	467	467	250	250	75	75	155*	155*

* Note: The original IPO limited Eastside CVP contract allocation to 90 TAF.

When the water supply condition is determined to be in the “Low” IPO designation, the IPO proposes no operations guidance. In this case, Reclamation would meet with the SRBS group to coordinate a practical strategy to guide annual New Melones Reservoir operations under this very limited water supply condition.

In addition, the IPO is limited in its ability to fully provide for CVP contract deliveries (155 TAF), and for the D-1641 Vernalis salinity and base flow objectives using Stanislaus River flows in all year types. If the Vernalis salinity standard cannot be met using the IPO designated Goodwin release pattern, then an additional volume of water is dedicated to meet the salinity standard. This permit obligation is met before an allocation is made available to CVPIA (b)(2) uses or CVP Eastside contracts.

In water years 2002, 2003, 2004, 2009, and 2010 Reclamation deviated from the IPO to provide additional releases for Vernalis salinity and Vernalis base flow standards and additional deliveries to CVP contractors. Several consecutive years of dry hydrology in the San Joaquin River Basin have demonstrated the limited ability of New Melones to fully satisfy all the demands placed on its yield. Despite the need to consider annual deviations, the IPO remains the initial guidance for New Melones Reservoir operations.

CVPIA Section 3406 (b)(2) releases from New Melones Reservoir consist of the portion of the fishery flow management volume utilized that is greater than the 1987 DFG Agreement and the volume used in meeting the Vernalis water quality requirements and/or Ripon dissolved oxygen requirements.

Vernalis Spring Pulse Flow/San Joaquin River Agreement/Vernalis Adaptive Management Plan (VAMP)

Adopted by the SWRCB in D-1641, the San Joaquin River Agreement (SJRA) included a 12-year program providing for flows and exports in the lower San Joaquin River during a 31-day pulse flow period during April and May. It also provided for the collection of experimental data during that time to further the understanding of the effects of flows, exports, and the barrier at the head of Old River on salmon survival. This experimental program is commonly referred to as the VAMP (Vernalis Adaptive Management Plan).

The SWRCB indicated that VAMP experimental data will be used to create permanent objectives for the pulse flow period. The SJRA expired 2009 and extensions of the VAMP were in place for both 2010 and 2011. Reclamation and DWR intend to continue a VAMP-like action for the foreseeable future or until the SWRCB adopts new permanent objectives that replace the current program. The SWRCB is currently developing a Basin Plan amendment for the San Joaquin River. It is anticipated that new SWRCB objectives will be as protective as the current program and that such protections will remain in place through 2030.

Continuation of a VAMP-like operation for the next few years may be considered reasonably foreseeable because it could be accomplished using well established capabilities and authorities already available to Reclamation and DWR. Specifically, flow increases to achieve designated pulse flow targets can be provided using CVPIA section 3406 (b)(3). Export reductions would be provided by Reclamation using CVPIA section 3406 (b)(1) or (b)(2), and by DWR using the substitution of the water supply acquired from the Yuba Accord flows. The combination of those operations elements would enable Reclamation and DWR to meet a VAMP-like operation for several years until the SWRCB completes its Basin Plan amendment. Chapter 9 contains an analysis of DWR's use of the 48,000 acre feet of substitute supply assumed to be available from the Yuba Accord.

The target flow at Vernalis for the spring pulse flow period is determined each year in a manner similar to the specifications contained in the SJRA, with the exception that a “single step” flow increase is no longer used to set the target flow. The target flow is determined prior to the spring pulse flows as an increase above the existing base flows, and so “adapts” to the prevailing hydrologic conditions. Possible target flows are (1) 2000 cfs, (2) 3200 cfs, (3) 4450 cfs, (4) 5700 cfs, and (5) 7000 cfs.

Water Temperatures

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold water resources in New Melones reservoir, Goodwin release rates for fishery flow management and water quality objectives, ambient air conditions as well as residence time in Tulloch Reservoir, as affected by local irrigation demand.

Reclamation anticipates that the Stanislaus River operations to meet instream flow, DO, and Vernalis flow and water quality requirements will typically meet a goal of an average daily water temperature of 65 °F at Orange Blossom Bridge for steelhead incubation and rearing during the late spring and summer. However, during critically dry years and low reservoir storages this temperature goal would likely be exceeded. FWS, in coordination with NMFS and DFG, identifies the schedule for Reclamation to provide fall pulse attraction flows for fall-run Chinook salmon. The pulse flows are a combination of purchased water and CVPIA (b)(2) and (3) water. This movement of water also helps to transport cold water from New Melones Reservoir into Tulloch Reservoir before the spawning season begins.

San Felipe Division

Construction of the San Felipe Division of the CVP was authorized in 1967 (Figure 11**Error! Reference source not found.**). The San Felipe Division provides a supplemental water supply (for irrigation, M&I uses) in the Santa Clara Valley in Santa Clara County, and the north portion of San Benito County.

The San Felipe Division delivers both irrigation and M&I water supplies. Water is delivered within the service areas not only by direct diversion from distribution systems, but also through in-stream and offstream groundwater recharge operations being carried out by local interests. A primary purpose of the San Felipe Division in Santa Clara County is to provide supplemental water to help prevent land surface subsidence in the Santa Clara Valley. The majority of the water supplied to Santa Clara County is used for M&I purposes, either pumped from the groundwater basin or delivered from treatment plants. In San Benito County, a distribution system was constructed to provide supplemental water to about 19,700 arable acres.

The facilities required to serve Santa Clara and San Benito Counties include 54 miles of tunnels and conduits, two large pumping plants, and one reservoir. Water is conveyed from the Delta of the San Joaquin and Sacramento Rivers through the DMC. It is then pumped into the San Luis Reservoir and diverted through the 1.8-mile long of Pacheco Tunnel inlet to the Pacheco Pumping Plant. Twelve 2,000-horse-power pumps lift a maximum of 490 cfs a height varying from 85 feet to 300 feet to the 5.3-mile-long Pacheco Tunnel. The water then flows through the tunnel and without additional pumping, through 29 miles of concrete, high-pressure pipeline, varying in diameter from 10 feet to 8 feet, and the mile-long Santa Clara Tunnel. In Santa Clara County, the pipeline terminates at the Coyote Pumping Plant, which is capable of pumping water to into Anderson Reservoir or Calero Reservoir for further distribution at treatment plants or groundwater recharge.

Santa Clara Valley Water District is the non-Federal operating entity for all the San Felipe Division facilities except for the Hollister Conduit and San Justo Reservoir. The San Benito County Water District operates San Justo Reservoir and the Hollister Conduit.

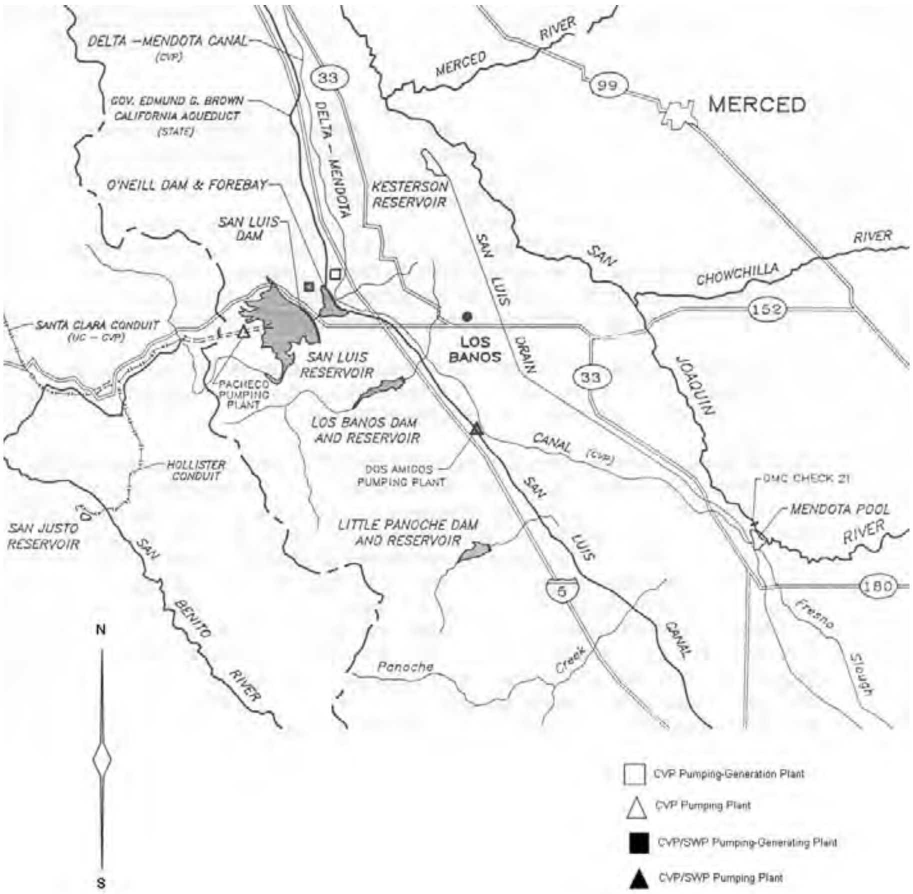

Figure 11. West San Joaquin Division and San Felipe Division

The Hollister Conduit branches off the Pacheco Conduit 8 miles from the outlet of the Pacheco Tunnel. This 19.1-mile-long high-pressure pipeline, with a maximum capacity of 83 cfs, terminates at the San Justo Reservoir.

The 9,906 af capacity San Justo Reservoir is located about three miles southwest of the City of Hollister. The San Justo Dam is an earthfill structure 141 feet high with a crest length of 722 feet. This project includes a dike structure 66 feet high with a crest length of 918 feet. This reservoir regulates San Benito County's import water supplies, allows pressure deliveries to some of the agricultural lands in the service area, and provides storage for peaking of agricultural water.

The San Benito County Water District operates San Justo Reservoir and the Hollister Conduit.

Friant Division

Historically, this division operated separately from the rest of the CVP and was not integrated into the CVP OCAP. Friant Dam is located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. The drainage basin is 1,676 square miles with an average annual runoff of 1,774,000 af. Completed in 1942, the dam is a concrete gravity structure, 319-feet high, with a crest length of 3,488 feet. Although the dam was completed in 1942, it was not placed into full operation until 1951. The reservoir, Millerton Lake, first stored water on February 21, 1944. It has a total capacity of 520,528 AF, a surface area of 4,900 acres, and is approximately 15-miles long. The lake's 45 miles of shoreline varies from gentle slopes near the dam to steep canyon walls farther inland. The reservoir provides boating, fishing, picnicking, and swimming.

The dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals. Water is delivered to a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla IDs. A minimum of 5 cfs is required to pass the last water right holding located about 40 miles downstream near Gravelly Ford. Before October 1, 2009, and the initiation of Interim Flows for the San Joaquin River Restoration Program (SJRRP), the Friant Division was generally hydrologically disconnected from the Delta. The San Joaquin River was dewatered in two reaches between Friant Dam and the confluence of the Merced River, except under flood conditions.

Flood control storage space in Millerton Lake is based on a complex formula, which considers upstream storage in the Southern California Edison reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately every 3 years and are managed based on downstream channel design flow of approximately 8,000 cfs, to the extent possible. Under flood conditions, water is diverted into two bypass channels that carry flood flows to near the confluence of the Merced River, as well as divert flows into the Mendota Pool that may be used to meet irrigation demands there.

In 2006, parties to *NRDC, et al., v. Rodgers, et al.,* executed a stipulation of settlement that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook salmon fishery while reducing or avoiding adverse water supply impacts. The SJRRP implements the Settlement consistent with the San Joaquin River Restoration Settlement Act in Public Law 111-11. Consultation with the National Marine Fisheries Service and U.S. Fish and Wildlife Service under the Endangered Species Act on implementation of the settlement will occur as part of the SJRRP and will evaluate the effects of implementation of settlement actions on listed species. Recapture and recirculation at Mendota Pool of Friant Dam releases made pursuant to the settlement and the effects of any flows that may reach the confluence of the Stanislaus River will be included in the SJRRP ESA consultation. Any export changes that may occur as a result of SJRRP flows reaching the Delta are included within this consultation on the Coordinated Long-term Operation of the CVP/SWP.

Figure 12 shows the settlement-required flow targets for releases from Friant Dam. The settlement includes six water year types for releases depending upon available water supply as measures as inflow to Millerton Lake. The releases from Friant Dam include the flexibility to reshape and retime releases forwards or backwards by four weeks during the spring pulse and fall pulse periods. Flood flows may potentially occur and meet or exceed the settlement flow targets. If flood flows meet the settlement flow targets, then Reclamation would not release additional water. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the Merced River and releases are limited accordingly. Reclamation has initiated planning and environmental compliance activities to improved conveyance and allow for the full release of the flows. Diversions and infiltration losses reduce the amount of settlement flows reaching the San Joaquin and Merced River confluence. Figure 13 shows the targets for flows below Mendota Pool. These flows would then continue downstream to the San Joaquin and Merced River confluence and on to the Delta.

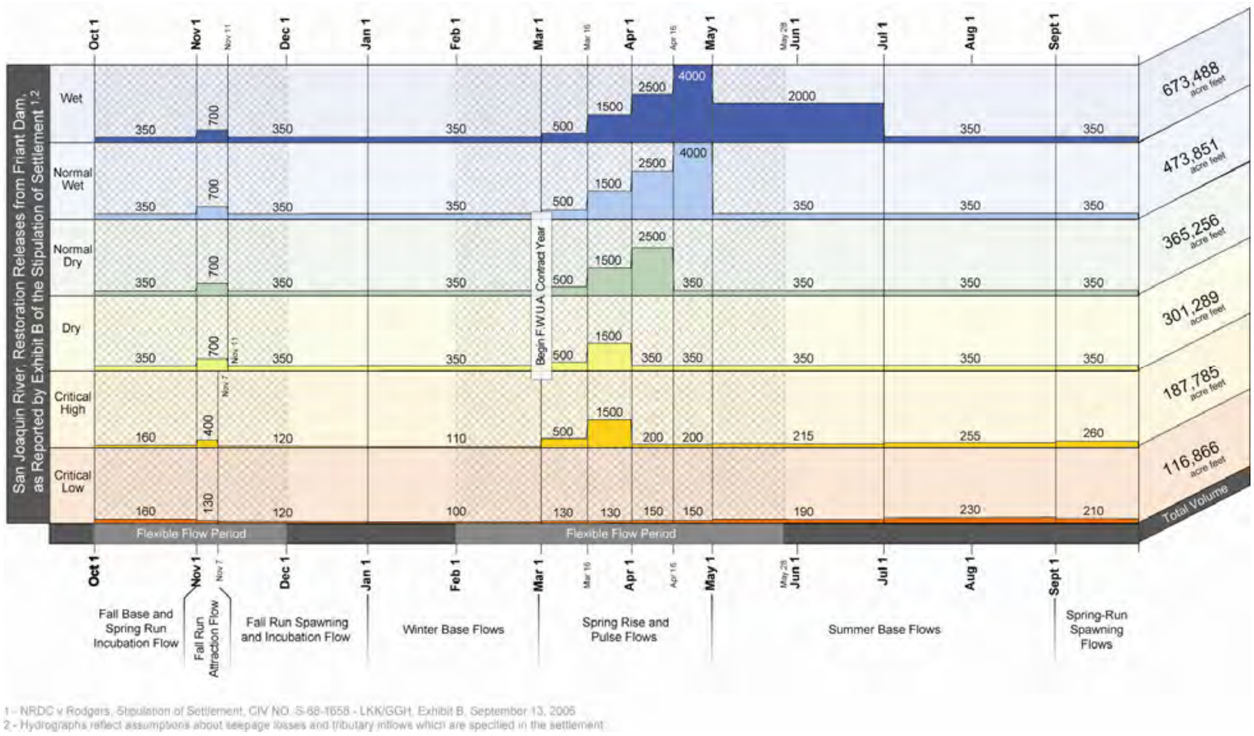

Figure 12. Settlement Flow Target Releases from Friant Dam

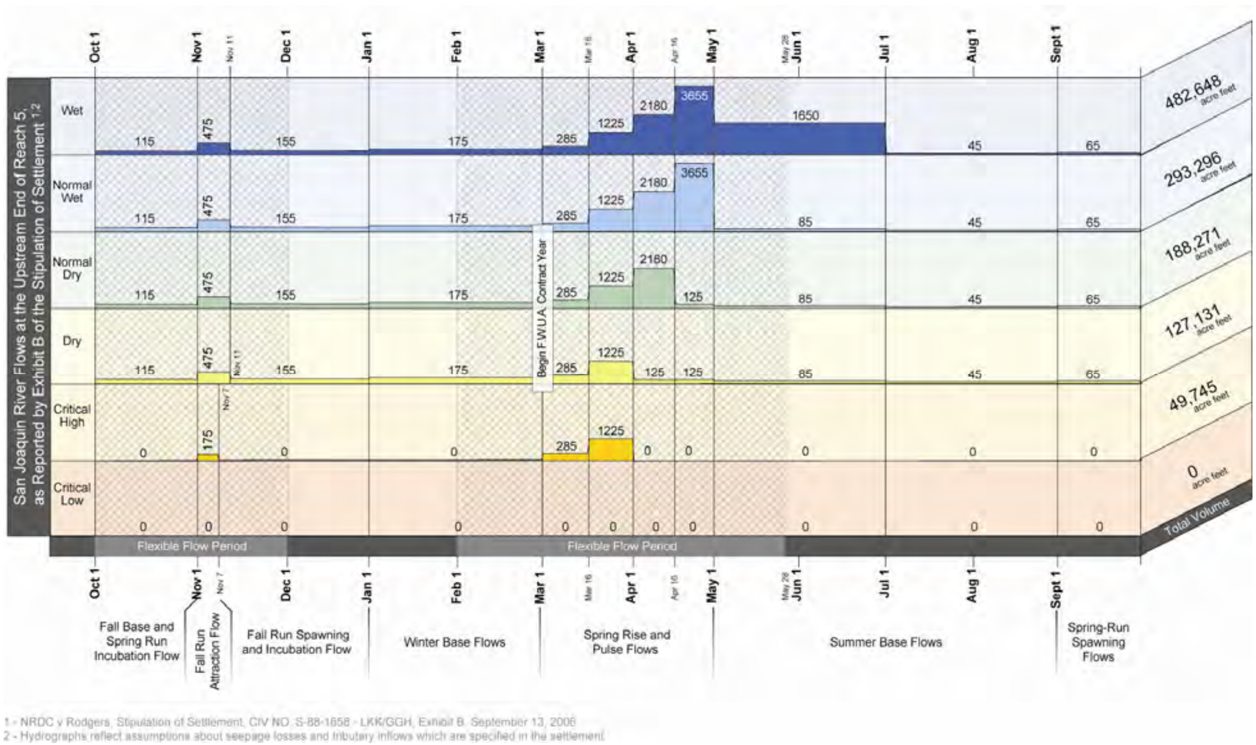

Figure 13. Settlement Flow Targets for Flows below Mendota Pool

State Water Project

The DWR holds contracts with 29 public agencies in Northern, Central and Southern California for water supplies from the SWP. Water stored in the Oroville facilities, along with excess water available in the Sacramento-San Joaquin Delta is captured in the Delta and conveyed through several facilities to SWP contractors.

The SWP is operated to provide flood control and water for agricultural, municipal, industrial, recreational, and environmental purposes. Water is conserved in Oroville Reservoir and released to serve three Feather River area contractors and two contractors served from the North Bay Aqueduct, and to be pumped at the Harvey O. Banks Pumping Plant (Banks) in the Delta and delivered to the remaining 24 contractors in the SWP service areas south of the Delta. In addition to pumping water released from Oroville Reservoir, the Banks pumps water from other sources entering the Delta.

Project Management Objectives

Clifton Court Forebay

Inflows to Clifton Court Forebay (CCF) are controlled by radial gates, whose real-time operations are constrained by a scouring limit (i.e. 12,000 cfs) at the gates and by water level concerns in the South Delta for local agricultural diverters. An interim agreement between DWR and South Delta Water Agency specifies three modes, or "priorities" for CCF gate operation. Of the three priorities, Priority 1 is the most protective of South Delta water levels. Under Priority 1, CCF gates are only opened during the ebb tides, allowing the flood tides to replenish South Delta channels. Priority 2 is slightly less protective because the CCF gates may be open as in

Priority 1, but also during the last hour of the higher flood tide and through most of the lower flood tide. Finally, Priority 3 requires that the CCF gates be closed during the rising limb of the higher flood tide and also during the lowest part of the lower tide, but permits the CCF gates to be open at all other times.

When a large head differential exists between the outside and the inside of the gates, theoretical inflow can be as high as 15,000 cfs for a very short time. However, existing operating procedures identify a maximum design flow rate of 12,000 cfs, to minimize water velocities in surrounding South Delta channels, to control erosion, and to prevent damage to the facility.

The SWP is managed to maximize the capture of water in the Delta and the usable supply released to the Delta from Oroville storage. The maximum daily pumping rate at Banks is controlled by a combination of the D-1641, the real-time decision making to assist in fishery management process described previously, and permits issued by the Corps that regulate the rate of diversion of water into CCF for pumping at Banks. This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to CCF and 6,993 cfs as a one-day average inflow to CCF. CCF diversions may be greater than these rates between December 15 and March 15, when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis when those flows are equal to or greater than 1,000 cfs. Additionally, the SWP has a permit to export an additional 500 cfs between July 1 and September 30 (further details on this pumping are found later in the Project Description). The purpose for the current permitted action is to replace pumping foregone for the benefit of Delta fish species, making the summer limit effectively 7,180 cfs.

The hourly operation of the CCF radial gates is governed by agreements with local agricultural interests to protect water levels in the South Delta area. The radial gates controlling inflow to the forebay may be open during any period of the tidal cycle with the exception of the two hours before and after the low-low tide and the hours leading up to the high-high tide each day. CCF gate operations are governed by agreements and response plans to protect South Delta water usersBanks is operated to minimize the impact to power loads on the California electrical grid to the extent practical, using CCF as a holding reservoir to allow that flexibility. Generally more pump units are operated during off-peak periods and fewer during peak periods. Because the installed capacity of the pumping plant is 10,300 cfs, the plant can be operated to reduce power grid impacts, by running all available pumps at night and a reduced number during the higher energy demand hours, even when CCF is admitting the maximum permitted inflow.

There are years (primarily wetter years) when CFF operations are demand limited, and enough water from the Delta to fill San Luis Reservoir and meet all contractor demands without maximizing its pumping capability every day of the year. However, CFF operations are more often supply limited. Under these current full demand conditions, CFF is almost always operated to the maximum extent possible to maximize the water captured, subject to the limitations of water quality, Delta standards, and a host of other variables, until all needs are satisfied and all storage south of the Delta is full.

San Luis Reservoir is an offstream storage facility located along the California Aqueduct downstream of Banks. San Luis Reservoir is used by both projects to augment deliveries to their contractors during periods when Delta pumping is insufficient to meet downstream demands.

San Luis Reservoir operates like a giant regulator on the SWP system, accepting any water pumped from Banks that exceeds contractor demands, then releasing that water back to the aqueduct system when Banks pumping is insufficient to meet demands. The reservoir allows the SWP to meet peak-season demands that are seldom balanced by Banks pumping.

San Luis Reservoir is generally filled in the spring or even earlier in some years. When it and other SWP storage facilities south of the Delta are full or nearly so, when Banks pumping is meeting all current Table A demands, and when the Delta is in excess conditions, DWR will use any available excess pumping capacity at Banks to deliver Article 21 water to the SWP contractors.

Article 21water is one of several types of SWP water supply made available to the SWP contractors under the long-term SWP water supply contracts between DWR and the SWP contractors. As its name implies, Article 21 water is provided for under Article 21 of the contracts[4]. Unlike Table A water, which is an allocated annual supply made available for scheduled delivery throughout the year, Article 21 water is an interruptible water supply made available only when certain conditions exist. As with all SWP water, Article 21 water is supplied under existing SWP water rights permits, and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP supplies.

When Article 21 water is available, DWR may only offer it for a short time, and the offer may be discontinued when the necessary conditions no longer exist. Article 21 deliveries are in addition to scheduled Table A deliveries; this supply is delivered to contractors that can, on relatively short notice, put it to beneficial use. Typically, contractors have used Article 21 water to meet needs such as additional short-term irrigation demands, replenishment of local groundwater basins, and storage in local surface reservoirs, all of which provide contractors with opportunities for better water management through more efficient coordination with their local water supplies. When Article 21 of the long-term water supply contracts was developed, both DWR and the contractors recognized that DWR was not capable of meeting the full contract demands in all years because not all of the planned SWP facilities had been constructed.

Article 21 water is typically offered to contractors on a short-term (daily or weekly) basis when all of the following conditions exist: the SWP share[5] of San Luis Reservoir is physically full, or projected to be physically full; other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; the Delta is in excess condition; current Table A demand is being fully met; and Banks has export capacity beyond that which is needed to meet current Table A and other SWP operational demands. The increment of available unused Banks capacity is offered as the Article 21 delivery capacity. Contractors then indicate their desired rate of delivery of Article 21 water. It is allocated in proportion to their Table A contractual quantities if requests exceed the amount offered. Deliveries can be discontinued at any time, when any of the above factors change. In the modeling for Article 21, deliveries are

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[4]Article 21 provides, in part: "Each year from water sources available to the project, the State shall make available and allocate interruptible water to contactors. Allocations of interruptible water in any one year may not be carried over for delivery in a subsequent year, nor shall the delivery of water in any year impact a contractor's approved deliveries of annual [Table A water] or the contractor's allocation of water for the next year. Deliveries of interruptible water in excess of a contractor's annual [Table A water] may be made if the deliveries do not adversely affect the State's delivery of annual [Table A water] to other contractors or adversely affect project operations…"

[5] Not including any carried-over EWA or limited EWA asset which may reside in the SWP share of San Luis Reservoir.

only made in months when the State share of San Luis Reservoir is full. In actual operations, Article 21 may be offered a few days in advance of actual filling.

By April or May, demands from both agricultural and M&I contractors usually exceed the pumping rate at Banks, and releases from San Luis Reservoir to the SWP facilities are needed to supplement the Delta pumping at Banks to meet contractor demands for Table A water.

During this summer period, DWR is also releasing water from Oroville Reservoir to supplement Delta inflow and allow Banks to export the stored Oroville water to help meet demand. These releases are scheduled to maximize export capability and gain maximum benefit from the stored water while meeting fish flow requirements, temperature requirements, Delta water quality, and all other applicable standards in the Feather River and the Delta.

DWR must balance storage between Oroville and San Luis Reservoirs carefully to meet flood control requirements, Delta water quality and flow requirements, and optimize the supplies to its contractors consistent with all environmental constraints. Oroville Reservoir may be operated to move water through the Delta to San Luis Reservoir via Banks under different schedules depending on Delta conditions, reservoir storage volumes, and storage targets. Predicting those operational differences is difficult, as the decisions reflect operator judgment based on many real-time factors as to when to move water from Oroville Reservoir to San Luis Reservoir.

As San Luis Reservoir is drawn down to meet contractor demands, it usually reaches its low point in late August or early September. From September through early October, demand for deliveries usually drops below the ability of Banks to divert from the Delta, and the difference in Banks pumping is then added to San Luis Reservoir, reversing its spring and summer decline. From early October until the first major storms in late fall or winter unregulated flow continues to decline and releases from Lake Oroville are restricted (due to flow stability agreements with DFG) resulting in export rates at Banks that are somewhat less than demand typically causing a second seasonal decrease in the SWP's share of San Luis Reservoir. Once the fall and winter storms increase runoff into the Delta, Banks can increase its pumping rate and eventually fill (in all but the driest years) the state portion of San Luis Reservoir before April of the following year.

Water Service Contracts, Allocations, and Deliveries

The following discussion presents the practices of DWR in determining the overall amount of Table A water that can be allocated and the allocation process itself. There are many variables that control how much water the SWP can capture and provide to its contractors for beneficial use.

The allocations are developed from analysis of a broad range of variables that include:

- Volume of water stored in Oroville Reservoir
- Flood operation restrictions at Oroville Reservoir
- End-of-water-year (September 30) target for water stored in Oroville Reservoir
- Volume of water stored in San Luis Reservoir
- End-of-month targets for water stored in San Luis Reservoir
- Snow survey results
- Forecasted runoff

- Feather River flow requirements for fish habitat
- Feather River service area delivery obligations
- Feather River flow for senior water rights river diversions
- Anticipated depletions in the Sacramento River basin
- Anticipated Delta flow and water quality requirements
- Precipitation and streamflow conditions since the last snow surveys and forecasts
- Contractor delivery requests and delivery patterns

From these and other variables, the Operations Control Office within DWR estimates the water supply available to allocate to contractors and meet other project needs. The Operations Control Office transmits these estimates to the State Water Project Analysis Office, where staff enters the water supply, contractor requests, and Table A amounts into a spreadsheet and computes the allocation percentage that would be provided by the available water supply.

The staffs of the Operations Control Office and State Water Project Analysis Office meet with DWR senior management, usually including the Director, to make the final decision on allocating water to the contractors. The decision is made, and announced in a press release followed by Notices to Contractors.

The initial allocation announcement is made by December 1 of each year. The allocation of water is made with a conservative assumption of future precipitation, and generally in graduated steps, carefully avoiding over-allocating water before the hydrologic conditions are well defined for the year.

Both the DWR and the contractors are conservative in their estimates, leading to the potential for significant variations between projections and actual operations, especially under wet hydrologic conditions.

Other influences affect the accuracy of estimates of annual demand for Table A and the resulting allocation percentage. One factor is the contractual ability of SWP contractors to carry over allocated but undelivered Table A from one year to the next if space is available in San Luis Reservoir. Contractors will generally use their carryover supplies early in the calendar year if it appears that San Luis reservoir will fill. By using the prior year's carryover, the contractors reduce their delivery requests for the current year's Table A allocation and instead schedule delivery of carryover supplies.

Carryover supplies left in San Luis Reservoir by SWP contractors may result in higher storage levels in San Luis Reservoir at December 31 than would have occurred in the absence of carryover. If there were no carryover privilege, contractors would seek to store the water within their service areas or in other storage facilities outside of their service areas. As project pumping fills San Luis Reservoir, the contractors are notified to take or lose their carryover supplies. If they can take delivery of and use or store the carryover water, San Luis Reservoir storage then returns to the level that would have prevailed absent the carryover program.

If the contractors are unable to take delivery of all of their carryover water, that water then converts to project water as San Luis Reservoir fills, and Article 21 water becomes available for delivery to contractors.

Article 21 water delivered early in the calendar year may be reclassified as Table A later in the year depending on final allocations, hydrology, and contractor requests. Such reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules. The total water exported from the Delta and delivered by the SWP in any year is a function of a number of variables that is greater than the list of variables shown above that help determine Table A allocations.

If there are no carryover or Article 21 supplies available, Table A requests will be greater in the January-April period, and there would be a higher percentage allocation of Table A for the year than if carryover and Article 21 were available to meet demand.

Monterey Agreement

In 1994, DWR and certain representatives of the SWP contractors negotiated a set of principles designed to modify the long-term SWP water supply contracts. This set of principles which came to be known as the Monterey Agreement, helped to settle long-term water allocation disputes, and to establish new water management strategies for the SWP. The Monterey Agreement resulted in 27 of the 29 SWP contractors signing amendments to their long-term water supply contracts in 1995, with implementation since 1996. The 1995 Program Environmental Impact Report prepared for the Monterey Agreement was subject to judicial challenge, and in 2000 the PEIR was decertified. In May 2003, the parties to the litigation negotiated a settlement agreement which committed DWR to a process for including the plaintiffs and SWP contractors in the development of a new EIR on the Monterey Amendment. A draft of the new EIR was released in October 2007. After incorporating over 600 comments, the final EIR was noticed with the State Clearinghouse on May 5, 2010. After considering the final EIR and the alternatives, DWR determined that the proposed project could be carried out by continuing to operate under the existing Monterey Amendment and Settlement Agreement. Additionally, the Court explicitly ordered that DWR could continue to operate the SWP in accordance with the Monterey Amendment as it had done since 1996.

Changes in DWR's Allocation of Table A Water and Article 21 Water

The Monterey Amendment revised the allocation procedures for both Table A and Article 21 water supplies. The revised Article 18(a) eliminated the temporary shortage provision that specified an initial reduction of supplies for agricultural use when requests for SWP water exceeded the available supply. The Amendment specifies instead that whenever the supply of Table A water is less than the total of all contractors' requests, the available supply of Table A water is allocated among all contractors in proportion to each contractor's annual Table A amount.

The Monterey Amendment also amended Article 21 by eliminating the category of scheduled "surplus water," which was available for scheduled delivery and by renaming "unscheduled water" to "interruptible water." Surplus water was scheduled water made available to the contractors when DWR had supplies beyond what was needed to meet Table A deliveries, reservoir storage targets, and Delta regulatory requirements. Surplus water and unscheduled water were made available first to contractors requesting it for agricultural use or for groundwater replenishment. Because of the contractors' increasing demands for Table A water and the increasing regulatory requirements imposed on SWP operations, DWR is now able to supply water that is not Table A water only on an unscheduled, i.e., interruptible basis.

Pursuant to the revised Article 21, DWR allocates the available interruptible supply (now referred to by DWR as Article 21 water) to requesting contractors in proportion to their annual Table A amounts.

The result of these contractual changes are that DWR now allocates Table A and Article 21 water among SWP contractors in proportion to annual Table A amounts without consideration of whether the water would be used for M&I or agricultural purposes. Agricultural and M&I contractors share any reductions in deliveries or opportunities for surplus water in proportion to their annual Table A amounts.

Historical Water Deliveries to Southern California

The pumping from the Delta to serve southern California has been influenced by changes in available water supply sources to serve the region. The Colorado River and the SWP have been the major supply sources for southern California.

The Quantification Settlement Agreement (QSA) signed in 2003 resulted in a decrease in the amount of Colorado River water available to California. To illustrate the impact of that decrease on demand from the Sacramento-San Joaquin Delta, it is instructive to look at the magnitude of the two imported supply sources available to MWDSC.

During part of this period, MWDSC was also filling Diamond Valley Lake (810,000 acre-feet, late 1998-early 2002) and adding some water to groundwater storage programs. In wetter years, demand for imported water may often decrease because local sources are augmented and local rainfall reduces irrigation demand. Table 12 below illustrates the effects of the wet years from 1995-1998 on demand for imported water and the effect of reduced Colorado River diversions under the QSA on MWDSC deliveries from the Delta.

Table 12. Wet Year effects

Calendar Year	Sacramento Valley Water Year Type	Delta Supplies	Colorado Supplies	Total
1994	Critically Dry	807,866	1,303,212	2,111,078
1995	Wet	436,042	997,414	1,433,456
1996	Wet	593,380	1,230,353	1,823,733
1997	Wet	721,810	1,241,821	1,963,631
1998	Wet	410,065	1,073,125	1,483,190
1999	Wet	852,617	1,215,224	2,067,841
2000	Above Normal	1,518,941	1,303,148	2,822 089
2001	Dry	1,017,186	1,253,579	2,270,765
2002	Dry	1,333,927	1,241,088	2,575,015
2003	Above Normal	1,563,842	688,043	2,251,885
2004	Below Normal	1,615,929	733,095	2,349,024
2005	Above Normal	1,478,045	839,704	2,317,749

Calendar Year	Sacramento Valley Water Year Type	Delta Supplies	Colorado Supplies	Total
2006	Wet	1,512,186	594,544	2,106,730
2007	Dry	1,327,623	713,456*	2,041,079

Project Facilities

Oroville Field Division

Oroville Dam and related facilities comprise a multipurpose project. The reservoir stores winter and spring runoff, which is released into the Feather River to meet the Project's needs. It also provides pumpback capability to allow for on-peak electrical generation, 750,000 acre-feet of flood control storage, recreation, and freshwater releases to control salinity intrusion in the Sacramento-San Joaquin Delta and for fish and wildlife protection.

The Oroville facilities are shown in Figure 14. Two small embankments, Bidwell Canyon and Parish Camp Saddle Dams, complement Oroville Dam in containing Lake Oroville. The lake has a surface area of 15,858 acres, a storage capacity of 3,538,000 AF, and is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 million AF.

A maximum of 17,000 cfs can be released through the Edward Hyatt Powerplant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately four miles downstream of Oroville Dam and Edward Hyatt Powerplant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot-long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure.

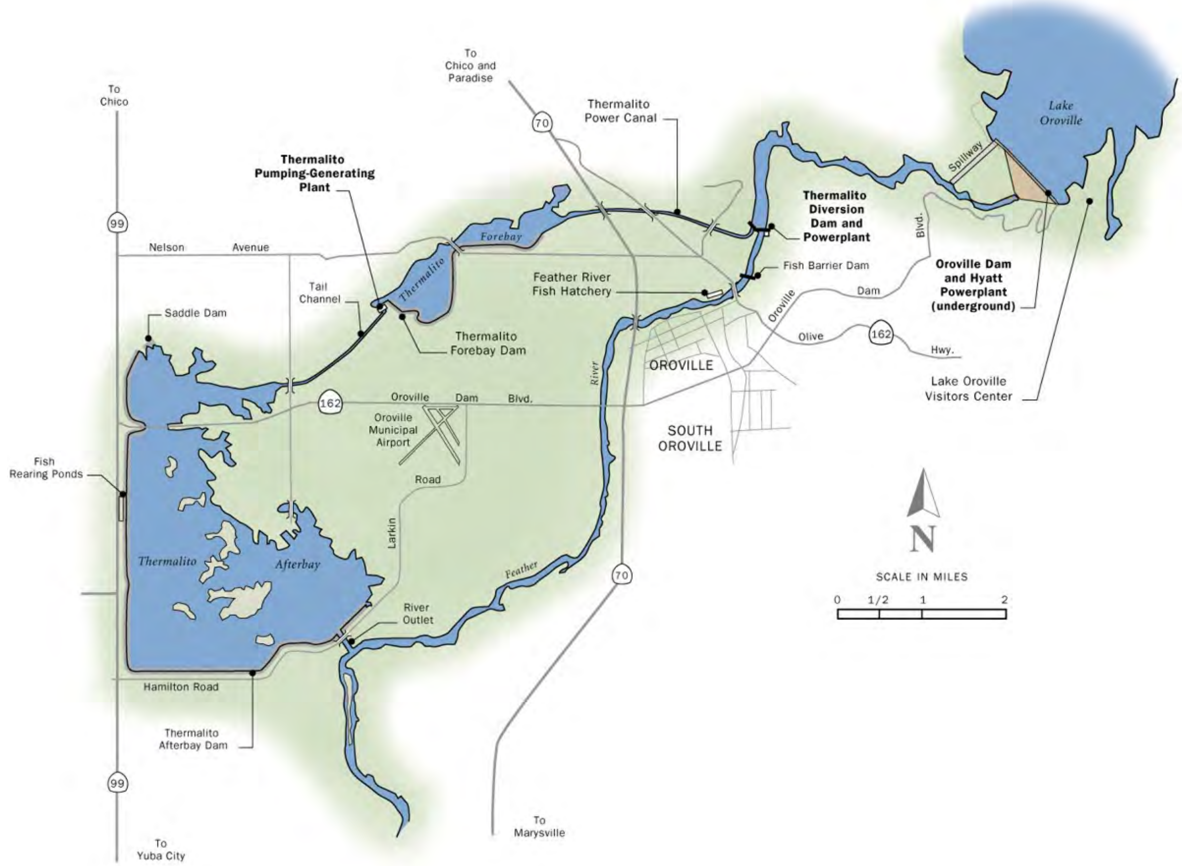


Figure 14. Oroville Facilities on the Feather River

The purpose of the diversion dam is to divert water into the 2-mile long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (called Thermalito Diversion Pool) for Edward Hyatt Powerplant. The Thermalito Diversion Pool acts as a forebay when Hyatt is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Powerplant, with a capacity of 600 cfs that releases water to the low-flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11,768 AF), which is the off-stream regulating reservoir for Thermalito Powerplant. Thermalito Powerplant is a generating-pumping plant operated in tandem with the Edward Hyatt Powerplant. Water released to generate power in excess of local and downstream requirements is conserved in storage and, at times, pumped back through both powerplants into Lake Oroville during off-peak hours. Energy price and availability are the two main factors that determine if a pumpback operation is economical. A pumpback operation most commonly occurs when energy prices are high during the weekday on-peak hours and low during the weekday off-peak hours or on the weekend. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the powerplants, which can be returned to the Feather River via the Afterbay's river outlet.

Local agricultural districts divert water directly from the afterbay. These diversion points are in lieu of the traditional river diversion exercised by the local districts whose water rights are senior to the SWP. The total capacity of afterbay diversions during peak demands is 4,050 cfs.

The Feather River Fish Hatchery (FRFH), mitigation for the construction of Oroville Dam, produces Chinook salmon and steelhead and is operated by DFG. The FRFH program, operations and production, is detailed in the FERC biological assessment for the Oroville Project and will be detailed in the NMFS FERC biological opinion. Both indirect and direct take resulting from FRFH operations will be authorized through section 4(d) of the Endangered Species Act, in the form of NMFS-approved Hatchery and Genetic Management Plans (HGMPs). DWR is preparing HGMPs for the spring and fall-run Chinook and steelhead production programs at the FRFH.

Current Operations - Minimum Flows and Temperature Requirements

Operation of Oroville will continue under existing criteria, consistent with past project descriptions, until DWR receives the new FERC license. The release temperatures from Oroville Dam are designed to meet FRFH and Robinson Riffle temperature schedules included in the 1983 DFG Agreement, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife", concerning the operations of the Oroville Division of the State Water Project for Management of Fish and Wildlife while also conserving the coldwater pool in Lake Oroville. Current operation indicates that water temperatures at Robinson Riffle are almost always met when the hatchery objectives are met. Due to temperature requirements of endangered fish species and the hatchery and overriding meteorological conditions, the temperature requests for agriculture can be difficult to satisfy.

Water is withdrawn from Lake Oroville at depths that will provide sufficiently cold water to meet the Feather River Fish Hatchery and Robinson Riffle temperature targets. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, modify downstream river temperatures. Altering the reservoir release depth requires installation or removal of shutters at the intake structures. Shutters are held at the minimum depth necessary to release water that meets the FRFH and Robinson Riffle criteria. In order to conserve the coldwater pool during dry years, DWR has strived to meet the Robinson Riffle temperatures by increasing releases to the Low flow Channel (LFC) rather than releasing colder water.

Additionally, DWR maintains a minimum flow of 600 cfs within the Feather River LFC (except during flood events when flows are governed by the Flood Operations Manual and under certain other conditions as described in the 1984 FERC order). Downstream of the Thermalito Afterbay Outlet, in the High Flow Channel (HFC), a minimum release for flows in the Feather River is to be 1,000 cfs from April through September and 1,700 cfs from October through March, when the April-to-July unimpaired runoff in the Feather River is greater than 55 percent of normal. When the April-to-July unimpaired runoff is less than 55 percent of normal, the License requires minimum flows of 1,000 cfs from March to September and 1,200 cfs from October to February (Table 13). In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

According to the 1983 Agreement, if during the period of October 15 to November 30, the average highest 1-hour flow of combined releases exceeds 2,500 cfs; with the exception of flood management, accidents, or maintenance; then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31. The 1983 Agreement also states that if the April 1 runoff forecast in a given year indicates that the reservoir level will be drawn down to 733 feet, water releases for fish may be reduced, but not by more than 25 percent.

Table 13. Combined Minimum Instream Flow Requirements in the Feather River Below Thermalito Afterbay Outlet When Lake Oroville Elevation is Projected to be Greater vs. Less Than 733' in the Current Water Year

Conditions	Period	Minimum Flows
When Lake Oroville Elevation is Projected to be Greater Than 733' & the **Preceding** Water Year's April – July Water Conditions are ≥ 55% of Normal (1)	October - February	1,700 cfs
	March	1,700 cfs
	April - September	1,000 cfs
When Lake Oroville Elevation is Projected to be Greater Than 733' & the Preceding Water Year's April – July Water Conditions are < 55% of Normal (1)	October - February	1,200 cfs
	March	1,000 cfs
	April - September	1,000 cfs
When Lake Oroville Elevation is Projected to be Less Than 733' in the **Current** Water Year (2)	October - February	900 cfs < Q < 1,200 cfs
	March	750 cfs < Q < 1,000 cfs
	April - September	750 cfs < Q < 1,000 cfs

Notes:

1) Normal is defined as the Mean April – July Unimpaired Runoff of the Feather River near Oroville of 1,942,000 AF (1911 – 1960).
2) In accordance with FERC's Order Amending License dated September 18, 1984, Article 53 was amended to provide a third tier of minimum flow requirements defined as follows: If the April 1 runoff forecast in a given water year indicates that, under normal operation of Project 2100, the reservoir level will be drawn to elevation 733 feet (approximately 1,500,000 AF), releases for fish life in the above schedule may suffer monthly deficiencies in the same proportion as the respective monthly deficiencies imposed upon deliveries of water for agricultural use from the Project. However, in no case shall the fish water releases in the above schedule be reduced by more than 25 percent.

Current operations of the Oroville Facilities are governed by water temperature requirements at two locations: the FRFH and in the LFC at Robinson Riffle. DWR has taken various temperature management actions to achieve the water temperature requirements, including curtailing pumpback operations, removing shutters at intakes of the Hyatt Pumping-Generating Plant, releasing flow through the river valves (for FRFH only), and redirecting flows at the Thermalito Diversion Dam to the LFC (for Robinson Riffle only).

To date, the river valves have been used infrequently. Prior to 1992, they were used twice: first in 1967 during the initial construction of the dam, and second in 1977 during the drought of record. Since 1992, the river valves have only been used for temperature control: in 2001 and

2002 and in 2008. Currently the river valves are inoperable. DWR plans to manage its cold water storage and its intake shutters in order to meet its temperature obligations.Other than local diversions, outflow from the Oroville Complex is to the Feather River, combining flows from the LFC and Thermalito Afterbay. Outflow typically varies from spring seasonal highs averaging 8,000 cfs to about 3,500 cfs in November. The average annual outflow from the Project is in excess of 3 MAF to support downstream water supply, environmental, and water quality needs.

Error! Reference source not found.Error! Reference source not found. shows an example of releases from Oroville for various downstream uses during dry hydrologic conditions (WYs 2001 and 2002). As a practical matter, water supply exports are met with water available after Delta requirements are met. Some of the water released for instream and Delta requirements may be available for export by the SWP after Delta standards have been met.

Feather River Flow Requirements

The existing Feather River flow requirements below Oroville Dam are based on an August 1983 Agreement between the DWR and DFG and the Federal Energy Regulatory Commission license terms. The 1983 Agreement established criteria and objectives for flow and temperatures in the LFC, FRFH, and HFC. This agreement includes the following:

- Established minimum flows between the Thermalito Afterbay Outlet and Verona that vary by WY type
- Required flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except flood management operations
- Required flow stability during the peak of the fall-run Chinook spawning season
- Set an objective of suitable water temperature conditions during the fall months for salmon and during the later spring/summer months for shad and striped bass
- Established a process whereby DFG would recommend each year, by June 1, a spawning gravel maintenance program to be implemented during that calendar year

Low Flow Channel

The 1983 Agreement specifies that DWR release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fishery purposes. This is the total volume of flows from the Diversion Dam Outlet, Diversion Dam Powerplant, and FRFH Pipeline.

High Flow Channel

Based on the 1983 Agreement, Table 14 summarizes the minimum flow requirement for the HFC when releases would not draw Oroville Reservoir below elevation 733 feet above mean sea level (ft msl).

Table 14. High Flow Channel minimum flow requirements as measured downstream from the Thermalito Afterbay Outlet.

Forecasted April-through- July unimpaired runoff (percent of normal[1])	Minimum Flow in HFC (cfs)		
	October through February	March	April through September
55 percent or greater	1,700	1,700	1,000
Less than 55 percent	1,200	1,000	1,000

Key: cfs = cubic feet per second; HFC = High Flow Channel (Source: 1983 Agreement)

[1] The preceding water year's unimpaired runoff shall be reported in Licensee's Bulletin 120, "*Water Conditions in California-Fall Report*." The term "normal" is defined as the April-through-July mean unimpaired runoff near Oroville of 1,942,000 AF in the period of 1911 through 1960.

If the April 1 forecast in a given WY indicates that Oroville Reservoir would be drawn down to elevation 733 ft msl, minimum flows in the HFC may be diminished on a monthly average basis, in the same proportion as the respective monthly deficiencies imposed on deliveries for agricultural use of the Project. However, in no case shall the minimum flow releases be reduced by more than 25 percent. If between October 15 and November 30, the highest total 1-hour flow exceeds 2,500 cfs, DWR shall maintain a minimum flow within 500 cfs of that peak flow, unless such flows are caused by flood flows, or an inadvertent equipment failure or malfunction.

Temperature Requirements

Low Flow Channel

NMFS has established a water temperature requirement for steelhead trout and spring-run Chinook salmon at Feather River RM 61.6 (Robinson Riffle in the LFC) from June 1 through September 30. The water temperature should be maintained at less than or equal to 65°F on a daily average basis.

High Flow Channel

While no numeric temperature requirement currently exists for the HFC, the 1983 Agreement requires DWR to provide suitable Feather River water temperatures for fall-run salmon not later than September 15, and to provide for suitable water temperatures below the Thermalito Afterbay Outlet for shad, striped bass, and other warm water fish between May 1 and September 15. Current FRFH intake water temperature, as required by the 1983 DFG and DWR Agreement and the FERC license are in Table 15.

Table 15. Feather River Fish Hatchery Temperature Requirements

Period		Degrees F (± 4 ºF allowed)
April 1 – November 30		
	April 1 – May 15	51
	May 16 – May 31	55
	June 1 – June 15	56
	June 16 – August 15	60
	August 16 – August 31	58
	September 1 – September 30	52
	October 1 – November 30	51
December 1 – March 31		No greater than 55

Table 16 summarizes current flow and temperature management in the Feather River Fish Hatchery and the Lower Feather River below Oroville Dam. These operational measures are in place in compliance with FERC license terms, agency agreements or ESA biological opinions and are provided to fully describe the baseline conditions.

Table 16. Lower Feather River Flows and Temperature Management under Existing Conditions

Type of Measure	Title	Description
Minimum Flows	Minimum Release to Low Flow Channel (this includes water that returns from hatchery)	Maintain minimum flow of 600 cubic feet per second (cfs) within the Feather River downstream of the Thermalito Diversion Dam and the Feather River Fish Hatchery. FERC 1984. [Low Flow Channel Flow Standard]
	Minimum Release to High Flow Channel	Release water necessary to maintain flows in the Feather River below the Thermalito Afterbay Outlet in accordance with the minimum flow schedule presented in the Federal Energy Regulatory Commission (FERC) order, provided that releases will not cause Lake Oroville to be drawn below elevation 733 feet (ft) (approximately 1.5 million acre-feet [maf] of storage). If the April 1 runoff forecast in a given year indicates that the reservoir level will be drawn to 733 ft, water releases for fish may be reduced, but not by more than 25 percent.
Maximum Flows (non-flood control)	Maximum Flow into Feather River Fish Hatchery	Maximum flow into Feather River Fish Hatchery from the Diversion Pool is 115 cfs year round.
	Maximum Flow in the High Flow Channel	Maximum flow at Feather River below Thermalito Afterbay Outlet is **10,000 cfs** when Lake Oroville inflow is less than 10,000 cfs. [High Flow Channel Flow Standard] When Lake Oroville inflow is greater than 10,000 cfs, the maximum flow in the river below Thermalito Afterbay Outlet will be limited to inflow. If higher flow releases coincide with Chinook spawning activity, the ramping rate used to return to the minimum flow requirement will be chosen to avoid redd dewatering.
Ramping Rates	Ramping Rate Criteria	Flows less than 2,500 cfs cannot be reduced more than **300 cfs** during any 24-hour period, except for flood releases, failures, etc.
Water Supply	Releases from Lake Oroville	Releases for water supply, flood control, Sacramento–San Joaquin Delta (Delta) water quality requirements, and instream flow requirements of an average of 3 million acre-feet per year (maf/year) and approximately 1 maf/year to the Feather River Service Area (FRSA) for agricultural, municipal, and industrial uses in accordance with SWP contracts, DWR agreements, and water rights.
	Diversions from Feather River	Diversion of an estimated 60–70 thousand acre-feet per year (TAF/year) from the Feather River by senior water right holders per State Water Resources Control Board (SWRCB) licenses or permits for appropriative users.

Type of Measure	Title	Description
Flood Protection/Management	Flood Protection	The Oroville Facilities are operated for flood control purposes in conformance with the flood management regulations prescribed by the Secretary of the Army under the provisions of an Act of Congress (58 Stat. 890; 33 United States Code [USC] 709). - During floods, water releases from Oroville Dam and Thermalito Afterbay Dam will not increase floodflows above those prior to project existence. Operation of the project in the interest of flood control shall be in accordance with Section 204 of the Flood Control Act of 1958. - At high flows, fluctuate releases at least every couple of days to avoid riverbank/levee damage at one level. - Avoid extended periods of flow over the quantities listed above as much as possible to minimize the risk of seepage damage to orchards adjacent to the Feather River. - Maximum allowable flow is 180,000 cfs year round at the Feather River above the Yuba River. Maximum allowable flow is 300,000 cfs year round at the Feather River below the Yuba River. - Maximum allowable flow is 320,000 cfs year round at the Feather River below the Bear River.
Temperature Criteria/Targets	At the Feather River Fish Hatchery and Robinson Riffle	Water temperature at Robinson Riffle must be less than 65 degrees between June and September. Water temperature during the fall months, after September 15, should be suitable for fall-run Chinook salmon. Water temperature from May through August should be suitable for American shad, striped bass, etc. At the Feather River Fish Hatchery Temperature (+/- 4°F) April 1–May 15 51° May 16–May 31 55° June 1–June 15 56° June 16–August 15 60° August 16–August 31 58° September 1–September 30 52° October 1–November 30 51° December 1–March 31 no greater than 55°
	Thermalito Afterbay Temperature Control	Operate facilities pursuant to the May 1968 Joint Water Agreement.

Type of Measure	Title	Description
Natural Salmonid Spawning and Rearing Habitat	Salmonid Habitat Improvement – Endangered Species Act (ESA) Species Recovery Measures	Maintain conditions in the Low Flow Channel pursuant to 1983 Operating Agreement between DFG and DWR which is to prevent damage to fish and wildlife resources from operations and construction of the project.

Excerpt from Appendix B of the FERC Preliminary Draft Environmental Assessment, Oroville Facilities—FERC Project No. 2100

Flood Control

Flood control operations at Oroville Dam are conducted in coordination with DWR's Flood Operations Center and in accordance with the requirements set forth by the Corps. The Federal Government shared the expense of Oroville Dam, which provides up to 750,000 AF of flood control space. The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over natural terrain.

Feather River Ramping Rate Requirements

Maximum allowable ramp-down release requirements are intended to prevent rapid reductions in water levels that could potentially cause redd dewatering and stranding of juvenile salmonids and other aquatic organisms. Ramp-down release requirements to the LFC during periods outside of flood management operations, and to the extent controllable during flood management operations, are shown in Table 17.

Table 17. Lower Feather River Ramping Rates

Releases to the Feather River Low Flow Channel (cfs)	Rate of Decrease (cfs)
5,000 to 3,501	1,000 per 24 hours
3,500 to 2,501	500 per 24 hours
2,500 to 600	300 per 24 hours

Key: cfs = cubic feet per second (Source: NMFS 2004a)

Proposed Operational Changes with the Federal Energy Regulatory Commission (FERC) Relicensing of the Oroville Project– Near Term and Future Operations

Until FERC issues the new license for the Oroville Project, DWR will not significantly change the operations of the facilities and when the FERC license is issued, it is assumed that downstream of Thermalito Afterbay Outlet, the future flows will remain the same.

Given the uncertainty of what will be in the FERC license or 401 Certification, it is not possible to establish the DWR proposed Settlement Agreement (SA) conditions as the baseline for the OCAP Biological Assessment.

The original FERC license to operate the Oroville Project expired in January 2007. Since then, annual licenses have been issued, with DWR operating to the existing FERC license. FERC continues to issue an annual license until it is prepared to issue the new 50-year license. In preparation for the expiration of the FERC license, DWR began working on the relicensing process in 2001. As part of the process, DWR entered into a SA, signed in 2006, with State, federal and local agencies, State Water Contractors, Non-Governmental Organizations, and Tribal governments and others to implement improvements within the FERC Boundary. The FERC boundary includes all of the Oroville Project facilities, extends upstream into the tributaries of Lake Oroville, includes portions of the LFC on the lower Feather River and downstream of the Thermalito Afterbay Outlet into the HFC. In addition to the SA, a Habitat Expansion Agreement was negotiated to address the fish passage issue over Oroville Dam and NMFS and FWS' Section 18 Authority under the Federal Power Act.

The Oroville FERC license may be issued in 2011. The Final EIS was prepared by FERC and completed in 2007. The Final EIR was prepared by DWR and completed in 2008. A draft Biological Opinion was prepared by NMFS in 2009 but is not yet final. The SWRCB issued the Clean Water Act Section 401 Certification (401 Cert) for the project in 2010. The new FERC license, when issued, will include the FERC license terms and conditions, the 401 Cert and the terms and conditions therein, and DWR will also comply with the requirements in the NMFS Final Biological Opinion. The new FERC license may include most if not all of the commitments from the SA so a summary is provided below. The SA does not change the flows in the HFC although there will be a proposed increase in minimum flows in the LFC. The SA includes habitat restoration actions such as side-channel construction, structural habitat improvement such as boulders and large woody debris, spawning gravel augmentation, a fish counting weir, riparian vegetation and floodplain restoration, and facility modifications to improve coldwater temperatures in the low and high flow channels. The SA, EIR, and the FERC Biological Assessment provide substantial detail on the SA restoration actions in the Lower Feather River.

Below is a summary of articles in the SA referred to by number and is by no means a complete description of the terms and conditions therein. The numbering of the tables in this section is consistent with the numbering in the SA for direct comparison. The reader is encouraged to read the source document for a full understanding of the terms and related details.

Minimum Flows in the Low Flow and High Flow Channels

In the SA, a minimum flow of 700 cfs will be released into the Low Flow Channel (LFC). The minimum flow shall be 800 cfs from September 9 to March 31 of each year to accommodate spawning of anadromous fish, unless the NMFS, FWS, DFG, and California SWRCB provide a written notice that a lower flow (between 700 cfs and 800 cfs) substantially meets the needs of anadromous fish. If the DWR receives such a notice, it may operate consistent with the revised minimum flow. HFC flows will remain the same as the existing license, consistent with the 1983 DWR and DFG Operating Agreement to continue to protect Chinook salmon from redd dewatering (A108.2).

Water Temperatures for the Feather River Fish Hatchery

When the FERC license is issued, DWR will use the temperatures in Table 18 as targets, and will seek to achieve them through the use of operational measures described below.

Table 18. Maximum Mean Daily Temperatures

September 1-September 30	56 °F
October 1 – May 31	55 °F
June 1 – August 31	60°F

The temperatures in Table 18 are Maximum Mean Daily Temperatures, calculated by adding the hourly temperatures achieved each day and dividing by 24. DWR will strive to meet Maximum Mean Daily Temperatures through operational changes including but not limited to (i) curtailing pump-back operation and (ii) removing shutters on Hyatt intake and (iii) after river valve refurbishment. DWR will consider the use of the river valve up to a maximum of 1500 cfs; however these flows need not exceed the actual flows in the HFC, and should not be less than those specified in HFC minimum flows described above, which will not change with the new FERC license. During this interim period, DWR shall not be in violation if the Maximum Mean Daily Temperatures are not achieved through operational changes.

Prior to FERC license implementation, DWR agreed to begin the necessary studies for the refurbishment or replacement of the river valve. On October 31, 2006, DWR submitted to specific agencies a Reconnaissance Study of Facilities Modification to address temperature habitat needs for anadromous fisheries in the Low Flow Channel and the HFC. Under the provisions of Settlement Agreement Appendix B Section B108(a), DWR has begun a study to evaluate whether to refurbish or replace the river valve that may at times be used to provide cold water for the Feather River Fish Hatchery.

Upon completion of Facilities Modification(s) as provided in A108, and no later than the end of year ten following license issuance, Table 6 temperatures shall become requirements, and DWR shall not exceed the Maximum Mean Daily Temperatures in Table 20 for the remainder of the License term, except in Conference Years as referenced in A107.2(d). During the term of the FERC license, DWR will not exceed the hatchery water temperatures in. There will be no minimum temperature requirement except for the period of April 1 through May 31, during which the temperatures shall not fall below 51 ºF.

Table 19. Hatchery Water Temperatures

September 1-September 30	56 °F
October 1 – November 30	55 °F
December 1 – March 31	55 °F
April 1 – May 15	55 °F
May 16-May 31	59°F
June 1-June 15	60°F
June 16- August 15	64°F
August 16 – August 31	62°F

Upon completion of Facilities Modification(s) as provided in A108 (discussed below), DWR may develop a new table for hatchery temperature requirements that is at least as protective as Table 19. If a new table is developed, it shall be developed in consultation with the Ecological Committee, including specifically the Service, NMFS, DFG, California SWRCB, and RWQCB. The new table shall be submitted to FERC for approval, and upon approval shall become the temperature requirements for the hatchery for the remainder of the license term.

During Conference Years, as defined in A108.6, DWR shall confer with the Service, NMFS, DFG, and California SWRCB to determine proper temperature and hatchery disease management goals.

Water Temperatures in the Lower Feather River

Under the SA, DWR is committing to a Feasibility Study and Implementation Plan to improve temperature conditions (Facilities Modification(s)) for spawning, egg incubation, rearing and holding habitat for anadromous fish in the Low Flow Channel and HFC (A108.4). The Plan will recommend a specific alternative for implementation and will be prepared in consultation with the resource agencies.

Prior to the Facilities Modification(s) described in Article A108.4, if DWR does not achieve the applicable Table 20 Robinson Riffle temperature upon release of the specified minimum flow, DWR shall singularly, or in combination perform the following actions:

(1) Curtail pump-back operation,

(2) Remove shutters on Hyatt Intake, and

(3) Increase flow releases in the LFC up to a maximum of 1500 cfs, consistent with the minimum flow standards in the HFC. Table 20 temperatures are targets and if they are not met there is no license violation.

If in any given year DWR anticipates that these measures will not achieve the temperatures in Table 20, DWR shall consult with the NMFS, the Service, DFG, and California SWRCB to discuss potential approaches to best managing the remaining coldwater pool in Lake Oroville, which may result in changes in the way Licensee performs actions (1), (2), and (3) listed above.

Table 20. LFC as Measured at Robinson Riffle.

(all temperatures are in daily mean value (degrees F))

Month	Temperature (° F)
January	56
February	56
March	56
April	56
May 1-15	56-63*
May 16-31	63
June 1 – 15	63
June 16 – 30	63
July	63
August	63
September 1-8	63-58*
September 9 – 30	58
October	56
November	56
December	56

* Indicates a period of transition from the first temperature to the second temperature.

After completion of the Facilities Modification(s), DWR shall no longer be required to perform the measures listed in (1), (2), and (3), unless Table 20 temperatures are exceeded. DWR shall operate the project to meet temperature requirements in Table 20 in the LFC, unless it is a Conference Year as described in Article 108.6. The proposed water temperature objectives in Table 20**Error! Reference source not found.** (in Article 108), measured at the southern FERC project boundary, will be evaluated for potential water temperature improvements in the HFC. DWR will study options for Facilities Modification(s) to achieve those temperature benefits.

There would be a testing period of at least five years in length to determine whether the HFC temperature benefits are being realized (A108.5). At the end of the testing period, DWR will prepare a testing report that may recommend changes in the facilities, compliance requirements for the HFC and the definition of Conference Years (those years where DWR may have difficulties in achieving the temperature requirements due to hydrologic conditions). The challenges of implementing Table 21 temperatures will require the phased development of the Table 21 water temperature objective and likely, a revision to Table 21 prior to Table 21 becoming a compliance obligation.

Table 21. HFC as measured at Downstream Project Boundary

(all temperatures are in daily mean value (degrees F))

Month	Temperature (° F)
January	56
February	56
March	56
April	61
May	64
June	64
July	64
August	64
September	61
October	60
November	56
December	56

Habitat Expansion Agreement

The Habitat Expansion Agreement is a component of the 2006 SA to address DWR obligations in regard to blockage and fish passage issues in regard to the construction of Oroville Dam. Because it deals with offsite mitigation it will not included in the new FERC license.

Construction of the Oroville Facilities and Pacific Gas and Electric Company's construction of other hydroelectric facilities on the upper Feather River tributaries blocked passage and reduced available habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead. The reduction in spring-run habitat resulted in spatial overlap with fall-run Chinook salmon and has led to increased redd superimposition, competition for limited habitat, and genetic introgression. FERC relicensing of hydroelectric projects in the Feather River basin has focused attention on the desirability of expanding spawning, rearing and adult holding habitat available for Central Valley spring-run and steelhead. The SA Appendix F includes a provision to establish a habitat enhancement program with an approach for identifying, evaluating, selecting and implementing the most promising action(s) to expand such spawning, rearing and adult holding habitat in the Sacramento River Basin as a contribution to the conservation and recovery of these species. The specific goal of the Habitat Expansion Agreement is to expand habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run or steelhead for spawning (Habitat Expansion Threshold). The population size target of 2,000 to 3,000 spawning individuals was selected because it is approximately the number of spring-run and steelhead that historically migrated to the upper Feather River. Endangered species issues will be addressed and documented on a specific project-related basis for any restoration actions chosen and implemented under this Agreement.

Anadromous Fish Monitoring on the Lower Feather River

Until the new FERC license is issued and until a new monitoring program is adopted, DWR will continue to monitor anadromous fish in the Lower Feather River in compliance with the project description set out in Reclamation's 2004 OCAP biological assessment.

As required in the FERC SA (Article A101), within three years following the FERC license issuance, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan that will provide an overall strategy for managing the various environmental measures developed for implementation, including the implementation schedules, monitoring, and reporting. Each of the programs and components of the Lower Feather River Habitat Improvement Plan shall be individually evaluated to assess the overall effectiveness of each action within the Lower Feather River Habitat Improvement Plan.

SWP facilities in the southern Delta include CCF, John E. Skinner Fish Facility, and the Banks Pumping Plant. CCF is a 31,000 af reservoir located in the southwestern edge of the Delta, about ten miles northwest of Tracy. CCF provides storage for off-peak pumping, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the California Aqueduct (CA). Diversions from Old River into CCF are regulated by five radial gates.

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, two miles upstream of the Banks Pumping Plant. The Skinner Fish Facility screens fish away from the pumps that lift water into the CA). Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

The Banks Pumping Plant is in the south Delta, about eight miles northwest of Tracy and marks the beginning of the CA. The plant provides the initial lift of water 244 feet into the CA by means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity. The nominal capacity of the Banks Pumping Plant is 10,300 cfs.

Other SWP operated facilities in and near the Delta include the North Bay Aqueduct (NBA), the Suisun Marsh Salinity Control Gates (SMSCG), Roaring River Distribution System (RRDS), and up to four temporary barriers in the south Delta. Each facility is discussed further in later sections.

Clifton Court Forebay Aquatic Weed Control Program

Dense growth of submerged aquatic weeds in CCF, predominantly *Egeria densa*, can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into "mats," and drift into the trashracks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Ultimately, this all results in a reduction in the volume of water diverted by the State Water Project. Algal blooms in CCF are also problematic because they degrade drinking water quality through tastes and odors and production of algal toxins.

Beginning in 1995, DWR will applied copper based herbicide complexes to control aquatic weeds and algal blooms in CCF. These herbicides included copper sulfate pentahydrate, Komeen,® and Nautique®. These herbicides were appliedon an as-needed basis. Komeen® is a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique® is a copper carbonate compound (see Sepro product labels).

Due to concerns that the pesticide treatments may adversely affect the green sturgeon, during 2006 DWR ceased using aquatic pesticides and employed the use of a mechanical aquatic weed harvester. That practice continues today.

If DWR resumes herbicide treatments, they will occur only in July and August on an as needed basis in the CCF dependent upon the level of vegetation biomass in the enclosure. It is not possible to predict future CCF conditions with climate change. However, the frequency of herbicide applications is not expected to occur more than twice per year, as demonstrated by the history of past applications. Herbicides are typically applied early in the growing season when plants are susceptible to the herbicides due to rapid growth and formation of plant tissues, or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for over wintering senescence.

Aquatic weed management problems in CCF have historically been limited to about 700 acres of the 2,180 total water surface acres. Application of the herbicide during 1995-2006 was limited to only those areas in CCF that require treatment. The copper based herbicides, Komeen® or Nautique, were applied by helicopter or boat to only those portions where aquatic weeds presenedt a management problem to the State.

Historically, algal problems in CCF have been caused by attached benthic cyanobacteria which produce unpleasant tastes and odors in the domestic drinking water derived from the SWP operations. Copper sulfate is applied to the nearshore areas of CCF when results of Solid phase microextraction (SPME) (APHA, 2005) analysis exceed the control tolerances (MIB < 5 ng/L and geosmin < 10 ng/L are not detected by consumers in drinking water supplies). (Aquatic Pesticide Application Plan, 2004). Highest biomass of taste and odor producing cyanobacteria was present in the nearshore areas but not limited to shallow benthic zone. Historically, application areas varied considerably based on the extent of the algal infestation in CCF.

DWR receives Clean Water Act pollutant discharge coverage under the National Pollutant Discharge Elimination System (NPDES) Permit No. CAG990005 (General Permit) issued by the SWRCB for application of aquatic pesticides to the SWP aqueducts, forebays, and reservoirs. The State Board functions as the U.S. Environmental Protection Agency's non-federal representative for implementation of the Clean Water Act in California.

A Mitigated Negative Declaration was prepared by DWR to comply with CEQA requirements associated with regulatory requirements established by the SWRCB. DWR, a public entity, was granted a Section 5.3 Exception by the SWRCB (Water Quality Order 2004-0009-DWQ). Under the exception, DWR is not required to meet the copper limitation in receiving waters during the exception period from March 1 to November 30 as described in the DWR's Aquatic Pesticide Application Plan. DWR's Mitigated Negative Declaration was reviewed by DFG and no comments were submitted. However, to date, neither DWR nor the SWRCB has engaged the Services in section 7 consultations regarding the adverse impacts of the aquatic weed control program on listed fish species within the Forebay as a result of actions undertaken under the authority of DWR's NPDES permit.

Proposed Measures to Reduce Fish Mortality

If DWR resumes application of Komeen® or similar aquatic herbicides, it will be applied according to the manufacturer instructions, following the operational procedures in Table 23, and in accordance with state and federal law. CCF elevation will be raised to +2 feet above mean sea level for an average depth of about 6 feet within the 700-water surface acre treatment zone. The herbicide will be applied at a rate of 13 gallons per surface acre to achieve a final operational concentration in the water body of 0.64 mg/L Cu^{2+}. (640 ppb). The application rate of 13 gallons per surface area is calculated based on mean depth. The product label allows applications up to 1 mg/L (1000 ppb or 1 ppm). DWR applies Komeen in accordance with the product label that states, "If treated water is a source of potable water, the residue of copper must not exceed 1 ppm (mg/L)".

In 2005, 770 surface acres were treated with Komeen®. CCF has a mean depth of 6 feet at 2 feet above mean sea level; thus the volume treated was 4,620 acre-feet.

The concentration of the active ingredient (Cu^{2+}) is calculated from the following equation:

Cu^{2+} (ppm) = Komeen (gallon)/ (Mean Depth (feet) * 3.34)) Source: Komeen® Specimen Label EPA reg No. 67690-25

The calculated concentration of Cu^{2+} for the 2005 application was 0.65 mg/L Cu^{2+}. The copper level required to control *Egeria densa* (the main component of the CCF aquatic plant community) is 0.5 - 0.75 mg/L Cu^{2+}. Source: Komeen® Specimen Label.

Toxicity testing and literature review of LC-50 levels for salmon, steelhead, delta smelt, and green sturgeon were conducted.Once applied, the initial stock copper concentration is reduced rapidly (hours) by dilution (Komeen® applied according to the Specimen Label (SePro Corporation) in the receiving water will achieve final concentration levels. Based on the treatment elevation of +2 feet, only about 20 percent (4,630 AF) of the 22,665 AF CCF will be treated (AF = Acre-feet= volume). If herbicide treatments resume, the copper will be applied beginning on one side of the CCF allowing fish to move out of the treatment area. In addition, Komeen® will be applied by boats at a slower rate than in previous years when a helicopter was used.

North Bay Aqueduct Intake at Barker Slough

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery in Napa and Solano Counties. Maximum pumping capacity is 175 cfs (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs. The current maximum pumping rate is 140 cfs because an additional pump is needed to be installed to reach 175 cfs. In addition, growth of biofilm in a portion of the pipeline is also limiting the NBA ability to reach its full capacity.

The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Per salmon screening criteria, the ten NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish approximately one inch or larger from being entrained. The bays tied to the two smaller units have an approach velocity of about 0.2 ft/s. The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities.

Delta smelt monitoring was required at Barker Slough under the March 6, 1995 OCAP BO. Starting in 1995, monitoring was required every other day at three sites from mid-February through mid-July, when delta smelt may be present and continued monitoring was stopped in 2005. As part of the Interagency Ecological Program (IEP), DWR has contracted with the DFG to conduct the required monitoring each year since that BO was issued. Details about the survey and data are available on DFG's website (http://www.delta.dfg.ca.gov/data/NBA).

Beginning in 2008, the NBA larval sampling was replaced by an expanded 20 mm survey (described at http://www.delta.dfg.ca.gov/data/20mm) that has proven to be fairly effective in tracking delta smelt distribution and reducing entrainment. The expanded survey covers all existing 20-mm stations, in addition to a new suite of stations near NBA. The expanded survey also has an earlier seasonal start and stop date to focus on the presence of larvae in the Delta. TA towed surface boom was the preferred survey gear, as opposed to oblique sled tows that have traditionally been used to sample larval fishes in the San Francisco Estuary.

Coordinated Facilities of the CVP and SWP

Joint Project Facilities

Suisun Marsh

Since the early 1970's, the California Legislature, SWRCB, Reclamation, DFG, Suisun Resource Conservation District (SRCD), DWR, and other agencies have worked to preserve beneficial uses of Suisun Marsh in mitigation for perceived impacts of reduced Delta Outflow on the salinity regime. Early on, salinity standards set by the SWRCB to protect alkali bulrush production, a primary waterfowl plant food. The most recent standard under SWRCB D-1641 acknowledges that multiple beneficial uses deserve protection.

A contractual agreement between DWR, Reclamation, DFG and SRCD contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from the SWP and CVP operations and other upstream diversions. The Suisun Marsh Preservation Agreement (SMPA) requires DWR and Reclamation to meet salinity standards (Figure 15), sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements. In addition to the contractual agreement, SWRCB D-1485 codified salinity standards in 1978, which have been carried forward to SWRCB D-1641.

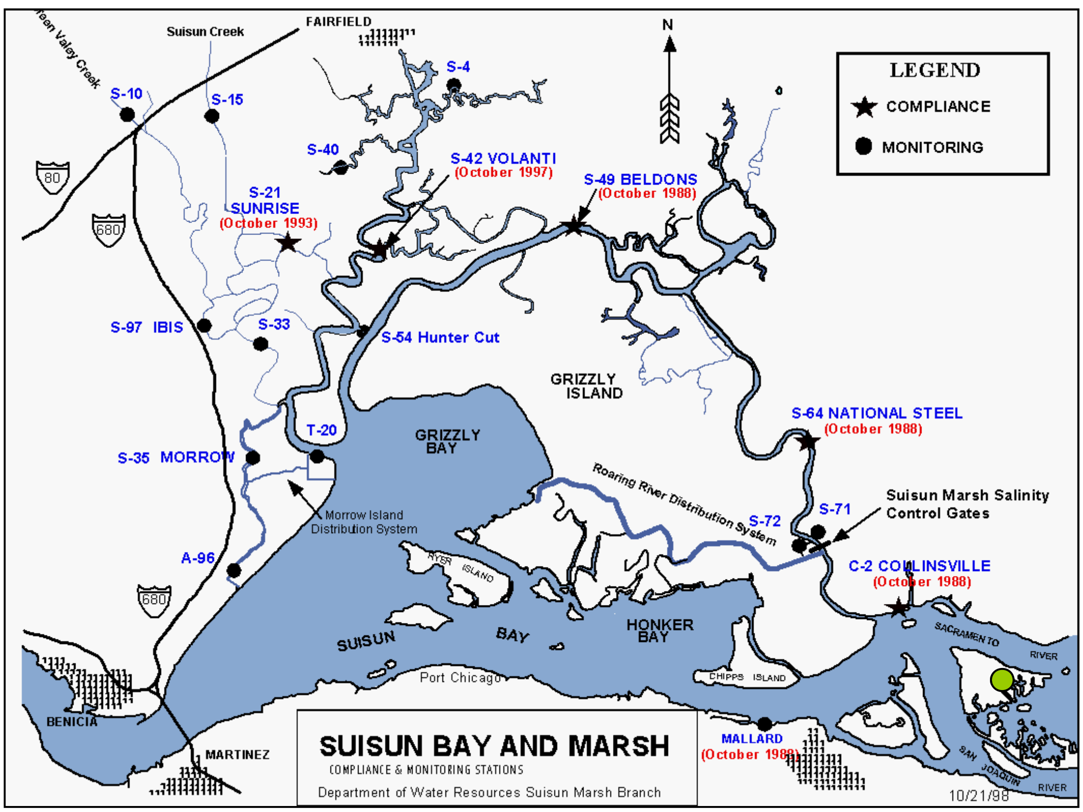


Figure 15. Compliance and monitoring stations and salinity control facilities in Suisun Marsh.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e. facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since the early 1980s and have proven to be a highly reliable method for meeting standards. However, since Delta outflow cannot be actively managed by the Suisun Marsh Program, Marsh facility operations must be adaptive in response to changing salinity levels in the Delta.

CALFED Charter for Development of an Implementation Plan for Suisun Marsh Wildlife Habitat Management and Preservation

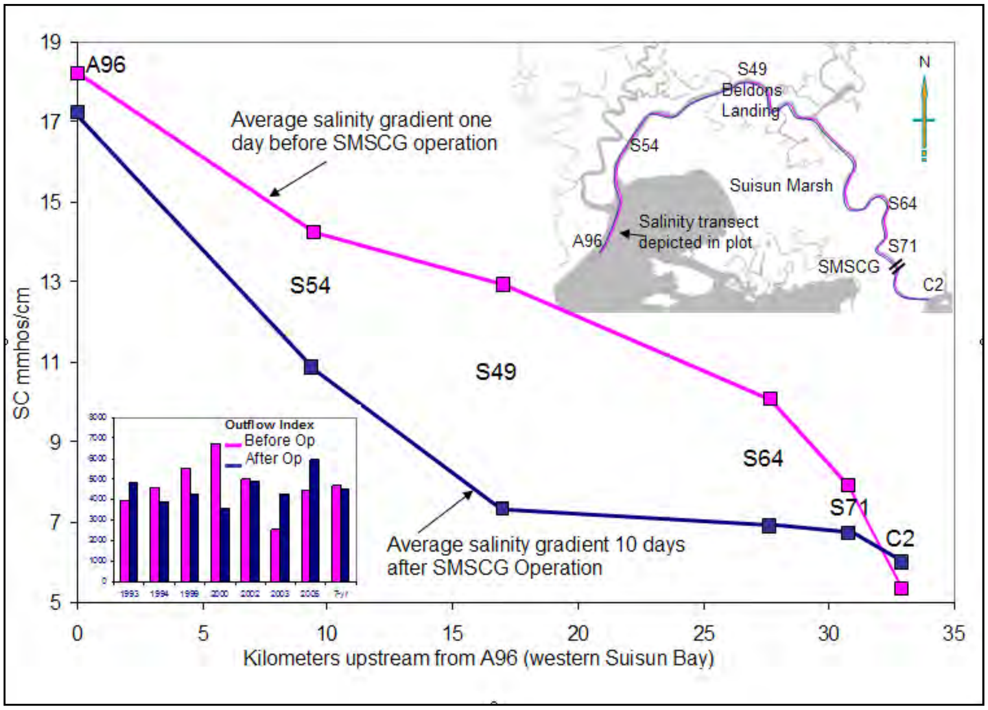
The goal of the CALFED Charter is to develop a regional plan that balances implementation of the CALFED Program, SMPA, and other management and restoration programs within Suisun Marsh. This is to be conducted in a manner that is responsive to the concerns of stakeholders and based upon voluntary participation by private land owners. The Habitat Management, Preservation, and Restoration Plan for the Suisun Marsh (Suisun Marsh Plan) and its accompanying Programmatic Environmental Impact Statement/Report will develop, analyze, and evaluate potential effects of various actions in the Suisun Marsh. The actions are intended to preserve and enhance managed seasonal wetlands, implement a comprehensive levee protection/improvement program, and protect ecosystem and drinking water quality, while restoring habitat for tidal marsh-dependent sensitive species, consistent with the CALFED Bay-Delta Program's strategic goals and objectives. The Service and Reclamation are NEPA co-leads while DFG is the lead state CEQA agency. The Suisun Marsh Plan is anticipated to be finalized in 2011.

Suisun Marsh Salinity Control Gates

The SMSCG are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. Operation of the SMSCG began in October 1988 as Phase II of the Plan of Protection for the Suisun Marsh. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough. The facility, spanning the 465 foot width of Montezuma Slough, consists of a boat lock, a series of three radial gates, and removable flashboards. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west.

When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately +/- 5,000-6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000-6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500-2,800 cfs. The Corps of Engineers permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as October 1, while in some years (e.g. 1996) the gate was not operated at all. When the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season, the flashboards are removed and the gates raised to allow unrestricted movement through Montezuma Slough. Details of annual gate operations can be found in “Summary of Salinity Conditions in Suisun Marsh During WYs 1984-1992", or the “Suisun Marsh Monitoring Program Data Summary” produced annually by DWR, Division of Environmental Services.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at moving the salinity downstream in Montezuma Slough. Salinity is reduced by roughly one-hundred percent at Beldons Landing, and lesser amounts further west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow (measured nominally at Chipps Island) is reduced by gate operation (Figure 16). Net outflow through Carquinez Strait is not affected. Figure 17 indicates the approximate position of X2 and how is transported upstream when the gate is operated.



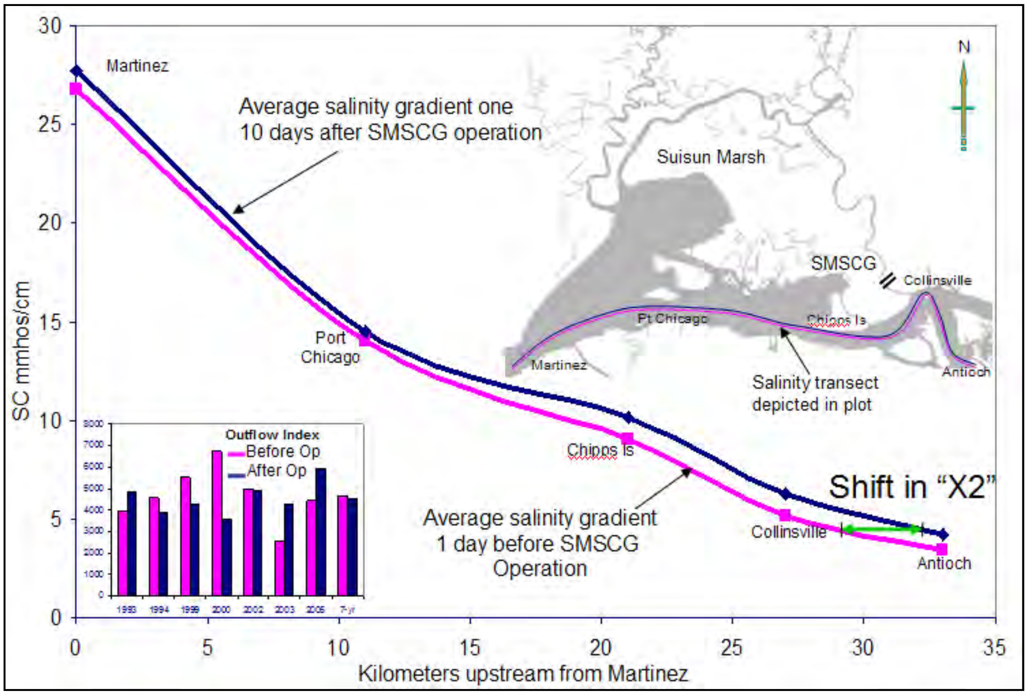


Figure 16. Average of seven years salinity response to SMSCG gate operation in Montezuma Slough and Suisun Bay. (Note: Magenta line is salinity profile 1 day before gate operation; blue line is salinity 10 days after gate operation.)

It is important to note that historical gate operations (1988 – 2002) were much more frequent than recent and current operations (2006 – May 2008). Operational frequency is affected by many drivers (hydrologic conditions, weather, Delta outflow, tide, fishery considerations, etc). The gates have also been operated for scientific studies. **Error! Reference source not found.** shows that the gates were operated between 60 and 120 days between October and December during the early years (1988-2004). Salmon passage studies between 1998 and 2003 increased the number of operating days by up to 14 to meet study requirements. After discussions with NMFS based on study findings, the boat lock portion of the gate is now held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. With increased understanding of the effectiveness of the gates in lowering salinity in Montezuma Slough, salinity standards have been met with less frequent gate operation since 2006. Despite very low outflow in the fall of the two most recent WYs, gate operation was not required at all in fall 2007 and was limited to 17 days in winter 2008 21 days in 2009 and 22 days in 2010. Assuming no significant, long-term changes in the drivers mentioned above, this level of operational frequency (10 – 22 days per year) can generally be expected to continue to meet standards in the future except perhaps during the most critical hydrologic conditions and/or other conditions that affect Delta outflow.

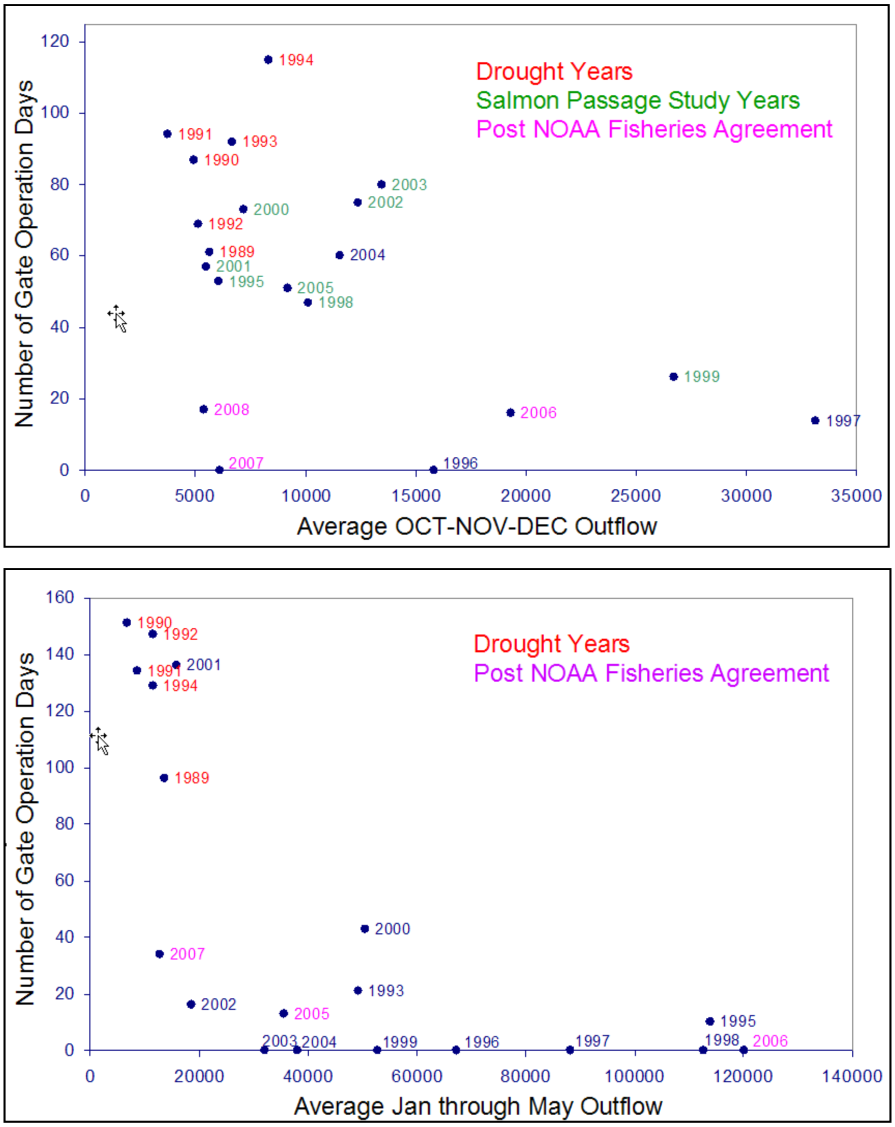


Figure 17. SMSCG operation frequency versus outflow since 1988.

SMSCG Fish Passage Study

The SMSCG were constructed and operate under Permit 16223E58 issued by the Corps, which includes a special condition to evaluate the nature of delays to migrating fish. Ultrasonic telemetry studies in 1993 and 1994 showed that the physical configuration and operation of the gates during the Control Season have a negative effect on adult salmonid passage (Tillman et al 1996: Edwards et al 1996).

DWR coordinated additional fish passage studies in 1998, 1999, 2001, 2002, 2003, and 2004. Migrating adult fall-run Chinook salmon were tagged and tracked by telemetry in the vicinity of the SMSCG to assess potential measures to increase the salmon passage rate and decrease salmon passage time through the gates.

Results in 2001, 2003, and 2004 indicate that leaving the boat-lock open during the Control Season when the flashboards are in place at the SMSCG and the radial gates are tidally operated provides a nearly equivalent fish passage to the Non-Control Season configuration when the flashboards are out and the radial gates are open. This approach minimizes delay and blockage of adult Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead migrating upstream during the Control Season while the SMSCG is operating. However, the boat-lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

Reclamation and DWR are continuing to coordinate with the SMSCG Steering Committee in identifying water quality criteria, operational rules, and potential measures to facilitate removal of the flashboards during the Control Season that would provide the most benefit to migrating fish. However, the flashboards would not be removed during the Control Season unless it was certain that standards would be met for the remainder of the Control Season without the flashboards installed.

Roaring River Distribution System

The RRDS was constructed during 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The system was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of DFG managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands.

The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides.

Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. DWR designed and installed the screens based on DFG criteria. The screen is a stationary vertical screen constructed of continuous-slot stainless steel wedge wire. All screens have 3/32-inch slot openings. After the listing of delta smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.2 ft/s at the intake fish screen. Initially, the intake culverts were held at about 20 percent capacity to meet the velocity criterion at high tide. Since 1996, the motorized slide gates have been operated remotely to allow hourly adjustment of gate openings to maximize diversion throughout the tide.

Routine maintenance of the system is conducted by DWR and primarily consists of maintaining the levee roads and fish screens. RRDS, like other levees in the marsh, have experienced subsidence since the levees were constructed in 1980. In 1999, DWR restored all 16 miles of levees to design elevation as part of damage repairs following the 1998 flooding in Suisun Marsh. In 2006, portions of the north levee were repaired to address damage following the January 2006 flooding.

Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 in the south-western Suisun Marsh as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The contractual requirement for the Reclamation and DWR is to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough (GYS).

The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles in length and the C-Line ditch is approximately 0.8 miles in length.

The 1997 Service biological opinion issued for dredging of the facility included a requirement for screening the diversion to protect delta smelt. Due to the high cost of fish screens and the lack of certainty surrounding their effectiveness at MIDS, DWR and Reclamation proposed to investigate fish entrainment at the MIDS intake with regard to fishery populations in Goodyear Slough and to evaluate whether screening the diversion would provide substantial benefits to local populations of listed fish species. DWR and Reclamation are analyzing conservation alternatives to a fish screen in coordination with FWS and DFG to meet this requirement.

To meet contractual commitments, the typical MIDS annual operations are described in detail in the biological assessment. There are currently no plans to modify operations.

South Delta Temporary Barriers Project

The South Delta Temporary Barrier Project (TBP) was initiated by DWR in 1991. Permit extensions were granted in 1996, 2001, 2008 and 2011, when DWR obtained permits to extend the Temporary Barriers Project through 2016. The current Biological Opinion issued by the FWS for the construction and demolition effects is still applicable. Continued coverage by FWS for the TBP operational effects is separate and will be assessed under this BA for the continued long-term operation of the SWP and CVP. The NMFS recently submitted a biological opinion to the Corps which provides incidental take coverage for the construction of the TBP in 2011. DWR will re-initiate consultation with NMFS via Corps to extend the TBP construction coverage through 2016. DWR plans to seek approvals through 2016 prior to 2012 construction, and Corps and NMFS staff are supportive of a multiple year BO and Corps permit. The project consists of four rock barriers across south Delta channels. In various combinations, these barriers improve water levels and San Joaquin River salmon migration in the south Delta. The existing TBP consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal
- Old River near Tracy, about 0.5 miles east of the DMC intake
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge
- The head of Old River at the confluence of Old River and San Joaquin River

The barriers on Middle River, Old River near Tracy, and Grant Line Canal are flow control facilities designed to improve water levels for agricultural diversions and are in place during the irrigation season. Under the FWS BO for the Temporary Barriers, operation of the barriers at Middle River and Old River near Tracy can begin May 15, or as early as April 15 if the spring barrier at the head of Old River is in place. From May 16 to May 31 (if the barrier at the head of Old River is removed) the tide gates are tied open in the barriers in Middle River and Old River near Tracy. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

During the spring, the barrier at the head of Old River is designed to reduce the number of out-migrating salmon smolts entering Old River. During the fall, this barrier is designed to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook salmon. The barrier at the head of Old River barrier is typically in place between April 15 to May 15 for the spring, and between early September to late November for the fall. Installation and operation of the barrier at the head of Old river also depends on the San Joaquin flow conditions.

Proposed Installation and Operations of the Temporary Barriers

The installation and operation of the TBP is planned to continue indefinitely. The proposed installation schedule through 2010 will be identical to the current schedule. However, because of recent court rulings to protect Delta smelt, the installation of the spring HOR barrier is prohibited for 2016. As a result, the agricultural barriers installations are delayed according to the current permits until mid-May.

In lieu of the HOR spring rock barrier, an experimental non-physical barrier was installed in 2009 and 2010 with the intention of deterring out-migrating juvenile salmonids from entering Old River. This experimental barrier is a patented technology using sound and light as a deterrent. Although high flows prohibited installation of the non-physical barrier in 2011, a without-barrier study of predator behavior was conducted. The barrier designed for installation in 2011 is planned to be installed in 2012.

To improve water circulation and quality, DWR in coordination with the South Delta Water Agency and Reclamation, began in 2007 to manually tie open the culvert flap gates at the Old River near Tracy barrier to improve water circulation and untie them when water levels fell unacceptably. This operation is expected to continue in subsequent years as needed to improve water quality. In addition, DWR has consulted with Corps and received FWS and NMFS approval to raise the Middle River weir height by one foot. The weir height will be raised during the summer irrigation season only after Delta smelt concerns have passed. The requested modification was approved late in the 2010 irrigation season, and although approval for 2011 has been received the weir has not needed to be raised because of high river flows.

In the absence of permanent operable gates, the TBP will continue as planned and permitted. Computer model forecasts, real time monitoring, and coordination with local, State, and federal agencies and stakeholders will help determine if the temporary rock barriers operations need to be modified during the transition period.

Conservation Strategies and Mitigation Measures for TPB

Various measures and conditions required by regulatory agencies under past and current permits to avoid, minimize, and compensate for the TBP effects have been complied with by DWR. An ongoing monitoring plan is implemented each year the barriers are installed and an annual monitoring report is prepared to summarize the activities. The monitoring elements include fisheries monitoring and water quality analysis, salmon smolt survival investigations, barrier effects on SWP and CVP entrainment, Swainson's Hawk monitoring, water elevation, water quality sampling, and hydrologic modeling. DWR operates fish screens to offset TBP impacts at Sherman Island. Studies of predator behavior in the vicinity of the non-physical barrier began in 2011 as required by DFG.

The 2008 NMFS BO for the TBP requires a fisheries monitoring program using biotelemetry techniques to examine the movements and survival of juvenile salmon and juvenile steelhead through the channels of the south Delta. The BO also requires that predation effects associated with the barriers be examined. Information gained as part of the 2009 pilot study was used to develop the full scale study that started in 2010. 2011 was the third and final year of the studies mandated in the 2008 BO. Any future telemetry studies at the barriers would be required from a subsequent BO.

The DFG Incidental Take Permit provides California Endangered Species coverage through 2016. Six acres of shallow water habitat is required by this permit and will be provided through a purchase from the Wildlands Liberty Island mitigation bank.

San Luis Complex

Water in the mainstem of the California Aqueduct flows south by gravity into the San Luis Joint-Use Complex (Figure 18), which was designed and constructed by the federal government and is operated and maintained by the DWR. This section of the California Aqueduct serves both the SWP and the federal CVP.

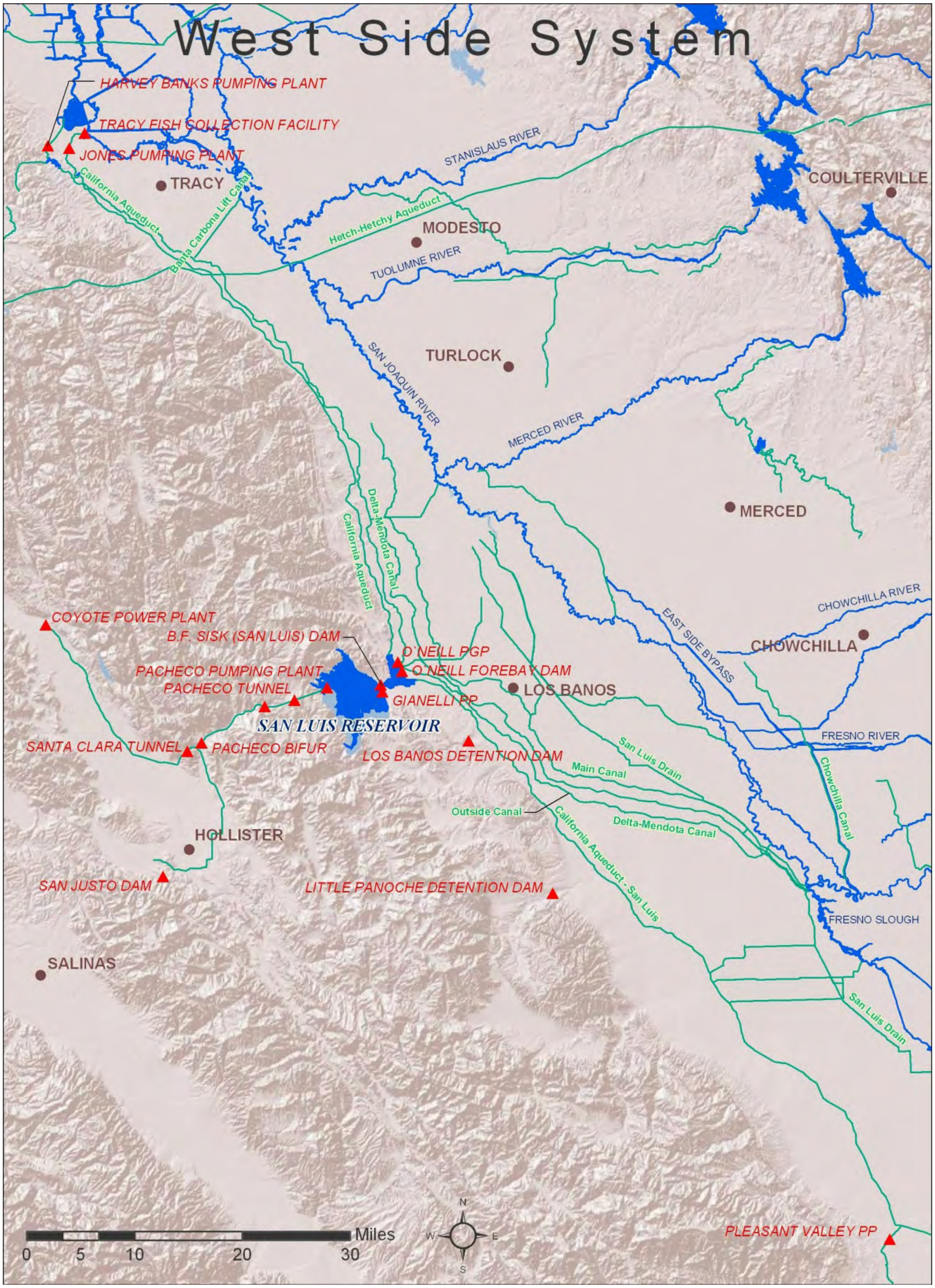


Figure 18. San Luis Complex

San Luis Reservoir, the nation's largest offstream reservoir (it has no natural watershed), is impounded by Sisk Dam, lies at the base of the foothills on the west side of the San

Joaquin Valley in Merced County, about two miles west of O'Neill Forebay. The reservoir provides offstream storage for excess winter and spring flows diverted from the Delta. It is sized to provide seasonal carryover storage. The reservoir can hold 2,027,840 AF, of which 1,062,180 AF is the state's share, and 965,660 AF is the federal share. Construction began in 1963 and was completed in 1967. Filled in 1969, the reservoir also provides a variety of recreational activities as well as fish and wildlife benefits.

In addition to the Sisk Dam, San Luis Reservoir and O'Neill Dam and Forebay, the San Luis Complex consists of the following: (1) O'Neill Pumping-Generating Plant (Federal facility); (2) William R. Gianelli Pumping-Generating Plant (joint Federal-State facilities); (3) San Luis Canal (joint Federal-State facilities); (4) Dos Amigos Pumping Plant (joint Federal-State facilities); (5) Coalinga Canal (Federal facility); (6) Pleasant Valley Pumping Plant (Federal facility); and (7) the Los Banos and Little Panoche Detention Dams and Reservoirs (joint Federal-State facilities).

The O'Neill Pumping-Generating Plant pumps water from the Delta-Mendota Canal to the O'Neill Forebay where it mixes with water from the California Aqueduct. From O'Neill Forebay, the water can either be pumped up into San Luis Reservoir via Gianelli Pumping-Generating Plant or leave via the San Luis Canal. The Dos Amigos Pumping Plant is located on the San Luis Canal and 18 miles southeast of Sisk Dam. It lifts water 113 feet from the Aqueduct as it flows south from O'Neill Forebay.

Los Banos Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta Mendota Canal, the City of Los Banos, and other downstream developments. Between September and March, 14,000 AF of space is maintained for flood control under specified conditions. Little Panoche Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta Mendota Canal and other downstream developments. Water is stored behind the dam above dead storage of 315 AF only during the period that inflow from Little Panoche Creek exceeds the capacity of the outlet works.

To provide water to CVP and SWP contractors: (1) water demands and anticipated water schedules for water service contractors and exchange contractors must be determined; (2) a plan to fill and draw down San Luis Reservoir must be made; and (3) Delta pumping and San Luis Reservoir use must be coordinated.

The San Luis Reservoir has very little natural inflow. Water is redirected during the fall, winter and spring months when the two pumping plants can divert more water from the Delta than is needed for scheduled demands. Because the amount of water that can be diverted from the Delta is limited by available water supply, Delta constraints, and the capacities of the two pumping plants, the fill and drawdown cycle of San Luis Reservoir is an extremely important element of Project operations.

Reclamation attempts to maintain adequate storage in San Luis Reservoir to ensure delivery capacity through Pacheco Pumping Plant to the San Felipe Division. Delivery capacity is significantly diminished as reservoir levels drop to the 326 ft elevation (79,000 acre-feet), the bottom of the lowest Pacheco Tunnel Inlet pipe. Lower reservoir elevations can also result in turbidity and algal treatment problems for the San Felipe Division water users. These conditions of reduced or impending interruption in San Felipe Division deliveries require operational responses by Santa Clara Valley Water

District to reduce or eliminate water deliveries for in-stream and offstream groundwater recharge, and to manage for treatment plant impacts. Depending on availability of local supplies, prolonged reduction or interruption in San Felipe Division deliveries may also result in localized groundwater overdraft.

A typical San Luis Reservoir annual operation cycle starts with the CVP's share of the reservoir storage nearly empty at the end of August. Irrigation demands decrease in September and the opportunity to begin refilling San Luis Reservoir depends on the available water supply in the northern CVP reservoirs and the pumping capability at Jones Pumping Plant that exceeds water demands. Jones Pumping Plant operations generally continue at the maximum diversion rates until early spring, unless San Luis Reservoir is filled or the Delta water supply is not available. As outlined in the Interior's Decision on Implementation of Section 3406 (b)(2) of the CVPIA, Jones Pumping Plant diversion rates may be reduced during the fill cycle of the San Luis Reservoir for fishery management.

In April and May, export pumping from the Delta is limited during the SWRCB D-1641 San Joaquin River pulse period standards as well as by the Vernalis Adaptive Management Program. During this same time, CVP-SWP irrigation demands are increasing. Consequently, by April and May the San Luis Reservoir has begun the annual drawdown cycle. In some exceptionally wet conditions, when excess flood water supplies from the San Joaquin River or Tulare Lake Basin occur in the spring, the San Luis Reservoir may not begin its drawdown cycle until late in the spring.

In July and August, the Jones Pumping Plant diversion is at the maximum capability and some CVP water may be exported using excess Banks Pumping Plant capacity as part of a Joint Point of Diversion operation. Irrigation demands are greatest during this period and San Luis continues to decrease in storage capability until it reaches a low point late in August and the cycle begins anew (Figure 19, Table 22).

San Luis Unit Operation

The CVP operation of the San Luis Unit requires coordination with the SWP since some of its facilities are entirely owned by the State and others are joint State and Federal facilities. Similar to the CVP, the SWP also has water demands and schedules it must meet with limited water supplies and facilities. Coordinating the operations of the two projects avoids inefficient situations (for example, one entity pumping water at the San Luis Reservoir while the other is releasing water).

Total CVP San Luis Unit annual water supply is contingent on coordination with the SWP needs and capabilities. When the SWP excess capacity is used to support additional pumping for the CVP JPOD allowance it may be of little consequence to SWP operations, but extremely critical to CVP operations. The availability of excess SWP capacity for the CVP is contingent on the ability of the SWP to meet its SWP contractors' water supply commitments. Generally, the CVP will utilize excess SWP capacity; however, there are times when the SWP may need to utilize excess CVP capacity. Additionally, close coordination by CVP and SWP is required during this type of operation to ensure that water pumped into O'Neill Forebay does not exceed the CVP's capability to pump into San Luis Reservoir or into the San Luis Canal at the Dos Amigos Pumping Plant.

Although secondary to water management concerns, power scheduling at the joint facilities also requires close coordination. Because of time-of-use power cost differences, both entities will likely want to schedule pumping and generation simultaneously. When facility capabilities of the two projects are limited, equitable solutions are achieved between the operators of the SWP and the CVP.

From time to time, coordination between the Projects is also necessary to avoid sustained rapid drawdown limit at San Luis Reservoir which can cause sloughing of the bank material into the reservoir, resulting in water quality degradation and requiring additional maintenance on the dam.

With the existing facility configuration, the operation of the San Luis Reservoir could impact the water quality and reliability of water deliveries to the San Felipe Division, if San Luis Reservoir is drawn down too low. Reclamation has an obligation to address this condition and may solicit cooperation from DWR, as long as changes in SWP operations to assist with providing additional water in San Luis Reservoir (beyond what is needed for SWP deliveries and the SWP share of San Luis Reservoir minimum storage) does not impact SWP allocations and/or deliveries. If the CVP is not able to maintain sufficient storage in San Luis Reservoir, there could be potential impacts to resources in Santa Clara and San Benito Counties. Solving the San Luis low point problem or developing an alternative method to deliver CVP water to the San Felipe Division would allow Reclamation to utilize the CVP share of San Luis Reservoir fully without impacting the San Felipe Division water supply. If Reclamation pursues changes to the operation of the CVP (and SWP), such changes would have to be consistent with the operating criteria of the specific facility. If alternate delivery methods for the San Felipe Division are implemented, it may allow the CVP to utilize more of it available storage in San Luis Reservoir, but may not change the total diversions from the Delta. For example, any changes in Delta pumping that would be the result of additional effective storage capacity in San Luis Reservoir would be consistent with the operating conditions for the Banks and Jones Pumping Plants.

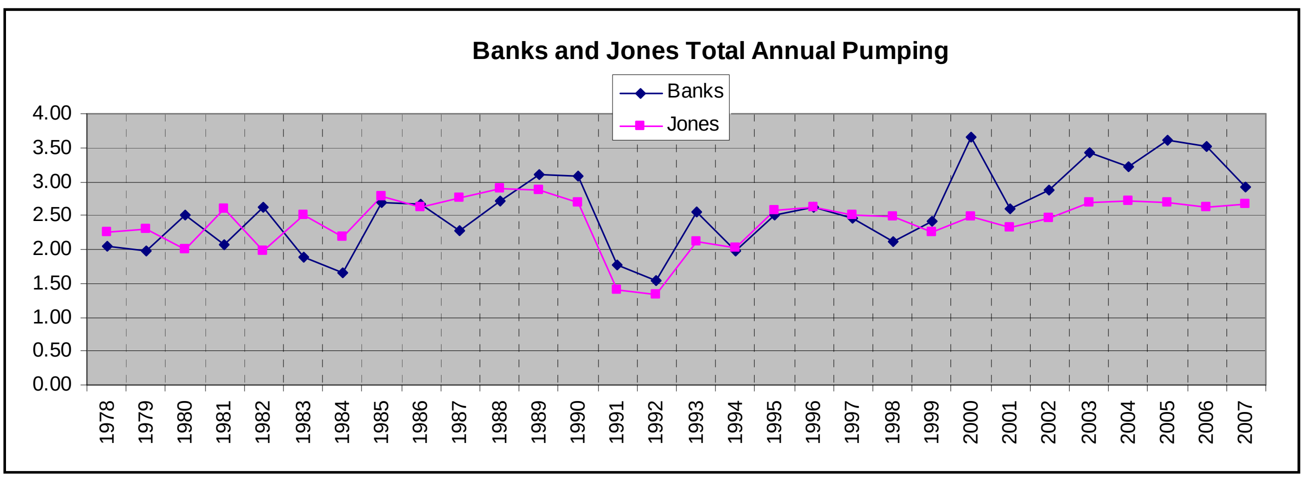


Figure 19. Total Annual Pumping at Banks and Jones Pumping Plant 1978-2007 (MAF)

Table 22. Total Annual Pumping at Banks and Jones Pumping Plant 1978-2007 (MAF)

WY	Hydrologic Index 40-30-30	Banks SWP	Banks CVP	Banks Total	Jones SWP	Jones CVP	Jones Total	Contra Costa	CVP Total Delta Pumping	SWP Total Delta Pumping	CVP SOD-Ag Allocation	Shasta Index Critical
1978	AN	2.01	0.04	2.05	0.00	2.26	2.26	0.08	2.38	2.01	100%	
1979	BN	1.76	0.23	1.98	0.00	2.30	2.30	0.09	2.61	1.76	100%	
1980	AN	2.17	0.34	2.52	0.00	2.00	2.00	0.09	2.43	2.17	100%	
1981	D	1.97	0.10	2.07	0.00	2.60	2.60	0.11	2.80	1.97	100%	
1982	W	2.43	0.20	2.63	0.00	1.97	1.97	0.08	2.25	2.43	100%	
1983	W	1.76	0.13	1.89	0.00	2.51	2.51	0.08	2.72	1.76	100%	
1984	W	1.40	0.25	1.65	0.00	2.19	2.19	0.10	2.54	1.40	100%	
1985	D	2.16	0.53	2.68	0.00	2.79	2.79	0.11	3.43	2.16	100%	
1986	W	2.46	0.21	2.67	0.00	2.62	2.62	0.11	2.94	2.46	100%	
1987	D	2.01	0.27	2.28	0.00	2.76	2.76	0.13	3.16	2.01	100%	
1988	C	2.32	0.38	2.71	0.00	2.90	2.90	0.14	3.42	2.32	100%	
1989	D	2.70	0.39	3.10	0.00	2.87	2.87	0.13	3.40	2.70	100%	
1990	C	2.85	0.24	3.09	0.00	2.70	2.70	0.14	3.07	2.85	50%	
1991	C	1.64	0.14	1.78	0.00	1.41	1.41	0.11	1.65	1.64	25%	C
1992	C	1.51	0.04	1.55	0.00	1.34	1.34	0.10	1.49	1.51	25%	C
1993	AN	2.53	0.02	2.56	0.00	2.11	2.11	0.10	2.22	2.53	50%	
1994	C	1.73	0.24	1.97	0.00	2.02	2.02	0.11	2.37	1.73	35%	C
1995	W	2.48	0.03	2.50	0.00	2.58	2.58	0.09	2.70	2.48	100%	
1996	W	2.60	0.01	2.61	0.06	2.57	2.63	0.10	2.68	2.66	95%	
1997	W	2.12	0.34	2.46	0.00	2.51	2.51	0.11	2.96	2.12	90%	
1998	W	2.07	0.04	2.11	0.01	2.46	2.47	0.16	2.66	2.09	100%	
1999	W	2.37	0.04	2.41	0.00	2.26	2.26	0.13	2.44	2.37	70%	
2000	AN	3.45	0.22	3.66	0.00	2.49	2.49	0.13	2.83	3.45	65%	
2001	D	2.37	0.23	2.60	0.01	2.31	2.32	0.10	2.65	2.38	49%	
2002	D	2.70	0.17	2.87	0.00	2.46	2.46	0.12	2.75	2.70	70%	
2003	AN	3.39	0.04	3.43	0.00	2.68	2.68	0.14	2.86	3.39	75%	
2004	BN	3.14	0.09	3.23	0.00	2.72	2.72	0.12	2.93	3.14	70%	
2005	AN	3.58	0.03	3.61	0.00	2.68	2.68	0.12	2.83	3.58	85%	
2006	W	3.50	0.01	3.51	0.00	2.62	2.62	0.12	2.74	3.50	100%	
2007	D	2.82	0.11	2.93	0.00	2.67	2.67	0.11	2.90	2.82	50%	

Source: CVO Operations Data Base

Transfers

California Water Law and the CVPIA promote water transfers as important water resource management measures to address water shortages provided certain protections to source areas and users are incorporated into the water transfer. Parties seeking water transfers generally acquire water from sellers who have surplus reservoir storage water, sellers who can pump groundwater instead of using surface water, or sellers who will fallow crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions.

Water transfers (relevant to this document) occur when a water right holder within the Sacramento-San Joaquin River watershed undertakes actions to make water available for transfer by export through the Delta. With the exception of the Component 1 pursuant to the Yuba River Accord discussed below, this BA does not address the upstream operations that may be necessary to make water available for transfer. Also, this document does not address the impacts of water transfers to terrestrial species.

Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities is available to move the water. Additionally, operations to accomplish these transfers must be carried out in close coordination with CVP and SWP operations, such that the capabilities of the Projects to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way.

In particular, parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. All transfers will be in accordance with all existing regulations and requirements.

Purchasers of water for transfers may include Reclamation, CVP Contractors, DWR, SWP contractors, other State and Federal agencies, or other parties. DWR and Reclamation have operated water acquisition programs in the past to provide water for environmental programs and additional supplies to SWP contractors, CVP contractors, and other parties. Past transfer programs include:

- DWR administrated the 1991, 1992, 1994, and 2009 Drought Water Banks and Dry Year Programs in 2001 and 2002
- Reclamation operated a forbearance program in 2001 by purchasing CVP contractors’ water in the Sacramento Valley for CVPIA in-stream flows, and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery in-stream flows.
- DWR, and potentially Reclamation in the future, has agreed to participate in the Yuba River Accord that will provide fish flows on the Yuba River and also water supply that may be transferred at DWR and Reclamation Delta Facilities
- Also in the past, CVP and SWP contractors have independently acquired water and arranged for pumping and conveyance through SWP facilities. State Water Code provisions grant other parties access to unused conveyance capacity from the SWP, although SWP contractors have priority access to capacity not being used by the DWR to meet SWP contract amounts.

Yuba River Accord

The Yuba River Accord includes three sets of agreements designed to protect and enhance fisheries resources in the lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to state and federal water contractors. These agreements are the:

- Lower Yuba River Fisheries Agreement (Fisheries Agreement)
- Agreements for the Conjunctive Use of Surface and Groundwater Supplies (Conjunctive Use Agreements)
- Agreement for the Long-term Purchase of Water from Yuba County Water Agency by the Department of Water Resources (Water Purchase Agreement)

The Fisheries Agreement is the cornerstone of the Yuba Accord. It was developed by state, federal, and consulting fisheries biologists, fisheries advocates, policy representatives, and the YCWA. Compared to the interim flow requirements of the SWRCB Revised Water Right Decision 1644 (RD-1644), the Fisheries Agreement establishes higher minimum instream flows during most months of most water years.

To assure that Yuba County Water Agency's (YCWA) water supply reliability is not reduced by the higher minimum instream flows and water transfers, YCWA and seven of its Member Units have signed Conjunctive Use Agreements. These agreements establish a conjunctive use program that facilitates the integration of the surface water and groundwater supplies of the seven local irrigation districts and mutual water companies that YCWA serves in Yuba County. Integration of surface water and groundwater allows YCWA to increase the efficiency of its water management.

Under the Water Purchase Agreement, DWR administers the water transfer activities. The Water Transfer Agreement allows DWR to purchase water from YCWA to generally off-set water costs resulting from export restrictions in April and May each year to benefit out-migrating San Joaquin River salmonids.. This quantity of water is known as "C1" under the Water Purchase Agreement and is quantified as a 60,000 AF of water from YCWA that generally can produce a mitigation offset of approximately 48,000 AF of reduced exports.

Additional water supplies purchased by the SWP contractors and/or CVP contractors under the Water Purchase Agreement is administered by DWR as a water transfer program in drier years. Reclamation is not a signatory to the Water Purchase Agreement, but may consider partnering under the agreement at a future date.

All three sets of agreements (Fisheries, Water Purchase, and Conjunctive Use) completed CEQA and NEPA review in 2007 and were fully executed between late 2007 and early 2008. The SWRCB approved the flow schedules and water transfer aspects of the Yuba River Accord on March 18, 2008. The Fisheries Agreement expires in 2015, the Water Purchase Agreement expires in 2025, and the expiration of the Conjunctive Use Agreements is contingent on the Fisheries and Water Purchase Agreement expiration terms. The FERC license for the Yuba River Development Project expires in April 2016.

A new FERC license is expected to impose new flow requirements, and a renegotiation of the agreements is expected to be required at that time.

Transfer Capacity

The assumption in this BA is that under both existing conditions and in the future, water transfer programs for environmental and water supply augmentation will continue in some form, and that in most years (all but the driest), the scope of annual water transfers will be limited by available Delta pumping capacity, and exports for transfers will be limited to the months July-September. As such, looking at an indicator of available transfer capacity in those months is one way of estimating an upper boundary to the effects of transfers on an annual basis.

The CVP and SWP may provide Delta export pumping for transfers using pumping capacity at Banks and Jones beyond that which is being used to deliver project water supply, up to the physical maximums of the pumps, consistent with prevailing operations constraints such as E/I ratio, conveyance or storage capacity, and any protective criteria in effect that may apply as conditions on such transfers. For example, pumping for transfers may have conditions for protection of Delta water levels, water quality, fisheries, or other beneficial uses.

The surplus capacity available for transfers will vary a great deal with hydrologic conditions. In general, as hydrologic conditions get wetter, surplus capacity diminishes because the CVP and SWP are more fully using export pumping capacity for Project supplies. CVP's Jones Pumping Plant has little surplus capacity, except in the driest hydrologic conditions. SWP has the most surplus capacity in critical and some dry years, less or sometimes none in most median hydrologic conditions, and some surplus again in some above normal and wet years when demands may be lower because some water users may have alternative supplies.

The availability of water for transfer and the demand for transferred water may also vary with hydrologic conditions. Accordingly, since many transfers are negotiated between willing buyers and sellers under prevailing market conditions, price of water also may be a factor determining how much is transferred in any year. This document does not attempt to identify how much of the available and useable surplus export capacity of the CVP and SWP will actually be used for transfers in a particular year, but given the recent history of water transfer programs and requests for individual water transfers, trends suggest a growing reliance on transfers to meet increasing water demands.

Under both the present and future conditions, capability to export transfers will often be capacity-limited, except in Critical and some Dry years. In Critical and some Dry years, both Banks and Jones will likely have surplus capacity for transfers. As a result, export capacity is less likely to limit transfers in these years. During such years, low project exports and high demand for water supply could make it possible to transfer larger amounts of water.

Proposed Exports for Transfers

Although transfers may occur at any time of year, this BA covers proposed exports for transfers during only the months July through September. For transfers outside those months, or in excess of the proposed amounts, Reclamation and DWR would request separate consultation. In consideration of the estimates of available capacity for export of transfers during July-September, and in recognition of the many other possible operations contingencies and constraints that may limit actual use of that capacity for transfers, the proposed use of SWP/CVP export capacity for transfers is as follows:

Water Year Class	Maximum Transfer Amount
Critical	up to 600 kaf
Dry (following Critical)	up to 600 kaf
Dry (following Dry)	up to 600 kaf
All other Years	up to 360 kaf

Other Projects

The following projects may not have final approval. However, Reclamation believes they may be implemented in the near term. Reclamation is including these actions in the project description so that the effects of these actions on aquatic species may be analyzed as it pertains to operations. The analysis does not include any effects to terrestrial species. These will be addressed in separate construction consultation.

Sacramento River Reliability Project

The Sacramento River Reliability Project (SRRP) consists of constructing an in-river intake and fish screens (Elverta Diversion) on the Sacramento River at RM 74.6 and support facilities, north of Elverta Road, in Sacramento County. The SRRP includes realignment of 0.3 miles of the Garden Highway near the new Elverta intake structure; constructing a 235 mgd (365 cfs) North Natomas water treatment plant near the new intake facility, water pipelines from the intake structure to the North Natomas water treatment plant, a booster pump station, and 27 to 30 miles of new underground treated water pipelines from the North Natomas water treatment plant to connection points within existing water distribution systems of Placer County Water Agency (PCWA), City of Roseville (Roseville), Sacramento Suburban Water District (SSWD), and City of Sacramento (Sacramento).

Diversion from the SRRP would be made as described below:

- PCWA would divert its 35-taf CVP water from the Elverta Diversion.
- SSWD would divert up to 29 taf of PCWA's MFP water from the Elverta Diversion through exchange with the CVP during Water Forum non-wet years.
- Roseville would divert its CVP water first, and MFP water next, at Folsom Dam in accordance with its WFA limitation on American River Diversion (maximum annual amount of 54.9 taf). Roseville would also receive 4 taf transfer of MFP water from SJWD at Folsom Dam during Water Forum wet and average years. Roseville would divert from Elverta Diversion the remaining of 30 taf PCWA's

MFP water not diverted at Folsom Dam through exchange with CVP due to its WFA limitation on diversion from the American River.

- For the City of Sacramento diversion priority would be the (1) Fairbairn WTP, (2) North Natomas WTP, and (3) Sacramento River WTP. The annual diversion amount at Fairbairn WTP is subject to WFA limitations (varied with hydrological conditions) while the annual diversion amount at the North Natomas WTP is up to Sacramento's Sacramento River water right (81.8 taf per year). The diversion amount at Sacramento River WTP is intended to meet the remaining demand after diversions from Fairbairn WTP and North Natomas WTP.

DMC/CA Intertie Proposed Action

DMC and CA Intertie (DMC/CA Intertie) is currently under construction. The project consists of a pumping plant and pipeline connections between the DMC and the CA. The DMC/CA Intertie Pumping Plant is located at DMC milepost 7.2 where the DMC and the CA are about 500 feet apart.

The DMC/CA Intertie will be used in a number of ways to achieve multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies. The Intertie will allow flow in both directions, which would provide additional flexibility to both CVP and SWP operations. The Intertie includes a pumping plant at the DMC that will allow up to 467 cfs to be pumped from the DMC to the CA. Up to 900 cfs can be conveyed from the CA to the DMC using gravity flow.

The DMC/CA Intertie will be operated by the San Luis and Delta-Mendota Water Authority (Authority). Agreements between Reclamation, DWR, and the Authority will identify the responsibilities and procedures during operation of the Intertie.

Operations

The Intertie will be used under three different scenarios:

1. Up to 467 cfs may be pumped from the DMC to the CA to ease DMC conveyance constraints and help meet water supply demands of CVP contractors. This would allow Jones Pumping Plant to pump to its design capacity of up to 4,600 cfs, subject to all applicable export pumping restrictions for water quality and fishery protections.
2. Up to 467 cfs may be pumped from the DMC to the CA to minimize impacts to water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the Intertie) or the upper CA (north of the Intertie) for system maintenance or due to an emergency shutdown.
3. Up to 900 cfs may be conveyed from the CA to the DMC using gravity flow to minimize impacts to water deliveries due to temporary restrictions in flow or water levels on the lower CA (south of the Intertie) or the upper DMC (north of the Intertie) for system maintenance or due to an emergency shutdown.

The DMC/CA Intertie provides operational flexibility between the DMC and CA. It will not result in any changes to authorized pumping capacity at Jones Pumping Plant or Banks Delta Pumping Plant.

Water conveyed at the Intertie to minimize reductions to water deliveries during system maintenance or an emergency shutdown on the DMC or CA can include pumping of CVP water at Banks Pumping Plant or SWP water at Jones Pumping Plant through use of JPOD. In accordance with COA Articles 10(c) and 10(d), JPOD may be used to replace conveyance opportunities lost because of scheduled maintenance, or unforeseen outages. Use of JPOD for this purpose can occur under Stage 2 operations defined in SWRCB D-1641, or could occur as a result of a Temporary Urgency request to the SWRCB. Use of JPOD in this case does not result in any net increase in allowed exports at CVP and SWP export facilities. When in use, water within the DMC will be conveyed to the CA via the Intertie. Water diverted through the Intertie will then be conveyed through the CA to O'Neill Forebay.

Freeport Regional Water Project

The Freeport Regional Water Project (FRWP) is currently under construction. Once completed FRWP will divert up to a maximum of about 286 cubic feet per second (cfs) from the Sacramento River near Freeport for Sacramento County (deliveries expected in 2011) and East Bay Municipal Utility District (EBMUD) deliveries expected in late 2009. EBMUD will divert water pursuant to its amended contract with Reclamation. The County will divert using its water rights and its CVP contract supply. This facility was not in the 1986 COA, and the diversions will result in some reduction in Delta export supply for both the CVP and SWP contractors. Pursuant to an agreement between Reclamation, DWR, and the CVP and SWP contractors in 2003, diversions to EBMUD will be treated as an export in the COA accounting and diversions to Sacramento County will be treated as an in-basin use.

Reclamation proposes to deliver CVP water pursuant to its respective water supply contracts with SCWA and EBMUD through the FRWP, to areas in central Sacramento County. SCWA is responsible for providing water supplies and facilities to areas in central Sacramento County, including the Laguna, Vineyard, Elk Grove, and Mather Field communities, through a capital funding zone known as Zone 40.

The FRWP has a design capacity of 286 cfs (185 millions of gallons per day [mgd]). Up to 132 cfs (85 mgd) would be diverted under Sacramento County's existing Reclamation water service contract and other anticipated water entitlements and up to 155 cfs (100 mgd) of water would be diverted under EBMUD's amended Reclamation water service contract. Under the terms of its amendatory contract with Reclamation, EBMUD is able to take delivery of Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 AF. When this condition is met, the amendatory contract entitles EBMUD to take up to 133,000 AF annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 mgd), and are further limited to no more than 165,000 AF in any 3-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 AF. EBMUD would take delivery of its entitlement at a maximum rate of 100 mgd (112,000 AF per year). Deliveries would start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries would cease when EBMUD's CVP allocation for that year is reached, when the 165,000 AF limitation is reached, or when EBMUD no longer needs the water (whichever comes first). Average annual deliveries to EBMUD are approximately 23,000 AF. Maximum delivery in any one WY is approximately 99,000 AF.

The primary project components are (1) an intake facility on the Sacramento River near Freeport, (2) the Zone 40 Surface Water Treatment Plant (WTP) located in central Sacramento County, (3) a terminal facility at the point of delivery to the Folsom South Canal (FSC), (4) a canal pumping plant at the terminus of the FSC, (5) an Aqueduct pumping plant and pretreatment facility near Comanche Reservoir, and (6) a series of pipelines carrying water from the intake facility to the Zone 40 Surface WTP and to the Mokelumne Aqueducts. The existing FSC is part of the water conveyance system. See Chapter 9 for modeling results on annual diversions at Freeport in the American River Section, Modeling Results Section subheading.

Alternative Intake Project

CCWD's Alternative Intake Project (AIP) consists of a new 250 cfs screened intake in Victoria Canal, and a pump station and ancillary structures, utilities, and access and security features; levee improvements; and a conveyance pipeline to CCWD's existing conveyance facilities.

CCWD will operate the intake and pipeline together with its existing facilities to better meet its delivered water quality goals and to better protect listed species. Operations with the AIP will be similar to existing operations: CCWD will deliver Delta water to its customers by direct diversion when salinity at its intakes is low enough, and will blend Delta water with releases from Los Vaqueros Reservoir when salinity at its intakes exceeds the delivered water quality goal. Los Vaqueros Reservoir will be filled from the existing Old River intake or the new Victoria Canal intake during periods of high flow in the Delta, when Delta salinity is low. The choice of which intake to use at any given time will be based in large part upon salinity, consistent with fish protection requirements in the biological opinions; salinity at the Victoria Canal intake site is at times lower than salinity at the existing intakes. The no-fill and no-diversion periods described above will continue as part of CCWD operations, as will monitoring and shifting of diversions among the four intakes to minimize impacts to listed species.

The AIP is a water quality project, and will not increase CCWD's average annual diversions from the Delta. However, it will alter the timing and pattern of CCWD's diversions in two ways: winter and spring diversions will decrease while late summer and fall diversions increase because Victoria Canal salinity tends to be lower in the late summer and fall than salinity at CCWD's existing intakes; and diversions at screened intakes will increase. It is estimated that with the AIP, Rock Slough intake diversions will fall to about 10 percent of CCWD's total diversions, with the remaining diversions taking place at the other screened intakes. About 88 percent of the diversions will occur at the Old River and Victoria Canal intakes, with the split between these two intakes largely depending on water quality.

The effects of the AIP are covered by the April 27, 2007 Service biological opinion for delta smelt (amended on May 16, 2007).

Red Bluff Diversion Dam Pumping Plant

Reclamation signed the ROD July 16, 2008 for RBDD pumping plant and plans to change the operation of the RBDD to improve fish passage problems. The project features construction of a new pumping plant and operation of the RBDD gates in the out position for approximately 10 months of the year. Reclamation is calling for the construction of a pumping plant upstream from the dam that could augment existing capabilities for diverting water into the Tehama-Colusa Canal during times when gravity diversion is not possible due to the RBDD gates being out. Reclamation completed ESA section 7 consultations with the Service and the NMFS to address construction of a new pumping plant at maximum capacity of 2,500 cfs.

The new pumping plant would be capable of operating throughout the year, providing both additional flexibility in dam gate operation and water diversions for the Tehama-Colusa Canal Authority (TCCA) customers. In order to improve adult green sturgeon passage during their spawning migrations (generally March through July) the gates could remain open during the early part of the irrigation season and the new pumping plant could be used alone or in concert with other means to divert water to the Tehama-Colusa and Corning canals.

Green sturgeon spawn upstream of the diversion dam and the majority of adult upstream and downstream migrations occur prior to July and after August. After the new pumping plant has been constructed and is operational, Reclamation proposes to operate the Red Bluff Diversion Dam with the gates in during the period from four days prior to the Memorial Day weekend to three days after the holiday weekend (to facilitate the Memorial Day boat races in Lake Red Bluff), and between July 1 and the end of the Labor Day weekend. This operation would provide for improved sturgeon and salmon passage.

The pumping plant project will occur in three phases. The first, completion of the NEPA/CEQA process has already been accomplished. The design and permitting phase is commencing, subject to the availability of funding, and is anticipated to take about 18-36 months. As funding permits, property acquisition will also occur during this phase, and further funding commitments would be secured during this time. The final phase, facilities construction, is anticipated to take approximately 18-36 months but this timeline will be updated during final design and permitting.

South Delta Improvements Program Stage 1

The objectives of the SDIP are to: 1) reduce the movement of outmigrating salmon from the San Joaquin River into Old River, 2) maintain adequate water levels and circulation in South Delta channels, and 3) increase water delivery and reliability to the SWP and CVP by increasing the diversion limit at Clifton Court Forebay to 8500 cfs.[6]

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[6] This project description does not include any aspect of the SDIP that is not explicitly identified in the text. Examples of SDIP actions that are not included are construction of the four permanent gates and dredging. Both of these activities will be covered by subsequent consultation.

The decision to implement the proposed action is being done in two stages. Stage 1 will address the first two objectives and involves the construction and operation of gates at four locations in the South Delta channels. A decision to implement Stage 2 would address increasing the water delivery reliability of the SWP and CVP by increasing the diversion limit at Clifton Court Forebay. This decision has been deferred indefinitely.

The Final EIR/EIS was completed in December 2006. DWR certified the final EIR as meeting the requirements of the California Environmental Quality Act at that time. The Department plans to issue a Notice of Determination to proceed with implementing Stage 1 of the SDIP once the biological opinions on the continued long term operations of the CVP/SWP and the biological opinions for the dredging and construction of the gates are received.

Reclamation and DWR are seeking to construct and operate the gates proposed for the four locations. Key operational features of these gates are included as part of this project description. Separate biological opinions will be conducted for the impacts of constructing the gates and the channel dredging contained in Stage 1.

The permanent operable gates, which are planned to be constructed in the South Delta in late 2012, will be operated within an adaptive management framework, as described below under “Gate Operations Review Team,” so that the benefits from these gate operations can be maximized. The gates can be opened or closed at any time in response to the local tidal level and flow conditions within the South Delta. In this regard, they are very different from the temporary barriers that have been installed for the past several years.

Because these operable gates are designed as “lift gates” that are hinged at the bottom of the channel, “closure” of the gates can be specified at any tidal level, leaving a weir opening for some tidal flow over the gate. The ability to operate the tidal gates to a specified weir crest elevation (i.e., top of the gates) that is relatively precise provides a great deal of flexibility. The top elevation of each individual gate can be slightly different (i.e., steps) to provide less weir flow as the tidal level declines. The top elevation of the gates can also be slowly raised or lowered to adjust the tidal level and/or tidal flow in response to local South Delta conditions.

South Delta Gates

The proposed management of South Delta tidal level and tidal flow conditions involves the use of five gates:

- CCF intake tidal gate (existing),
- Grant Line Canal (at western end) flow control gate,
- Old River at DMC flow control gate,
- Middle River flow control gate, and
- Head of Old River fish control gate.

The CCF intake gate already exists and has been used since SWP began Banks operations in 1972 to control flows from Old River and maintain the water level inside of CCF. Unlike the existing CCF intake gate, the four other gates are proposed by SDIP and are not in place. The operation of the CCF intake gate is directly related to SWP export operations, but the operation of the fish and flow control gates, will serve the primary purpose of protecting fisheries and beneficial uses.

These five gates in the South Delta would be operated to accomplish the following purposes:

1. Maintain a relatively high water level within the CCF to allow SWP to maximize Banks pumping during the off-peak (nighttime) hours. The CCF level cannot be allowed to fall below –2 feet msl because of cavitation concerns at the SWP's Banks pumps. The CCF gates are closed when the outside tidal level in Old River drops below the CCF level (to avoid outflow from CCF). As described earlier in this chapter, the CCF gates are also operated under three "gate priorities" to reduce water level impacts to other South Delta water users.
2. Control the inflow to CCF below the design flow of about 15,000 cfs to prevent excessive erosion of the entrance channel. The CCF gates are partially closed when the difference between the CCF level and Old River tidal level is more than 1.0 foot to avoid inflow velocities of greater than 10 feet/sec.
3. Maintain the high-tide conditions in the South Delta by not diverting into CCF during the flood-tide period that precedes the higher-high tide each day. The CCF intake gates are closed for about 6 hours each day to preserve the high-tide level in Old River to supply sufficient water for Tom Paine Slough siphons. This CCF tidal gate operation is referred to as priority 3 by DWR, as described earlier in this chapter.
4. Control the minimum tidal level elevation upstream of the flow-control gates to be greater than a selected target elevation (i.e., 0.0 feet msl). The flow-control gates can be closed (raised) to maintain a specified top elevation (e.g., 0.0 feet msl) as the upstream tidal level declines during ebb tide.
5. Control the tidal flushing upstream of the flow-control gates with relatively low-salinity water from Old River and Middle River downstream of the gates (i.e., high fraction of Sacramento River water). The flow-control gates would remain fully open during periods of flood tide (i.e., upstream flow) and then two of the gates would be fully closed (i.e., top elevation of gates above upstream water surface) during periods of ebb tide (i.e., downstream flow). The remaining gate (i.e., Grant Line) would be maintained at a lower elevation (i.e., 0.0 feet msl) to allow the ebb tide flow to exit from the South Delta channels so that the flood-tide flow over the gates can be maximized during each tidal cycle.

Control the San Joaquin River flow diversion into Old River. This could increase the flow past Stockton and raise the low DO concentrations in the San Joaquin Deep Water Ship Channel. Reduced flow to Old River might also reduce salinity in the South Delta channels by limiting the volume of relatively high-salinity water from the San Joaquin River that enters the South Delta channels. The head of Old River temporary barrier has been installed in October and November of many years to improve flow and DO conditions in the San Joaquin Deep Water Ship Channel for up-migrating Chinook salmon. In recent years, the barrier has also been installed in April and/or May during a portion of the outmigration period to reduce the percentage of Chinook salmon smolts that are diverted into Old River and toward Banks and Jones. The proposed SDIP gate operations will increase the tidal circulation in the South Delta channels. Gate operations to promote circulation would raise the Old River at Tracy and Middle River gates at each high tide to produce a circulation of water in the South Delta channels down Grant Line Canal. The Old River at Tracy and Middle River gates remain raised (closed) until the next flood-tide period when the downstream level is above the upstream water level. These gates are then lowered (opened) to allow flood-tide (upstream) flows across the gates. Gate operations to promote circulation use a Grant Line gate weir crest at -0.5 feet msl during most periods of ebb tide (downstream flow) to protect the minimum level elevation of 0.0 feet msl. All gates are lowered (i.e., opened) during floodtide periods as soon as the downstream tidal level is above the upstream water level.

Head of Old River Fish Control Gate

Spring Operations/ Real Time Decision Making

Operation (closing) of the head of Old River fish control gate is proposed to begin on April 15. Spring operation is generally expected to continue through May 15, to protect outmigrating salmon and steelhead. During this time, the head of Old River gate would be fully closed, unless the San Joaquin River is flowing above 10,000 cfs or the GORT recommends a partial opening for other purposes. The real time decision making process is described in detail previously.

Summer and Fall Operations

When the Spring operation is completed and through November 30, the head of Old River fish control gate would be operated to improve flow in the San Joaquin River, thus helping to avoid historically-present low dissolved oxygen conditions in the lower San Joaquin River near Stockton. During this period, partial operation of the gate (partial closure to restrict flows from the San Joaquin River into Old River to approximately 500 cfs) may also be warranted to protect water quality in the South Delta channels. Generally, water quality in the South Delta channels is acceptable through June.

Operations during the months of October and November to improve flow and water quality conditions (i.e., low dissolved oxygen) in the San Joaquin River for adult migrating Chinook salmon is expected to provide a benefit similar to that achieved with the temporary barrier. Operations would not occur if the San Joaquin River flow at Vernalis is greater than 5,000 cfs because it is expected that this flow would maintain sufficient DO in the San Joaquin River.

When the gate is not operated, it is fully lowered in the channel. Operation of the gate is not proposed during the period December through March.

Flow Control Gates

The flow control gates in Middle River, Grant Line Canal, and Old River near the DMC, would be operated (closed during some portion of the tidal cycle) throughout the agricultural season of April 15 through November 30. As with the head of Old River fish control gate, when the gates are not operated, they are fully lowered in the channel. Operation of the gates is not proposed during the period December through March. Any operation of the gates proposed for the December-March period would require re-initiation of ESA consultation.

Spring Operations

During April 15 through May 15 (or until the Spring operation of the head of Old River gate is completed), water quality in the South Delta is acceptable for the beneficial uses, but closure of the head of Old River fish control gate has negative impacts on water levels in the South Delta. Therefore, the flow control gates would be operated to control minimum water levels in most year types. In the less frequent year types, dry or critically dry, when water quality in the South Delta is threatened by this static use of the gates, circulation may be induced to improve water quality in the South Delta channels. Circulation using the flow control gates is described in the summer operations section which follows. During these times, Reclamation and DWR have committed to maintaining 0.0 foot msl water levels in Old River near the CVP Tracy facility and at the west end of Grant Line Canal.

Summer and Fall Operations

When the Spring operation of the head of Old River fish control gate is completed and through November 30, the gates would be operated to control minimum water levels and increase water circulation to improve water quality in the South Delta channels. Reclamation and DWR have committed to maintaining water levels during these times at 0.0 foot msl in Old River near the CVP Tracy facility, 0.0 foot msl at the west end of Grant Line Canal, and 0.5 foot msl in Middle River at Mowry Bridge. It is anticipated that the target level in Middle River would be lowered to 0.0 foot msl following extension of some agricultural diversions.

The proposed gate operations will increase the tidal circulation in the South Delta channels. This is accomplished by tidal flushing upstream of the flow-control gates with relatively low-salinity water from Old River and Middle River downstream of the gates (i.e., high fraction of Sacramento River water). The flow-control gates would remain fully open during periods of flood tide (i.e., upstream flow) and then two of the gates would be fully closed (i.e., top elevation of gates above upstream water surface) during periods of ebb tide (i.e., downstream flow). The remaining gate (i.e., Grant Line) would be maintained at a lower elevation (i.e., 0.0 feet msl) to allow the ebb tide flow to exit from the South Delta channels so that the flood-tide flow over the gates can be maximized during each tidal cycle. This is the same operation described as Purpose 5 earlier in the description of the SDIP gates.

Gate Operations and Jones and Banks Exports

Because of the hydraulic interconnectivity of the South Delta channels, the CCF, and the export facilities, the permanent operable gates would not be operated entirely independent of Banks and Jones exports. The flow control gate opening and closing frequencies and durations would be adjusted to meet the water level and circulation objectives. Furthermore, the head of Old River Fish Control Gate operation period and duration would be adjusted to address the presence of fish species and the water quality conditions in the San Joaquin River. Opportunities to adjust gate operations in a manner that reduces entrainment and impingement of aquatic species or improves in-Delta water supply conditions that are associated with Delta exports could result.

As described in the Flow Control Gates operations sections, the Middle River, Grant Line Canal, and Old River near DMC flow control gates are operated to improve stage and water quality in the South Delta. The flow control gates increase the stage upstream of the barriers while Banks and Jones are all downstream of the permanent operable gates. The gates are designed to capture the flood tide upstream of the structures, and the operation of the flow control gates is not based on exports.

ESA coverage for the SDIP operable gates is being accomplished through two consultation processes. A separate biological opinion will address terrestrial and aquatic effects from channel dredging and construction and will be included in a separate consultation process.

State Water Project Oroville Facilities

Implementation of the new FERC license for the Oroville Project will occur when FERC issues the new license. Because it is not known exactly when that will occur, it is considered a near term and future project. The current, near term and future operations for the Oroville Facilities were previously described.

Analytical Framework for the Jeopardy Determination

The following analysis relies on four components to support the jeopardy determination for the delta smelt: (1) the *Status of the Species*, which evaluates the delta smelt's range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the delta smelt in the action area, the factors responsible for that condition, and the role of the action area in the delta smelt's survival and recovery; in this case the action area covers nearly the entire range of the delta smelt so the *Status of the Species/Environmental Baseline* sections are combined into one section; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the delta smelt; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the delta smelt.

In accordance with the implementing regulations for section 7 and Service policy, the jeopardy determination is made in the following manner: the effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the delta smelt's current status and, for non-Federal activities in the action area, those actions likely to affect the delta smelt in the future, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the delta smelt in the wild.

The following analysis places an emphasis on using the range-wide survival and recovery needs of the delta smelt and the role of the action area in providing for those needs as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Analytical Framework for the Adverse Modification Determination

This first draft biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

The following analysis relies on four components to support the adverse modification determination: (1) the *Status of Critical Habitat*, which evaluates the range-wide condition of designated critical habitat for the delta smelt in terms of primary constituent elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall, as well as the intended recovery function of discrete critical habitat units; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; in this case the action area covers nearly the entire range of delta smelt critical habitat so the *Status of the Critical Habitat/Environmental Baseline* sections are combined into one section; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

In accordance with Service policy and guidance, the adverse modification determination is made in the following manner: the effects of the proposed Federal action on critical habitat are evaluated in the context of the aggregate effects of all factors that have contributed to the current status of the critical habitat range-wide and, for non-Federal activities in the action area, those actions likely to affect the critical habitat in the future, to determine if the critical habitat would remain functional (or retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve the intended recovery role for the species with implementation of the proposed Federal action.

The following analysis places an emphasis on using the intended range-wide recovery function of delta smelt critical habitat and the role of the action area relative to that intended function as the context for evaluating the significance of effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

Status of the Species/Environmental Baseline

The action area for this consultation covers the entire range of the delta smelt, except for the Napa River. For that reason, the Status of the Species and Environmental Baseline sections are combined into one section in this document.

Delta Smelt

The Service proposed to list the delta smelt (*Hypomesus transpacificus*) as threatened with proposed critical habitat on October 3, 1991 (56 FR 50075). The Service listed the delta smelt as threatened on March 5, 1993 (58 FR 12854), and designated critical habitat for this species on December 19, 1994 (59 FR 65256). The delta smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (Service 1995). This recovery plan is currently under revision. A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The 2004 review affirmed the need to retain the delta smelt as a threatened species. A 12-month finding on a petition to reclassify the delta smelt was completed on April 7, 2010 (75 FR 17667). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted but precluded by other higher priority listing actions (Service 2010).

Distribution

The delta smelt is endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta) in California, and is restricted to the area from San Pablo Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties (Moyle 2002) (Figure 20). Their range extends from San Pablo Bay upstream to Verona on the Sacramento River and Mossdale on the San Joaquin River. The delta smelt was formerly considered to be one of the most common pelagic fish in the upper Sacramento-San Joaquin Estuary.

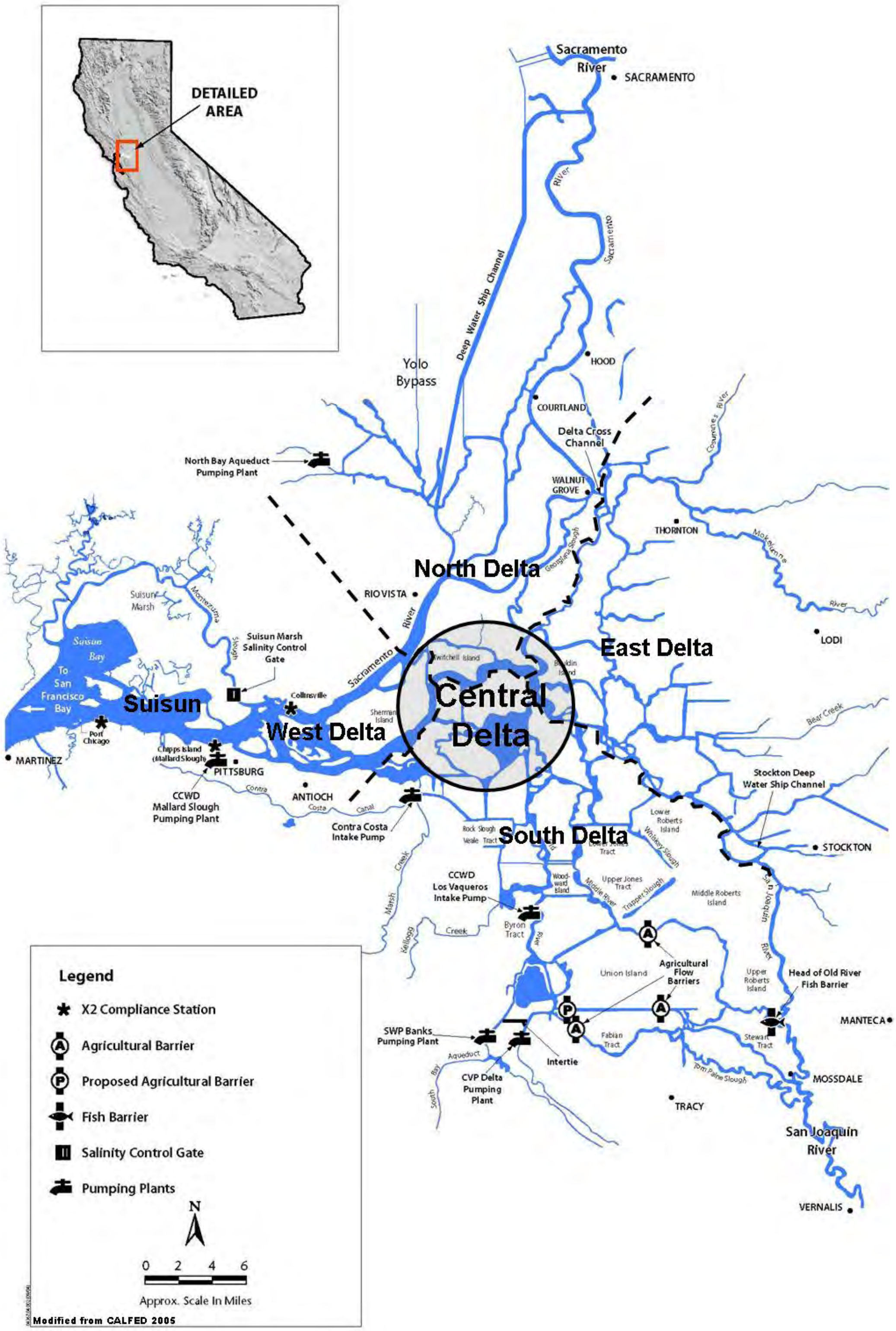

Figure 20. Map of the Delta with Delta Regions Identified

Description

Live delta smelt are nearly translucent with a steely-blue sheen to their sides and have been characterized to have a pronounced odor reminiscent of cucumber (Moyle 2002). Although delta smelt have been recorded to reach lengths of up to 120 mm (4.7 in) (Moyle 2002), mean fork length of the delta smelt from 1975- 1991 was measured to be 64.1 ± 0.1 mm. Since then, catch data from 1992 - 2004 showed mean fork length decreased to 54.1 ± .01 mm (Bennett 2005; Sweetnam 1999). Delta smelt are also identifiable by their relatively large eye to head size. The eye can occupy approximately 25-30 percent of their head length (Moyle 2002). Delta smelt have a small, translucent adipose fin located between the dorsal and caudal fins. Occasionally one chromatophore (a small dark spot) may be found between the mandibles, but most often there is none (Moyle 2002).

Delta smelt are small slender bodied fish within the Osmeridae family of fishes (smelts) (Moyle 2002). The delta smelt is one of six species currently recognized in the *Hypomesus* genus (Bennett 2005). Genetic analyses have confirmed that *H. transpacificus* presently exists as a single intermixing population (Stanley et al. 1995; Trenham et al. 1998; Fisch et al. 2011). Within the genus, delta smelt is most closely related to surf smelt (*H. pretiosis*), a species common along the western coast of North America. Despite morphological similarities, the delta smelt is less-closely related to the wakasagi (*H. nipponensis*), an anadromous western Pacific species introduced to Central Valley reservoirs in 1959, and may be seasonally sympatric with delta smelt in the estuary (Trenham et al. 1998). Allozyme studies have demonstrated that wakasagi and delta smelt are genetically distinct and presumably derived from different marine ancestors (Stanley et al. 1995). Genetic introgression among *H. transpacificus* and *H. nipponensis* is low.

Life History and Biology

Adults: Spawning

Adult delta smelt spawn during the late winter and spring months, with most spawning occurring during April through mid-May (Moyle 2002). Spawning occurs primarily in sloughs and shallow edge areas in the Delta. Delta smelt spawning has also been recorded in Suisun Marsh and the Napa River (Moyle 2002). Most spawning occurs at temperatures between 12-18°C. Although spawning may occur at temperatures up to 22°C, hatching success of the larvae is very low (Bennett 2005).

Fecundity of females ranges from about 1,200 to 2,600 eggs, and is correlated with female size (Moyle 2002). Moyle et al. (1992) considered delta smelt fecundity to be “relatively low.” However, based on Winemiller and Rose (1992), delta smelt fecundity is fairly high for a fish its size. In captivity, females survive after spawning and develop a second clutch of eggs (Mager et al. 2004); field collections of ovaries containing eggs of different size and stage indicate that this also occurs in the wild (Adib-Samii 2008). Captive delta smelt can spawn up to 4-5 times. While most adults do not survive to spawn a second season, a few (<5 percent) do (Moyle 2002; Bennett 2005). Those that do survive are typically larger (90-110 mm Standard Length [sdl]) females that may contribute disproportionately to the population's egg supply (Moyle 2002 and references therein). Two-year-old females may have 3-6 times as many ova as first year spawners.

Most of what is known about delta smelt spawning habitat in the wild is inferred from the location of spent females and young larvae captured in the California Department of Fish and Game Spring Kodiak Trawl (SKT) and 20-mm survey, respectively. In the laboratory, delta smelt spawned at night (Baskerville-Bridges et al. 2000; Mager et al. 2004). Other smelts, including marine beach spawning species and estuarine populations and the landlocked Lake Washington longfin smelt, are secretive spawners, entering spawning areas during the night and leaving before dawn. If this behavior is exhibited by delta smelt, then delta smelt distribution based on the SKT, which is conducted during daylight hours in offshore habitats, may reflect general regions of spawning activity, but not actual spawning sites.

Delta smelt spawning has only been directly observed in the laboratory and eggs have not been found in the wild. Consequently, what is known about the mechanics of delta smelt spawning is derived from laboratory observations and observations of related smelt species. Delta smelt eggs are 1 mm diameter and are adhesive and negatively buoyant (Moyle 1976, 2002; Mager et al. 2004; Wang 1986, 2007). Laboratory observations indicate that delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand and/or pebble in current (DWR and Reclamation 1994; Brown and Kimmerer 2002; Lindberg et al. 2003; Wang 2007). Spawning over gravel or sand can also aid in the oxygenation of delta smelt eggs. Eggs that may have been laid in silt or muddy substrates might get buried or smothered, preventing their oxygenation from water flow (Lindberg pers. comm. 2011). The eggs of surf smelts and other beach spawning smelts adhere to sand particles, which keeps them negatively buoyant but not immobile, as the sand may move ("tumble") with water currents and turbulence (Hay 2007; slideshow available at http://www.science.calwater.ca.gov/pdf/workshops/workshop_smelt_presentation_Hay_111508.pdf). It is not known whether delta smelt eggs "tumble incubate" in the wild, but tumbling of eggs may moderately disperse them, which might reduce predation risk within a localized area.

The locations in the Delta where newly hatched larvae are present, most likely indicates spawning occurrence. The 20-mm trawl has captured small (~5 mm sdl) larvae in Cache Slough, the lower Sacramento River, San Joaquin River, and at the confluence of these two rivers (e.g., 20-mm trawl survey 1 in 2005). Larger larvae and juveniles (size > 23 mm sdl), which are more efficiently sampled by the 20-mm trawl gear, have been captured in Cache Slough (Sacramento River) and the Sacramento Deep Water Channel in July (e.g. 20-mm trawl survey 9 in 2008). Because they are small fish inhabiting pelagic habitats with strong tidal and river currents, delta smelt larval distribution depends on both the spawning area from which they originate and the effect of transport processes caused by flows. Larval distribution is further affected by water salinity and temperature. Hydrodynamic simulations reveal that tidal action and other factors may cause substantial mixing of water with variable salinity and temperature among regions of the Delta (Monson et al 2007). This could result in rapid dispersion of larvae away from spawning sites.

The timing of spawning may affect delta smelt population dynamics. Lindberg (2011) has suggested that smelt larvae that hatch early, around late February, have an advantage over larvae hatched during late spawning in May. Early season larvae have a longer growing season and may be able to grow larger faster during more favorable habitat conditions in the late winter and early spring. An early growing season may result in higher survivorship and a stronger spawning capability for that generation. Larvae hatched later in the season have a shorter growing season which effectively reduces survivorship and spawning success for the following spawning season.

Sampling of larval delta smelt in the Bay-Delta in 1989 and 1990 suggested that spawning occurred in the Sacramento River; in Georgiana, Prospect, Beaver, Hog, and Sycamore sloughs; in the San Joaquin River adjacent to Bradford Island and Fisherman's Cut; and possibly other areas (Wang 1991). However, in recent years, the densest concentrations of both spawners and larvae have been recorded in the Cache Slough/Sacramento Deepwater Ship Channel complex in the North Delta. Some delta smelt spawning occurs in Napa River, Suisun Bay and Suisun Marsh during wetter years (Sweetnam 1999; Wang 1991; Hobbs et al. 2007). Early stage larval delta smelt have also been recorded in Montezuma Slough near Suisun Bay (Wang 1986).

Larval Development

Mager et al. (2004) reported that embryonic development to hatching takes 11-13 days at 14-16º C for delta smelt, and Baskerville-Bridges et al. (2000) reported hatching of delta smelt eggs after 8-10 days at temperatures between 15-17º C. Lindberg et al. (2003) reported high hatching rates of delta smelt eggs in the laboratory at 15º C, and Wang (2007) reported high hatching rates at temperatures between 14-17º C. Bennett (2005) showed hatching success peaks near 15º C. Swim bladder inflation occurring at 60-70 days post-hatch at 16-17º C (Mager et al. 2004).

At hatching and during the succeeding three days, larvae are buoyant, swim actively near the water surface, and do not react to bright direct light (Mager et al. 2004). As development continues, newly hatched delta smelt become semi-buoyant and sink in stagnant water. However, larvae are unlikely to encounter stagnant water in the wild.

Growth rates of wild-caught delta smelt larvae are faster than laboratory-cultured individuals. Mager et al. (2004) reported growth rates of captive-raised delta smelt reared at near-optimum temperatures (16ºC-17ºC). Their fish were about 12 mm long after 40 days and about 20 mm long after 70 days. In contrast, analyses of otoliths indicated that wild delta smelt larvae were 15-25 mm, or nearly twice as long at 40 days of age (Bennett 2005). By 70 days, most wild fish were 30-40 mm long and beyond the larval stage. This suggests there is strong selective pressure for rapid larval growth in nature, a situation that is typical for fish in general (Houde 1987).

The food available to larval fishes is constrained by mouth gape and status of fin development. Larval delta smelt cannot capture as many kinds of prey as larger individuals, but all life stages have small gapes that limit their range of potential prey.

Prey availability is also constrained by habitat use, which affects what types of prey are encountered. Larval delta smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges et al. 2004). Thus, delta smelt diets are largely comprised of small crustacea that inhabit the estuary's turbid, low-salinity, open-water habitats (i.e., zooplankton). Larval delta smelt have particularly restricted diets (Nobriga 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods, *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding delta smelt larvae are largely restricted to the larval stages of these copepods; older, larger life stages of the copepods are increasingly targeted as the delta smelt larvae grow, their gape increases, and they become stronger swimmers.

In the laboratory, a turbid environment (>25 Nephelometric Turbidity Units [NTU]) was necessary to elicit a first feeding response (Baskerville-Bridges et al. 2000; Baskerville-Bridges 2004). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges et al. 2000; Mager et al. 2004; Baskerville-Bridges et al. 2004). Laboratory-cultured delta smelt larvae have generally been fed rotifers at first-feeding (Baskerville-Bridges et al. 2004; Mager et al. 2004). However, rotifers rarely occur in the guts of wild delta smelt larvae (Nobriga 2002). The most common first prey of wild delta smelt larvae is the larval stages of several copepod species. These copepod 'nauplii' are larger and have more calories than rotifers. This difference in diet may enable the faster growth rates observed in wild-caught larvae.

The triggers for and duration of delta smelt larval movement from spawning areas to rearing areas are not known. Hay (2007) noted that eulachon larvae are probably flushed into estuaries from upstream spawning areas within the first day after hatching, but downstream movement of delta smelt larvae occurs much later. Most larvae gradually move downstream toward the two parts per thousand (ppt) isohaline (X2). X2 is scaled as the distance in kilometers from the Golden Gate Bridge (Jassby et al. 1995). It is a physical attribute of the Bay-Delta that is used as a habitat indicator and as a regulatory standard in the SWRCB D-1641, as described in the project description.

At all life stages, delta smelt are found in greatest abundance in the water column and usually not in close association with the shoreline. They inhabit open, surface waters of the Delta and Suisun Bay, where they presumably aggregate in loose schools where conditions are favorable (Moyle 2002). In years of moderate to high Delta outflow (above normal to wet WYs), delta smelt larvae are abundant in the Napa River, Suisun Bay and Montezuma Slough, but the degree to which these larvae are produced by locally spawning fish versus the degree to which they originate upstream and are transported by tidal currents to the bay and marsh is uncertain.

Juveniles

Young-of-the-year delta smelt rear in the low salinity zone (LSZ) from late spring through fall and early winter. Once in the rearing area growth is rapid, and juvenile fish are 40-50 mm sdl long by early August (Erkkila et al. 1950; Ganssle 1966; Radtke 1966). They reach adult size (55-70 mm sdl) by early fall (Moyle 2002). Delta smelt growth during the fall months slows considerably (only 3-9 mm total), presumably because most of the energy ingested is being directed towards gonadal development (Erkkila et al. 1950; Radtke 1966).

Abundance

Channelization, conversion of Delta islands to agriculture, and water operations have substantially changed the physical appearance, water salinity, water clarity, and hydrology of the Delta. As a consequence of these changes, most life stages of the delta smelt are now distributed across a smaller area than historically (Arthur et al. 1996; Feyrer et al. 2007). Wang (1991) noted in a 1989 and 1990 study of delta smelt larval distribution that, in general, the San Joaquin River was used more intensively for spawning than the Sacramento River.

Nobriga et al. (2008) found that delta smelt capture probabilities in the TNS are highest at specific conductance levels of 1,000 to 5,000 $\mu S\ cm^{-1}$ (approximately 0.6 to 3.0 practical salinity unit [psu]). Similarly, Feyrer et al. (2007) found a decreasing relationship between abundance of delta smelt in the FMWT and specific conductance during September through December. The location of the LSZ and changes in delta smelt habitat quality in the San Francisco Estuary can be indexed by changes in X2 (see effects section). The LSZ historically had the highest primary productivity and is where zooplankton populations (on which delta smelt feed) were historically most dense (Knutson and Orsi 1983; Orsi and Mecum 1986). However, this has not always been true since the invasion of the overbite clam (Kimmerer and Orsi 1996). The abundance of many local aquatic species has tended to increase in years when winter-spring outflow was high and X2 was pushed seaward (Jassby et al. 1995), implying that the quantity and quality (overall suitability) of estuarine habitat increases in years when outflows are high. However, delta smelt is not one of the species whose abundance has statistically covaried with winter-spring freshwater flows (Stevens and Miller 1983; Moyle et al. 1992; Kimmerer 2002; Bennett 2005). As presented in this BO, there is evidence that X2 in the spring influences delta smelt population dynamics.

The distribution of juvenile delta smelt has also changed over the last several decades. During the years 1970 through 1978, delta smelt catches in the TNS survey declined rapidly to zero in the Central and South Delta and have remained near zero since. A similar shift in FMWT catches occurred after 1981 (Arthur et al. 1996). This portion of the Delta has also had a long-term trend increase in water clarity during July through December (Arthur et al. 1996; Feyrer et al. 2007; Nobriga et al. 2008).

Habitat

The existing physical appearance and hydrodynamics of the Delta have changed substantially from the environment in which native fish species like delta smelt evolved. The Delta once consisted of tidal marshes with networks of diffuse dendritic channels connected to floodplains of wetlands and upland areas (Moyle 2002). The in-Delta channels were further connected to drainages of larger and smaller rivers and creeks entering the Delta from the upland areas. In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin Rivers were highly seasonal and more strongly and reliably affected by precipitation patterns than they are today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of the Delta aquatic ecosystem was greater in the past than it is today (Kimmerer 2002). For instance, in the early 1900s, the location of maximum salinity intrusion into the Delta during dry periods varied from Chipps Island in the lower Delta to Stockton along the San Joaquin River and Merritt Island in the Sacramento River (DWR Delta Overview). Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage have increased late summer and fall inflows (Knowles 2002), though Delta outflows have been tightly constrained during late summer-fall for several decades (see Effects section). The following is a brief description of the changes that have occurred to delta smelt's habitat that are relevant to the environmental baseline for this consultation.

Changes to the LSZ

There have been documented changes to the delta smelt's low-salinity zone habitat that have led to present-day, baseline habitat conditions. The close association of delta smelt with the San Francisco estuary LSZ has been known for many years (Stevens and Miller 1983; Moyle et al. 1992). Peterson (2003) developed a conceptual model that hypothesized how, "stationary and dynamic components of estuarine habitats" interacted to influence fisheries production in tidal river estuaries (Figure 21). Peterson's model suggests that when the dynamic and static aspects of estuarine habitat sufficiently overlap, foraging, growth, density, and survival are all high, and that enables fish production to outpace losses to predators. The result is high levels of successful recruitment of new individuals. The model also hypothesizes that when the dynamic and static aspects of an estuarine habitat do not sufficiently overlap, foraging, growth, density, and survival are impaired such that losses to predators increase and recruitment of new individuals decreases. This model was developed specifically for species spawned in marine environments that were subsequently transported into estuaries. However, the concept of X2, which was developed in the San Francisco estuary to describe how freshwater flow affected estuarine habitat (Jassby et al. 1995), played a role in the intellectual development of Peterson's model. The Peterson model also provides a useful framework to conceptualize delta smelt's LSZ habitat.

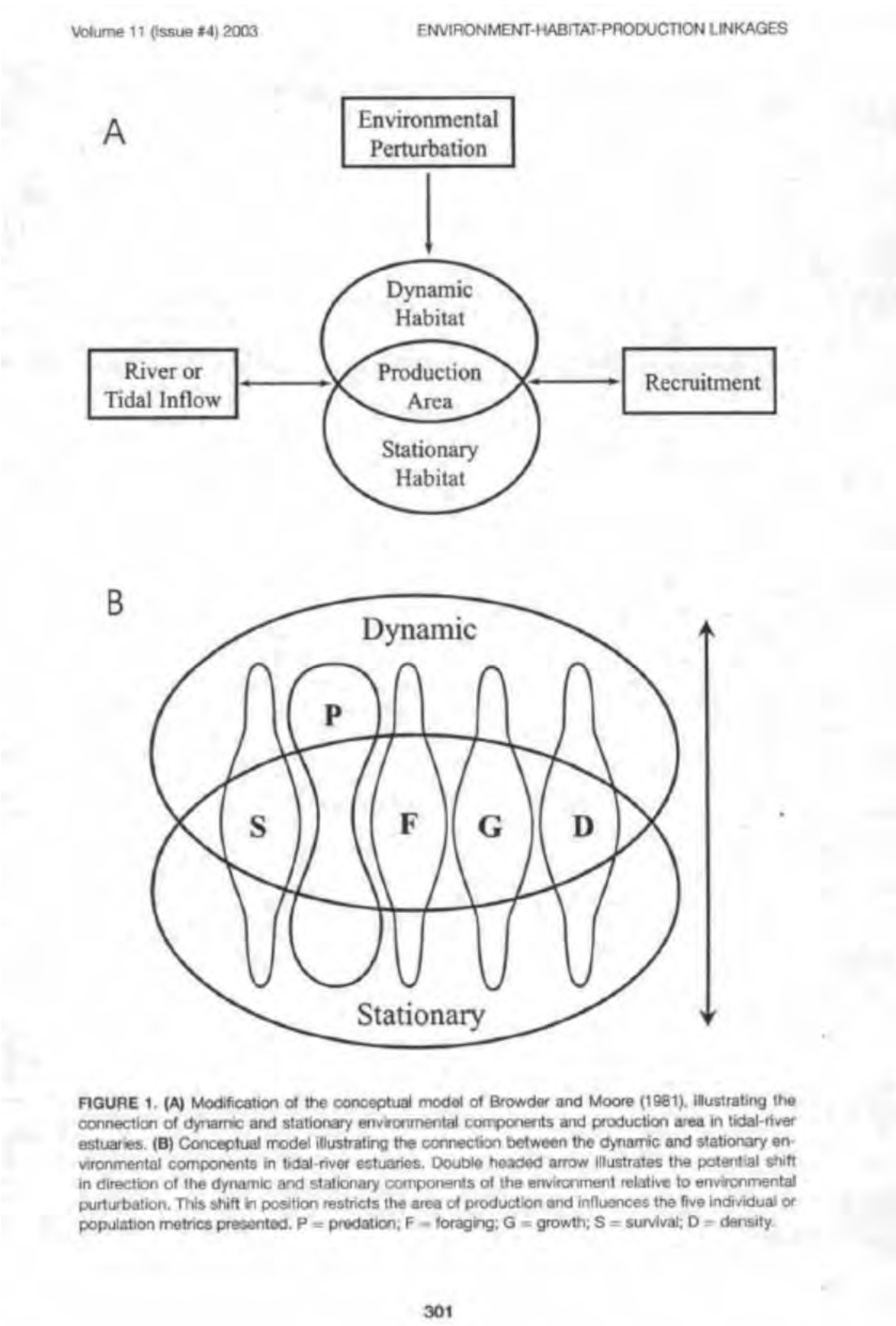

Figure 21. Image copied from Peterson (2003)

Currently available information indicates that delta smelt habitat is most suitable for the fish when low-salinity water is near 20°C, highly turbid, oxygen saturated, low in contaminants, supports high densities of calanoid copepods and mysid shrimp (Moyle et al. 1992; Lott 1998; Nobriga 2002), and occurs over comparatively static ‘landscapes’ that support sandy beaches and bathymetric variation that enables the fish and their prey to aggregate (Kimmerer et al. 2002; Bennett et al. 2002; Hobbs et al. 2006). Almost every component listed above has been degraded over time (see below). The Service has determined that this accumulation of habitat change is the fundamental reason or mechanism that has caused delta smelt to decline.

Alterations to estuarine bathymetry and salinity distribution (~ 1850-present)

The position of the LSZ, where delta smelt rear, has changed over the years. The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Moyle and Bennett 2010). The ancestral Delta was a large tidal marsh-floodplain habitat totally approximately 700,000 acres (DFG?). Most of the historic wetlands were diked and reclaimed for agriculture or other human uses by 1920 (Atwater 1979). Channels were dredged deep (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the confluence of the Sacramento-San Joaquin Rivers as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle et al. 1992; Jassby et al. 1995). However, the deepened channelscreated to support shipping and flood control, requires more freshwater outflow to maintain the LSZ in the large Suisun Bay and River confluence than was once required (Gartrell 2010). The construction of the CVP and SWP not only provided water supply for urban, agricultural and industrial users, but also provided water needed to combat salinity intrusion into the Delta, which was observed by the early 20th century. California's demand for freshwater (keeps) continues to increase, thus seasonal salinity intrusion perpetually reduces the temporal overlap of the LSZ (indexed by X2) within the Suisun Bay (region), especially in the fall (Feyrer et al. 2007; 2011). Consequently, the second major habitat change in the Delta has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation (Figure 7). There was a step-decline in the LSZ in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer et al. 2011).

Summer and fall environmental quality has decreased overall in the Delta because outflows are lower and water transparency is higher. These changes may be due to increased upstream water diversions for flooding rice fields (Kawakami et. al. 2008). The confluence of the Sacramento and San Joaquin Rivers has, as a result, become increasingly important as a rearing location for delta smelt, with physical environmental conditions constricting the species range to a relatively narrow area (Feyrer et al. 2007; Nobriga et al. 2008). This has increased the likelihood that most of the juvenile population is exposed to chronic and cyclic environmental stressors, or catastrophic events. For instance, all seven delta smelt collected during the September 2007 FMWT survey were captured at statistically significantly higher salinities than what would be expected based upon historical distribution data generated by Feyrer et al. (2007). During the same year, the annual bloom of toxic cyanobacteria (*Microcystis aeruginosa*) spread far downstream to the west Delta and beyond during the summer (Peggy Lehman, pers comm). This has been suggested as an explanation for the anomaly in the distribution of delta smelt relative to water salinity levels (Reclamation 2008).

Turbidity

From 1999 to present, the Delta experienced a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. Sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2004). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008).

Delta smelt associate with highly turbid waters; there is a negative correlation between the frequency of delta smelt occurrence in survey trawls during summer, fall and early winter and water clarity. For example, the likelihood of delta smelt occurrence in trawls at a given sampling station decreases with increasing Secchi depth at the stations (Feyrer et al. 2007, Nobriga et al. 2008). This is very consistent with behavioral observations of captive delta smelt (Nobriga and Herbold 2008). Few daylight trawls catch delta smelt at Secchi depths over one half meter and capture probabilities for delta smelt are highest at 0.40 m depth or less. Turbid waters are thought to increase foraging efficiency (Baskerville-Bridges et al. 2004) and reduce the risk of predation for delta smelt.

Temperature

Temperature also affects delta smelt distribution. Swanson and Cech (1995) and Swanson et al. (2000) indicate delta smelt tolerate temperatures (<8^{o} C to >25^{o} C), however warmer water temperatures >25^{o} C restrict their distribution more than colder water temperatures (Nobriga and Herbold 2008). Delta smelt of all sizes are found in the main channels of the Delta and Suisun Marsh and the open waters of Suisun Bay where the waters are well oxygenated and temperatures are usually less than 25^{o} C in summer (Nobriga et al. 2008).

Currently, delta smelt are subjected to thermally stressful temperatures every summer (Figure 8), and all available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). We expect warmer estuary temperatures to be yet another significant conservation challenge based on climate change models. Warmer water temperatures would increase delta smelt mortality and constrict suitable habitat throughout the Delta during the summer months. Higher temperatures would shrink delta smelt distribution into the fall, limiting their presence to Suisun Bay, in waters with less than optimal salinities (Brown et al. unpublished data). Water temperatures are presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding the nominal lethal limit of 25°C for short periods. Coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi et al. 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become moreso if temperatures warm in the coming decades.

Foraging Ecology

Delta smelt feed primarily on small planktonic crustaceans, and occasionally on insect larvae (Moyle 2002). Juvenile-stage delta smelt prey upon copepods, cladocerans, amphipods, and insect larvae (Moyle 2002). Historically, the main prey of delta smelt was the euryhaline copepod *Eurytemora affinis* and the euryhaline mysid *Neomysis mercedis*. The slightly larger *Pseudodiaptomus forbesi* has replaced *E. affinis* as a major prey source of delta smelt since its introduction into the Bay-Delta, especially in summer, when it replaces *E. affinis* in the plankton community (Moyle 2002). Another smaller copepod, *Limnoithona tetraspina*, which was introduced to the Bay-Delta in the mid-1990s, is now one of the most abundant copepods in the LSZ, but not abundant in delta smelt diets. *Acartiella sinensis*, a calanoid copepod species that invaded the Delta at the same time as *L. tetraspina*, also occurs at high densities in Suisun Bay and in the western Delta over the last decade. Delta smelt eat these newer copepods, but *Pseudodiaptomus* remains their dominant prey (Baxter et al. 2008).

River flows influence estuarine salinity gradients and water residence times and thereby affect both habitat suitability for benthos and the transport of pelagic plankton upon which delta smelt feed. High tributary flow leads to lower residence time of water in the Delta, which generally results in lower plankton biomass (Kimmerer 2004). In contrast, higher residence times, which result from low tributary flows, can result in higher plankton biomass but water diversions, overbite clam grazing (Jassby et al. 2002) and possibly contaminants (Baxter et al. 2008) remove a lot of plankton biomass when residence times are high. These factors all affect food availability for planktivorous fishes that utilize the zooplankton in Delta channels. Delta smelt cannot occupy much of the Delta anymore during the summer (Nobriga et al. 2008). Thus, there is the potential for mismatches between regions of high zooplankton abundance in the Delta and delta smelt distribution now that the overbite clam has decimated LSZ zooplankton densities (see effects section).

The delta smelt compete with and are prey for several native and introduced fish species in the Delta. The introduced Mississippi silverside may prey on delta smelt eggs and/or larvae and compete for copepod prey (Bennett and Moyle 1996; Bennett 2005). Young striped bass also use the LSZ for rearing and may compete for copepod prey and eat delta smelt. Centrarchid fishes and coded wire tagged Chinook salmon smolts released in the Delta for survival experiments since the early 1980s may potentially also prey on larval delta smelt (Brandes and McLain 2001; Nobriga and Chotkowski 2000). Studies during the early 1960s found delta smelt were only an occasional prey fish for striped bass, black crappie and white catfish (Turner and Kelley 1966). However, delta smelt were a comparatively rare fish even then, so it is not surprising they were a rare prey. Striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did, following severe declines in the abundance of mysid shrimp (Feyrer et al. 2003). Nobriga and Feyrer (2008) showed that Mississippi silverside, which is similar in size to delta smelt, was only eaten by subadult striped bass less than 400 mm fork length. While largemouth bass are not pelagic, they have been shown to consume some pelagic fishes (Nobriga and Feyrer 2007).

Existing Monitoring Programs

Most research and monitoring of fish populations in the Bay-Delta is coordinated through the Interagency Ecological Program (IEP). The IEP is a cooperative effort led by state and federal agencies with university and private partners. There are currently 16 fish monitoring programs that are implemented year-round across the entire Bay-Delta system (Honey et al. 2004). Figure 22 shows the some of the monitoring stations that are sampled in the Bay-Delta Estuary. Each of the IEP's fish monitoring programs captures delta smelt. However, only a select few are commonly used to index the abundance or distribution of delta smelt, and only two are designed specifically to capture delta smelt.

The FMWT (initiated in 1967) and the TNS (initiated in 1959) are the two longest-running IEP fish monitoring programs that are used to index delta smelt abundance. They work well because they were designed to target age-0 striped bass, which have a distribution in the estuary that is broadly similar to delta smelt. Two more recent programs, the 20-mm Survey (20mm; initiated in 1995) and the SKT (initiated in 2002), were designed specifically to sample delta smelt and are also commonly used to evaluate relative abundance and distribution. Each of these four sampling programs targets or incidentally collects delta smelt of different life stages and essentially encompasses the entire spatial distribution. The efficiency of sampling gears used for delta smelt is unknown. However, they were all designed to target open-water pelagic fishes and data from these programs have been used extensively in prior studies of delta smelt abundance and distribution (e.g., Stevens and Miller 1983; Moyle et al. 1992; Jassby et al. 1995; Dege and Brown 2004; Bennett 2005; Feyrer et al. 2007).

Data from the FMWT are used to calculate indices of relative abundance for delta smelt. The program has been conducted each year since 1967, except that no sampling was done in 1974 or 1979. Samples (10-minute tows) are collected at 116 sites each month from September to December throughout the upper estuary. Detailed descriptions of the sampling program are available from Stevens and Miller (1983) and Feyrer et al. (2007). The delta smelt recovery index includes distribution and abundance components and is calculated from the September and October FMWT sampling (http://www.delta.dfg.ca.gov/). The details on the calculation of the recovery index can be found in the Delta Native Fishes Recovery Plan (Service 1995).

Data from the TNS are used to calculate indices of abundance for young-of-year delta smelt during the summer. The TNS has been conducted annually since 1959 except from 1966-1968. Detailed descriptions of the sampling program are available from (Turner and Chadwick 1972). It involves sampling at up to 32 stations with three replicate tows to complete a survey. A minimum of two surveys is conducted each year. The delta smelt index is generated from the first two TNS surveys (Moyle et al. 1992). The TNS sampling has had an average survey starting date of July 13, but surveys have been conducted as early as June 4 and as late as August 28 in some years (Nobriga et al. 2008).

Data from the 20-mm survey are used to examine the abundance and distribution of post-larval/early juvenile delta smelt during the spring (Dege and Brown 2004). The survey has been conducted each year since 1995, and involves the collection of three replicate samples at up to 48 sites; additional sites have been added in recent years. A complete set of samples from each site is termed a survey and 5-9 surveys are completed each year from approximately March through July. This survey also simultaneously samples zooplankton with a Clarke-Bumpus net during one of the three sampling tows at each site.

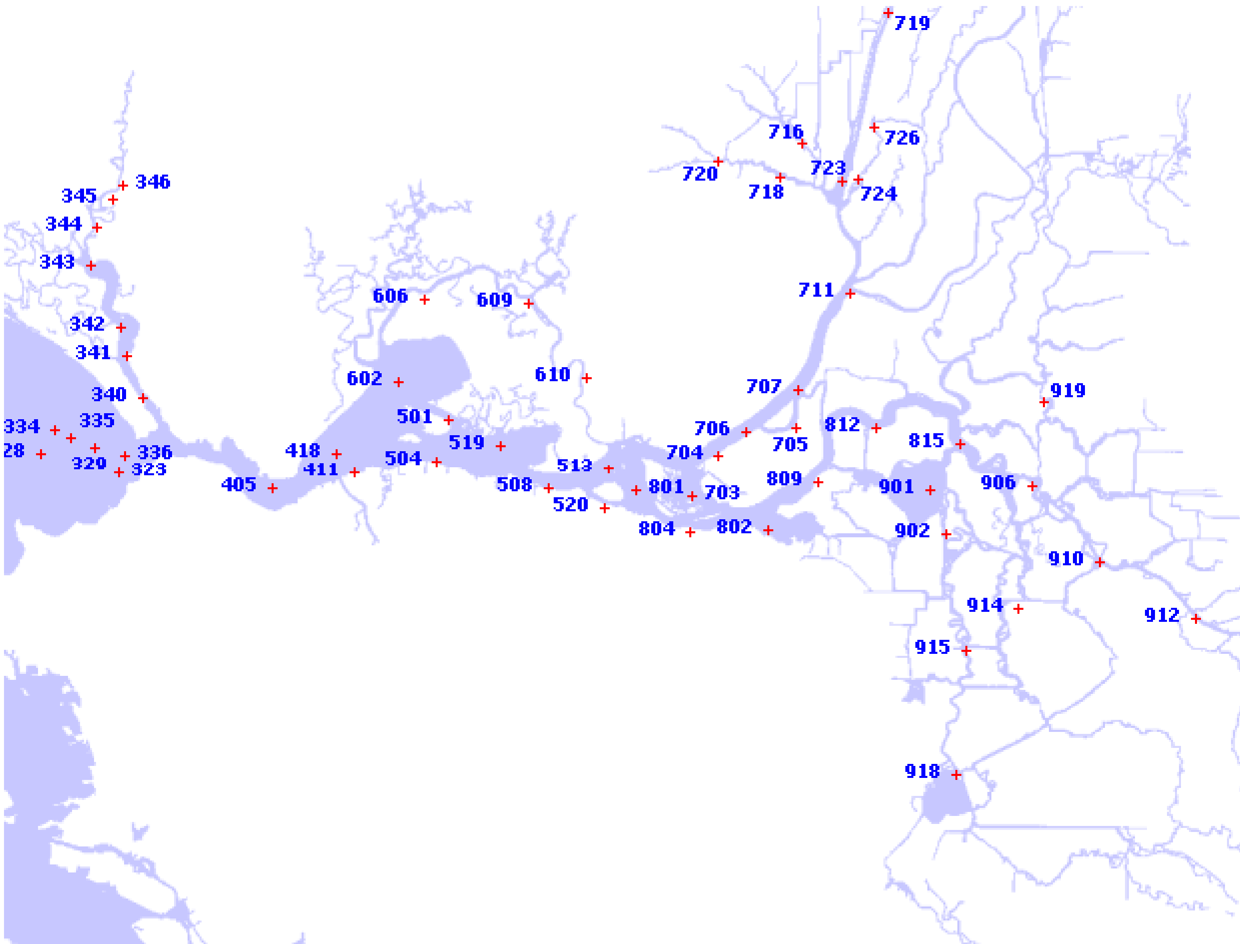

Figure 22. Map of Bay Delta Estuary Sampling Locations for the TNS and 20-mm Survey (DFG Bay Delta website 2011)

Data from the SKT are used to monitor the pre-spawning and spawning distributions of delta smelt. This survey also categorizes the reproductive maturity status of all adult delta smelt collected. SKT sampling has been conducted since 2002, typically at 39 stations. Sampling at each station is completed five or more times per year from January to May. Supplemental surveys are often completed at subsets of the full station array when additional information is requested by managers to assist with decisions relating to water project operations.

An additional source of information on delta smelt comes from salvage operations at the Banks and Jones diversion pumps. Banks and Jones are screened with fish-behavioral louvers designed to salvage young Chinook salmon and striped bass before they enter the pumps (Brown et al. 1996). In general, the salvage process consists of fish capture, transport, and ultimately release at locations where they are presumed safe from further influence of Banks and Jones. However, unlike some species, it is common knowledge that delta smelt often do not survive the salvage process. Data on delta smelt salvage is typically used to provide an index of entrainment into the diversion pumps, but not as an index of general population abundance. However, there are a number of caveats with these data including unknown sampling efficiency, unknown pre-screen mortality in Clifton Court Forebay, and no sampling of fish smaller than 20mm (Kimmerer 2008). Fortunately, some of this information may become available in the future because of targeted studies on efficiency and pre-screen mortality being conducted by the IEP and Reclamation. Although monitoring from Banks and Jones is limited in geographic range compared to the other surveys, they sample substantially larger volumes of water, and therefore may have a greater likelihood to detect low densities of delta smelt larger than 20mm.

Delta smelt entrainment is presently estimated (or indexed) by extrapolating catch data from periodic samples of salvaged fish (≥ 20 mm). Fish are counted from a sub-sample of water from the facility holding tanks and numbers are extrapolated based on the volume of water diverted during collection of that sample to estimate the number of fish entrained into Banks and Jones during the sampling interval. Intervals typically range from 1-24 hours depending on time of year, debris loads, etc. Fish salvage is also affected by variable rates of pre-screen loss (PSL; Castillo et al. 2010). In CCF, this PSL influences the relationship between entrainment and salvage. It is caused by variable predation rates on entrained fish and variable efficiency of the louvers designed to guide fish into the salvage facilities.

Overview of Delta Smelt's Life Cycle

The delta smelt life cycle is completed within the freshwater and brackish LSZ of the Bay-Delta. Figure 23 portrays the conceptual model used for delta smelt. Delta smelt are moderately euryhaline (Moyle 2002). However, salinity requirements vary by life stage. Delta smelt are a pelagic species, inhabiting open waters away from the bottom and shore-associated structural features (Nobriga and Herbold, 2008). Although delta smelt spawning has never been observed in the wild, clues from the spawning behavior of related osmerids suggests delta smelt use bottom substrate and nearshore features during spawning. However, apart from spawning and egg-embryo development, the distribution and movements of all life stages are influenced by transport processes associated with water flows in the estuary, which also affect the quality and location of suitable open-water habitat (Dege and Brown 2004; Feyrer et al. 2007; Nobriga et al. 2008).

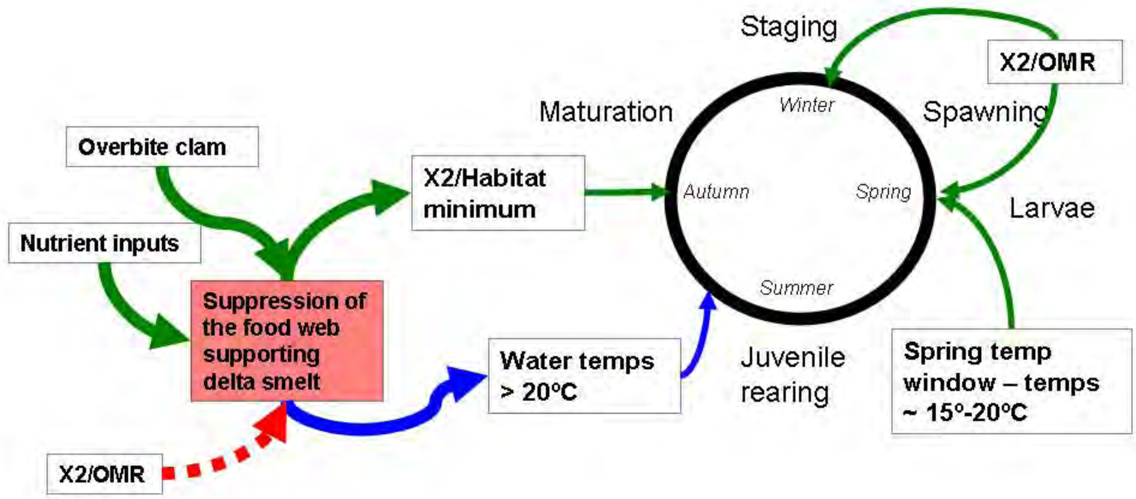

Figure 23. Lifecycle Conceptual Model For Delta Smelt. The Larger the Arrow Size, the Stronger the Influence on the Process

Generally, delta smelt undergo an annual spawning migration from brackish water to freshwater (Sommer et al. 2011). In early winter, mature delta smelt migrate from brackish, downstream rearing areas in and around Suisun Bay and the confluence of the Sacramento and San Joaquin Rivers, upstream to freshwater spawning areas in the Delta. Delta smelt historically have also spawned in the freshwater reaches of Suisun Marsh (Moyle 2002). In winters with high Delta outflow, the spawning range of delta smelt shifts west to include the Napa River (Hobbs et al. 2007). Some delta smelt may reside year-round in the Cache Slough region and spawn there without making any substantive spawning migration (Sommer et al. 2011). Fish inhabiting Suisun Marsh and the Sacramento-San Joaquin River confluence may also spawn near their rearing habitat when water quality conditions enable them (i.e., when flows increase and fresher water moves over these seasonally brackish rearing habitats).

The upstream migration of delta smelt, which ends with their dispersal into river channels and sloughs in the Delta (Radtke 1966; Moyle 1976, 2002; Wang 1991), seems to be triggered by abrupt changes in flow and turbidity associated with the first flush of winter precipitation (Grimaldo et al2009) but can also occur after very high flood flows have receded. Grimaldo et al. (2009) noted salvage often occurred when total inflows exceeded over 25,000 cfs or when turbidity elevated above 12 NTU (CCF station). Delta smelt spawning may occur from mid-winter through spring; most spawning occurs when water temperatures range from about 12^0C to 18^0C (Bennett 2005). Most adult delta smelt die after spawning. However, some fraction of the population may hold over as two-year-old fish and spawn in the subsequent year.

Delta Food Web

The Deltafood web has been altered since 1987 and continues presently, particularly after the overbite clam (*Corbula amurensis*) invasion of the estuary. The overbite clam was first detected in 1986 and from 1987-1990 its distribution and grazing influence on the ecosystem became evident. Since 1987, there has been a step-decline in phytoplankton biomass (Alpine and Cloern 1992; Jassby et al. 2002). Not only does the overbite clam reduce food for lower trophic consumers, it can also graze on larval stages of the Eurytemora affinis (Kimmerer et al. 1994), an historically dominant LSZ copepod and major prey item of delta smelt. The grazing pressure applied by the overbite clam rippled through the historical zooplankton community that fueled fishery production in the LSZ (Kimmerer et al. 1996; Orsi and Mecum 1996; Kimmerer 2002b; Feyrer et al. 2003). This major energetic shift in the ecosystem has likely facilitated the numerous invasions of the estuary by lower trophic level organisms that have occurred since, and it has measurably affected the distribution and abundance of several LSZ fishes (Kimmerer 2002b; Kimmerer 2006; Rosenfield and Baxter 2007; Mac Nally et al. 2010). Surprisingly, the changes in phytoplankton and zooplankton production have not been as evident for delta smelt as for other organisms (Kimmerer 2002b; Kimmerer 2006; Sommer et al. 2007). Nonetheless, delta smelt collected in the FMWT have persistently been smaller since the overbite clam invasion (Sweetnam 1999; Bennett 2005). This is evidence for reduced, delta smelt growth rates that could have been caused by food web changes stemming from overbite clam grazing.

Delta Smelt Population Dynamics and Abundance Trends

The California Department of Fish and Game (CDFG) has conducted several long-term monitoring surveys that have been used to index the relative abundance of delta smelt. The 20-mm Survey has been conducted every year since 1995. This survey targets late-stage delta smelt larvae. Most sampling has occurred April-June. The Summer Townet Survey (TNS) has been conducted nearly every year since 1959. This survey targets 38-mm striped bass, but collects similar-sized juvenile delta smelt. Most sampling has occurred June-August. The Fall Midwater Trawl Survey (FMWT) has been conducted nearly every year since 1967. This survey also targets age-0 striped bass, but collects delta smelt > 40 mm in length. The FMWT samples monthly, September-December. The relative abundance index data and maps of the sampling stations used in these surveys are available at http://www.dfg.ca.gov/delta/. The methods that underlie the surveys have been described previously (Stevens and Miller 1983; Moyle and others 1992; Dege and Brown 2004). The delta smelt catch data and relative abundance indices derived from these sampling programs have been used in numerous publications (e.g., Stevens and Miller 1983; Moyle and others 1992; Jassby and others 1995; Kimmerer 2002b; Dege and Brown 2004; Bennett 2005; Feyrer and others 2007; Sommer and others 2007; Kimmerer 2008; Newman 2008; Nobriga and others 2008; Kimmerer and others 2009; Mac Nally and others 2010; Thomson and others 2010; Feyrer and others 2011; Maunder and Deriso 2011). The index time series are shown in Figure 24. These abundance index time series document the long-term decline of the delta smelt. The relationships among successive indices are shown in Figure 24 and discussed in more detail below.

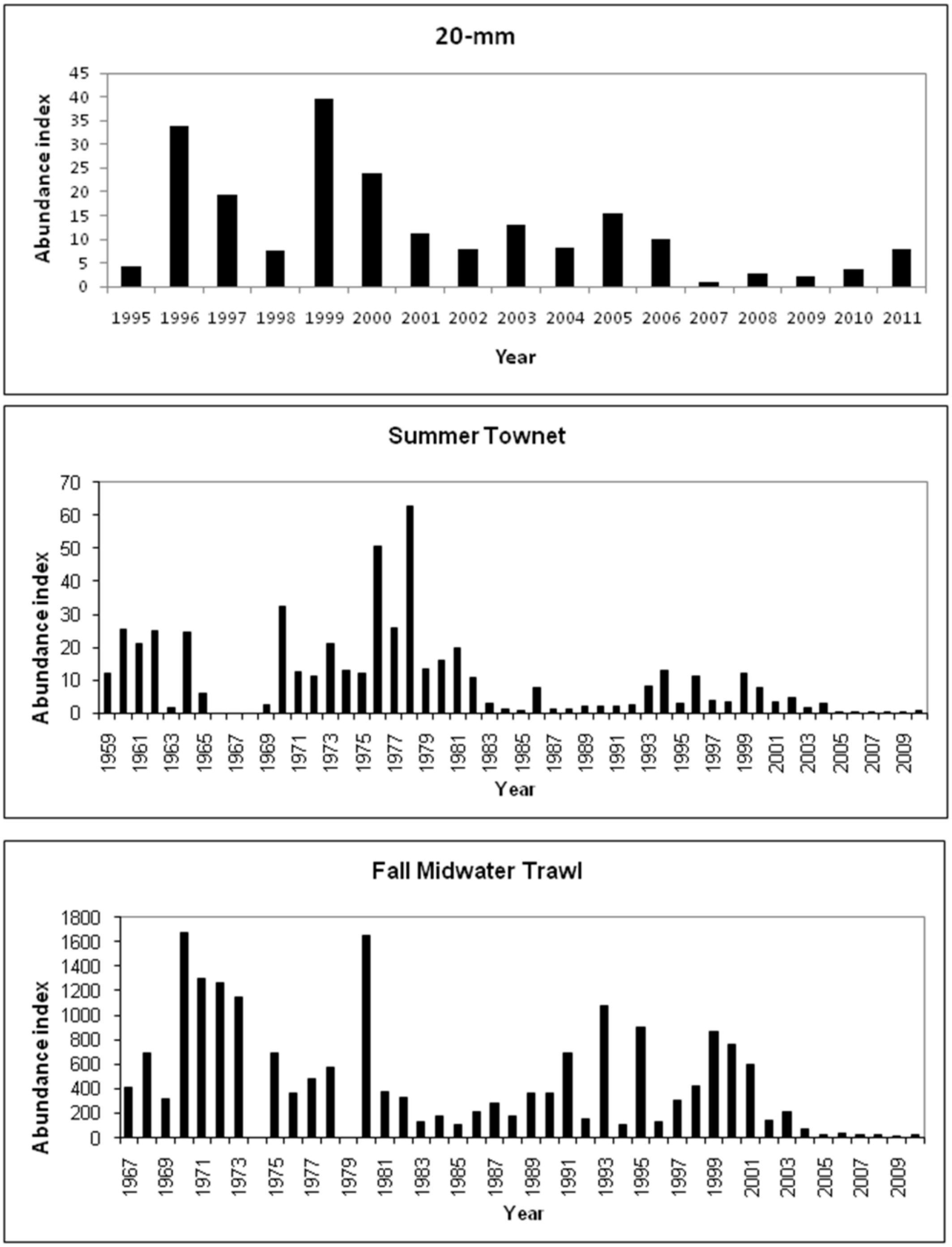

Figure 24. Delta smelt abundance indicies per survey by year.

Early statistical assessments of delta smelt population dynamics concluded that at best, the relative abundance of the adult delta smelt population had only a very weak influence on subsequent juvenile abundance (Sweetnam and Stevens 1993). Thus, early attempts to describe abundance variation in delta smelt ignored stock-recruit effects and researchers looked for environmental variables that were directly correlated with interannual abundance variation (e.g., Stevens and Miller 1983; Moyle and others 1992; Sweetnam and Stevens 1993; Herbold 1994; Jassby and others 1995). Because delta smelt live in a habitat that varies in size and quality with Delta outflow, the authors cited above searched for a linkage between Delta outflow (or X2) and the TNS and FMWT indices. Generally, these analyses did not find strong support for an outflow-abundance linkage. These analyses led to a prevailing conceptual model that multiple interacting factors had caused the delta smelt decline (Moyle and others 1992; Bennett and Moyle 1996; Bennett 2005). It has also recently been noted that delta smelt's FMWT index is partly influenced by concurrent environmental conditions (Feyrer and others 2007; 2011). This may be a partial explanation for why few analyses could consistently link springtime environmental conditions to delta smelt's fall index.

One published exception to the multi-factor hypothesis was proposed by Glibert (2010), who posited that nutrient pollution was the root cause of all the food web and fish assemblage changes that caused the decline of delta smelt and other pelagic fishes. However, the statistical approach she used to support her hypothesis was not appropriate and the untransformed data sets do not support this hypothesized chain of consequences stemming solely from wastewater inputs to the Delta (Jassby and others in press).

It is now recognized that delta smelt abundance plays an important role in subsequent abundance (Bennett 2005; Maunder and Deriso 2011). Bennett (2005) assessed (1) the influence of adult stock as indexed by the FMWT versus the next generation of juveniles indexed by the following calendar year's TNS; (2) the influence of the juvenile stock indexed by the TNS versus the subsequent adult stock indexed a few months later in the FMWT; (3) the influence of the FMWT on the following year's FMWT and on the FMWT two years later, and (4) he did the same for the TNS data. He concluded that (1) two-year-old delta smelt might play an important role in delta smelt population dynamics, (2) it was not clear whether juvenile production was a density-independent or density-dependent function of adult abundance, and (3) adult production was a density-dependent function of juvenile abundance and the carrying capacity of the estuary to support this life-stage transition had declined over time. These conclusions are also supported by Maunder and Deriso (2011).

The concept of density-dependence[7] and how it has affected the delta smelt is important because (1) it may be used as a reason not to protect particular life stages from sources of mortality, and (2) Maunder and Deriso (2011) showed how important the selection of predictor variables is to deciding which forms of density-dependence best explain delta smelt's long-term abundance trends. Specifically, it was the interaction of the density-dependence and covariate assumptions that they used to decide on a best available life cycle model ("LCM").

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[7] Density-dependence refers to situations where vital rates like growth or survival change as a population's density changes (Rose et al. 2001). When vital rates do not vary with population density, they are considered to be density-independent. Density-dependence occurs in populations when one or more factors is in limited supply or when crowding results in predator aggregation or faster disease transmission.

Table 23 shows that the degree of support for density-dependence and the relative importance of factors influencing delta smelt varies considerably among the three currently published delta smelt LCM frameworks (Mac Nally et al. 2010; Thompson et al. 2010; Maunder and Deriso 2011) and even among the several alternatives explored by Maunder and Deriso. Note however, that the treatment of density-dependence in the Maunder and Deriso manuscript is far more sophisticated than in the other authors' models. Further, the Maunder and Deriso conclusions about density-dependence are essentially identical to those of Bennett (2005).   Bennett (2005) likewise concluded it was (statistically) unclear whether density-dependence occurs between generations.   He also noted that the delta smelt indices strongly suggest that density-dependence has occurred, at least over the long-term, during the juvenile stage.

The uncertainty about density-dependence between generations results because statistical assessments of the relationship between the adult stock and the next generation of recruits (juveniles) result in similar fits for linear (density-independent) and nonlinear (density-dependent) relationships (Bennett 2005; Maunder and Deriso 2011).

One reason for this is that delta smelt population dynamics may have changed over time. Previous papers have reported a delta smelt step-decline during 1981-1982 (Kimmerer 2002; Thomson et al. 2010). Prior to this decline, the stock-recruit data are consistent with "Ricker" type density-dependence where increasing adult abundance resulted in decreased juvenile abundance (Figure 25). Since the decline, recruitment has been positively and essentially linearly related to prior adult abundance, suggesting that reproduction has been basically density-independent for about the past 30 years. This means that since the early 1980s, more adults translates into more juveniles and fewer adults translates into fewer juveniles without being 'compensated for' by density-dependence.

In contrast to the transition among generations, the weight of scientific evidence strongly supports the hypothesis that, at least over the history of IEP fish monitoring, delta smelt has experienced density-dependence during the juvenile stage of its life cycle, i.e., between the summer and fall (Bennett 2005; Maunder and Deriso 2011). This has been inferred because, statistically, the FMWT index does not increase linearly with increases in the summer townet index. Rather, the best-fitting relationships between the summer townet index and the FMWT index show that the FMWT indices approach an asymptote as the summer townet increases or possibly even declines at the highest summer townet indices (Figure 25). From a species conservation perspective, the most relevant aspect of this juvenile density dependence is that the carrying capacity of the estuary for delta smelt has declined (Bennett 2005).

Table 23. Summary of quantitative delta smelt life cycle model methods and results.

Appendix A Authors	Appendix A Description	Appendix A Number of covariates	Appendix A Life stage interval	Appendix A Results for density-dependence	Appendix A Factors correlated with delta smelt abundance
Appendix A Mac Nally et al. (2010)	**Appendix B Analyzed delta smelt within the context of a food web**	**Appendix B 16 covariates attributed to the opinion of the authors tested for an influence on 7 fish and invertebrate species including delta smelt that were also tested for influences on each other**	**Appendix B Assumed all delta smelt live 1 year; analyzed data on a 1 year (FMWT to the next FMWT) time step**	**Appendix B Found a "strongly negative" term for all fish species implying density-dependence**	**Appendix B The only factor found to have "strong" support (defined by the authors as an odds ratio > 3.2 was summer water temperature (-). Several other factors were found to have lesser statistical support (defined by the authors as an odds ratio between 1 and 3.2). These were winter exports (-), spring exports (-), spring spawning temperature window (+), largemouth bass density (-), and summer calanoid copepod biomass (+)[1].**
Appendix A Thomson et al. (2010)	**Appendix C Analyzed delta smelt by itself and combined with**	**Appendix C 19 covariates attributed to the**	**Appendix C Assumed all delta smelt live 1 year; analyzed**	**Appendix C In this study, the density-dependent term is**	**Appendix C The only factors found to have "strong"**

	the other 3 POD fishes; this table only reports results for the delta smelt model	**opinion of the authors. Note that Thomson et al. have more covariates because prey species were termed covariates in this framework**	**data on a 1 year (FMWT to the next FMWT) time step**	**an autocorrelation term testing for the effect of one generation on the next. The authors found a positive slope term with a confidence interval that included zero. Thus, prior abundance has either no effect or a positive effect on subsequent abundance. This does not provide support for density-dependence in contrast to the Mac Nally et al. finding.**	**support (defined by the authors as an odds ratio > 3 were fall Secchi disk depth (-) and winter exports (-). Several other factors were found to have lesser statistical support (confidence intervals that included zero). These were spring chlorophyll (+), spring calanoid copepod biomass (+)[1], Limnoithona density (-), largemouth bass density (-), summer water temperature (-), and prior abundance (+)**
Appendix A Maunder and Deriso (in press)	**Appendix D Analyzed delta smelt by itself**	**Appendix D 14 covariates attributed to Manly (2010)[2]**	**Appendix D Assumed all delta smelt live 1 year; analyzed data on an intra-annual time step; FMWT → 20mm Survey → Summer TNS[3] → to FMWT**	**Appendix D Found that without covariates included, 4 alternative density-dependence scenarios were similarly supported;**	**Appendix D Five variables were supported regardless of which density-dependence assumption was used: spawning temperature window, July**

				density-dependence was possible but not certain from adults to larvae; no support for density-dependence from larvae to juveniles; density-dependence from juveniles to adults was well supported but the functional form was uncertain; the covariates affected this result and were used to decide what the most likely model was from the four most plausible starting models.	**temperature, a spring prey density variable, a summer prey density variable, and a predator density variable. A few other variables were included only under some of the density-dependence assumptions: a second summer prey density variable, a second predator density variable, adult entrainment, and fall Secchi disk depth**

[1]*This was the only variable used by Mac Nally et al. (2010) and Thomson et al. (2010) that was not just a summary of raw IEP data. The zooplankton counts were converted to biomass based on species and prey size so they better reflected calories per unit volume available to the fish.*

[2]*In most cases, these covariates are qualitatively similar to those used by Mac Nally et al. 2010 and Thomson et al. (2010). However, they are quantitatively different due to various weighting factors, transformations, and derivations from regression relationships.*

[3]*The authors used an alternative townet index developed by Bryan Manly rather than the official version reported by the Department of Fish and Game.*

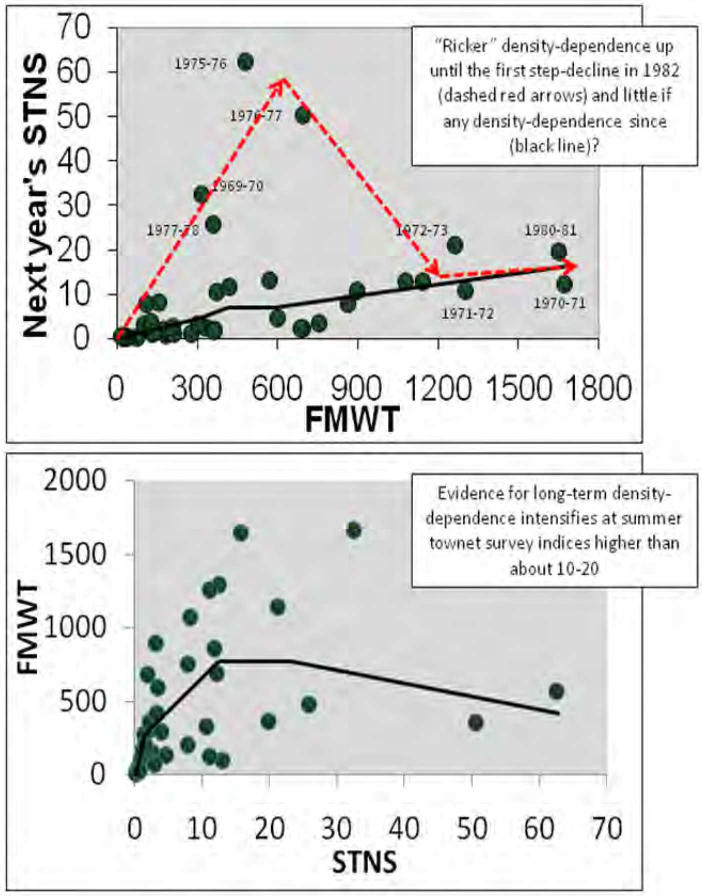

Figure 25. Upper Panel: plot of the Fall Midwater Trawl index for delta smelt vs the following year's summer townet index. The "pre-decline" years based on Kimmerer (2002) are individually labelled. The red arrows reflect my hypothesis that a "Ricker" type curve would best fit the data through 1981. The black line is a trace of the LOWESS spline that the Systat software program fit to the entire time series. Lower Panel: plot of the summer townet index for delta smelt vs the Fall Midwater Trawl index determined a few months later in the same calendar year. The black line is a trace of the LOWESS spline that the Systat software program fit to the entire time series.

Thus, the delta smelt population decline has occurred for two basic reasons. First, the compensatory density-dependence that historically enabled juvenile abundance to rebound from low adult numbers stopped happening. This change had occurred by the early 1980s as described above. The reason is still not known, but the consequence of the change is that for the past several decades, adult abundance drives juvenile production in a largely density-independent manner. Thus, if numbers of adults or adult fecundity decline, juvenile production will also decline (Kimmerer 2011). Second, because juvenile carrying capacity has declined, juvenile production hits a 'ceiling' at a lower abundance than it once did. This limits adult abundance and possibly per capita fecundity, which cycles around and limits the abundance of the next generation of juveniles. The mechanism causing carrying capacity to decline is likely due to the long-term accumulation of deleterious habitat changes – both physical and biological – during the summer-fall (Bennett and others 2008; Feyrer and others 2007; 2011; Maunder and Deriso 2011).

Other Stressors

Aquatic Macrophytes

For many decades, the Delta's waterways were turbid and growth of submerged plants was apparently unremarkable. That began to change in the mid 1980s, when the Delta was invaded by the non-native plant, Egeria densa, a fast-growing aquatic macrophyte that has now taken hold in many shallow habitats throughout the Delta (Brown and Michnuik 2007; Hestir 2010). Egeria densa and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (> 20^{0}C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer et al. 2008). First, the dense nature of SAV promotes sedimentation of particulate matter from the water column which increases water transparency. Increased water transparency leads to a loss of habitat for delta smelt (Feyrer et al. 2007; Nobriga et al. 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes that occupy the littoral and shallow habitats of the Delta, displacing native fishes (Nobriga et al. 2005; Brown and Michniuk 2007). Finally, the rise in SAV colonization over the last three decades has led to a shift in the dominant trophic pathways that fuel fish production in the Delta. Until the latter 1980s, the food web of most fishes was often dominated by mysid shrimp (Feyrer et al. 2003) that were subsidized by phytoplankton food sources (Rast and Sutton 1988). Now, most littoral and demeral fishes of the Delta have diets dominated by the epibenthic amphipods that eat SAV detritus or the epiphytic algae attached to SAV (Grimaldo et al. 2009b).

Egeria densa and other non-native submerged aquatic vegetation (e.g., *Myriophyllum spicatum*) can affect delta smelt in direct and indirect ways. Directly, submerged aquatic vegetation can overwhelm littoral habitats (inter-tidal shoals and beaches) where delta smelt may spawn making them unsuitable for spawning. Indirectly, submerged aquatic vegetation decreases turbidity (by trapping suspended sediment) which has contributed to a decrease in both juvenile and adult smelt habitat (Feyrer et al. 2007; Nobriga et al. 2008). Increased water transparency may delay feeding and may also make delta smelt more susceptible to predation pressure.

Predators

Delta smelt is a rare fish and has been a rare fish (compared to other species) for at least the past several decades (Nobriga and Herbold 2008). Therefore, it has also been rare in examinations of predator stomach contents. Delta smelt were occasional prey fish for striped bass, black crappie and white catfish in the early 1960s (Turner and Kelley 1966) but went undetected in a recent study of predator stomach contents (Nobriga and Feyrer 2007). Striped bass are likely the primary predator of juvenile and adult delta smelt given their spatial overlap in pelagic habitats. Despite major declines in age-0 abundance, there remains much more biomass of striped bass in the upper estuary than delta smelt. This means it is not possible for delta smelt to support any significant proportion of the striped bass population. It is unknown whether incidental predation by striped bass (and other lesser predators) represents a substantial source of mortality for delta smelt.

Nothing is known about the historic predators of delta smelt or their possible influence on delta smelt population dynamics. Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals. There has always been a very long list of potential predators of delta smelt's eggs and larvae. The eggs and newly-hatched larvae of delta smelt are thought to be prey for Mississippi silversides in littoral habitats (Bennett 2005). Other potential predators of eggs and larvae of smelt in littoral habitats are yellowfin goby, centrarchids, and Chinook salmon. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

The introduction of striped bass into the San Francisco Estuary in 1879 added a permanently resident, large piscivorous fish to the low-salinity zone. The LSZ is a habitat not known to have had an equivalent predator prior to the establishment of striped bass (Moyle 2002). Striped bass likely changed predation rates on delta smelt, but there are no data available to confirm this hypothesis. For many decades the estuary supported higher striped bass and delta smelt numbers than it does currently (Moyle 2002). This is evidence that delta smelt is able to successfully coexist with striped bass.

The current influence of striped bass and other predators on delta smelt population dynamics is unknown, mainly because predator effects on rare prey are extremely difficult to quantify. Delta smelt were observed in the stomach contents of striped bass and other fishes in the 1960s (Stevens 1963; Turner and Kelley 1966), but have not been in more recent studies (Feyrer et al. 2003; Nobriga and Feyrer 2007). Predation is a common source of density-dependent mortality in fish populations (Rose et al. 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observable in delta smelt population dynamics that has been noted by Bennett (2005) and Maunder and Deriso (2011). As is the case with other fishes, the vulnerability of delta smelt to predators may be influenced primarily by habitat suitability. It is widely documented that pelagic fishes, including many smelt species, experience lower predation risks under turbid water conditions (Thetmeyer and Kils 1995; Utne-Palm 2002; Horpilla et al. 2004,). Growth rates, a result of feeding success plus water temperature, are also well known to affect fishes cumulative vulnerability to predation (Sogard 1997).

Competition

It has been hypothesized that delta smelt are adversely affected by competition from other introduced fish species that use overlapping habitats, including Mississippi silversides, (Bennett and Moyle 1995) striped bass, and wakasagi (Sweetnam 1999). Laboratory studies show that delta smelt growth is inhibited when reared with Mississippi silversides (Bennett 2005) but there is no empirical evidence to support the conclusion that competition between these species is a factor that influences the abundance of delta smelt in the wild. There is some speculation that the overbite clam competes with delta smelt for copepod nauplii (Nobriga and Herbold 2008). It is unknown how intensively overbite clam grazing and delta smelt directly compete for food, but overbite clam consumption of shared prey resources does have other ecosystem consequences that appear to have affected delta smelt indirectly.

Microcystis

Large blooms of toxic blue-green alga, *Microcystis aeruginosa*, were first detected in the Delta during the summer of 1999 (Lehman et al. 2005). Since then, *M. aeruginosa* has bloomed each year, forming large colonies throughout most of the Delta and increasingly down into eastern Suisun Bay. Blooms typically occur between late spring and early fall (peak in the summer) when temperatures are above 20 ^{o}C. *Microcystis aeruginosa* can produce natural toxins that pose animal and human health risks if contacted or ingested directly. Preliminary evidence indicates that the toxins produced by local blooms are not toxic to fishes at current concentrations. However, it appears that *M. aeruginosa* is toxic to copepods that delta smelt eat (Ali Ger 2008 CALFED Science Conference). In addition, *M. aeruginosa* could out-compete diatoms for light and nutrients. Diatoms are a rich food source for zooplankton in the Delta (Mueller-Solger et al. 2002). Studies are underway to determine if zooplankton production is compromised during *M. aerguinosa* blooms to an extent that is likely to adversely affect delta smelt. *Microcystis* blooms may also decrease dissolved oxygen to lethal levels for fish (Saiki et al. 1998), although delta smelt do not strongly overlap the densest *Microcystis* concentrations, so dissolved oxygen is not likely a problem. *Microcystis* blooms are a symptom of eutrophication and high ammonia to nitrate ratios in the water.

Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. However, contaminant loading and its ecosystem effects within the Delta are not well understood. Although a number of contaminant issues were first investigated during the POD years, concern over contaminants in the Delta is not new. There are long-standing concerns related to mercury and selenium levels in the watershed, Delta, and San Francisco Bay (Linville et al. 2002; Davis et al. 2003). Phytoplankton growth rate may, at times, be inhibited by high concentrations of herbicides (Edmunds et al. 1999). New evidence indicates that phytoplankton growth rate is chronically inhibited by ammonium concentrations in and upstream of Suisun Bay (Wilkerson et al. 2006, Dugdale et al. 2007). Contaminant-related toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (e.g., Kuivila and Foe 1995, Giddings 2000, Werner et al. 2000, Weston et al. 2004). Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish and have chronic effects on growth (Saiki et al. 1992). Evidence for mortality of young striped bass due to discharge of agricultural drainage water containing rice herbicides into the Sacramento River (Bailey et al. 1994) led to new regulations for water discharges. Bioassays using caged Sacramento sucker (*Catostomus occidentalis*) have revealed deoxyribonucleic acid strand breakage associated with runoff events in the watershed and Delta (Whitehead et al. 2004). Kuivila and Moon (2004) found that peak densities of larval and juvenile delta smelt sometimes coincided in time and space with elevated concentrations of dissolved pesticides in the spring. These periods of co-occurrence lasted for up to 2-3 weeks, but concentrations of individual pesticides were low and much less than would be expected to cause acute mortality. However, the effects of exposure to the complex mixtures of pesticides actually present are unknown.

Current science suggests a possible link between contaminants and POD, may be the effects of contaminant exposure on prey items, resulting in an indirect effect on the survival of POD species (Johnson et al. 2010).The POD investigators initiated several studies beginning in 2005 to address the possible role of contaminants and disease in the declines of Delta fish and other aquatic species. Their primary study consists of twice-monthly monitoring of ambient water toxicity at fifteen sites in the Delta and Suisun Bay. In 2005 and 2006, standard bioassays using the amphipod *Hyalella azteca* had low (<5 percent) frequency of occurrence of toxicity (Werner et al. 2008). The results indicated that 2007, a dry year, showed a higher incidence of toxic events than in the previous (wetter) year, 2006 (Werner et al. 2010). Parallel testing with the addition of piperonyl butoxide, an enzyme inhibitor, indicated that both organophosphate and pyrethroid pesticides may have contributed to the pulses of toxicity. Most of the tests that were positive for *H. azteca* toxicity have come from water samples from the lower Sacramento River.

Pyrethroids are of particular interest because use of these insecticides has increased within the Delta watershed (Ameg et al. 2005, Oros and Werner 2005) as use of some organophosphate insecticides has declined. Urban source waters have shown toxicity to *H. azteca* with high mortality rates and swimming impairment in fishes due to pyrethroid pesticides (Weston and Lydy 2010). The Sacramento Regional Wastewater Treatment Plant was identified as the largest source of pyrethroids to the Delta (Weston and Lydy 2010). Toxicity of sediment-bound pyrethroids to macroinvertebrates has also been observed in small, agriculture-dominated watersheds tributary to the Delta (Weston et al. 2004, 2005). The association of delta smelt spawning with turbid winter runoff and the association of pesticides including pyrethroids with sediment is of potential concern.

In conjunction with the POD investigation, larval delta smelt bioassays were conducted simultaneously with a subset of the invertebrate bioassays. The water samples for these tests were collected from six sites within the Delta during May-August of 2006 and 2007. Results from 2006 indicate that delta smelt are highly sensitive to high levels of ammonia, low turbidity, and low salinity. There is some preliminary indication that reduced survival may be due to disease organisms (Werner et al. 2008). No significant mortality of larval delta smelt was found in the 2006 bioassays, but there were two instances of significant mortality in June and July of 2007. In both cases, the water samples were collected from sites along the Sacramento River and had relatively low turbidity and salinity levels and moderate levels of ammonia. It is also important to note that no significant *H. azteca* mortality was detected in these water samples. While the *H. azteca* tests are very useful for detecting biologically relevant levels of water column toxicity for zooplankton, interpretation of the *H. azteca* test results with respect to fish should proceed with great caution. The relevance of the bioassay results to field conditions remains to be determined.

Werner et al. (2010b) conducted *in situ* testing in the laboratory and compared contaminant sensitivity of delta smelt to common bioassay organisms, including *H. azteca*. The investigations included contaminants commonly observed in the Delta, such as organophosphate and pyrethroid insecticides, copper, and total ammonia. In the laboratory, delta smelt were 1.8 to >11 times more sensitive than fathead minnow to ammonia, copper, and all insecticides tested (except permethrin). The invertebrates tested were more sensitive to contaminants than delta smelt or fathead minnows. *Eurytemora affinis* and *Ceriodaphnia dubia* were the most sensitive to total ammonia. *C. dubia* was the most sensitive to copper and organophosphates pesticides. *H. azteca* was the most sensitive test organism to pyrethroids. Toxicity was not detected for the Sacramento River at Hood or the San Joaquin River at Rough and Ready Island during the 2009 *in situ* testing period. Delta smelt survival was low in treatment and control waters. Werner et al. (2010b) concluded that larval smelt may be too sensitive to salinity, temperature and transport stress for *in situ* exposures and recommended using surrogate species in future tests.

Persistent confinement of the spawning population of delta smelt to the Sacramento River increases the likelihood that a substantial portion of the spawners will be affected by a catastrophic event or localized chronic threat. For instance, large volumes of highly concentrated ammonia released into the Sacramento River from the Sacramento Regional County Sanitation District may affect embryo survival or inhibit prey production. Further, agricultural fields in the Yolo Bypass and surrounding areas are regularly sprayed by pesticides, and water samples taken from Cache Slough sometimes exhibited toxicity to *H. azteca* (Werner et al. 2008; 2010). The thresholds of toxicity for delta smelt for most of the known contaminants have not been determined, but the exposure to a combination of different compounds increases the likelihood of adverse effects. The extent to which delta smelt larvae are exposed to contaminants varies with flow entering the Delta. Flow pulses during spawning increase exposure to many pesticides (Kuivila and Moon 2004) but decrease ammonia concentrations entering the Delta from wastewater treatment plants.

The POD investigations into potential contaminant effects also include the use of biomarkers that have been used previously to evaluate toxic effects on POD fishes (Bennett et al. 1995, Bennett 2005). The results to date have been mixed. A pathogen survey of 105 adult delta smelt, sampled from January through May, at several sites in the Delta, found that disease did not appear to overtly influence the health of the surveyed population for that year (Foott and Bigelow 2010). Histopathological and viral evaluation of young longfin smelt collected in 2006 indicated no histological abnormalities associated with exposure to toxics or disease (Foott et al. 2006). There was also no evidence of viral infections or high parasite loads. Similarly, young threadfin shad showed no histological evidence of contaminant effects or of viral infections (Foott et al. 2006). Parasites were noted in threadfin shad gills at a high frequency but the infections were not considered severe. Both longfin smelt and threadfin shad were considered healthy in 2006. Adult delta smelt collected from the Delta during the winter of 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Teh et al. 2007). However, there was some evidence of low frequency endocrine disruption. In 2005, nine of 144 (six percent) of adult delta smelt males sampled were intersex, having immature oocytes in their testes (Teh et al. 2007). Bennett (2005) reported that about 10% of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure. In contrast, 30%-60% of these fish had liver glycogen depletion consistent with food limitation.

In contrast, preliminary histopathological analyses have found evidence of significant disease in other species and for POD species collected from other areas of the estuary. Massive intestinal infections with an unidentified myxosporean were found in yellowfin goby (*Acanthogobius flavimanus*) collected from Suisun Marsh. Severe viral infection was also found in Mississippi silverside and juvenile delta smelt collected from Suisun Bay during summer 2005. Lastly, preliminary evidence suggests that contaminants and disease may impair survival of age-0 striped bass. Baxter et al. 2008 found high occurrence and severity of parasitic infections, inflammatory conditions, and muscle degeneration in young striped bass collected in 2005; levels were lower in 2006. Several biomarkers of contaminant exposure including P450 activity (i.e., detoxification enzymes in liver), acetylcholinesterase activity (i.e., enzyme activity in brain), and vitellogenin induction (i.e., presence of egg yolk protein in blood of males) were also reported from striped bass collected in 2006 (Ostrach 2008).

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon et al. 2009; 2011; in review). This research has also shown that gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality.

Climate Change

There is currently no quantitative analysis of how ongoing climate change is currently affecting delta smelt and the Delta ecosystem. 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.

Summary of Delta Smelt Status and Environmental Baseline

In summary, delta smelt’s LSZ ecosystem has been changing and has changed very rapidly on several occasions during the past several decades. First, suitable land area was reduced, then water diversions increased, then the temporal overlap of low-salinity water with the best remaining landscape was reduced, then the food web began dramatically changing, then the turbidity delta smelt are assumed to use to see their food as larvae (Baskerville-Bridges et al. 2004) and use to hide from predators at later life stages (sensu Gregory and Levings 1998) lessened. Water temperatures are expected to rise (Dettinger 2005), which can only generate greater areas of stressful or even lethal temperature conditions for longer periods. Modeled future conditions suggest difficult conservation challenges and choices lie ahead (Feyrer et al. 2011; Brown et al. unpublished data).

Ongoing Operations

A Section 7 analysis of ongoing project's effects on listed species is conducted in the following manner: The total effects of all past activities, including effects of the past operation of the project, current non-Federal activities, and Federal projects with completed section 7 consultations, form the environmental baseline. To this baseline, future direct and indirect impacts of the operation, including effects of any interrelated and interdependent activities, and any reasonably certain future non-Federal activities (cumulative effects), are added to determine the total effect on listed species and their habitat (Conservation Handbook 1998).

Entrainment

From 1951 to present, the amount of water diverted from the estuary has generally increased over time (Figure 30), and most of the increase during the 1950s and 1960s was due to CVP exports and since the latter 1960s, SWP exports. Water diversions are unnatural 'predators' because they 'consume' organisms at every trophic level in the ecosystem from phytoplankton (Jassby et al. 2002) to fish (Kimmerer 2008). Unlike natural predators which typically shift their prey use over time in association with changes in prey fish density (Nobriga and Feyrer 2008), fractional entrainment losses of fishes to diversions are functions of water demand (e.g., Grimaldo et al. 2009). Thus, water diversions not only elevate 'predation' mortality in an aquatic system, but they can do so in an atypical, density-independent manner. Lastly, the SWP and CVP water diversions and fish collection facilities in the south Delta are very large structures which attract large aggregations of predatory fishes that prey on smaller species like delta smelt (Gingras 1997). This gauntlet of predators may bias the empirical data that often are used to link the operations and hydrodynamic influence of these diversions with entrainment (Castillo et al. in review). Estimated losses of delta smelt to the CVP and SWP water diversions may be substantial in some years (Kimmerer 2008).

The entrainment losses of delta smelt larvae are not generally observed, but the combination of empirical distribution data and hydrodynamic modeling provide evidence that risk of entrainment into the SWP and CVP water diversions can be described by any of several indices that combine Delta inflow and export flow (Kimmerer and Nobriga 2008; Kimmerer 2008; USFWS 2008; Grimaldo et al. 2009). Fish losses estimated from survey data and hydrodynamics can be substantial in some years (Kimmerer 2008), though it is possible that Kimmerer may have overestimated them (Miller 2011). Nonetheless, increasingly higher outflow (or lower position of X2) moves larval delta smelt increasingly west, which results in fewer larvae distributed in the south Delta where they are at highest risk of entrainment. At the same time, indices like the export to inflow ratio or Old and Middle River (OMR) flow are useful metrics for gauging the effect of exports on south Delta hydrodynamics.

The risk of delta smelt entrainment into smaller agricultural irrigation diversions, used mainly to irrigate crops within the Delta, is also related to outflow conditions. These in-Delta irrigation diversions generally have mean flow rates less than 1 cubic meter per second (Nobriga et al. 2004). The lower the Delta outflow, the higher the proportion of the young delta smelt population that overlaps the array of irrigation diversions in the Delta (Kimmerer and Nobriga 2008). However, irrigation diversions are not currently considered to represent a substantial source of mortality because they individually draw small quantities of water relative to channel volumes. Irrigation diversions entrain fish at much lower densities than the SWP and CVP (Nobriga et al. 2004).

In Suisun Marsh, water diversions are largely made to support waterfowl production. Some Suisun Marsh diversions are larger for the size of channels they are in than most of the agricultural irrigation diversions in the Delta. Based on hydrodynamic simulations, proximity to water diversions in the marsh s expected to correlate strongly with entrainment (Culberson et al. 2004), and substantial delta smelt losses have been reported when these diversions are not screened (Pickard 1982). However, entrainment risk for delta smelt further west in the Morrow Island Distribution System is considered low because the habitat surrounding the diversions is often too saline (Enos et al. 2007).

Water Diversions and Reservoir Operations

Banks and Jones Export Facilities

In 1951, the Tracy Pumping Plant (now referred to as the Jones Pumping Plant; hereafter Jones), with a capacity of 4,600 cfs, was completed along with the Delta Mendota Canal which conveys water diverted at Jones for use in the San Joaquin Valley. Simultaneously, Reclamation also constructed the Delta Cross Channel to aid in transferring water from the Sacramento River across the Delta to Jones. From its inception and formulation, the CVP (inclusive of upstream reservoirs, river and Delta conveyance, the Jones Pumping Plant, Delta-Mendota Canal, and San Luis Reservoir) was intended to function as an integrated system to deliver and export water, rather than separate or independent units.

In 1968 the first stage of the Banks Pumping Plant for the SWP was completed with seven units having a combined capacity of 6,400 cfs. In 1973, the California Aqueduct was completed. In 1974, CCF was completed. In 1991 an additional four pumping units were added, increasing Banks Pumping plant capacity to 10,300 cfs. This diversion rate has historically been restricted to 6,680 cfs as a three-day average inflow to CCF. However, between December 15 and March 15, when the San Joaquin River is above 1,000 cfs, pumping in excess of 6680 cfs at a rate equal to one-third of the San Joaquin River flow at Vernalis has historically been permissible. Furthermore, during the EWA, the SWP has been permitted to pump an additional 500 cfs between July 1 and September 30 (since 2002) to offset water costs associated with fisheries actions making the summer limit effectively 7,180 cfs. The Army Corps of Engineers' permit for increased pumping at Banks expired and is no longer authorized. The completion and operation of the Jones and Banks pumping plants have increased Delta water exports (see Figure 30 [from CALFED Science Report]).

Export of water from the Delta has long been recognized to have multiple effects on the estuarine ecosystem upon which species such as the delta smelt depend (Stevens and Miller 1983; Arthur et al. 1996; Bennett and Moyle 1996). In general, water is conveyed to Jones and Banks via the Old and Middle River channels resulting in a net (over a tidal cycle or tidal cycles) flow towards Jones and Banks. When combined water export exceeds San Joaquin River inflows, the additional water is drawn from the Sacramento

River through the Delta Cross Channel, Georgina Slough, and Three-Mile Slough. At high pumping rates, net San Joaquin River flow is toward Banks and Jones (Arthur et al. 1996). Combined flow in the Old and Middle Rivers is measured as “OMR” flows while flow in the San Joaquin River at Jersey Island is estimated as “Qwest” (Dayflow at http://www.iep.ca.gov/dayflow/). Flow towards the pumps is characterized as negative flow for both measurements. OMR flow towards the pumps is increased seasonally by installation of the South Delta Temporary Barriers. In particular, the Head of Old River barrier reduces flow from the San Joaquin River downstream into Old River so more water is drawn from the Central Delta via Old and Middle Rivers.

Because large volumes of water are drawn from the Estuary, fish entrainment at Jones and Banks is among the best-studied sources of fish mortality in the San Francisco Estuary (Sommer et al. 2007). As described in the Project Description, the Tracy Fish Collection Facility (CVP) and the Skinner Fish Facility (SWP) serve to reduce the mortality of fish entrained at Jones and Banks. The export facilities are known to entrain all species of fish inhabiting the Delta (Brown et al. 1996), and are of particular concern in dry years, when the distribution of young striped bass, delta smelt, and longfin smelt shift upstream, closer to the diversions (Stevens et al. 1985; Sommer et al. 1997). As an indication of the magnitude of entrainment effects caused by Banks and Jones, approximately 110 million fish were salvaged at the Skinner Fish Facility screens and returned to the Delta over a 15-year period (Brown et al. 1996). However, this number greatly underestimates the actual number of fish entrained. It does not include losses through the guidance louvers at either facility (Bowen et al. 2004; Castillo et al. in review). For Banks in particular, it does not account for high rates of predation on fish in CCF (Gingras 1997; Castillo et al. in review). The entrainment of adult delta smelt at Jones and Banks occurs mainly during their upstream spawning migration between December and April (Grimaldo et al. 2009). Entrainment risk depends on the location of the fish relative to the export facilities and the level of exports. The spawning distribution of adult delta smelt varies among years. In some years a large proportion of the adult population has migrated to the Central and South Delta, placing both spawners and their progeny in relatively close proximity to the export pumps and increasing entrainment risk. In other years, the bulk of adults migrate to the North Delta, reducing entrainment risk. In very wet periods, some spawning occurs west of the Delta.

The CVP and SWP water operations are thought to have a minor impact on delta smelt eggs because they remain attached to substrates or at least strongly negatively buoyant due to attached sand grains (see Spawning section above). Shortly after hatching, larvae become subject to flow-mediated transport, and are vulnerable to entrainment. However, delta smelt and other fish are not officially counted at Banks or Jones unless they are 20 mm or greater in total length and transitioning to the juvenile stage. Juvenile delta smelt are vulnerable to entrainment and are counted in salvage operations once they reach 20-25 mm in length, but the fish facilities remain inefficient collectors of delta smelt until they surpass 30 mm in length (Kimmerer 2008). Most salvage of juvenile delta smelt occurs from April-July with a peak in May-June (Grimaldo et al. 2009).

High winter entrainment has been suspected as a contributing cause of both the early 1980s (Moyle et al. 1992) and the POD-era declines of delta smelt (Baxter et al. 2008). To address the increases in winter salvage during 2002-2004, three key issues were evaluated. First, there was an increase in exports during winter as compared to previous years, attributable to the SWP. Second, the proportion of tributary inflows shifted. Specifically, San Joaquin River inflow decreased as a fraction of total inflow around 2000, while Sacramento River inflow increased (Reclamation 2008).

Overall, these operational changes may have contributed to a shift in Delta hydrodynamics that increased fish entrainment. The hydrodynamic change can be indexed using tidally averaged net flows through OMR that integrate changes in inflow, exports, and barrier operations (Monsen et al. 2007, Peter Smith, USGS, unpublished data). Several analyses have revealed strong, non-linear inverse relationships between net OMR flow and winter salvage of delta smelt at the Banks and Jones (Reclamation 2008; P. Smith, unpublished data; Grimaldo et al. 2009; Kimmerer 2008) (See Figure NEW FIGURE 26). While the specific details of these relationships vary by species and life stage, net OMR flow generally works very well as a binary switch: negative OMR is associated with some degree of entrainment, while positive OMR is usually associated with no, or very low, entrainment. Particle tracking modeling (PTM) also shows that entrainment of particles and residence time is highly related to the absolute magnitude of negative OMR flows, and that the zone of influence of the pumps increases as OMR becomes more negative. The rapid increase in the extent of the zone of entrainment at high negative OMR likely accounts for the faster-than-linear increase in entrainment as OMR becomes more negative. Adult delta smelt do not behave as passive particles, but they still use tidal flows to seek suitable staging habitats prior to spawning. When the water being exported is suitable staging habitat, for instance, when turbidity is > 12 NTU, delta smelt do not have a reason to avoid net southward transport toward the pumps so the OMR/entrainment relationship reinforces that tidally averaged net flow is an important determinant of the migratory outcome for delta smelt.

(NEW FIGURE 26 place holder)

PTM that simulates water movement using particles injected at various stations in the Delta gives a fairly good representation of the relative likelihood of larval and juvenile delta smelt entrainment (Kimmerer 2008; Kimmerer and Nobriga 2008). Predicted entrainment is high for the San Joaquin River region given recent winter and spring operations. Depending on Delta conditions, up to 70 percent of small organisms in the Old River south of Franks Tract would be entrained within 30 days at moderate flows in San Joaquin River and an OMR of negative 3,000 cfs (SWG notes 2008). Ten to twenty percent of larval delta smelt located in the San Joaquin River at Fisherman’s Cut would be expected to be entrained during the same period and OMR flows. This percentage increases to about 30 percent if OMR net flow is negative 5,000 cfs (DWR March 4, 2008, PTM runs: http://www.fws.gov/sacramento/).

Larvae are not currently sampled effectively at the fish-screening facilities and very small larvae (< 15-20 mm) are not sampled well by IEP either. Kimmerer and Nobriga (2008) and Kimmerer (2008) addressed larval delta smelt entrainment using PTM and 20-mm survey results to estimate historical larval entrainment. These approaches suggest that larval entrainment losses could exceed 50 percent[8] of the population if low flow and high export conditions coincide with a spawning distribution that includes the San Joaquin River. Although this does not occur every year, the effect of larval entrainment is substantial when it does. Since delta smelt are an annual fish, one year with distribution within the footprint of entrainment by the pumps can lead to a severe reduction in that year's production (Kimmerer 2011). In order to minimize the entrainment of undetected larval delta smelt, export reductions have recently focused on the time period when larval smelt are thought to be in the South Delta (based on adult distributions) to proactively protect these fish.

Salvage of delta smelt has historically been greatest in drier years when a high proportion of YOY rear in the Delta (Moyle et al. 1992; Reclamation and DWR 1994; and Sommer et al. 1997). In recent years however, salvage also has been high in moderately wet conditions (Nobriga et al. 2000; 2001; Grimaldo et al. 2009: springs of 1996, 1999, and 2000) even though a large fraction of the population was downstream of the Sacramento-San Joaquin River confluence. Nobriga et al. (2000; 2001) attributed recent high wet year salvage to a change in operations for the VAMP that began in 1996. The VAMP provides a San Joaquin River pulse flow from mid-April to mid-May each year that probably improves rearing conditions for delta smelt larvae and also slows the entrainment of fish rearing in the Delta. The high salvage events may have resulted from smelt that historically would have been entrained as larvae and therefore not counted at the fish salvage facilities growing to a salvageable size before being entrained. However, a more recent analysis provides an additional explanation. Delta smelt salvage in 1996, 1999, and 2000 was not outside of the expected historical range when three factors are taken into account, (1) delta smelt distribution as indexed by X2, and (2) delta smelt abundance as indexed by the TNS. Herbold, B. et al. (unpublished: http://198.31.87.66/pdf/ewa/EWA_Herbold_historical_patterns_113005.pdf) showed that salvage during 2003 through 2005 was relatively high compared to previous years given the low abundance indicated by the FMWT index (Table 27). Therefore, it is uncertain that operations changes for VAMP have influenced delta smelt salvage dynamics as suggested by Nobriga et al. (2000). In addition, assets from the EWA are often used during this time of year to further reduce delta smelt entrainment, though the temporary export curtailments from EWA have not likely decreased delta smelt entrainment by more than a few percent (Brown et al. 2008). Although the population level benefits of these actions are ultimately sometimes minor, they have been successful at keeping delta smelt salvage under the limits set in the Service's OCAP BOs (Brown and Kimmerer 2002).

In 2007 through 2011, CVP and SWP implemented actions to reduce entrainment at the pumps, including maintaining higher (less negative) OMR flows (Smelt Working Group Notes and Water Operations Management Team Notes at http://www.fws.gov/). During these years estimated number of delta smelt salvaged decreased considerably (see Table 27 above)

[8] This estimate may be biased upward (Miller 2011; Kimmerer 2011).

Environmental Water Account

The EWA, as described in the Project Description, was established in 2000. The EWA agencies acquired assets and determined how the assets should be used to benefit the at-risk native fish species of the Bay-Delta estuary. The EWA reduced diversions of water at Banks and Jones when listed fish species were present in the Delta and prevented the uncompensated loss of water to SWP and CVP contractors. Typically the EWA replaced water lost due to curtailment of pumping by purchase of surface or groundwater supplies from willing sellers and by taking advantage of regulatory flexibility and certain operational assets. These assets were moved through the Delta during the summer and fall, when entrainment effects to listed fish were minimal.

Generally, under past actions, the EWA has reduced water exports out of the Delta during the winter and spring and increased exports during the summer through early winter. These actions reduced entrainment at the facilities, but only by modest amounts (Brown et al. 2008). The movement of water in the summer and fall may have negatively influenced habitat suitability and prey availability (see Effects section).

500 cfs Diversion at Banks

This operation allowed the maximum allowable daily diversion rate into CCF during the months of July, August, and September to increase from 13,870 AF to 14,860 AF and three-day average diversions from 13,250 AF to 14,240 AF. The increase in diversions was permitted by the U.S. Army Corps of Engineers and has been in place since 2000. The current permit expired on September 30, 2008 and DWR is currently seeking an extension.

The purpose of this diversion increase into CCF was for the SWP to recover export reductions made due to the ESA or other actions like the EWA taken to benefit fisheries resources. This increased capacity allowed EWA assets to be moved through the Delta during the summer, when entrainment of listed species was minimal. This additional diversion rate was included as part of the EWA operating principles. This additional pumping occurred during the summer and likely did not result in much direct entrainment of delta smelt, but did likely result in entrainment of food for delta smelt, such as *Pseudodiaptomus* and contributed to lower habitat suitability as summer-fall export to inflow ratios increased to high levels regardless of preceding winter-spring flows.

CVP/SWP Actions Taken since the 2005 OCAP Biological Opinion was Issued

After the issuance of the 2005 biological opinion, the SWG used the DSRAM (Attachment A) to provide guidance for when the group needed to meet to analyze the most recent real-time delta smelt abundance and distribution data. Using the latest data, the SWG then determined if a recommendation to the Service to protect delta smelt from excessive entrainment was warranted. For the 2006 WY, a wet WY, based on the Service's recommendations, the Projects reduced exports to protect delta smelt by operating to an E/I ratio limit. The export curtailment operated to an E/I ratio of 15 percent beginning January 3 until February 21, 2006, when the E/I was expected to increase above 20 percent due to wet hydrologic conditions. No further actions were taken to protect fish that season as the E/I ratio was maintained at about 10 percent because of high spring flows. VAMP was implemented in May 2006, although the HORB was not installed due to high flows on the San Joaquin River.

For the 2007 WY, a dry year, the Service recommended a winter pulse flow increasing OMR flows to a daily average of negative 3500 cfs or if there were not Sacramento River flows above 25,000 cfs for three days, to moderate OMR to a range of negative 5000 cfs to negative 3500 cfs until February 15th . This action was implemented by the Projects, but since the Sacramento River never achieved 25,000 cfs for three days, the Projects operated to not exceed a 5-day average OMR flow of negative 4,000 cfs starting on January 15. To protect pre-spawning adult delta smelt from becoming entrained and based on the Service's recommendation, the Projects maintained OMR above negative 4,000 cfs and on March 13 the Project operated to a 5-day average OMR of negative 5,000 cfs.

To protect larval and juvenile delta smelt from entrainment the Projects operated the export facilities to achieve a non-negative daily net OMR flow. The Projects implemented the following actions: reduced combined Banks and Jones exports from 1,500 cfs to combined 1,200 cfs (850 cfs at the CVP and 350 cfs at the SWP) and evaluated increasing New Melones releases to 1,500 cfs for steelhead emigration. VAMP was then implemented and the HORB was removed on May15. The South Delta agricultural barriers maintained their flap gates in the open position and Reclamation increased exports from 850 cfs to 1,200 cfs on June 13 while DWR maintained an export level of 400 cfs.

Water Year 2008 Interim Remedial Order Following Summary Judgment and Evidentiary Hearing

For the 2008 WY, a dry WY, the Service, Reclamation and DWR implemented the direction contained in the 2008 Remedial Order.

A modified Adaptive Process was used during 2008. The SWG continued to use the DSRAM to identify the most recent delta smelt data and to help and provide a framework for the level of protection needed to protect delta smelt from entrainment. The SWG provided guidance to the Service, who then made a recommendation to WOMT. If WOMT did not agree to the Service's determination, WOMT would develop a counter proposal which was then sent back to Service, who would decide if WOMT's action was adequate to protect delta smelt or if the Service's original determination should be implemented instead.

For 2008, the fist action to protect delta smelt was a 10-day winter pulse flow that was implemented based on a turbidity trigger. The turbidity trigger was exceeded on December 25 and by December 28, the CVP and SWP began to operate such that a daily OMR flow would not be more negative than 2,000 cfs. This action was completed on January 6, 2008.

Second, OMR flow was limited to provide a net daily upstream OMR flow not to exceed 5,000 cfs to protect pre-spawning adult delta smelt from entrainment. This flow was calculated based on a 7-day running average. On January 7, 2008, immediately following the termination of the 10-day winter pulse flow, the CVP and SWP started to operate to achieve an average net upstream flow in OMR not to exceed 5,000 cfs over a 7-day running average period.

Next, OMR was limited to provide a net daily net upstream OMR flow of 750 to 5000 cfs to protect larval and juvenile delta smelt. These flows were determined by the Service, in consultation with Reclamation and DWR, on a weekly basis and were based upon the best available scientific and commercial information concerning delta smelt distribution and abundance. The Service used a control point method using PTM to limit predicted entrainment at Station 815 to 1 percent. When delta smelt abundances are low (the 2007 delta smelt FMWT Index was 28), the control point method is an appropriate method to protect delta smelt from entrainment at Banks and Jones. This is due in part because when delta smelt abundance is low, an accurate delta smelt distribution may not be determined from survey results. The control point method also sets a limit of entrainment from the Central Delta and it does not need distributional data to be protective. The CVP and SWP maintained OMR flow between -2000 and -3000 cfs, with an OMR flow agreed upon each week until June 20 (details on the OMR flow for each week can be found on the Sacramento Fish and Wildlife's website at http://www.fws.gov/sacramento/Delta_popup.htm). The CVP and SWP also implemented VAMP during this period, with San Joaquin River flows of 3,000 cfs and 1,500 cfs export flows. The HORB was not installed in 2008 and the SDTB maintained their flap gates in the open position.

Water Transfers

As described in the Project Description, purchasers of water for transfers have included Reclamation, DWR, SWP contractors, CVP contractors, other State and Federal agencies, or other parties. To date, transfers requiring export from the Delta have been done at times when pumping and conveyance capacity at Banks or Jones is available to move the water. Exports for transfers can not infringe upon the capability of the Projects to comply with the terms of SWQCP D-1641 and the existing biological opinions. Parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. All transfers have been in accordance with all existing regulations and requirements. Recent transfer amounts were 1,000 TAF in 2001-02, 608 TAF in 2002-03, 700 TAF in 2003-04, and 851 TAF in 2004-05 (DWR website: http://www.watertransfers.water.ca.gov). Generally, water transfers occur in the summer (July-September), when entrainment of listed fish is minimized. Most transfers have occurred at Banks because reliable capacity is generally only available at Jones in the driest 20 percent of years.

Article 21 and changes to Water Deliveries to Southern California

Changes in pumping in accordance with Article 21 and the associated changes in water deliveries have lead to recent increases in SWP water exports from the Delta. Article 21 deliveries are made when San Luis Reservoir is physically full or projected to be full and may result in export levels that are higher than if Article 21 was not employed. Recent changes in how Article 21 is invoked and used have increased the amount of Article 21 and Table A SWP water that has been pumped from the Delta.

Diamond Valley Lake was completed in 1999 and provided Metropolitan Water District of Southern California (MWDSC) an additional location for water storage in Southern California. Diamond Valley Lake holds 800,000 acre-feet of water, which makes it the largest reservoir in Southern California. MWDSC began filling the reservoir in November 1999 and the lake was filled by early 2002. Another factor involving water deliveries in southern California that changed Delta diversions is the Quantification

Settlement Agreement (QSA) signed in 2003, which resulted in a decrease in the amount of Colorado River water available to California.

Since 1999, MWDSC was filling Diamond Valley Lake and adding water to groundwater storage programs. Generally, in wetter years, demand for imported water decreases because local sources are augmented and local rainfall reduces irrigation demands. However, with the increased storage capacity in Southern California, the recent wet years did not result in lower exports from the Delta or the Colorado River. Table P-12 illustrates the demands for imported water during the recent wet years and the effect of reduced Colorado River diversions under the QSA on MWDSC deliveries from the Delta.

Vernalis Adaptive Management Plan

As described in the project description, VAMP was initiated in 2000 as part of the SWRCB D- 1641. VAMP schedules and maintains pulse flows in the San Joaquin River and reduced exports at Banks and Jones for a one month period, typically from April 15-May 15 (May 1-31 in 2005/06). Tagged salmon smolts released in the San Joaquin River are monitored as they move through the Delta in order to determine their fate. While VAMP-related studies attempt to limit CVP and SWP impacts to salmonids, the associated reduction in exports reduces the upstream flows that occur in the South and Central Delta. This reduction limits the southward draw of water from the Central Delta, and thus reduces the Projects' entrainment of delta smelt.

Based on Bennett's unpublished analysis, reduced spring exports resulting from VAMP have selectively enhanced the survival of delta smelt larvae spawned in the Central Delta that emerge during VAMP by reducing their entrainment. Initial otolith studies by Bennett's lab suggest that these spring-spawned fish dominate subsequent recruitment to adult life stages. By contrast, delta smelt spawned prior to and after the VAMP have been poorly-represented in the adult stock in recent years. The data suggests that the differential fate of early, middle and late cohorts affects sizes of delta smelt in fall because the later cohorts have a shorter growing season. These findings suggest that direct entrainment of larvae and juvenile delta smelt during the spring are relevant to population dynamics.

Other SWP/CVP Facilities

North Bay Aqueduct

The North Bay Aqueduct (NBA) diverts Sacramento River water from Barker Slough through Lindsay Slough. The 1995 OCAP biological opinion included monitoring delta smelt at the three stations in Barker Slough and the surrounding areas on a "recent-time" (within 72 hours) basis, and the posting of delta smelt information on the internet so that interested parties can use the information for water management decisions.

DWR contracted with DFG for the monitoring from 1995-2004 to estimate and evaluate larval delta smelt loss at the NBA due to entrainment, and to monitor the abundance and distribution of larval delta smelt in the Cache Slough complex and near Prospect Island. The sampling season for this monitoring was mid-February to mid-July with high priority stations (Barker and Lindsey Sloughs) sampled every two days and the remaining stations (Cache and Miner sloughs, and the Sacramento Deep Water Channel) sampled every four days.

NBA pumping was regulated by a weighted mean of the actual catch of delta smelt at the three Barker Slough stations. The weight assigned to each station was dependent on its proximity to the NBA intake. Station 721 had a 50 percent weighting, 727 had a 30 percent weighting and station 720 had a 20 percent weighting. As stated in the Service's 1995 OCAP biological opinion, the diversions at NBA were restricted to a 5-day running average of 65 cfs for five days when delta smelt were detected. In mathematical terms, the NBA restrictions were in place when the following equation was true:

$$0.5*(\text{Catch at } 721) + 0.3*(\text{Catch at } 727) + 0.2*(\text{Catch at } 720) >= 1.0$$

An entrainment estimate was then calculated as the weighted mean density of delta smelt multiplied by the total water exported for the sampling day and the day after. Based on this method, estimated annual entrainment of delta smelt at NBA was as follows: 1995 = 375; 1996 = 12,817; 1997 = 18,964; 1998 = 1,139; 1999 = 1,578; 2000 = 10,650; 2001 = 32,323; 2002 = 10,814; 2003 = 9,978; and 2004 = 8,246. 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). Thus, the fish screen at NBA may protect many of the delta smelt larvae that do hatch and rear in Barker Slough, so actual entrainment was probably lower.

In the Service's 2005 OCAP biological opinion, a broader larval smelt survey was included in the Project Description in lieu of the NBA monitoring. This change was suggested due to the low numbers of delta smelt caught in the NBA monitoring and it was thought that a broader sampling effort would be more helpful in determining where larval delta smelt are located. This broader monitoring effort was conducted during the spring of 2006, and used a surface boom tow at the existing 20-mm survey stations. The sampling was successful, and helped show that larval delta smelt could be caught in the Delta. However, this monitoring was not continued after 2006. Beginning in 2009, an expanded larval survey in the Delta was initiated and continues to be conducted (http://www.dfg.ca.gov/delta/data/sls/CPUE_map.asp). As discussed above, the number of delta smelt entrained at the NBA is unknown, but it may be low so long as the fish screen is maintained properly. in the distribution of delta smelt has recently been shifting toward the Cache Slough complex, which could increase proportional entrainment at the NBA.

Contra Costa Water District (CCWD)

CCWD diverts water from the Delta for irrigation and municipal and industrial uses in the Bay Area. CCWD's system includes intake facilities at Mallard Slough, Rock Slough, and Old River near State Route 4; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir as described in the Project Description. The total diversion by CCWD is approximately 127 TAF per year. Most CCWD diversions are made through facilities that are screened; the Old River (80 percent of CCWD diversions) and Mallard Slough (3 percent of CCWD diversions) facilities have fish screens to protect delta smelt. However, the fish screens on these facilities may not protect larval fish from becoming entrained. For that reason, in part, there are also no-fill and no-diversion periods at the CCWD facilities.

Before 1998, the Rock Slough Intake was CCWD's primary diversion point. It has been used less since 1998 when Los Vaqueros Reservoir and the Old River Pumping Plant began operating and now only accounts for 17 percent of CCWD's diversions. Reclamation, as described in the Project Description, constructed a fish screen at this facility under the authority of the CVPIA that will be operational after August 2011. The diversion at the Rock Slough Intake headworks structure is currently sampled with a sieve net three times per week from January through June and twice per week from July through December. A plankton net is fished at the headworks structure twice per week during times when larval delta smelt could be present in the area (generally March through June). A sieve net is fished at Pumping Plant #1 two times per week from the time the first Sacramento River winter-run Chinook salmon is collected at the Jones and Banks (generally January or February) through June. The numbers of delta smelt entrained by the facility since 1998 have been extremely low, with only a single fish observed in February 2005 (Reclamation 2008).

Other Delta Diversions and Facilities

Delta Cross Channel

When the DCC is open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the Central Delta. The closures for salmonid protection, as described in the Project Description, are likely to create more natural hydrologies in the Delta, by keeping Sacramento River flows in the Sacramento River and in Georgiana Slough, which may provide flow cues for migrating adult delta smelt. Larval and juvenile delta smelt are probably not strongly affected by the DCC if it is closed or open. Previous PTM modeling done for the SWG has shown that having the DCC open or closed does not significantly affect flows in the Central Delta (Kimmerer and Nobriga 2008). There could be times, however, when the DCC closure affects delta smelt by generating flows that draw them into the South Delta.

South Delta Temporary Barriers (SDTB)

The SDTB project was initiated by DWR in 1991. The U.S. Army Corps of Engineers (Corps) permit extensions for this project were granted in 1996 and again in 2001, when DWR obtained permits to extend operation of the SDTB through 2007. The Service approved the extension for operating the SDTB through 2008 (Service File No. 81420-2008-I-0403and 81420-2008-I-0522), and completed a 2009 consultation with DWR, through the Corps, for construction and demolition of the SDTB (Service File No. 81420-2008-F0522)-

Under the Service's 2001 biological opinion for the SDTB (Service File No. 1-1-01-F-81), operation of the barriers at Middle River and Old River near Tracy can begin May 15 or as early as April 15 if the spring barrier at the head of Old River is in place. From May 16 to May 31 (if the barrier at the head of Old River is removed) the tide gates are tied open in the barriers in Middle River and Old River near Tracy. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

During the spring, the HORB is designed to reduce the number of out-migrating salmon smolts entering Old River. During the fall, this barrier is designed to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook salmon. The HORB is typically in place from April 15 to May 15 in the spring, and from early September to late November in the fall. Installation and operation of the barrier also depends on San Joaquin River flow conditions.

The SDTB cause changes in the hydraulics of the Delta that affect fish and cause hydrodynamic changes within the interior of the Delta. When the HORB is in place, most water flow is effectively blocked from entering Old River. This, in turn, increases the flow to the west in Turner and Columbia cuts, two major Central Delta channels that flow toward Banks and Jones.

Susiun Marsh Salinity Control Gates

When Delta outflow is low to moderate and the SMSCG are not operating, tidal flow past the gates is approximately +/- 5,000-6,000 cfs while the net flow is near zero. When these gates are operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000-6,000 cfs. The net flow moves into Suisun Marsh via Montezuma Slough at approximately 2,500-2,800 cfs. The Army Corps of Engineers permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards set forth in SWRCB D-1641. Historically, the gates have been operated as early as October 1, while in some years (e.g., 1996) the gates were not operated at all. When the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season, the flashboards are removed and the gates are raised to allow unrestricted fish movement through Montezuma Slough.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at repelling the salinity in Montezuma Slough. Salinity is reduced by roughly one-hundred percent at Beldons Landing, and lesser amounts further west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow is reduced by SMSCG operation. Net outflow through Carquinez Strait is not demonstratably affected.

It is important to note that historical gate operations (1988-2002) were much more frequent than recent and current operations (2006-May 2008). Operational frequency is affected by many factors (e.g., hydrologic conditions, weather, Delta outflow, tide, fishery considerations, etc). The gates have also been operated for scientific studies. Salmon passage studies between 1998 and 2003 increased the number of operating days by up to 14 to meet study requirements. After discussions with NMFS based on study findings, the boat lock portion of the gates are now held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. With increased understanding of the effectiveness of the gates in lowering salinity in Montezuma Slough, salinity standards have been met with less frequent gate operation since 2006. Despite very low outflow in the fall of the two most recent WYs, gate operation was not required at all in fall of 2007 and was limited to 17 days in the winter 2008. When the SMSCG are operated or closed frequently, delta smelt may become trapped behind the gates in Montezuma Slough, which may prevent delta smelt from migrating upstream into the Delta to spawn. Salinity changes in Montezuma Slough could also affect delta smelt by changing or masking flow cues in the Delta which delta smelt use to migrate. However, the recent reduced operations likely have resulted in few adverse effects to delta smelt, since the reduced closures have minimized the migration blockage and salinity changes.

Upstream Diversion and Reservoir Operations

Construction and operation of reservoirs and water delivery systems upstream of the Delta, including CVP and SWP reservoirs, have changed the historical timing and quantity of flows through the Delta. The past and current operations of upstream diversions and reservoirs combined with the Delta water diversions affect the net Delta outflow and the location of the LSZ.

Delta smelt lives its entire life in the tidally-influenced fresh- and brackish waters of the San Francisco Estuary (Moyle 2002). It is an open-water species and does not associate strongly with structure. It may use nearshore habitats for spawning, but free-swimming life stages mainly occupy offshore waters. Thus, the population is strongly influenced by river flows because the quantity of fresh water flowing through the estuary changes the amount and location of suitable low-salinity, open-water habitat (Feyrer et al. 2007; Nobriga and Herbold 2008). Outflow plays a prominent role in delta smelt population dynamics year-round (Nobriga and Herbold 2008). X2 is an indicator of delta outflow (Jassby et al. 1995) and a useful metric by which to determine effects on delta smelt distribution and habitat suitability.

Survival and Recovery Needs of the Delta Smelt

Based on the above discussion of the current condition of the delta smelt, the factors responsible for that condition, and the final *Recovery Plan for the Delta Smelt* (Service 1995), the Service has identified the following survival and recovery needs for this species:

- Increase the abundance of the adult population and the potential for recruitment of juveniles into the adult population.

- Increase the quality and quantity of spawning, rearing, and migratory habitat with respect to turbidity, temperature, salinity, freshwater flow, and adequate prey availability by mimicking natural (i.e., pre-water development) water and sediment transport processes in the San Francisco Bay-Delta watershed to enhance reproduction and increase survival of adults and juveniles.

- Reduce levels of contaminants and other pollutants in smelt habitat to increase health, fecundity and survival of adults and juveniles.

- Reduce delta smelt exposure to disease and toxic algal blooms to increase health, fecundity and survival of adults and juveniles.

- Reduce entrainment of adult, larval, and juvenile delta smelt at CVP-SWP pumping facilities, over and above reductions achieved under the Vernalis Adaptive Management Plan and the Environmental Water Account, to increase the abundance of the spawning adult population and the potential for recruitment of juveniles into the adult population. Best available information indicates that delta smelt entrainment at CVP-SWP pumping facilities can be substantially reduced by maintaining a positive flow in the Old and Middle rivers. Entrainment reduction at other water diversion-related structures within the Bay-Delta where delta smelt adults or juveniles are known or likely to be entrained might also be needed to increase the adult population and the potential for recruitment of juveniles into the adult population, but there are secondary to reducing Banks and Jones entrainment.

- Restore the structure of the food web in the Bay-Delta to a condition that enhances diatom-based pelagic food chains in the LSZ.

- Maximize the resilience of the delta smelt population to the adverse effects of ongoing climate change. Achieving the above conditions should help with this need. In general, the management of CVP-SWP water storage and delivery facilities could have an important role to play in tempering the adverse effects of climate change on the Bay-Delta ecosystem upon which the delta smelt depends.

Delta Smelt Critical Habitat

The action area for this consultation covers the entire range of delta smelt critical habitat. For that reason, the Status of Critical Habitat and Environmental Baseline sections are combined into one section.

The Service designated critical habitat for the delta smelt on December 19, 1994 (59 FR 65256). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Service 1994).

Description of the Primary Constituent Elements

In designating critical habitat for the delta smelt, the Service identified the following primary constituent elements essential to the conservation of the species:

1. “Physical habitat” is defined as the structural components of habitat. Because delta smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary’s LSZ (Bennett et al. 2002; Hobbs et al. 2006).

2. “Water” is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt and are discussed in detail in the Status of the Species/Environmental Baseline section, above and below.. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

3. “River flow” is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflow, outflow, and OMR influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at Banks and Jones (refer to Status of the Species/Environmental Baseline section, above). River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where delta smelt rear.

4. “Salinity” is defined as the LSZ nursery habitat. The LSZ is where freshwater

transitions into brackish water; the LSZ is defined as 0.5-6.0 psu (parts per thousand salinity; Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby et al. 1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby et al. 1995; Kimmerer 2002). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low.

During the past 40 years, monthly average X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km). At all times of year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete their life cycle (see Biology and Life History section above). In general, delta smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence.

Conservation Role of Delta Smelt Critical Habitat

The Service's primary objective in designating critical habitat was to identify the key components of delta smelt habitat that support successful spawning, larval and juvenile transport, rearing, and adult migration. Delta smelt are endemic to the Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Delta must provide suitable habitat all year, every year. Different regions of the Delta provide different habitat conditions for different life stages, but those habitat conditions must be present when needed, and have sufficient connectivity to provide migratory pathways and the flow of energy, materials and organisms among the habitat components. The entire Delta and Suisun Bay are designated as critical habitat; over the course of a year, the entire habitat is occupied.

Factors Affecting the Delta, the CVP and SWP, and the Ability for Primary Constituent Elements to Fulfill Their Role

The physical environment at a location fundamentally constrains the kinds of ecosystems that are possible. For instance, if there is no possibility for fresh water and seawater to meet and mix, an estuary will not exist. However, the function of the ecosystem that results is often strongly influenced by its food web, which is usually affected not just by the local physical environment, but also by human manipulation of it (Jackson et al. 2001; Estes et al. 2011). The San Francisco Estuary has several key drivers of variability (Healey et al. 2008) that affect the PCEs within delta smelt's Critical Habitat (Table 24). All of the drivers have been shown to have some influence on the estuary's food web as described below. The Projects demonstrably affect a subset of these interactions between ecosystem drivers and the status of the PCEs.

Table 24. The association of the four Primary Constituent Elements (PCEs) of delta smelt Critical Habitat with several ecosystem drivers of the San Francisco Estuary. Table cells with an 'X' depict a substantive influence of the driver on the PCE. Table cells that also have a 'P' or 'p' denote a substantive effect of the Central Valley and State water projects on the PCE. Capital P's are intended to show qualitatively larger Project influences on the PCE than lower case p's.

	Primary Constituent Element							
	1 Physical habitat	2 Prey density	2 Turbidity	2 Temp	2 Contaminants[1]	3 River flow	4 Salinity	Food web function[3]
Climate				X	X	X	X	X
Landscape change	Xp		XP	x	x	X	X	Xp
Water diversion						XP	XP	Xp
Invasive species	X		X		x			X
(clams and aquatic plants[2])								

[1]Primary driver is urban and agricultural loading, which is not attributable to the Projects

[2]Delta smelt's Critical habitat has been invaded by many organisms. However, the two groups listed in the table are considered 'ecosystem engineers' that are fundamentally responsible for moving the system in a different ecological direction (Kimmerer et al. 2008).

[3]Defined here as the pathways that dominate the transfer of energy from the base of the food web up through its apex predators; put simply which plants and animals dominate the biomass of the estuary in its various habitats because they are best supported by habitat conditions.

Low-salinity zone habitat

The close association of delta smelt with the low-salinity zone (LSZ) has been known for many years (Stevens and Miller 1983; Moyle et al. 1992). Peterson (2003) developed a conceptual model that concisely hypothesizes how what he termed stationary and dynamic components of estuarine habitats interacted to influence fisheries production in tidal river estuaries (Figure 26). Peterson's model suggests that when the dynamic and static aspects of an estuarine organism's habitat sufficiently overlap, foraging, growth, density, and survival are all high, and that enables production to outpace losses to predators. The result is high levels of successful recruitment. The model also hypothesizes that when the dynamic and static aspects of an estuarine organism's habitat do not sufficiently overlap, foraging, growth, density, and survival are impaired such that losses to predators increase and recruitment decreases. Peterson developed the model specifically for species spawned in the marine environment that were subsequently transported into estuaries. However, the concept of X2, which was developed in the SFE to describe how freshwater flow affected estuarine habitat (Jassby et al. 1995), played a role in the intellectual development of Peterson's model. Therefore the Service believes that the Peterson model also provides a useful framework to conceptualize delta smelt's LSZ habitat. The following is a brief description of the changes that have occurred to delta smelt's habitat that are relevant to the environmental baseline for this consultation.

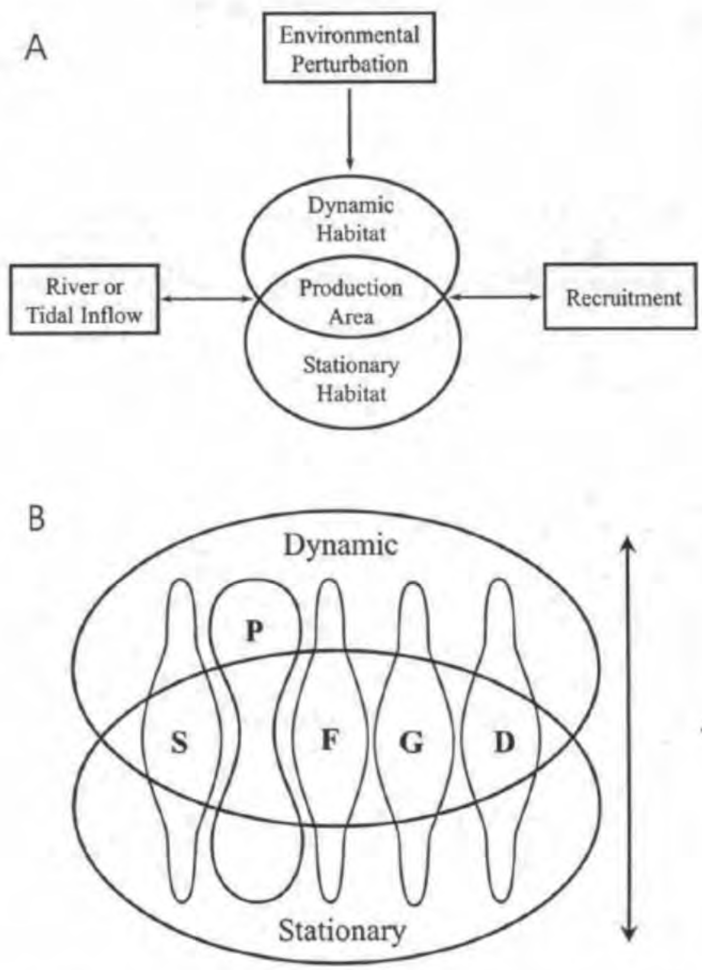
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FIGURE 1. (A) Modification of the conceptual model of Browder and Moore (1981), illustrating the connection of dynamic and stationary environmental components and production area in tidal-river estuaries. (B) Conceptual model illustrating the connection between the dynamic and stationary environmental components in tidal-river estuaries. Double headed arrow illustrates the potential shift in direction of the dynamic and stationary components of the environment relative to environmental purturbation. This shift in position restricts the area of production and influences the five individual or population metrics presented. P = predation; F = foraging; G = growth; S = survival; D = density.

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Figure 26. Image copied from Peterson (2003)

Currently, the best available scientific information indicates that delta smelt habitat suitability should be optimized when low-salinity water is near 20°C, highly turbid, oxygen saturated, low in contaminants, supports high densities of calanoid copepods and mysid shrimp (Moyle *et al*. 1992; Lott 1998; Nobriga 2002), and occurs over comparatively static 'landscapes' that support sandy beaches and bathymetric variation that enable the fish and their prey to aggregate (Kimmerer et al. 2002; Bennett et al. 2002; Hobbs et al. 2006). As detailed below, almost every component listed above has been greatly changed over time. The Service has determined that this accumulation of habitat change is the fundamental reason or mechanism that has caused delta smelt to decline (USFWS 2010).

Alterations to estuarine bathymetry, PCE # 1 (~ 1850-present):

The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Nichols et al. 1986). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 300,000 acres. Most of the wetlands were diked and reclaimed for agriculture or other human use by the 1920s. The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization that is not attributable to the Projects. However, the Projects have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the DCC, and storage reservoirs like Clifton Court Forebay, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

In the 1930s to 1960s, the shipping channels were dredged deeper (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento-San Joaquin river confluence region as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle et al. 1992; Jassby et al. 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the LSZ in the large Suisun Bay/river confluence region than was once required (Gartrell 2010). The construction of the Centrally Valley Project (CVP) and State Water Project (SWP) not only provided water supply for urban, agricultural and industrial users, but also provided the water needed to combat salinity intrusion into the Delta, which was being observed by the early 20th century.

Seasonal salinity intrusion reduces the temporal overlap of the LSZ (indexed by X2) with the Suisun Bay region, especially in the fall (Feyrer et al. 2007; 2011). Thus, the second major change has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation (DFG 2010). This metric showed a step-decline in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer et al. 2011). As such this alteration of PCE # 1 also affects the other PCEs, particularly PCE # 4. The major landscape factor affecting this interaction was the dredging of shipping channels, which was not a Project effect. Project infrastructure like the Suisun Marsh Salinity Control Gates can have local influences on the distribution of salinity in the Suisun Bay region.

The major invasive species effect on physical habitat is the dense growth of submerged aquatic vegetation in the Delta (described in more detail below). These plants carpet large areas in parts of the Delta such as Frank’s Tract. The vegetation beds act as mechanical filters removing turbidity and possibly other water quality components as the tides and river flows move water over them (Hestir 2010). Thus, the proliferation of submerged aquatic plants has likely also reduced the area of nearshore habitat suitable for delta smelt spawning.

Alterations to PCE # 2 ("Water")

PCE # 2 is primarily referring to a few key water quality components (other than salinity) that influence spawning and rearing habitat suitability for delta smelt. Research to date indicates that water quality conditions are more important than physical habitat conditions for predicting where delta smelt occur (Feyrer et al. 2007; Nobriga et al. 2008; Figure 27), probably because delta smelt is a pelagic fish except during its egg/embryo stage. Spawning delta smelt require all four PCEs, but spawners and embryos are the life stage that is believed to most require a specific structural component of habitat. Spawning delta smelt require sandy or small gravel substrates for egg deposition (Bennett 2005).

However, the interaction of water quality and bathymetry is thought to generally affect estuarine habitat suitability (Peterson 2003; Figure 26) and there is evidence that delta smelt habitat is optimized when appropriate water quality conditions overlap the Suisun Bay region (Moyle et al. 1992; Hobbs et al. 2006; Feyrer et al. 2011). This is discussed further in the section about PCE # 4 (salinity).

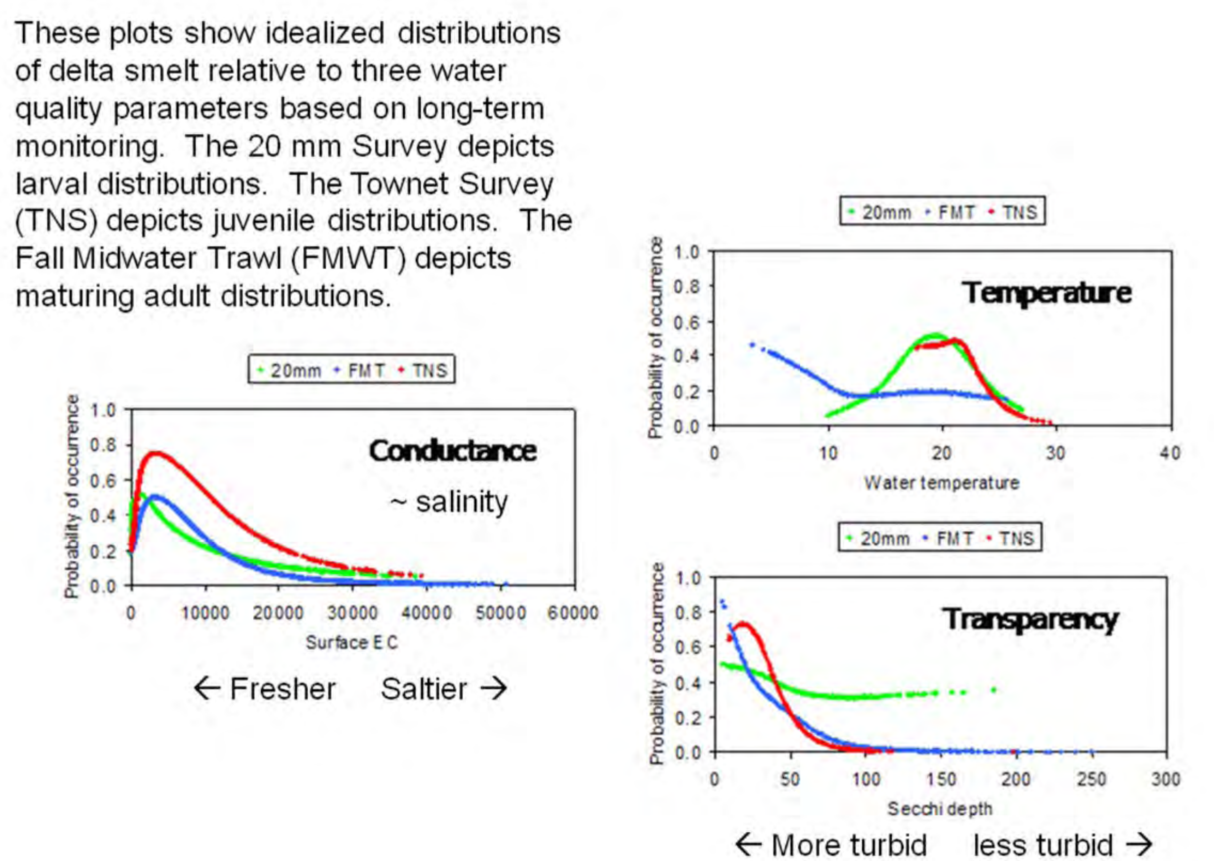

Figure 27. Predicted delta smelt frequency of occurrence relative to the specific conductance, transparency, and temperature of water in the San Francisco Estuary. Results are shown for three monitoring surveys: 20mm, Summer Townet, and Fall Midwater Trawl.

Changing predation pressure (1879 to present)

Nothing is known about the historical predators of delta smelt or their possible influence on delta smelt. Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals so there has always been a very long list of potential predators of delta smelt's eggs and larvae. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

The introduction of striped bass into the San Francisco Estuary in 1879 added a permanently resident, large piscivorous fish to the low-salinity zone, a habitat that is not known to have had an equivalent predator prior to the establishment of striped bass (Moyle 2002). This likely changed predation rates on delta smelt, but there are no data available to confirm this hypothesis. For many decades the estuary supported higher striped bass and delta smelt numbers than it does currently. This is evidence that delta smelt is able to successfully coexist with striped bass.

The current influence of striped bass and other predators on delta smelt population dynamics is also not known mainly because quantitative descriptions of predator impacts on rare prey are extremely difficult to generate. Delta smelt were observed in the stomach contents of striped bass and other fishes in the 1960s (Stevens 1963; Turner and Kelley 1966), but have not been observed in more recent studies (Feyrer et al. 2003; Nobriga and Feyrer 2007). Predation is a common source of density-dependent mortality in fish populations (Rose et al. 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observed in delta smelt population dynamics (Bennett 2005; Maunder and Deriso 2011). Because it is generally true for fishes, the vulnerability of delta smelt to predators is influenced primarily by habitat conditions. Turbidity may be a key mediator of delta smelt's vulnerability to predators (Nobriga et al. 2005; 2008). Growth rates, an interactive outcome of feeding success and water temperature, are also well known to affect fishes' cumulative vulnerability to predation (Sogard 1997). Thus, predation rate is best characterized as an aspect food web function linked to PCE # 2.

Food web alterations attributable to the overbite clam (1987-present)

The next major change to PCE # 2 occurred following the invasion of the estuary by overbite clam (*Corbula amurensis*). The overbite clam was first detected in 1986 and from 1987-1990 its influence on the ecosystem became evident. Since 1987, there has been a step-decline in phytoplankton biomass (Alpine and Cloern 1992; Jassby et al. 2002). Phytoplankton in the LSZ is an important component of the pelagic food web that delta smelt are a part of because a key part of the diet of delta smelt's prey is phytoplankton. Not only does the overbite clam reduce food for delta smelt's prey, it can also graze directly on the larval stages of the copepods eaten by delta smelt (e.g., Kimmerer et al. 1994). The grazing pressure applied by the overbite clam rippled through the historical zooplankton community that fueled fishery production in the LSZ (Kimmerer et al. 1996; Orsi and Mecum 1996; Kimmerer 2002b; Feyrer et al. 2003). This major change in the way energy moved through the ecosystem has likely facilitated the numerous invasions of the estuary by suppressing the production of historically dominant zooplankton, which increases the opportunity for invasion by other species that are less dependent on high densities of LSZ phytoplankton.

The distribution and abundance of several LSZ fishes have changed since 1987 (Kimmerer 2002b; Kimmerer 2006; Rosenfield and Baxter 2007; Mac Nally et al. 2010). Surprisingly, the changes in phytoplankton and zooplankton production have not been as evident for delta smelt as for other organisms (Kimmerer 2002b; Kimmerer 2006; Sommer et al. 2007; Mac Nally et al. 2010). Nonetheless, delta smelt collected in the FMWT have been persistently smaller since the overbite clam invasion (Sweetnam 1999; Bennett 2005). This is evidence for reduced growth rates that could have been caused by food web changes stemming from overbite clam grazing.

The Service considers the prey density aspect of the estuarine food web to be a component of PCE # 3 ("Water"). The Projects entrain some food web production (about 4.5% on a daily average basis was attributed to all Project and non-project water diversion in the Delta; Jassby et al. 2002). However, prey densities have been most strongly affected by clam grazing (Kimmerer et al. 1994; Jassby et al. 2002). Urban wastewater input, *Microcystis* blooms, and pesticide loads may also impair the production of zooplankton eaten by delta smelt or eaten by delta smelt's prey (Wilkerson et al. 2006; Dugdale et al. 2007; Jassby 2008; Ger et al. 2009; Werner et al. 2010).

Proliferation of Submerged Aquatic Vegetation (1980s to present)

For many decades, the Delta's waterways were turbid and the growth of submerged plants was apparently unremarkable. That began to change in the mid-1980s, when the Delta was invaded by the non-native plant *Egeria densa*, a fast-growing aquarium plant that has taken hold in many shallow habitats (Brown and Michnuik 2007; Hestir 2010). *Egeria densa* and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (> 20^{o}C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer et al. 2008). First, dense SAV promotes water transparency. Increased water transparency leads to a loss of habitat for delta smelt (Feyrer et al. 2007; Nobriga et al. 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes, including largemouth bass, which now dominate many shallow habitats of the Delta and displace native fishes (Nobriga et al. 2005; Brown and Michniuk 2007). Finally, SAV colonization over the last three decades has led to a shift in the dominant freshwater food web pathways that fuel fish production (Grimaldo et al. 2009b). It is noteworthy that SAV-dominated habitats are comparatively productive (Nobriga et al. 2005; Grimaldo et al. 2009b), but most of the productivity they generate remains in the nearshore environment and therefore does not contribute much to pelagic fish production (Grimaldo et al. 2009b).

Reduced turbidity (1999-present)

The next major change was a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. The sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2004). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008). Delta smelt larvae require turbidity to initiate feeding (Baskerville-Bridges et al. 2004), and as explained above, older fish are thought to use turbidity as cover from predators. Thus, turbidity is an aspect of PCE # 2 which is a necessary water quality aspect of delta smelt's Critical Habitat.

The Projects' infrastructure (dams and armored levees) have contributed to the long-term decline in sediment load to the estuary (Wright and Schoellhamer 2004). Thus, Project infrastructure contributed to the clearing of estuary water. This is a long-term effect that stemmed from building and maintaining Project infrastructure. Opportunities to substantively address this change are limited due to the extreme Central Valley flood and water supply risks that would result from decommissioning dams or removing Project levees.

Changing Water Temperature (present through long-term climate forecasts)

Delta smelt is already subjected to thermally stressful temperatures every summer. Water temperatures are presently above 20ºC for most of the summer in core habitat areas (Figure 28), sometimes even exceeding the nominal lethal limit of 25ºC for short periods. Note that coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi et al. 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become moreso if temperatures warm in the coming decades.

All available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). It is expected that warmer estuary temperatures will be yet another significant conservation challenge (Brown et al. unpublished data). This is true because they will limit abiotic habitat suitability further than indicated by flow-based projections (e.g., Feyrer et al. 2011). In addition, warmer water temperatures mean that higher prey densities will be required just to maintain present-day growth rates, which are already lower than they once were (Sweetnam 1999; Bennett 2005).

The Projects do not meaningfully influence water temperatures in delta smelt's Critical Habitat. Water temperature is mainly affected by climate variation, both as air temperature and as flood/drought scale flow variation (Kimmerer 2004; Wagner et al. 2010).

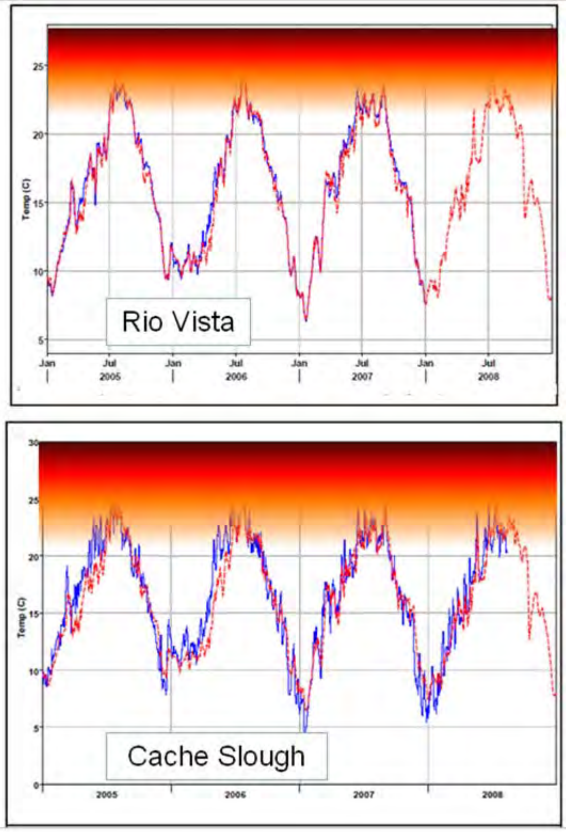

Figure 28. Source: Bay-Delta Conservation Plan, Chapter 5 Technical Appendix E. The red gradients were added by Service staff to show the temperatures where delta smelt health and survival can be impaired.

Sensitivities to Contaminants (ongoing)

Delta smelt's spawning migration coincides with early winter rains (Sommer et al. 2011). This 'first-flush' of inflow to the Delta brings sediment-bound pesticides with it (Bergamaschi et al. 2001), and peak densities of larvae and juveniles can co-occur with numerous pesticides (Kuivila and Moon 2004). Bennett (2005) reported that about 10% of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure, but this was low compared to the 30%-60% of these fish that appeared to be food-limited.

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon et al. 2009; 2011). This research has also shown that gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality.

Climatic scale flow variation (e.g., flood versus drought scale variation) affects the amount of methyl mercury (Darryl Slotton presentation) entering the ecosystem and may have some influence on the meaningful dilution of ammonium from urban wastewater inputs (Dick Dugdale presentation). However, the Service is not aware of evidence that the amount of flow variation that can be sustainably provided by Project operations substantively influences contaminant dynamics in the estuary.

Invasive species may also affect PCE # 2 by changing contaminant dynamics. For instance, *Microcystis* blooms generate toxic compounds that can kill delta smelt prey (Ger et al. 2009) and accumulate in the estuarine food web (Lehman et al. 2010). A second example is the biomagnification of selenium in the food web by *Corbula* (Stewart et al. 2004). This has been considered a potential issue for the clam's predators – namely sturgeon, splittail, and diving ducks (Richman and Lovvorn 2004; Stewart et al. 2004). However, it is not known whether this change in selenium dynamics negatively affects delta smelt and other fishes that do not directly prey on the clams.

Alterations of river flows (PCE # 3)

This PCE refers to the transport flows that help guide young delta smelt from spawning habitats to rearing habitats, and to flows that guide adult delta smelt from rearing habitats to spawning habitats. Delta outflow also has some influence on delta smelt's supporting food web (Jassby et al. 2002; Kimmerer 2002) and it affects abiotic habitat suitability as well (Feyrer et al. 2007; 2011). The latter is expanded upon in the discussion of PCE # 4. The environmental driver with the strongest influence on PCE # 3 is highly dependent on the time-scale being considered. The tide has the largest influence on flow velocities and directions in delta smelt's Critical Habitat at very short timescales (minutes to days), whereas interannual variation in precipitation and runoff has the largest influence on flows into and through the Delta at very long timescales (years to decades), and sometimes at shorter time scales (days to weeks) during major storm events. However, Project operations can strongly influence inflows, outflows and Old and Middle river (OMR) flows. Project changes to flow regimes can have the largest influence on PCE #3 at timescales of weeks to seasons. This is particularly true during periods of low natural inflow, for instance during the fall and during droughts, and in the south Delta where OMR flows are often managed using changes in export flow rates.

Entrainment into water export diversions (1951 to present)

The amount of water diverted from the estuary has generally increased over time (Figure 29), and most of the increase during the 1950s and 1960s was due to CVP exports and since the latter 1960s, State Water Project (SWP) exports. There are two basic potential fishery impacts that result from water diversion from the Delta: ecosystemic impacts and direct entrainment. From the ecosystemic perspective, water diversions are unnatural 'predators' because they 'consume' organisms at every trophic level in the ecosystem from phytoplankton (Jassby et al. 2002) to fish (Kimmerer 2008). Unlike natural predators which typically shift their prey use over time in association with changes in prey fish density (Nobriga and Feyrer 2008), fractional entrainment losses of fishes to diversions are functions of water demand (e.g., Grimaldo et al. 2009). Thus, water diversions not only elevate 'predation' mortality in an aquatic system, but they can do so in an atypical, density-independent manner. Additionally, the Project diversions and fish collection facilities in the south Delta are very large structures which attract large aggregations of actual predatory fish that prey on smaller species like delta smelt before they reach the fish salvage facilities and within these facilities (Gingras 1997). This gauntlet of predators may bias the salvage data that often are used to link the Project operations with entrainment (Castillo et al. in review).

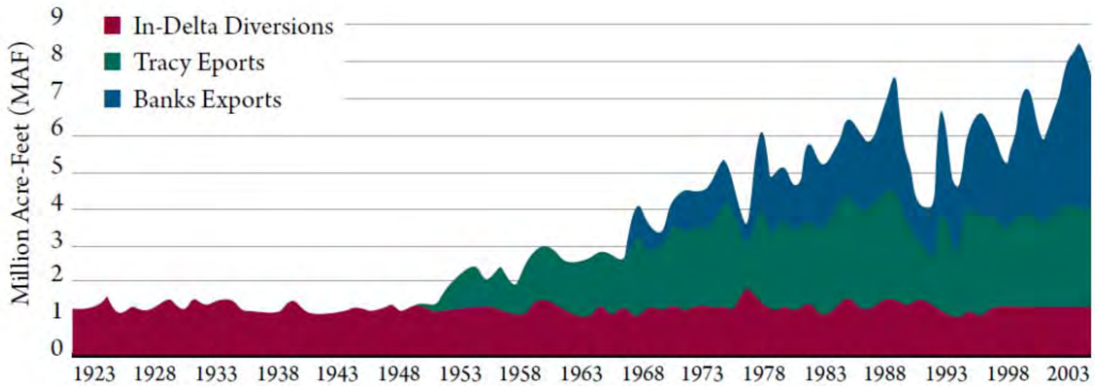

Figure 2.8. Delta Water Diversions and Exports. Delta diversions and exports have grown over time. In-Delta diversions for irrigation have been about the same since the early 1900s. Federal exports (Tracy) began in the early 1950s, and state exports (Banks) began in the late 1960s. (Source: URS Corporation 2007)

Figure 29. Source CALFED Science Program State of Science Report, 2008

Estimated entrainment losses of delta smelt to Project diversions can be substantial in some years (Kimmerer 2008). Given the delta smelt's current density-independent population dynamics, even a statistically indiscernable entrainment effect on the population is likely to cause the species to continue to decline (Kimmerer 2011). The entrainment losses of delta smelt are not generally observed until they reach the early juvenile stage (~ 20-30 mm in length), but combinations of 20mm Survey distribution data and hydrodynamic modeling provide evidence that their risk of entrainment into the Project diversions can be described by any of several indices that integrate Delta inflow and export flow (Kimmerer and Nobriga 2008; Kimmerer 2008; USFWS 2008; Grimaldo et al. 2009).

Delta smelt entrainment losses estimated from survey data and hydrodynamics can also be substantial in some years (Kimmerer 2008), though it is possible that Kimmerer may have overestimated them (Miller 2011; see Effects Analysis for further details). Nonetheless, increasingly higher outflow (or lower X2) moves the bulk of the larval population increasingly west, which results in fewer larvae distributed in the south Delta where they are at highest risk of entrainment. At the same time, indices like the export to inflow ratio or Old and Middle River (OMR) flow are useful metrics for gauging the effect of exports on the south Delta.

The risk of delta smelt entrainment into smaller agricultural irrigation diversions used mainly to irrigate crops within the Delta is also related to flow conditions. These in-Delta irrigation diversions generally have mean flow rates less than 1 cubic meter per second (Nobriga et al. 2004). The lower the Delta outflow, the higher the proportion of the young delta smelt population that overlaps the array of irrigation diversions in the Delta

(Kimmerer and Nobriga 2008). However, the irrigation diversions are not currently considered to represent a substantial source of mortality because they individually draw small quantities of water relative to channel volumes (Nobriga et al. 2004).

In Suisun Marsh, water diversions are largely made to support waterfowl production. Some Suisun Marsh diversions are larger for the size of channels they are in than most of the agricultural irrigation diversions in the Delta. Based on hydrodynamic simulations, proximity to water diversions in the marsh is expected to correlate strongly with entrainment (Culberson et al. 2004), and substantial delta smelt losses have been reported when these diversions are not screened (Pickard 1982). Entrainment risk for delta smelt in western Suisun Marsh is considered low because the habitat surrounding the diversions is often too saline (Enos et al. 2007).

PCE # 4 Salinity:

The core delta smelt habitat is the LSZ (Moyle et al. 1992; Bennett 2005). The low-salinity zone (LSZ) is where freshwater transitions into brackish water; the LSZ is defined as the area of the estuary where salinity ranges from 0.5-6.0 psu (parts per thousand salinity; Kimmerer 2004). This area is always moving due to tidal and river flow variation. The 2 psu isohaline is a specific location within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby and others 1995). By local convention, changes in the location of the LSZ are described in terms of the distance from the Golden Gate Bridge to the 2 psu isohaline (X2); X_2 is an indicator of habitat suitability for many of the estuary's organisms and it is associated with variance in abundance of diverse components of the ecosystem (Jassby and others 1995; Kimmerer 2002b; Kimmerer and others 2009). The LSZ expands and moves downstream when river flows into the estuary are high (Kimmerer et al. 2009). Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X_2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km).

Larval delta smelt tend to reside somewhat landward (upstream) of X2 (Dege and Brown 2004), but the center of juvenile distribution tends to be very near X2 until the fish start making spawning migrations in the winter (Feyrer et al. 2011; Sommer et al. 2011). Because of this association between the distribution of salinity in the estuary and the distribution of the delta smelt population, the tidal and river flows that comprise PCE # 3 affect PCE # 4. Thus, PCE # 4 can be affected by the Projects – particularly at the temporal scale of weeks to seasons. The Project effects on delta smelt habitat suitability are discussed further in the Effects Analysis.

The expansion and contraction of the LSZ affects the areal extent of abiotic habitat for delta smelt, both during spring (Kimmerer et al. 2009) and fall (Feyrer et al. 2007; 2011). In the spring, most delta smelt are larvae or young juveniles and the LSZ is typically maintained over the expansive Suisun Bay region. Thus, abiotic habitat "limitation" is unlikely and no consistent influence of spring X2 variation on later stage abundance estimates has been reported to date (Jassby et al. 1995; Bennett 2005; Kimmerer et al. 2009). In fact, historical maxima in juvenile abundance according to DFG's Summer Townet Survey occurred in low outflow years when abiotic habitat area was comparatively low (Kimmerer 2002; Kimmerer et al. 2009).

In contrast, during fall delta smelt are late stage juveniles and for the past decade or more, the LSZ has been persistently constricted by low Delta outflow (see Effects Analysis). Fall habitat conditions affect delta smelt distribution and the concurrent Fall Midwater Trawl abundance index (Feyrer et al. 2007; 2011). However, the quantitative life cycle models developed to date have not found evidence for a year over year affect of fall LSZ location on delta smelt population dynamics (Mac Nally et al. 2010; Thompson et al. 2010; Deriso 2011).

It is now recognized that some delta smelt occur year-around in the Cache Slough region including the Sacramento River Deep Water Shipping Channel and Liberty Island (Kimmerer 2011; Miller 2011; Sommer et al. 2011). The latter has been a consistently available habitat only since 1997. This region is often lower in salinity than 0.6 psu – the lower formal limit of the LSZ as defined by Kimmerer (2004). Delta smelt likely use it because it is one of the most turbid habitats remaining in the Delta (Nobriga et al. 2005). A recent population genetic study found no evidence that delta smelt inhabiting this region are unique compared to delta smelt using the LSZ-proper (Fisch et al. 2011), therefore it is likely that individual delta smelt migrate between the LSZ and the Cache Slough region. This is consistent with the high summer water temperatures observed there (Figure 3), which might compel individual delta smelt to seek out cooler habitats within and outside the Cache Slough region.

Effects of the Proposed Action

Introduction

The following section is preliminary and based on modeling received by the Service on August 28, 2011. Additional analyses will be required as Reclamation modifies or supplements its project description.

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 sometimes controlled to a large extent by CVP and SWP operations. Other sources of water diversion (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 CVP and SWP export facilities. While research indicates that there is no single primary driver of delta smelt population dynamics, hydrodynamic conditions driven or influenced by CVP/SWP operations may 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 influenced 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 (Winder et al. 2011). 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 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, 2010; Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011), 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. Complex life cycle models are necessary when populations are subject to density-dependence in one or more life stages (e.g., Maunder and Deriso 2011). However, as explained above, substantive compensatory density-dependence is unlikely to be occurring at baseline (present-day conditions). Thus, high mortality in one life stage will persist without being compensated for into subsequent life stages (Kimmerer 2011). 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, this BO specifically focuses on entrainment and flow-related effects on habitat suitability

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 habitat suitability. During December-June, when delta smelt are commonly entrained at Banks and Jones, their habitat including the co-occurring food supply also are being entrained, so CVP/SWP-related effects on habitat 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 tributaries are not appropriate to support delta smelt. The water is too warm and clear and thus, 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 these major effects, as 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.

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, some updates to those outputs provided in September 2011, 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. 2009) (Table 25).

Table 25. Summary of assumptions in the 20XX 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	Same as above		Same as	Same as		X	X		

D1641 (1994)			above	above					
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 BA to the 2008 BA. A summary of these changes are provided the Table 26.

Table 26. Changes in CALSIM II model updates and assumptions from 2004 to 20XX

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,	Future with Limited EWA with updated more explicit

	debts, and actions	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 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 BA (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 was 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.

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 Service 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 27), so most of the fish are not salvaged and therefore do not survive. Many, if not most, of the delta smelt that do reach the fish facilities likely die due to handling stress and predation (Bennett 2005). Pre-screen loss due to entrainment at the CVP and SWP, is an additional cause of mortailty for delta smelt. The PSL in CCF was estimated to be 100 percent during recent studies that used captive bred fish (Castillo et al. in review). The effects of NBA and CCWD operations on delta smelt are presented separately below.

Table 27. Factors affecting delta smelt entrainment and salvage.

	Adults	Larvae < 20 mm	Larvae > 20 mm and juveniles
Predation prior to encountering fish salvage facilities[a]	89.9-100%	unquantified	99.9%[b]
Fish facility efficiency (based on Kimmerer 2008)	Limited data indicate an efficiency of about 13 percent for the CVP facility; SWP efficiency averaged an estimated 50%, but actual efficiency was related to operating conditions	~ 0 percent	Likely < 13 percent at any size; << 13 percent at less than 30 mm; estimated at 24% and 30% in two experiments in June 2009 (Castillo et al. in review)

	(Castillo et al. in review)		
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[c]	Controlled conditions trial (2005): 94% were recovered from the Skinner fish facility; 87% survived for 48 hrs in a holding tank after the experiment Empirical salvage trial (2006): 90% were recovered from the Skinner fish facility; 78% survived for 48 hrs in a holding tank after the experiment	0 percent	Controlled conditions trial (2005): 73% were recovered from the Skinner fish facility; 37% survived for 48 hrs in a holding tank after the experiment Empirical salvage trial (2006): 89% were recovered from the Skinner fish facility; 58% survived for 48 hrs in a holding tank after the experiment

[a]Pre-screen loss (Castillo et al. in review)
[b]Based on one release experiment (Castillo et al. in review)
[c]Unpublished report sent by Jerry Morinaka (CDFG) on July 13, 2011; numbers reported do not include predation at release sites

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 ten 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 are entrained by the Projects during spawning migrations (Grimaldo et al. 2009; Sommer et al. 2011). Their spawning migrations occur during the winter when precipitation increases the freshwater flow and turbidity in the Delta. Salvage of adult delta smelt at the Projects is an index of entrainment. Salvage of adults has mainly occurred from late

December through March (Kimmerer 2008; Grimaldo et al. 2009). For migrating adults, the risk of entrainment is influenced by flow cues and turbidity in the south Delta.

Old and Middle Rivers are distributary channels of the San Joaquin River (Grimaldo et al. 2009). Project pumping (i.e., the export of water from the Delta) can cause the tidally filtered, or “net” flows in these channels to move “upstream”. This occurs because water removed by Banks and Jones is back-filled in by tidal and river flows. This phenomenon is mathematically depicted as negative flow. Negative Old and Middle River (OMR) flows are often associated with adult delta smelt entrainment, but there is no particular OMR flow that assures entrainment will or will not occur (Figure 30to 34). The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. Thus, it is possible the net flows themselves are the mechanism that increases entrainment risk for delta smelt. However, high exports can also lead to the loss of ebb tide flows in Old and Middle Rivers (Gartrell 2010), so altered tidal flows are a second, covarying mechanism that could increase delta smelt’s risk of entrainment.

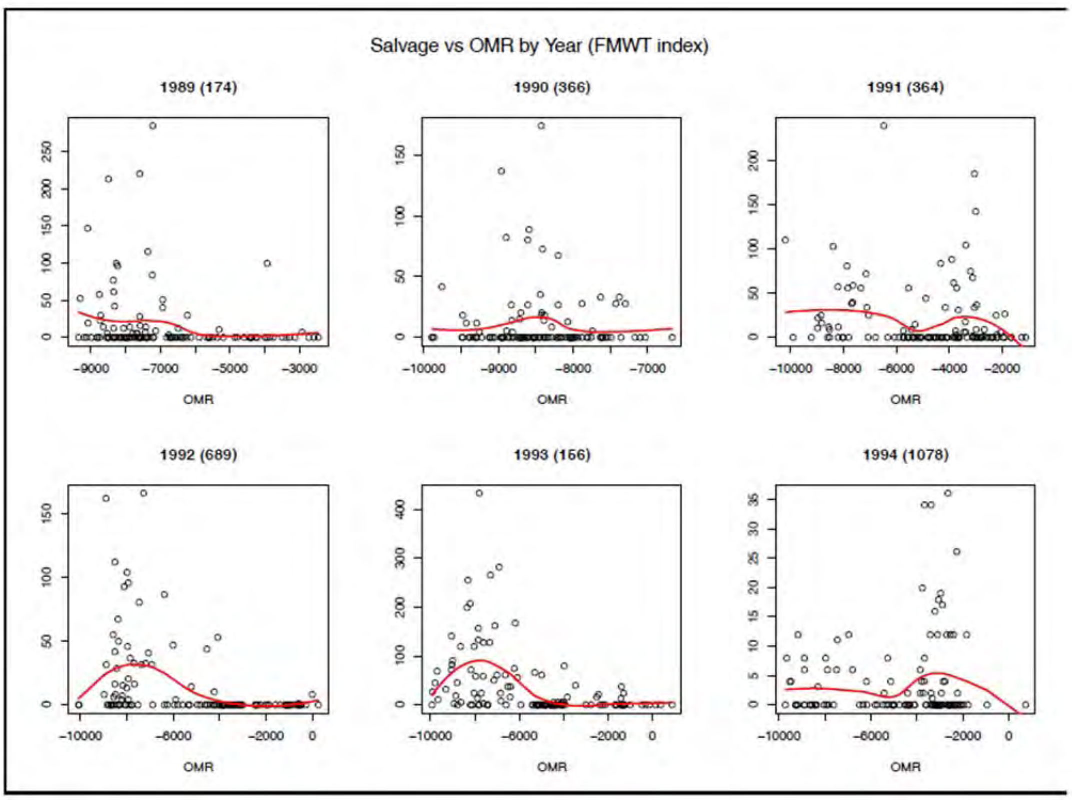

Figure 30.Scatterplots of net daily flow in Old and Middle rivers versus daily delta smelt salvage for the months December-March, 1989-1994 (December data are 1988-1993). The Fall Midwater Trawl abundance index for delta smelt that immediately precedes the salvage data in time is shown at the top of each panel in parentheses. The red lines are splines showing the empirical trend in the data. Source: Ken Newman (Stockton Fish and Wildlife Office)

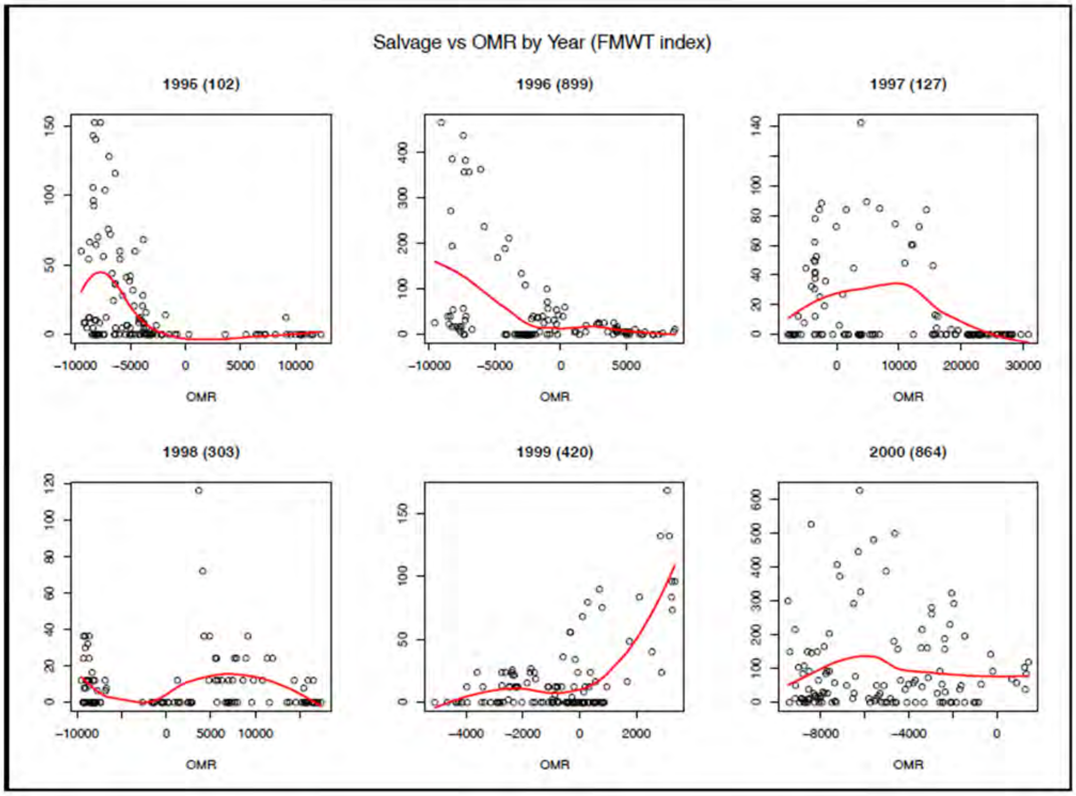

Figure 31. Scatterplots of net daily flow in Old and Middle rivers versus daily delta smelt salvage for the months December-March, 1995-2000 (December data are 1994-1999).The Fall Midwater Trawl abundance index for delta smelt that immediately precedes the salvage data in time is shown at the top of each panel in parentheses. The red lines are splines showing the empirical trend in the data. Source: Ken Newman (Stockton Fish and Wildlife Office)

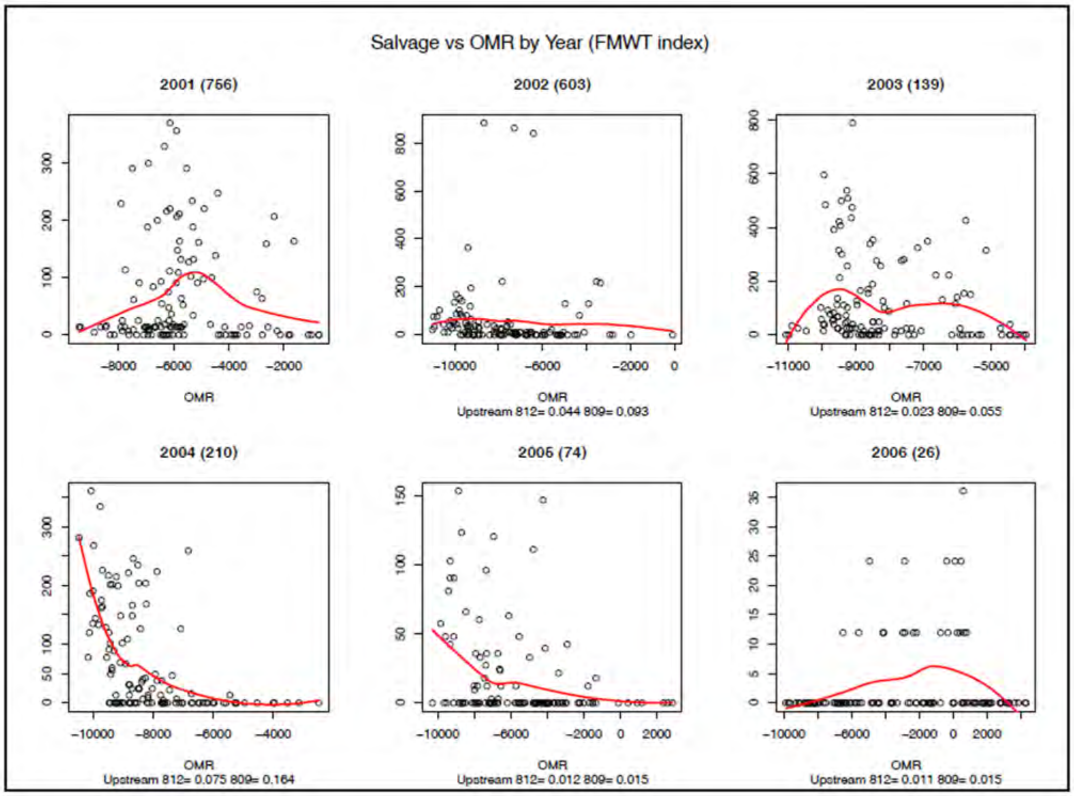

Figure 32. Scatterplots of net daily flow in Old and Middle rivers versus daily delta smelt salvage for the months December-March, 2001-2006 (December data are 2000-2005). The Fall Midwater Trawl abundance index for delta smelt that immediately precedes the salvage data in time is shown at the top of each panel in parentheses. The red lines are splines showing the empirical trend in the data. Source: Ken Newman (Stockton Fish and Wildlife Office)

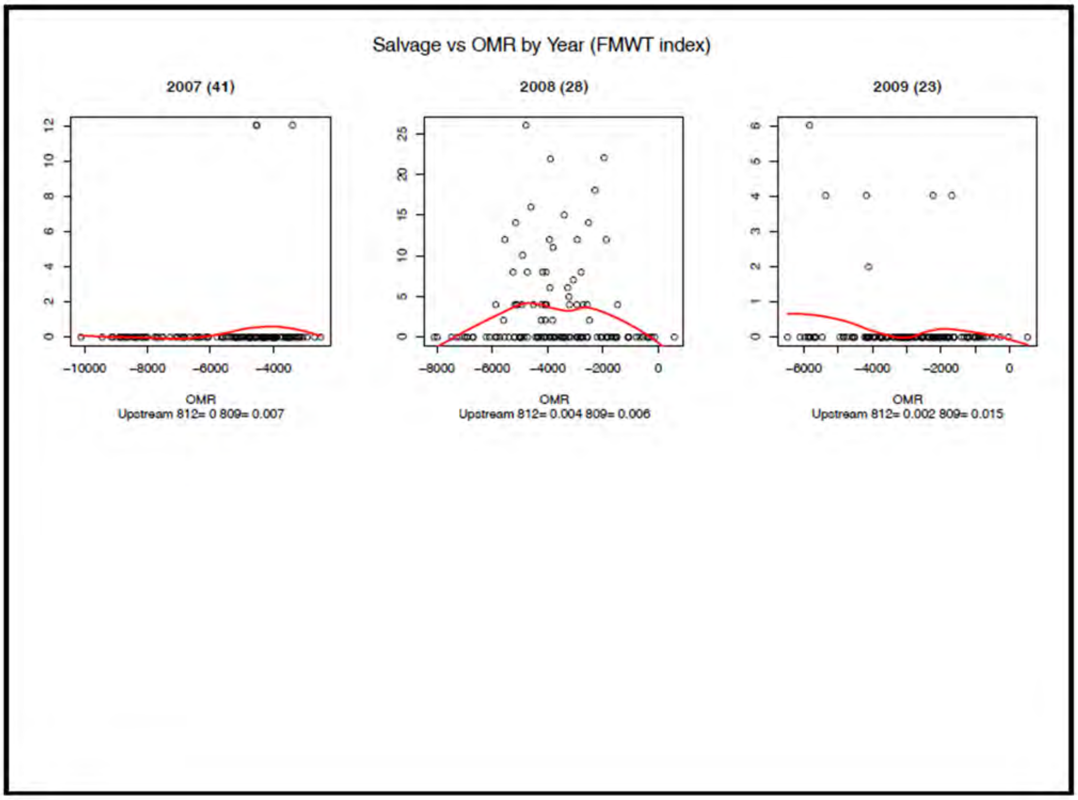

Figure 33. Scatterplots of net daily flow in Old and Middle rivers versus daily delta smelt salvage for the months December-March, 2007-2009 (December data are 2006-2008). The Fall Midwater Trawl abundance index for delta smelt that immediately precedes the salvage data in time is shown at the top of each panel in parentheses. The red lines are splines showing the empirical trend in the data. Source: Ken Newman (Stockton Fish and Wildlife Office)

The empirical shape of the associations between estuarine salinity distribution (X2), OMR, turbidity and adult delta smelt salvage normalized by the FMWT is shown in Figure 34. Normalized delta smelt salvage is correlated in a nonlinear way with X2. An interpretation of this is that the intermediate river flow or X2 conditions are associated with the highest salvage because flows are high enough to disperse turbidity around the Delta, but not so high that most delta smelt are distributed seaward of the Delta. Figure 34 shows that even when X2 and south Delta turbidity are accounted for, there is no OMR flow that assures delta smelt entrainment will or will not occur. The predicted relationship is a smooth, accelerating function with increasing normalized salvage as OMR flow becomes more negative.

```
Full Model

*** Generalized Additive Model ***

Call: gam(formula = Sal.pfmwt ~ s(O.M.flow) + s(CCFNTU) + s(X2),
family = gaussian,
                data = biop, na.action = na.omit, control = list(epsilon =
0.001,
                bf.epsilon = 0.001, maxit = 50, bf.maxit = 10, trace = F))
Deviance Residuals:
     Min        1Q      Median        3Q       Max
-0.6108443 -0.1510043 -0.05404843 0.0677257 4.971304

(Dispersion Parameter for Gaussian family taken to be 0.1261855 )

   Null Deviance: 355.2256 on 2060 degrees of freedom

Residual Deviance: 258.4277 on 2047.999 degrees of freedom

Number of Local Scoring Iterations: 1

DF for Terms and F-values for Nonparametric Effects

          Df Npar Df  Npar F       Pr(F)
(Intercept) 1
s(O.M.flow) 1      3 22.77489 1.698641e-014
  s(CCFNTU) 1      3 31.86953 0.000000e+000
     s(X2) 1      3 29.17776 0.000000e+000
```

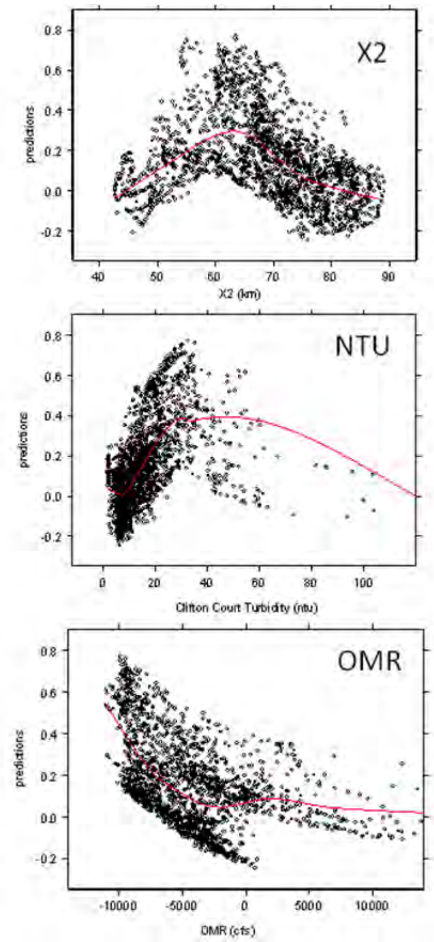

Figure 34. S-Plus output of a generalized additive model (GAM) testing for effects of X2, turbidity at Clifton Court Forebay (NTU), and net flow in Old and Middle rivers (OMR) on delta smelt salvage normalized by the preceding Fall Midwater Trawl abundance index. The text on the left shows the model code, the model fit is 1-(residual deviance/ null deviance). Thus, the model explains 1-(258/355) = 0.273 of the variation in normalized salvage. The column Pr(F) shows the probability of no trend in the data – these P-values are all much less than a standard 0.05 threshold due to the non-random trends in the data but also due somewhat to the very large sample size (> 2000 data points). The model predictions are shown in the panels on the right. The scatter in each panel is due to the interacting effects of the other two variables. The red lines are splines showing the empirical trends in the predictions. Source: Lenny Grimaldo (Reclamation Bay-Delta Office).

The Distribution of Spawning Delta Smelt

Delta smelt probably spawn in shallow, sandy habitats (Bennett 2005). This hypothesis is supported by laboratory experiments and by delta smelt's close evolutionary relationship with the marine surf smelt, which spawns in the intertidal habitat of Pacific coast beaches. Shallow, sandy habitats occur throughout the Delta (Nobriga 2011). Given suitable conditions, delta smelt can spawn successfully throughout the Delta, Suisun Marsh, and as far seaward as the Napa River, but this full range of potential spawning habitats is not available every year (Hobbs et al. 2005; 2007).

Snapshots of adult delta smelt distribution are available via trawl surveys. The Department of Fish and Game's Spring Kodiak Trawl Survey (SKTS) provides the best available information on where delta smelt are generally spawning (www.dfg.ca.gov/delta/; Figure 35). The survey is conducted once per month from January-May and has been occurring since 2002. During the first nine years of the SKTS, most delta smelt have been collected in Montezuma Slough (36%) and the Cache Slough region (32%); 6% have been collected in the Delta at trawl stations numbered 809 and higher, i.e., the San Joaquin River 'half' of the Delta[9]. Thus, the Service notes that most adult delta smelt have not been collected from locations where they would be expected to have a high risk of entrainment (i.e., stations numbered 809 and higher). However, the Service also notes that adult delta smelt have been collected in the lower San Joaquin River at or upstream of station 809 every year that the SKTS has been conducted (Figure 35) and that the ability of the survey to detect delta smelt appears to be dependent on population abundance (Figure 37). Note that both Kimmerer (2008; 2011) and Miller (2011) have assumed the SKTS is essentially 100% efficient for collecting delta smelt. This assumption is mainly for computational simplicity. However, this assumption of 100% gear efficiency is probably not strictly correct because (1) the ability to detect delta smelt in the San Joaquin River is contingent upon overall abundance (Figure 36), and (2) delta smelt are observed in salvage even when they are not observed in south Delta trawls (Figure 38).

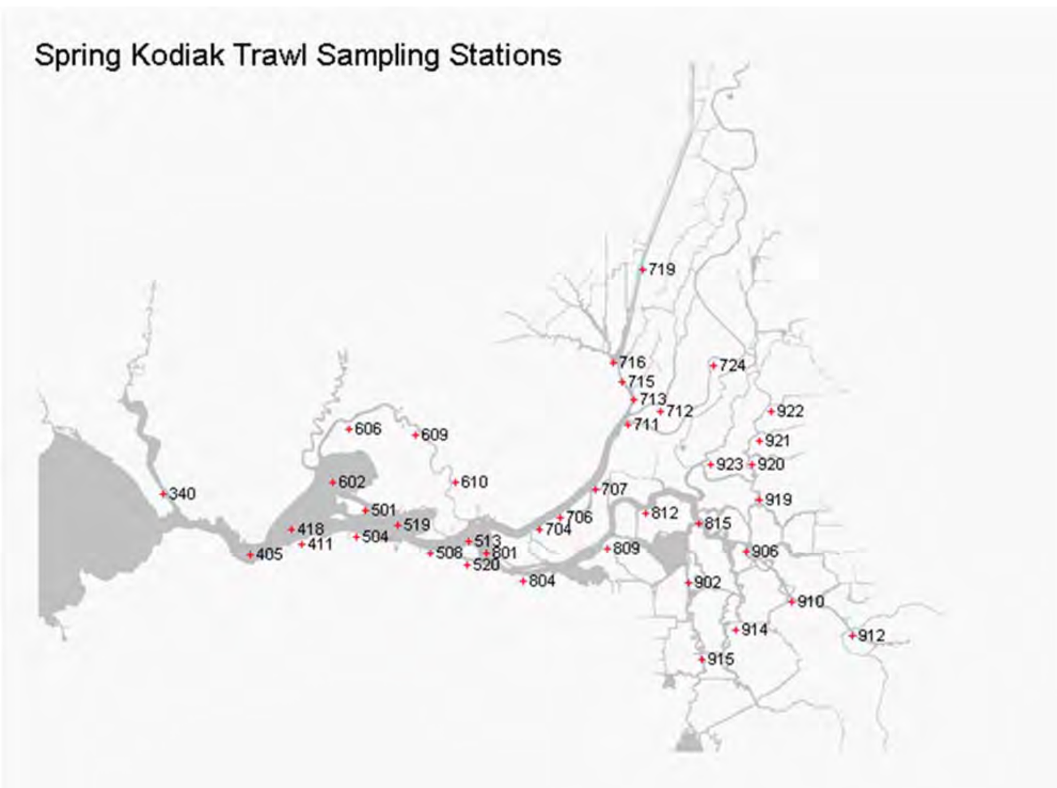

Figure 35. Map of the Department of Fish and Game's Spring Kodiak Trawl Survey sampling stations. Source: http://www.dfg.ca.gov/delta/data/skt/skt_stations.asp; August 30, 2011.

[9] Percentages calculated from the data shown in Figure 36. The region of the Delta encompassed by trawl stations numbered 809 and higher is considered by the Service to represent a region of elevated risk of entrainment based on Kimmerer and Nobriga (2008).

Sum of Catch — Column Labels

Row Labels	340	405	411	418	501	504	508	513	519	520	602	606	609	610	704	705	706	707	711	712	713	715
2002	1	3	2	3	1	0	5	13	3	17	8	257	256	76	17		26	3	41	1	8	6
2003	0	0	5	14	8	5	13	12	17	0	21	42	13	24	13		23	54	2	13	39	125
2004	1	0	0	3	6	2	0	8	15	23	7	170	360	1	98		25	15	0	0	4	6
2005	3	0	1	3	18	4	4	2	11	0	1	92	128	10	34		34	4	1	0	6	20
2006	34	2	5	1	8	5	3	3	8	2	1	49	10	4	1		0	1	0	0	0	18
2007	0	0	0	0	0	0	1	8	21	0	1	53	29	3	40		16	3	1	0	1	13
2008	0	1	0	0	4	1	4	3	4	0	1	4	3	0	63	4	19	11	0	0	2	9
2009	0	0	0	0	0	0	1	2	13	0	0	64	34	3	35		99	19	0	0	0	0
2010	0	0	0	1	0	0	2	3	3	0	1	64	37	1	27		11	2	0	0	5	18
Grand Total	39	6	13	25	45	17	33	54	95	42	41	795	870	122	328	4	253	112	45	14	65	215

Row Labels	716	719	724	725	801	804	809	812	815	902	906	910	912	914	915	919	920	921	922	923	Grand Total
2002	23			1	19	22	44	14	5	4	8	0	0	3	2	1	0	2	2	0	895
2003	173			7	8	1	28	4	2	0	3	0	0	1	0	0	0	0	2	9	681
2004	2			1	3	54	80	29	8	2	21	1	0	2	0	2	1	0	1	0	951
2005	51	42	1	0	1	0	2	4	2	2	1	0	0	0	0	0	2	0	0	0	484
2006	9	102	0		1	2	3	0	1	3	0	0	0	1	0	2	1	0	2	0	282
2007	12	187	0		0	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	398
2008	11	122	0		0	0	1	2	1	0	0	0	0	0	0	0	1	0	0	0	271
2009	3	459	0		0	0	11	0	1	0	0	0	0	0	0	0	0	0	1	0	745
2010	9	116	0		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	303
Grand Total	293	1028	1	9	32	82	178	53	20	11	31	1	0	7	2	5	5	2	8	9	5010

Figure 36. Cross-tabular summary of adult delta smelt catch by survey station in the Spring Kodiak Trawl, 2002-2010. The catch data were only summarized for surveys that sampled a full array of stations, i.e., no special surveys of only particular regions of the sampling grid. Empty cells show where no sampling occurred at a given station. Stations considered by the Service to potentially be within the typical hydrodynamic influence of the Projects' south Delta water diversions are shaded in light blue. See Figure 35 for locations of sampling stations.

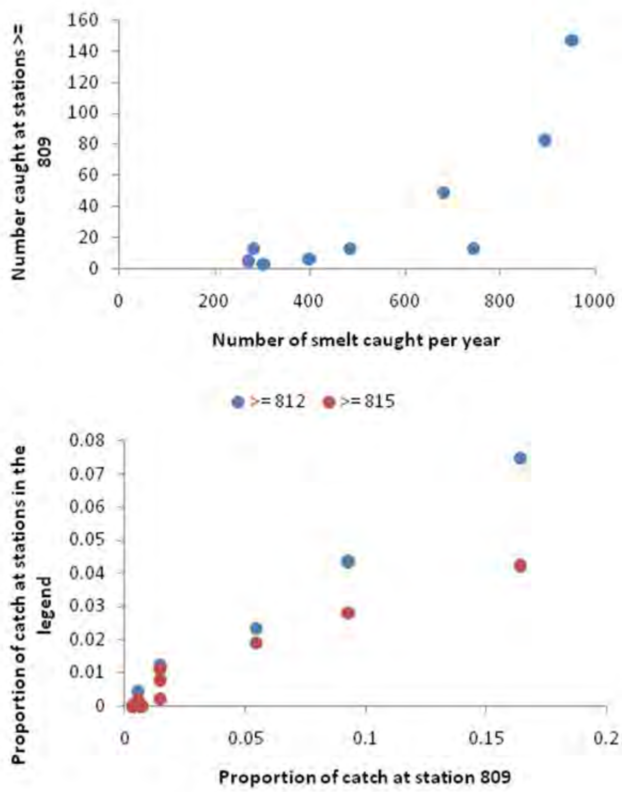

Figure 37. Scatterplot of the proportion of total SKTS catch collected from station 809 near Jersey Point on the San Joaquin River and the concurrent proportions collected at the next two stations located upstream, 812 (blue circles) and 815 (red circles). See Figure 35 for locations of sampling stations.

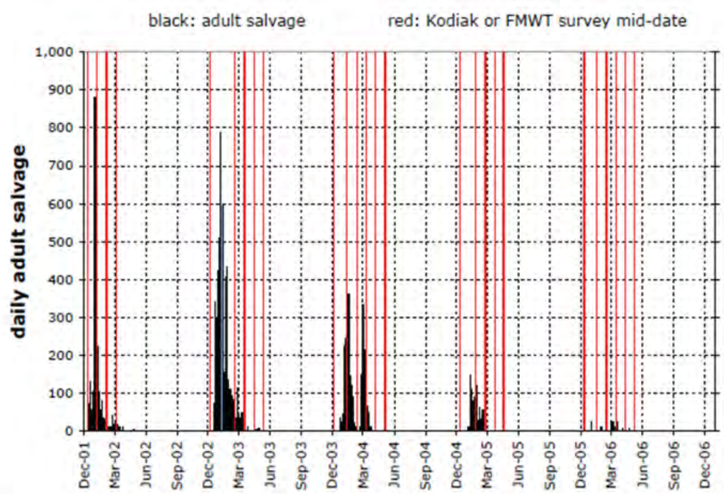

Figure 3 Daily adult salvage and mid-dates for Kodiak and Fall Midwater Trawl (FMWT) surveys

Figure 38. Copy of Figure 3 from Miller (2011). The vertical red lines denote dates of Spring Kodiak Trawl Surveys. The black histogram data show the timing and magnitude of adult delta smelt salvage at the Projects' fish facilities as a continuous time series for December 2001-2006.

Delta Smelt Life Cycle Models

There were no published life cycle models (LCMs) for delta smelt when the previous OCAP Biological Opinion was finished in December 2008. However, several have been developed and published since (Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011). The Mac Nally and Thomson models evaluate delta smelt population dynamics on an annual time step from one Fall Midwater Trawl Survey (FMWT) to the next. Maunder and Deriso (2011) developed a more sophisticated LCM framework. Their model evaluates population dynamics at three life stages represented by the FMWT, 20mm, and Summer Townet (STNS) surveys. All of these authors developed statistical LCMs, meaning models based on correlations of field observations rather than equations that explicitly describe delta smelt vital rates in terms of environmental variation. All of them correlate delta smelt abundance to prior abundance and to "covariates" that are physical and biological variables that are generally thought to affect delta smelt because they are the kinds of things that affect all organisms (predators, prey, and temperature) or they are factors of local management importance (X2, exports, and salvage).

The basic approach and findings of these LCMs are summarized in Table 28. If there is a 'big picture' conclusion to be gleaned from these studies, it is that the results depend *very strongly on how the model is set up and what covariates are considered*. The three LCMs have arrived at three different conclusions about the consequences of Project exports during winter on delta smelt abundance trends.

Table 28. Summary of results of published delta smelt life cycle models.

Authors	Description	Number of covariates	Life stage interval	Results for density-dependence	Factors correlated with delta smelt abundance
Mac Nally et al. (2010)	Analyzed delta smelt within the context of a food web	16 covariates attributed to the opinion of the authors tested for an influence on 7 fish and invertebrate species including delta smelt that were also tested for influences on each other	Assumed all delta smelt live 1 year; analyzed data on a 1 year (FMWT to the next FMWT) time step	Found a "strongly negative" term for all fish species implying density-dependence	The only factor found to have "strong" support (defined by the authors as an odds ratio > 3.2 was summer water temperature (-). Several other factors were found to have lesser statistical support (defined by the authors as an odds ratio between 1 and 3.2). These were winter exports (-), spring exports (-), spring spawning temperature window (+), largemouth bass density (-), and summer calanoid copepod biomass (+)[1].
Thomson et al. (2010)	Analyzed delta smelt by itself and	19 covariates attributed to the	Assumed all delta smelt live 1 year;	In this study, the density-dependent	The only factors found to have

	combined with the other 3 POD fishes; this table only reports results for the delta smelt model	opinion of the authors. Note that Thomson et al. have more covariates because prey species were termed covariates in this framework	analyzed data on a 1 year (FMWT to the next FMWT) time step	term is an autocorrelation term testing for the effect of one generation on the next. The authors found a positive slope term with a confidence interval that included zero. Thus, prior abundance has either no effect or a positive effect on subsequent abundance. This does not provide support for density-dependence in contrast to the Mac Nally et al. finding.	"strong" support (defined by the authors as an odds ratio > 3 were fall Secchi disk depth (-) and winter exports (-). Several other factors were found to have lesser statistical support (confidence intervals that included zero). These were spring chlorophyll (+), spring calanoid copepod biomass (+)[1], Limnoithona density (-), largemouth bass density (-), summer water temperature (-), and prior abundance (+)
Maunder and Deriso (2011)	Analyzed delta smelt by itself	14 covariates attributed to Manly (2010)[2]	Assumed all delta smelt live 1 year; analyzed data on an intra-annual time step; FMWT → 20mm Survey → Summer TNS[3] → to FMWT	Found that without covariates included, 4 alternative density-dependence scenarios were similarly supported; density-dependence was possible but not certain from adults	Five variables were supported regardless of which density-dependence assumption was used: spawning temperature window, July temperature, a

				to larvae; no support for density-dependence from larvae to juveniles; density-dependence from juveniles to adults was well supported but the functional form was uncertain; the covariates affected this result and were used to decide what the most likely model was from the four most plausible starting models.	spring prey density variable, a summer prey density variable, and a predator density variable. A few other variables were included only under some of the density-dependence assumptions: a second summer prey density variable, a second predator density variable, adult entrainment, and fall Secchi disk depth

[1]This was the only variable used by Mac Nally et al. (2010) and Thomson et al. (2010) that was not just a summary of raw IEP data. The zooplankton counts were converted to biomass based on species and prey size so they better reflected calories per unit volume available to the fish.

[2]In most cases, these covariates are qualitatively similar to those used by Mac Nally et al. 2010 and Thomson et al. (2010). However, they are quantitatively different due to various weighting factors, transformations, and derivations from regression relationships.

[3]The authors used an alternative townet index developed by Bryan Manly rather than the official version reported by the Department of Fish and Game. They also tested fall X2 in their modeling framework – though not in the published paper. It was not found to be an important predictor as tested.

This partly reflects the fact that the models have not all used the same input variables. Mac Nally et al. (2010) and Thomson et al. (2010) used winter exports as the explanatory variable to evaluate Project effects during the winter on delta smelt population trends. Thomson et al. (2010) developed an LCM that searched for abrupt changes in delta smelt abundance and attempted to correlate the timing of those changes with environmental variables. They found strong statistical support for an effect of winter exports on delta smelt. Mac Nally et al. (2010) developed an LCM that considered delta smelt in the context of a partial estuarine food web model. They found weaker statistical support for an influence of winter exports.

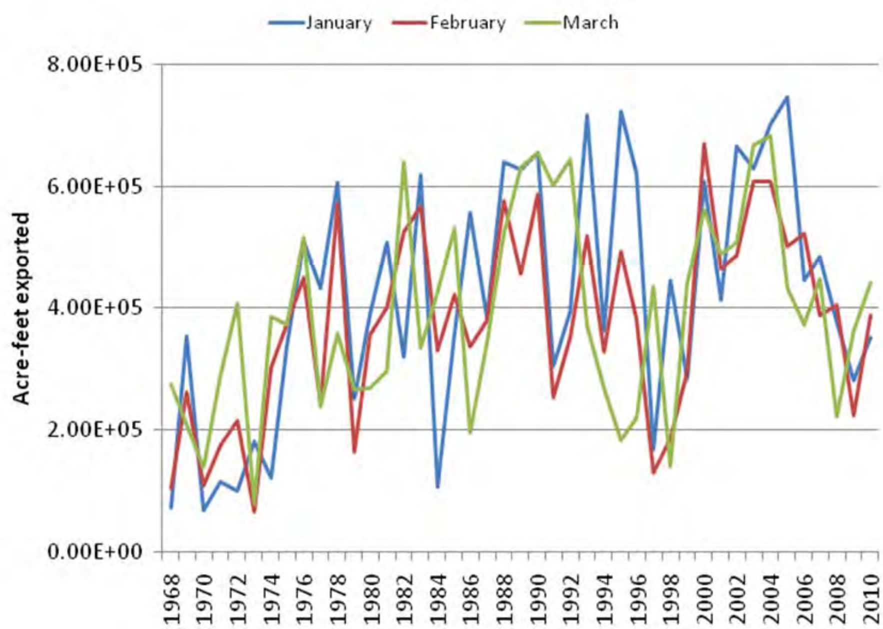

Figure 39. Time series of winter exports (CVP and SWP combined), 1968-2010. Source: Dayflow database

Winter exports first exceeded 400 TAF/month in March of 1972 (Figure 39). Since that time, monthly winter exports have seldom been less than that. Winter exports first exceeded 600 TAF/month in January 1978 and 700 TAF in January 1993. The frequency that monthly winter exports has exceeded 600-700 TAF has generally increased, though they were well below this level during the very wet middle of the 1990s and during the past few years, likely due to a combination of drought and export restrictions for fishery protection. Monthly winter exports have not dropped below 200 TAF since March of 1997.

Maunder and Deriso (2011) used predicted percentages of the adult population that were entrained based on the calculations of Kimmerer (2008). These were correlated to winter OMR flows and the historical estimates of those flows were used to predict adult entrainment for years that Kimmerer had not estimated it. Thus, the entrainment variable in the Maunder and Deriso model is basically average winter OMR flow. Miller (2011) extensively criticized Kimmerer's methodology. Kimmerer (2011) defended his work against several of these criticisms. An important point made by Miller (2011) was that large fractions of delta smelt have been collected in the Cache Slough region since the SKTS sampling expanded in that area. We agree that Kimmerer's (2008) estimates of proportions of the adult delta smelt population entrained in the winter were too high; Kimmerer (2011) agreed as well – though he did not agree they were biased as high as Miller suggested. The automated statistical procedure that Maunder and Deriso (2011) developed to choose a "best" LCM based on their input data determined that a model with strong density-dependence between generations and a very strong influence of adult entrainment was the best-fitting statistical model. However, the authors determined that the density-dependence was too strong and the parameter estimate for the entrainment effect was too high to be plausible, so they determined the second best-fitting model was the most believable LCM. This second best-fitting model did not retain entrainment as an important predictor of delta smelt population dynamics.

All three of the LCMs reviewed here have used long-time series of delta smelt abundance dating to the early 1970s when compensatory density-dependence was occurring in the population (see the Delta Smelt Population Dynamics section of this Opinion). The Service (2008) characterized delta smelt entrainment as "sporadically significant" in delta smelt population dynamics. This is supported by Maunder and Deriso's (2011) Figure 8, reproduced here as Figure 40. Maunder and Deriso ran their top two statistically best supported LCMs with and without the adult entrainment variable in them and compared the predicted delta smelt abundance trends. These comparisons are shown in the top panels of Figure 40; the black lines are predicted abundance without the adult entrainment variable and the gray lines are predicted abundance with it. In their models, the population declines whether entrainment happens or not. However, there are times when the population declines noticeably from the addition of the entrainment variable. Specifically, entrainment causes a more rapid decline prediction in the droughts of 1976-1977, 1987-1992, and the "POD" era (2002-2006).

Fig. 8. Estimates of the adult abundance with and without adult entrainment (top panels) and the ratio of adult abundance without adult entrainment to that with adult entrainment (bottom panels, *y* axis limited to show details) from the lowest AIC_c model (left panels) with Ricker survival from juveniles to adults and a Beverton–Holt stock–recruitment relationship and the alterative model (the model that has the fewest covariates and the AIC is less than two AIC units greater than the lowest AIC model) (right panels).

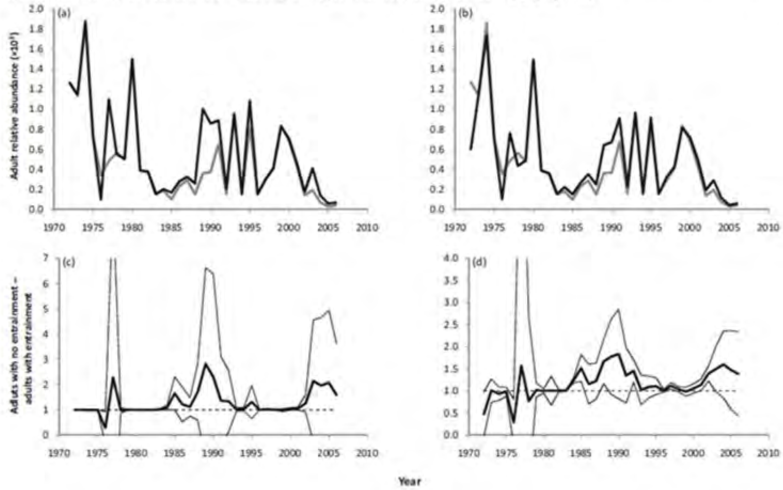

Figure 40. Copy of Figure 8 from Maunder and Deriso (2011). The top panels show predicted time series of delta smelt abundance based on two variations of life cycle models developed by the authors; black lines are predicted abundance without adult entrainment, gray lines are predicted abundance with adult entrainment. The bottom panels depict the same data as relative deviations. "AIC_c" in the authors' caption refers to the Akaike Information Criterion, an indicator of the relative fit of alternative statistical models.

The evidence for a negative effect of entrainment on delta smelt is also supported by Kimmerer's (2011) Figure 3, reproduced here as Figure 41. Kimmerer developed a simulation model which showed that, given delta smelt's present-day, density-independent population dynamics, an average entrainment loss of 10% would cause a 10-fold reduction in abundance and it would probably not be discernable using correlation-based statistics.

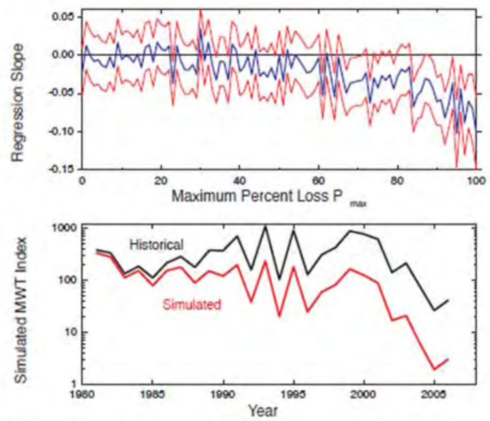

Figure 3 Results of simulation of ability to detect export loss through regression analysis. Upper panel: individual simulation results giving the slope (thick blue line) and 95% confidence limits (thin red lines) for regressions of the stock-recruit index on southward OMR flow. Lower panel: trajectory of the fall midwater trawl index (upper line) and the same index with a 20% P_{max} value imposed for the entire time series (mean P_L ~10%). This is for illustration only (see text), and does not imply anything about the cause of the decline in delta smelt.

Figure 41. Copy of Figure 3 from Kimmerer (2011). In the author's caption, P_{max} refers to a maximum proportion of the delta smelt population assumed to be entrained by the Projects and P_L refers to an average proportional entrainment loss of 10% of the population. The bottom panel shows how much this level of entrainment loss would cause the delta smelt population to decline in the absence of density-dependence. Note (1) the log-scale on the y-axis of the bottom panel; (2) the author made the case, similar to the Service, that density-dependence is unlikely to be presently occurring in the delta smelt population due to its very low abundance. The top panel shows that a standard regression analysis searching for an entrainment effect on delta smelt would be unlikely to find one unless the entrainment loss was exceptionally high (> 60% of the entire population).

In conclusion, the scientific evidence available to the Service is inconclusive about the *long-term* population-level importance of adult entrainment. However, there is new evidence based on model simulations that adult entrainment can cause the population to decline (Kimmerer 2011; Maunder and Deriso 2011). Presently, the loss of delta smelt at any life stage is not being compensated for by density-dependence in that life stage or in a later life stage.

Analysis of Project Effects and Relevant Environmental Trends in South Delta Water Quality

Adult delta smelt are strongly associated with turbid water (Feyrer et al. 2007; 2010; Miller 2011; Figure 42). Thus, if turbid water is present in the south Delta then delta smelt are more likely to inhabit that water and be more vulnerable to entrainment. Miller (2011) noted that south Delta waterways often are less turbid than regions to the north and west, a conclusion which had been reported several times in prior studies, albeit for different times of year (Nobriga et al. 2005; Feyrer et al. 2007; Nobriga et al. 2008).

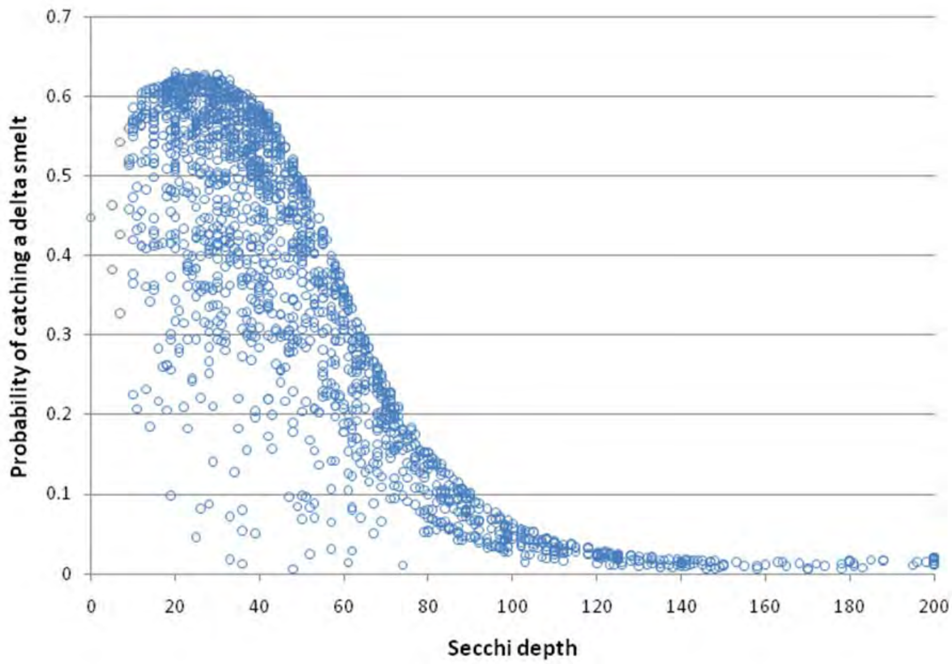

Figure 42. Scatterplot showing the predicted probability of capturing a delta smelt in the Spring Kodiak Trawl Survey relative to water transparency measured as Secchi disk depth in cm. The predictions are based on a binomial generalized additive model as was previously done by Feyrer et al. (2007) for the Fall Midwater Trawl and Nobriga et al. (2008) for the Summer Townet Survey. The scatter shows the variation in predictions caused by the interaction of two other variables (specific conductance and water temperature). In other words, probability of capture can be low in turbid water if salinity or temperature are too high, but probability of capture will never be high where turbidity is low, regardless of the other variables.

Despite the generality that the water in the south Delta is often comparatively clear, turbid conditions can occur there – particularly during winter storms (Grimaldo et al. 2009). The longest running turbidity sensor in the south Delta is at the intakes of Clifton Court Forebay (CCF). The data from this sensor were used by Deriso (2011) to develop an OMR flow + turbidity model to predict adult delta smelt entrainment events. Figure 44 shows the trend in CCF turbidity for the winter (December-March, 1988-2009). This time period is coincident with the time period of our adult delta smelt salvage analysis, presented below, which was done to expand on that of Deriso (2011). The turbidity at CCF declined during the 1987-1992 drought, then increased to a peak in 1997. The turbidity declined after 1997, but generally remained elevated relative to 1987-1996 levels, during 1998-2006. Turbidity was low in 2007 and 2009, but was fairly high again in 2008. Thus, there has not been a long-term unidirectional trend in turbidity at CCF during the winter. This indicates that comparably turbid conditions can be expected to keep occurring into the future. This contrasts with the south Delta regionally, which has been shown to have trended toward higher water transparency in the summer-fall (Feyrer et al. 2007; Nobriga et al. 2008) and for the estuary on the whole (Schoellhamer 2011), as described in the Environmental Baseline/Critical Habitat section. The trends in water transparency for the spring have not been reported in the literature, but they are analyzed in the larval-juvenile section of this Effects Analysis.

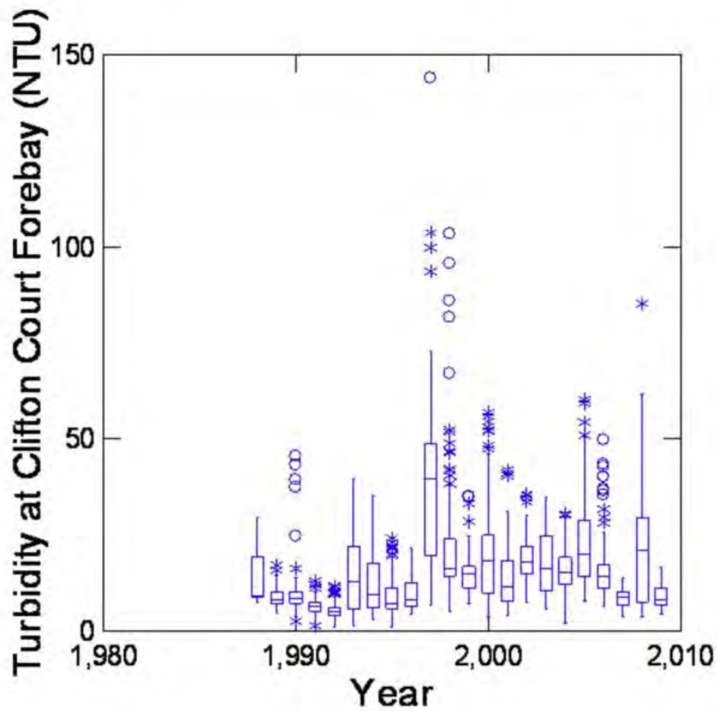

Figure 43. Time series of turbidity measurements at Clifton Court Forebay for the months of December-March (beginning December 1988 and ending March 2009). NTU = nephalometric turbidity units. The boxplots are as follows: rectangular box = interquartile range of observations; horizontal line in the box = median; vertical lines = 95% confidence intervals; open circles and asterisks = individual data points the Systat software program determined were "outliers".

Deriso (2011) proposed a statistical model to guide Project operations during winter. The model was developed to predict the combinations of OMR flow and CCF turbidity that resulted in large delta smelt salvage events. The model was developed using daily OMR flow and an average turbidity for the three days prior to the OMR flow estimate (Figure 43). The model predicts the median adult delta smelt salvage normalized to the prior FMWT abundance index.

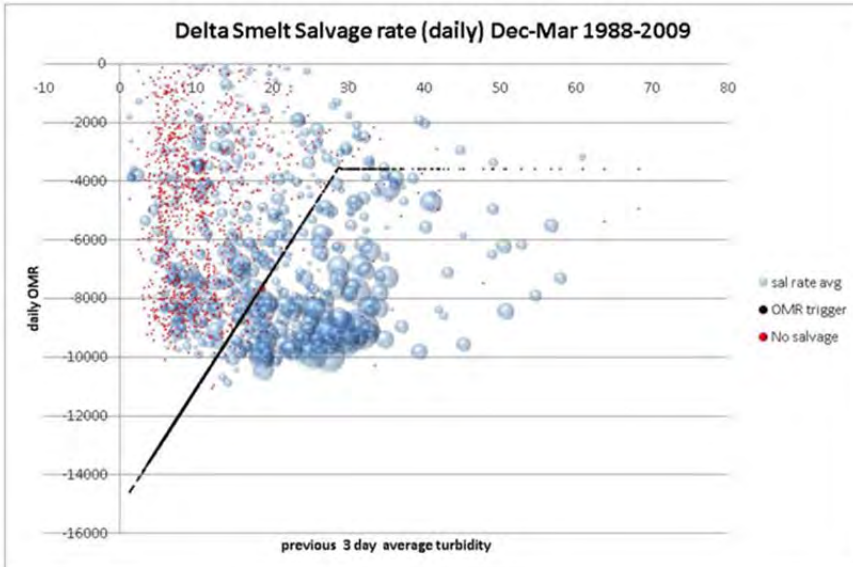

Figure 44. Copy of Figure 3 from Deriso (2011; January 28, 2011 Declaration in support of Plaintiffs' request for injunctive relief in the delta smelt consolidated cases; court document # 772). Bubble plot of average turbidity (NTU at Clifton Court Forebay) for three days prior to a daily net flow in Old and Middle rivers (OMR). The blue datapoints are sized to reflect the co-occurring adult delta smelt salvage normalized to the Fall Midwater Trawl abundance index immediately preceding fall. Red data = no salvage on that day. The black line is a prediction line generated by the author and proposed as a guide to developing Project operating rules based on combinations of turbidity and OMR. December-March data for December 1988 through March 2009.

The Service compiled a dataset based on historical salvage normalized to the prior FMWT, OMR flow and CCF turbidity and developed graphs similar to Figure 44 using several alternative time scales. We developed two plots for each of five time scales. The purpose of plotting the data over different averaging periods was to determine whether doing so affects the conclusions about what OMR + turbidity combinations envelope the historical normalized salvage data. The time scales evaluated were:

- daily – mimics Deriso's analysis
- 7-day – a typical management time scale, e.g., the Water Operations Management Team meets weekly to review fishery and operations data
- 14-day – the OMR flow averaging period used in the Service's December 2008 OCAP Biological Opinion
- 24-day – the estimated average migration time for delta smelt to migrate from Chipps Island to Banks (Sommer et al. 2011)
- 30 or 31-day – another time scale included in some previous OMR-salvage relationships including those submitted by DWR during the 2008 consultations with the Service and NMFS

The color plots for each time scale are similar to Deriso's in that they separate data for when delta smelt salvage occurred versus instances where it did not. In these plots, as in Deriso's, the bubble size is scaled to the normalized salvage such that higher normalized salvage is shown as a larger 'bubble'. The primary difference is that we have shown the data for both positive and negative OMR flows; Deriso limited his data presentation and analysis to negative OMR flows. In the grayscale version of each plot, only the normalized salvage data that were at least 1.0% of the maximum observed at that time step are shown, and the bubble sizes are rescaled into one of three bins: 1-5%, 5-10%, or greater than 10% of the maximum normalized salvage observed over that time-step. The expectation is that normalized salvage less than 5% of historically observed maxima is sufficiently low to represent a de minimis Project effect on the delta smelt population.

The plots show that high normalized salvage has occasionally occurred at OMR flows near zero and even at positive flows. This pattern is present at all time scales (Figure 45 to Figure 54). This is a known quirk in the data; these occurrences are mainly driven by salvage at the CVP facility (Kimmerer 2008; Miller 2011).

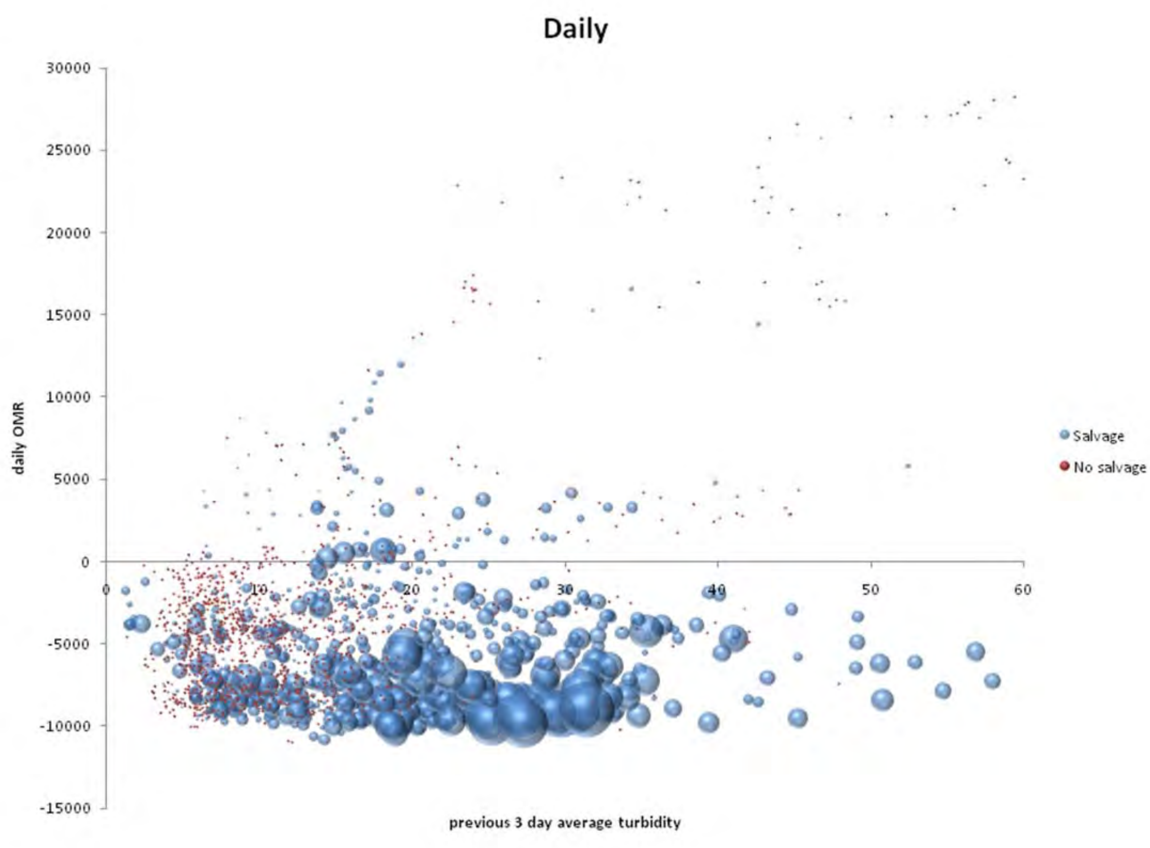

Figure 45. Recreation of Figure 44 by Service staff. This version includes data for when net flow in Old and Middle rivers was positive.

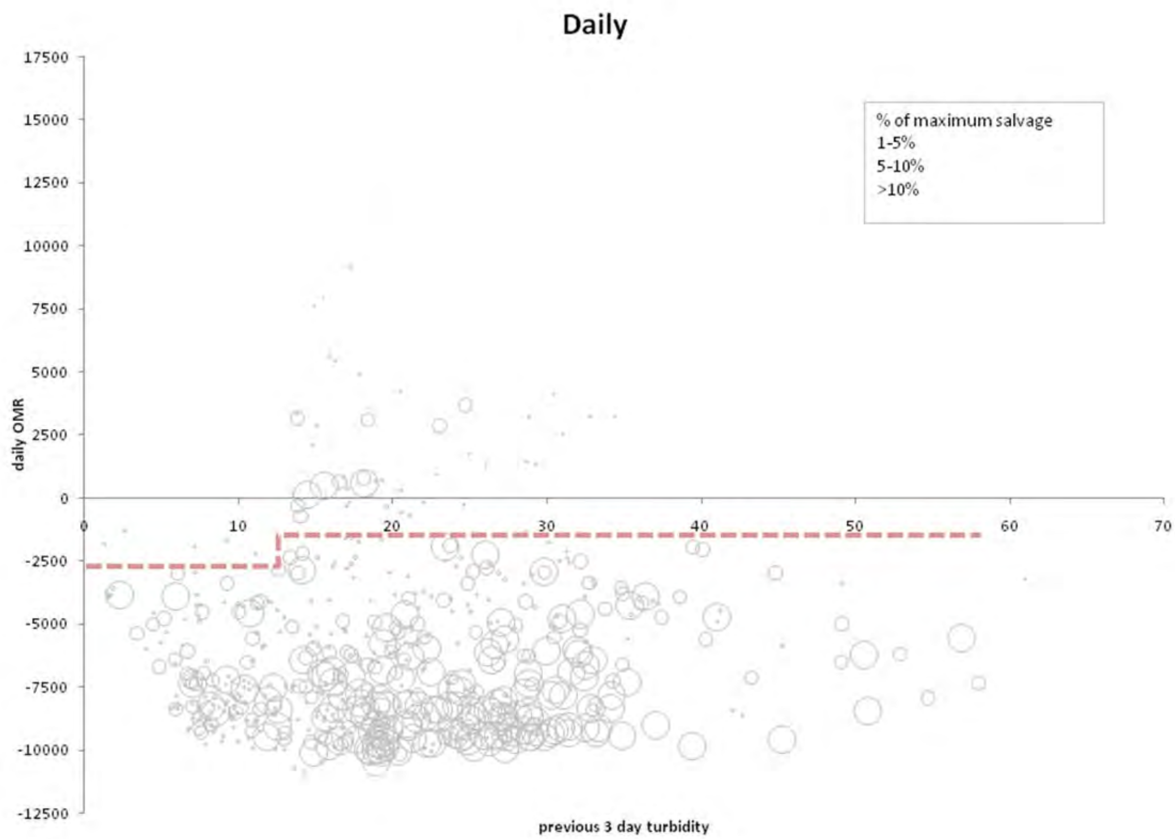

Figure 46. Alternative version of Figure 45 with data points removed if delta smelt normalized salvage was less than 1% of the maximum observed during the winter seasons bounded by December 1988 and March 2009. The bubble sizes have been rescaled into the bins shown in the Figure legend. The dashed red line shows the turbidity and OMR flow combinations that encompass all occurrences of normalized salvage ≥ 5% of the maximum observed on a daily time step (5.67) for OMR flows more negative than -1000 cfs.

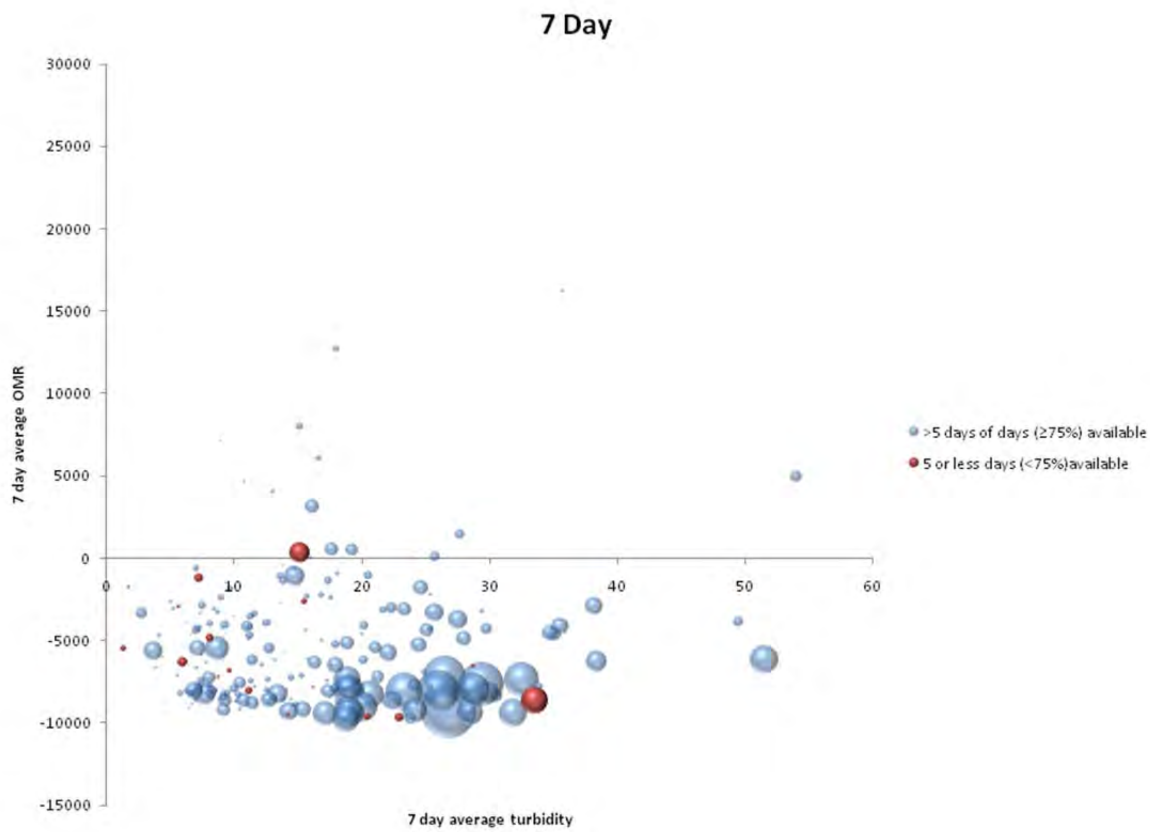

Figure 47. Recreation of Figure 44 by Service staff using 7-day averages of turbidity and OMR instead of 3-day averages and daily data, respectively. The red data points show potentially unreliable estimates caused by missing data; fewer than 75% or 5 days of data were available to calculate the nominal 7-day averages.

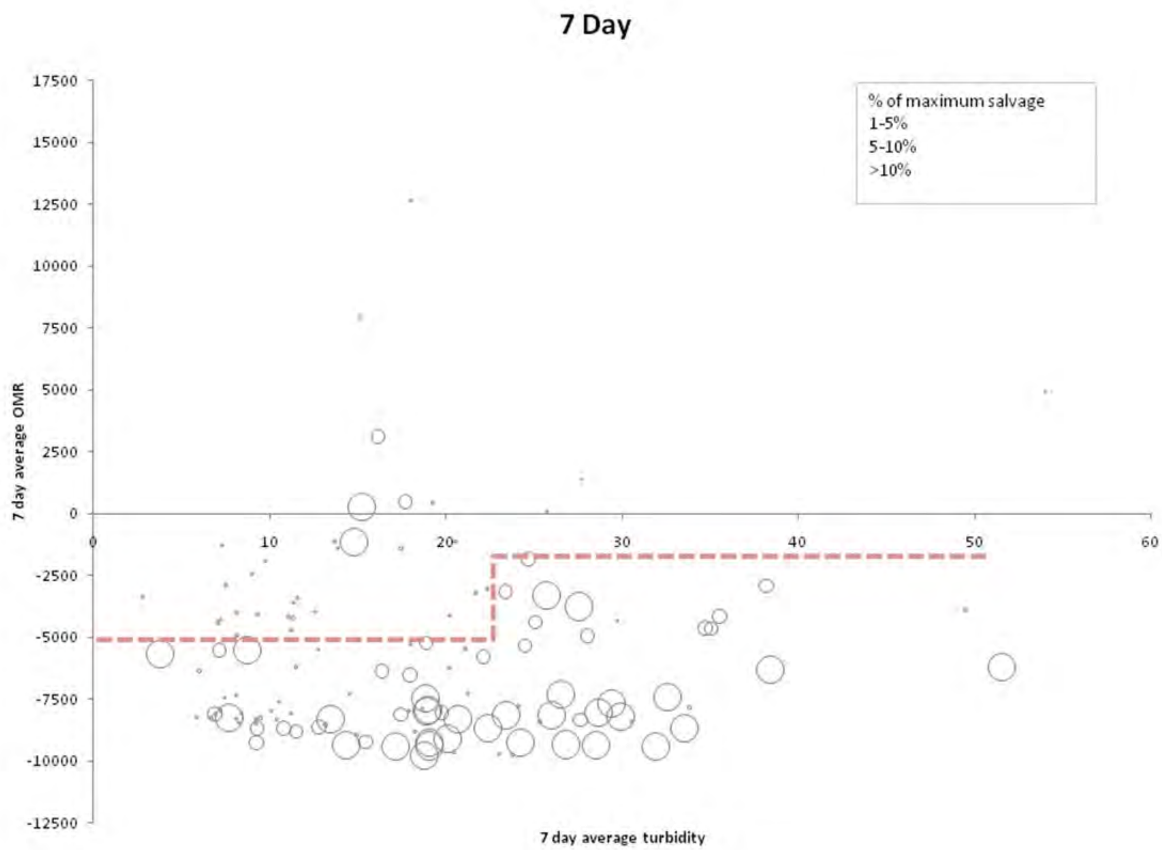

Figure 48. Alternative version of Figure 45 with data points removed if delta smelt normalized salvage was less than 1% of the maximum observed over 7-day averaging periods during the winter seasons bounded by December 1988 and March 2009. The bubble sizes have been rescaled into the bins shown in the Figure legend. The dashed red line shows the turbidity and OMR flow combinations that encompass all occurrences of normalized salvage ≥ 5% of the maximum observed on a 7-day time step (3.61) for OMR flows more negative than -1000 cfs.

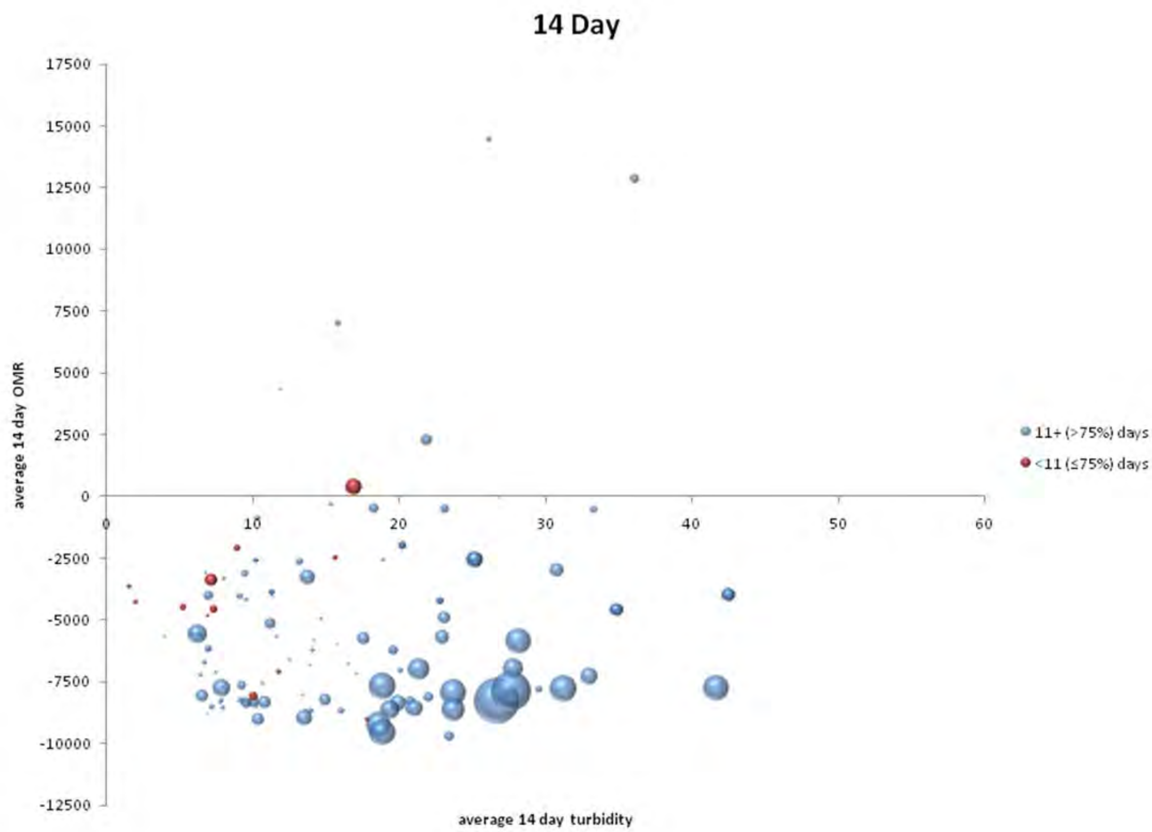

Figure 49. Recreation of Figure 44 by Service staff using 14-day averages of turbidity and OMR instead of 3-day averages and daily data, respectively. The red data points show potentially unreliable estimates caused by missing data; fewer than 75% or 11 days of data were available to calculate the nominal 14-day averages.

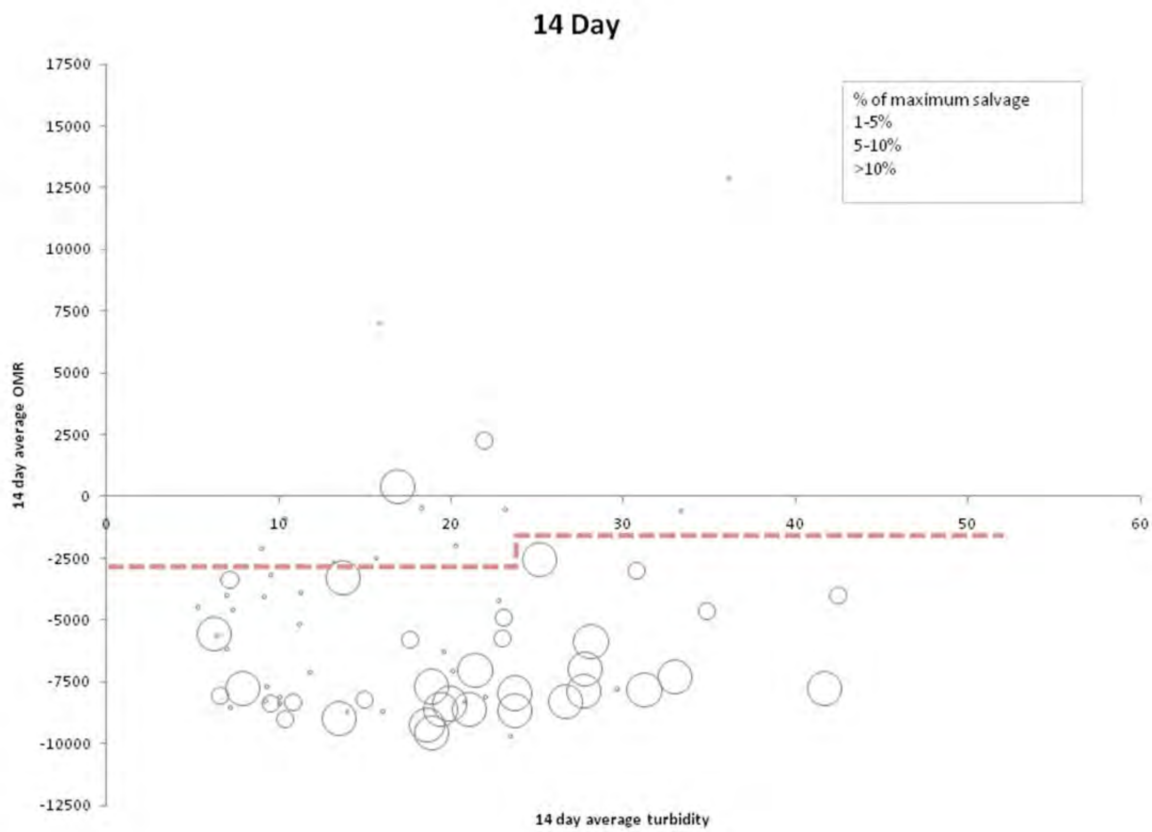

Figure 50. Alternative version of Figure 45 with data points removed if delta smelt normalized salvage was less than 1% of the maximum observed over 14-day averaging periods during the winter seasons bounded by December 1988 and March 2009. The bubble sizes have been rescaled into the bins shown in the Figure legend. The dashed red line shows the turbidity and OMR flow combinations that encompass all occurrences of normalized salvage ≥ 5% of the maximum observed on a 14-day time step (2.86) for OMR flows more negative than -1000 cfs.

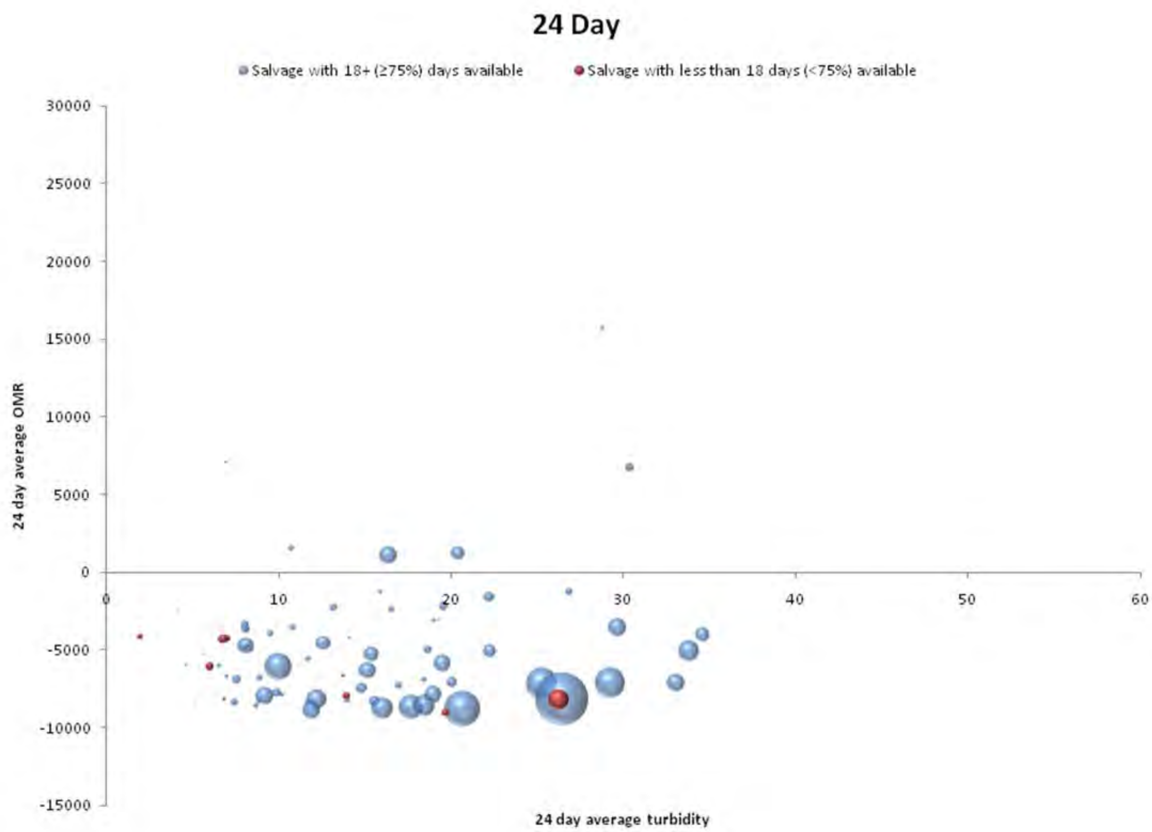

Figure 51. Recreation of Figure 44 by Service staff using 24-day averages of turbidity and OMR instead of 3-day averages and daily data, respectively. The red data points show potentially unreliable estimates caused by missing data; fewer than 75% or 18 days of data were available to calculate the nominal 24-day averages.

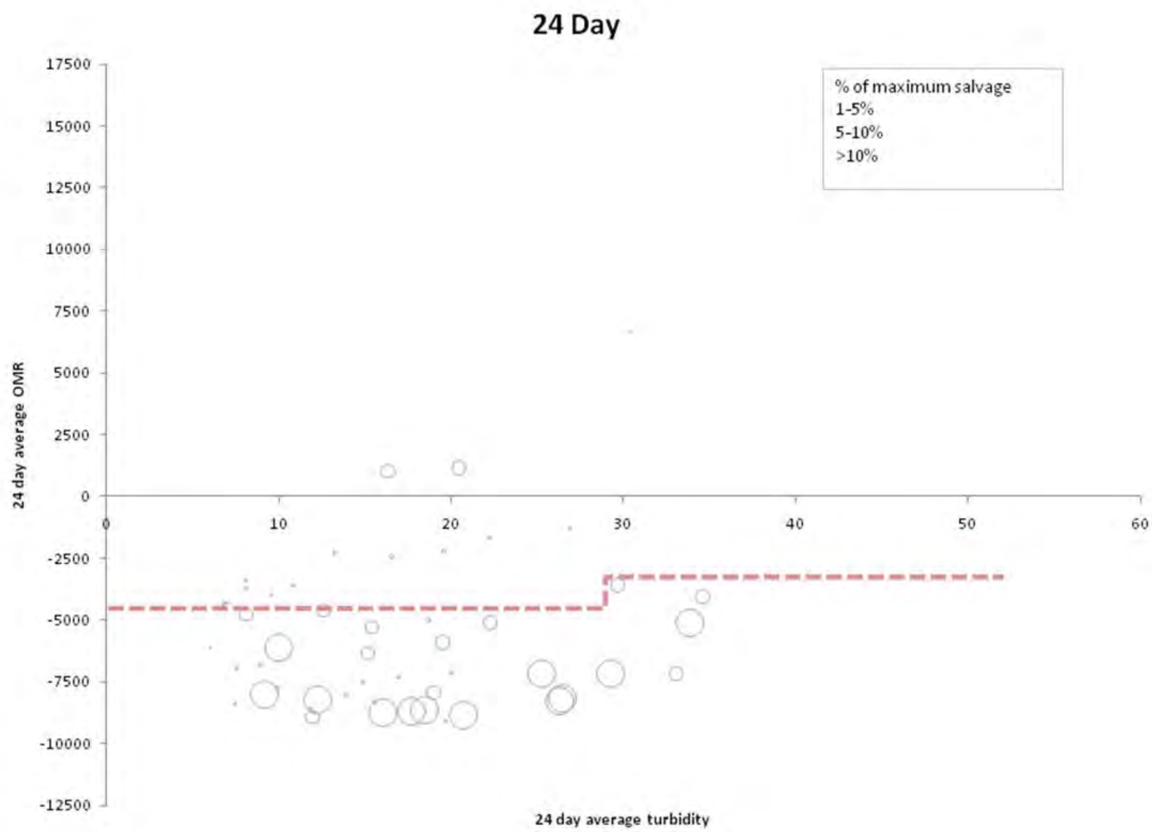

Figure 52. Alternative version of Figure 45 with data points removed if delta smelt normalized salvage was less than 1% of the maximum observed over 24-day averaging periods during the winter seasons bounded by December 1988 and March 2009. The bubble sizes have been rescaled into the bins shown in the Figure legend. The dashed red line shows the turbidity and OMR flow combinations that encompass all occurrences of normalized salvage ≥ 5% of the maximum observed on a 24-day time step (2.54) for OMR flows more negative than -1000 cfs.

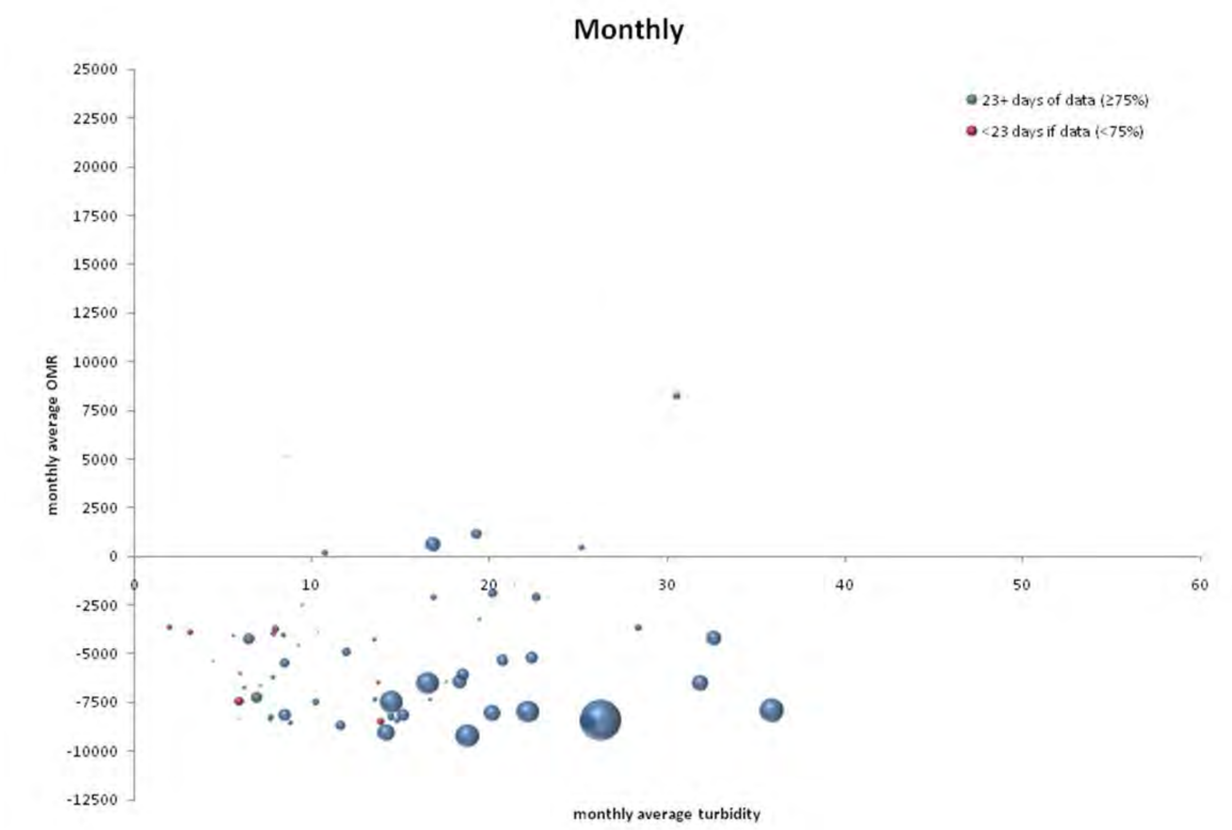

Figure 53. Recreation of Figure 44 by Service staff using monthly averages of turbidity and OMR instead of 3-day averages and daily data, respectively. The red data points show potentially unreliable estimates caused by missing data; fewer than 75% or 23 days of data were available to calculate the nominal monthly averages.

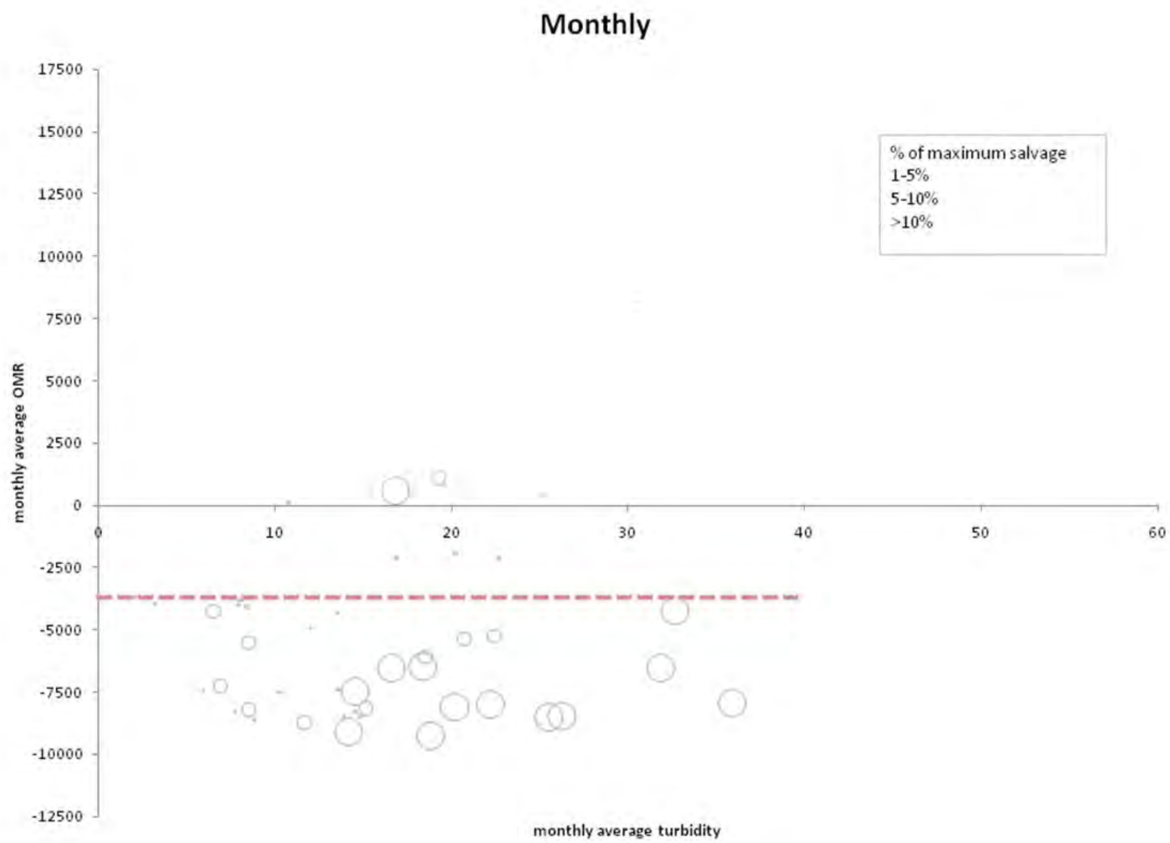

Figure 54. Alternative version of Figure 45 with data points removed if delta smelt normalized salvage was less than 1% of the maximum observed over monthly averaging periods during the winter seasons bounded by December 1988 and March 2009. The bubble sizes have been rescaled into the bins shown in the Figure legend. The dashed red line shows the turbidity and OMR flow combinations that encompass all occurrences of normalized salvage ≥ 5% of the maximum observed on a monthly time step (2.22) for OMR flows more negative than -1000 cfs.

As Deriso's model showed (Figure 45), the general trend in the data is for the highest normalized salvage to occur at combinations of high turbidity and highly negative OMR flows. This trend is generally maintained across each time scale the Service analyzed (Figures 45 to 54). Other general trends the Service found when analyzing the data over increasingly long time scales, is that the longer the averaging period for the data, (1) the higher the turbidity needed to be to affect the OMR flow that would envelope the data points reflecting more than 5% of the historical maximum normalized salvage, and (2) the more negative the OMR flow could be after the turbidity threshold had changed (Table 29). The starting point OMR flow or "low turbidity" OMR flow threshold varied inconsistently across averaging periods, but was always between -5200 cfs and -3000 cfs.

Table 29. Summary information of the data presented in Figures 46, 48, 50, 52, and 54. These estimates specify the locations depicted by dashed red lines in each of the Figures. They envelope all normalized salvage data points that were at least 5.1% of the historical maximum normalized salvage when OMR flow was less than -1000 cfs.

Time step (days)	Starting OMR (cfs)		Turbidity threshold (NTU)		Alternative OMR
1	-3000	until	13	Then	-1900
7	-5200	until	23	Then	-1900
14	-3300	until	25	Then	-2500
24	-4600	until	29	Then	-3600
28-31	-4200	until	No threshold	Then	-4200

The Service also calculated the daily residual mean square (RMS) tide height at Antioch for December-March, of water years 1989-2009. This variable indexes whether the tides are causing a net ‘filling’ or ‘draining’ of the Delta. We generated annual time series plots of (1) turbidity at CCF, or (2) adult delta smelt salvaged normalized to the prior FMWT versus RMS tide height Appendix X. No consistent influence of this tidal variable is evident on either turbidity or salvage. Thus, the Service does not see the merit in adding this variable into potential OMR flow rules.

The year to year variability in the OMR-salvage relationships (Figure 30 to Figure 33) is evidence that delta smelt spawning migrations and the distribution changes that result from those migrations also influence their risk of entrainment[10]. The Service recognizes that the upstream migration path of some individuals leads them into Old and Middle rivers regardless of south Delta exports because, as discussed above, adult delta smelt salvage has occurred at all OMR flows less than 0 cfs and has even occasionally occurred when OMR was positive (Figures 45 to 54).

In addition to variability in salvage caused by interannual differences in population distribution and environmental conditions, delta smelt that are entrained into the Projects are subject to variable collection efficiency and predation rates (Table 30). The pre-screen loss of adult delta smelt in Clifton Court Forebay has been estimated at nearly 100%[11] during recent pilot studies (Castillo et al. 2010). However, the experiments used captive-bred fish and the experimental design cannot feasibly include a control outside the forebay. Thus, it is uncertain how accurately these preliminary estimates represent wild fish mortality rates in the forebay. Nonetheless, the occurrence and variability of

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[10] Note that the Smelt Working Group considers data on adult delta smelt distribution when making OMR flow recommendations to the Service.

[11] The pre-screen loss estimates ranged from 89.9% to 100% in six experiments. The mean loss was 95.9%.

pre-screen loss adds additional statistical uncertainty or “noise” to the salvage data. This further affects the precision of conclusions that can be drawn from these data (future placement Table E-4).

Table 30. Annotated summary of estimates of SWP and CVP fish salvage efficiencies for delta smelt of several life stages.

	Adults	Larvae < 20 mm	Juveniles > 20 mm
Predation prior to encountering fish salvage facilities[a]	89.9-100%	unquantified	99.9%[b]
Fish facility efficiency (based on Kimmerer 2008)	Limited data indicate an efficiency of about 13 percent for the CVP facility; SWP efficiency averaged an estimated 50%, but actual efficiency was related to operating conditions (Castillo et al. in review)	~ 0 percent	Likely < 13 percent at any size; << 13 percent at less than 30 mm; estimated at 24% and 30% in two experiments in June 2009 (Castillo et al. in review)
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[c]	Controlled conditions trial (2005): 94% were recovered from the Skinner fish facility; 87% survived for 48 hrs in a holding tank after the experiment Empirical salvage trial (2006): 90% were recovered from the Skinner fish facility; 78% survived for 48 hrs in a holding tank after the experiment	0 percent	Controlled conditions trial (2005): 73% were recovered from the Skinner fish facility; 37% survived for 48 hrs in a holding tank after the experiment Empirical salvage trial (2006): 89% were recovered from the Skinner fish facility; 58% survived for 48 hrs in a holding tank after the experiment

[a]Pre-screen loss (Castillo et al. in review)

[b]Based on one release experiment (Castillo et al. in review)

[c]Unpublished report sent by Jerry Morinaka (CDFG) on July 13, 2011; numbers reported do not include predation at release sites

Effects of Old and Middle River Flow on Delta Smelt

The entrainment risk of larval delta smelt has been estimated quantitatively with particle tracking models (PTMs), in particular, the Department of Water Resources' DSM-2 PTM (Kimmerer and Nobriga 2008; Kimmerer 2008). The entrainment risk for adult delta smelt actively migrating into the lower San Joaquin River cannot be quantitatively summarized with current PTMs[12]. Even without a vetted quantitative modeling tool, the Service thinks that PTM data provide the best available indication of the hydrodynamic influence on adult delta smelt entrainment risk given two conditions: (1) turbid water is present in Old and Middle rivers, and (2) adult delta smelt migrate into the San Joaquin River. This is likely true because the particle tracking modeling shows the extent of the Projects' hydrodynamic influence on the Delta and how that influence changes as river flows and exports vary (Kimmerer and Nobriga 2008).

Miller (2011) assumed that because migrating delta smelt actively swim, that they would not be vulnerable to OMR flows and therefore scaling delta smelt loss to OMR flows[13] would result in loss estimates that were persistently biased high. Kimmerer (2011) disagreed, noting that there were not automatically any environmental cues that would signal migrating delta smelt to stop swimming toward the pumps. The Service agrees with Kimmerer (2011) that Miller (2011) was confounding bias with statistical uncertainty. Bias occurs when an estimate is always too high or too low, whereas statistical uncertainty is noise around an estimate that is sometimes too high and sometimes too low.

Migrating delta smelt are actively swimming, likely using a combination of their own swimming behaviors and tidal currents to move upstream against the net Delta outflow (e.g., Sommer et al. 2011). If they encounter an adverse environmental cue in the south Delta, such as water that is not sufficiently turbid, they might adjust their behavior and stop short of being entrained. However, if they do not perceive such a cue, they may keep migrating and move south down Old and Middle rivers *faster or slower* than the net flow. Note that the occurrence of a spawning migration itself demonstrates that delta smelt can move faster than net flow in the estuary. Thus, the link between adult delta smelt entrainment and OMR flows is more an issue of statistical uncertainty (sometimes their southward flux is slower than OMR flow and sometimes it is faster) than bias (always slower or higher).

OMR flows between -2000 and -5000 cfs minimizes the Projects' hydrodynamic influence in the San Joaquin River (mainstem) because extending that influence out that

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[12] DSM-2's particle tracking model can generate upstream particle movements when the particles are given simple tidal surfing behavior (Sommer et al. 2011). A PTM that may more accurately characterize delta smelt spawning migrations is being developed by RMA.

[13] which both Kimmerer (2008) and Maunder and Deriso (2011) did

far decreases the likelihood that delta smelt can reproduce successfully in the expanses of shallow sandy habitats that occur in the river from downstream of the City of Stockton to the City of Antioch.

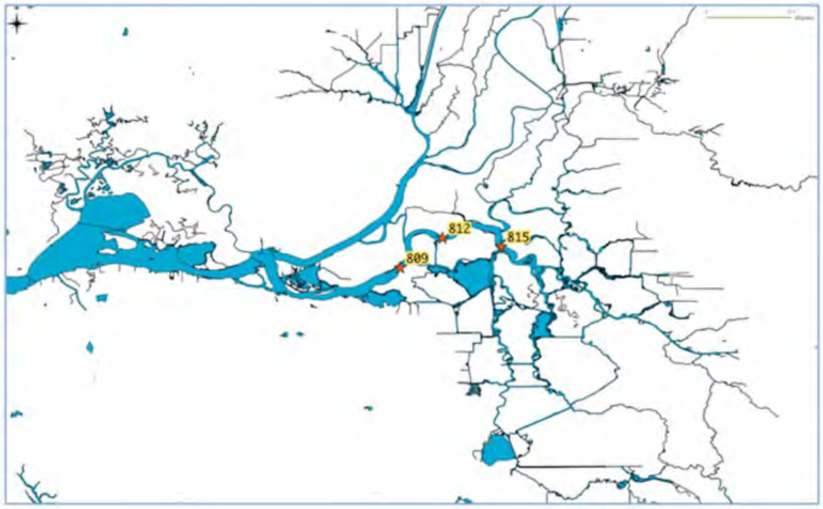

Figure 55. Map of the Delta showing the particle tracking model release locations discussed in the text. The release locations are Department of Fish and Game sampling stations 809-815.

The Service evaluated the Projects' influence on south Delta hydrodynamics by summarizing available PTM results from three San Joaquin River release locations (Figure 55). The PTM results show that there is considerable variance in entrainment risk at any given OMR flow (Figure 56). However, the risk of entrainment is usually very low at OMR flows higher than -2000 cfs. The risk of particle entrainment appears to increase abruptly in some model runs when OMR is -2000 cfs and then again when OMR flow declines to -5000 to -6000 cfs.

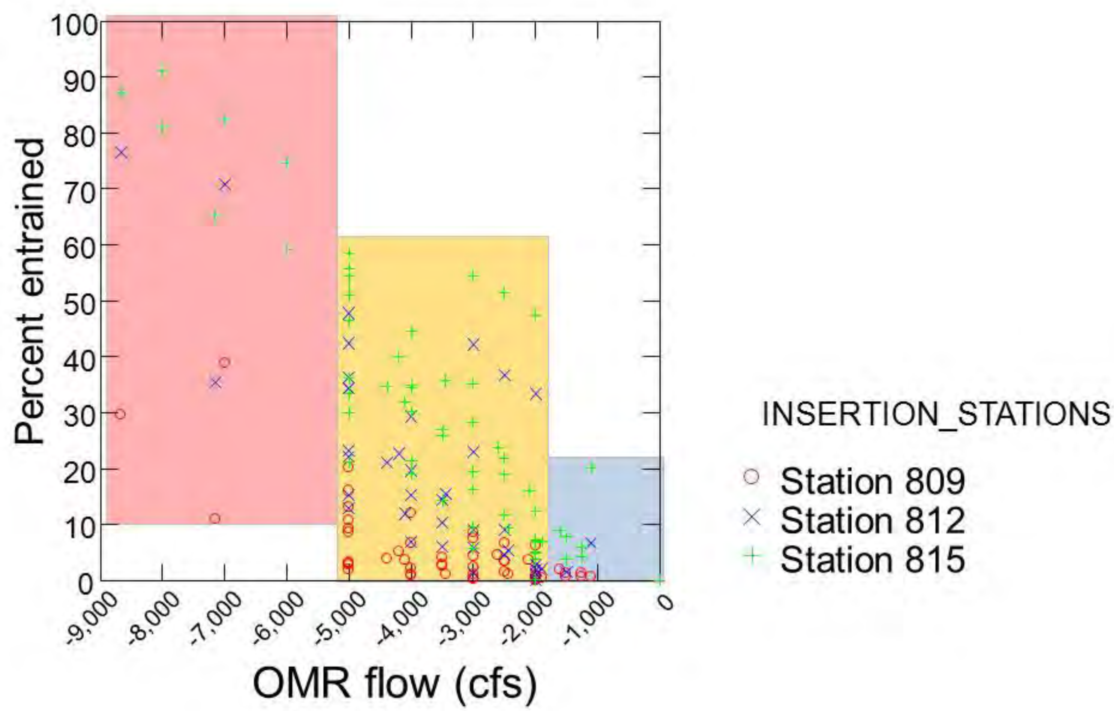

Figure 56. Boxplot summary the influence of net flow in Old and Middle rivers (OMR) on predicted particle entrainment into Banks and Jones pumping plants from three initial San Joaquin River starting locations (see Figure 55). The plot is a statistical summary of 81 individual model runs submitted by Department of Water Resources staff to the Department of Fish and Game in 2009 in support of the longfin smelt CESA Incidental Take Permit or the Smelt Working Group from 2007-2010 in support of its real-time operations recommendations. The OMR flow is the average for the first 14 days of each simulation. The particle entrainment is total entrainment for the duration of the simulation. Durations ranged from 14 to 90 days. Note the abrupt visual increases in entrainment risk as OMR gets more negative than -2000 cfs and again as it gets more negative than -5000 cfs. Minimum number of particles inserted into the model for any individual run was 1,000.

The frequency distributions of predicted monthly mean OMR flows based on proposed Project operations are shown for December-March in Figure 57. The frequency of predicted flows more negative than -5000 cfs decreases with each consecutive month, but remains high in each of them. In both studies, 89% of Decembers are predicted to have OMR flows more negative than -5000 cfs. The frequency of OMR flows more negative than -5000 cfs in January is predicted to be 84% in Study 7.1.1 and 85% in Study 8.0.1. The frequency of OMR flows more negative than -5000 cfs in February is predicted to be 59% in Study 7.1.1 and 60% in Study 8.0.1. The frequency of OMR flows more negative than -5000 cfs in March is predicted to be 37% in Study 7.1.1 and 48% in Study 8.0.1. Thus, the Projects' proposed operations would result in OMR flows that would be expected to frequently result in high adult entrainment based on (1) historical data, and (2) ptm summaries of the Projects' hydrodynamic influence on the San Joaquin River. Note these updated results are very similar to those submitted by Reclamation in support of the December 2008 OCAP Biological Opinion (Figure 58 and Figure 59). Linear regressions of prior model outputs versus revised model outputs for December-March explain between 96% and 99% of the variation among the sets of model outputs.

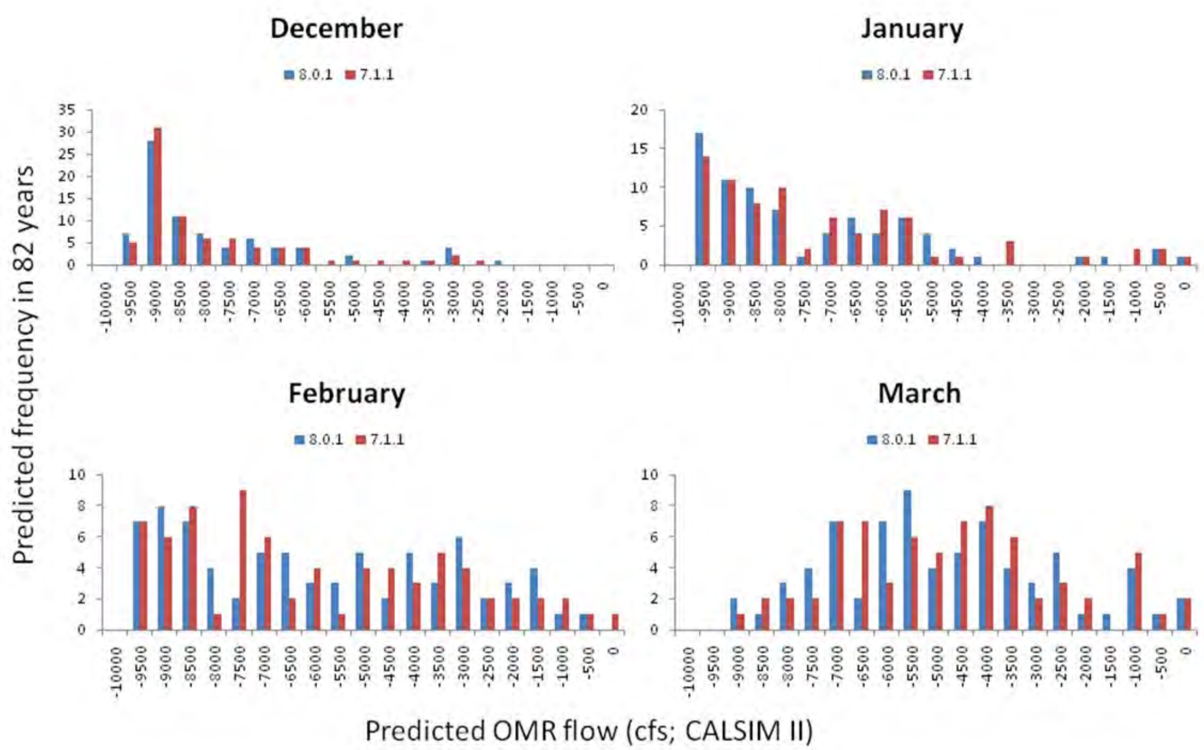

Figure 57. Distributions of monthly mean net flows in Old and Middle rivers (OMR) for winter months based on CALSIM II modeling of the Proposed Project as updated in August 2011. Study 8.0.1 reflects a 2025 level of Project demand. Study 7.1.1 reflects an approximately present day (2005) level of Project demand. Data source: Reclamation Bay-Delta Office

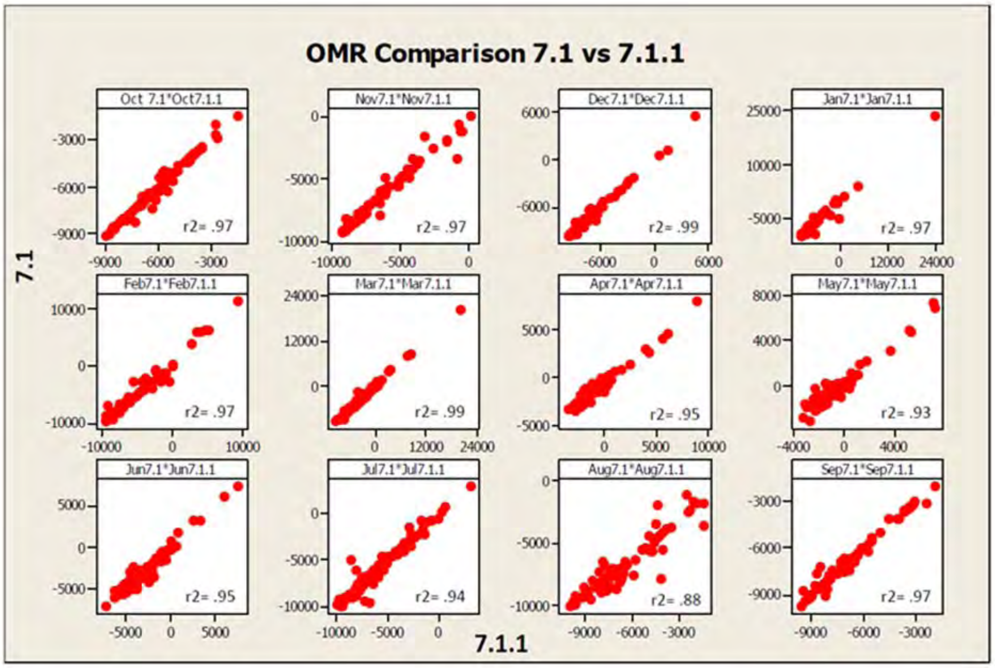

Figure 58. Linear regression comparisons of CALSIM II model estimates of monthly mean OMR flow from Study 7.1 submitted by Reclamation in support of the December 2008 OCAP Biological Opinion and the revised assumption modeling submitted by Reclamation in August 2011 to support the remanded Opinion. Source: Lenny Grimaldo (Reclamation Bay-Delta Office)

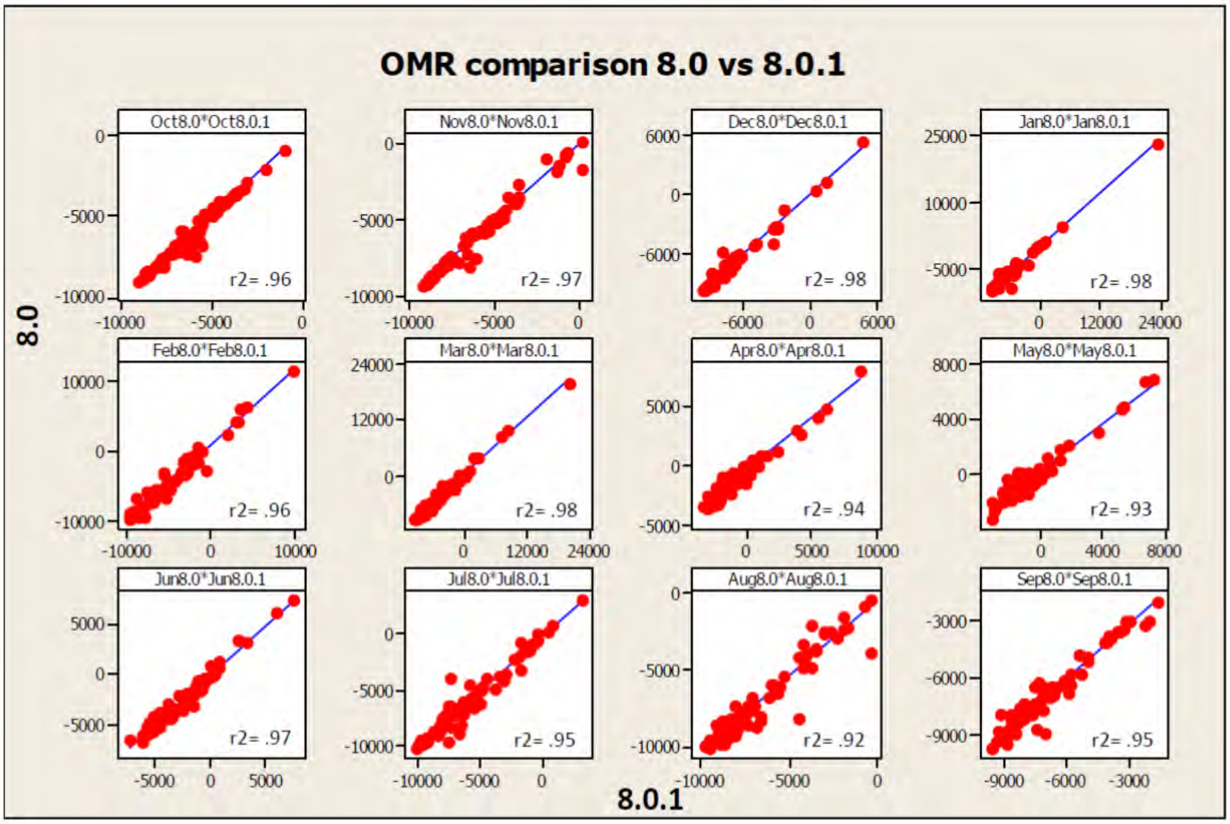

Figure 59. Linear regression comparisons of CALSIM II model estimates of monthly mean OMR flow from Study 8.0 submitted by Reclamation in support of the December 2008 OCAP Biological Opinion and the revised assumption modeling submitted by Reclamation in August 2011 to support the remanded Opinion. Source: Lenny Grimaldo (Reclamation Bay-Delta Office)

Article 21

The analysis of Banks pumping under Article 21 is qualitative because the CALSIM II modeling, as shown in the biological assessment, does not simulate the operations of two major South of the Delta storage facilities, the Kern Water Bank and Diamond Valley Lake. The latter came online in 2000. Both of these facilities have been used to store water delivered under Article 21. As such, the full quantity of SWP 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 Table 12 and Table 16, there has been an increase in SWP pumping corresponding to an increase in Article 21 deliveries. This increased pumping at the SWP since 2000 corresponds to the recent declines in the delta smelt population that is currently being studied by the IEP.

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 during the past decade because the highest amounts of Article 21 water were pumped in the months when adult delta smelt entrainment was 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 was 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 water was pumped under Article 21 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 year types, San Luis Reservoir can be filled in dryer years (for example if the preceding year was wet). It is during these conditions that the increased pumping associated with Article 21 would have the highest potential to increase adult delta smelt entrainment.

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.

North Bay Aqueduct Diversion

Over the past 20 years, NBA diversions have had no clear trend in the winter months (Figure 60). These historical numbers are substantially lower than values produced by CALSIMII Study 7.0 in the Winter months. For example, the modeled NBA diversions are almost always more than 100 cfs during January-March. However, the Barker Slough Pumping Plant is screened with fish screens that operate at approach velocities of 0.2 feet/second. Thus, the Service does not anticipate that NBA operations will be detrimental to adult delta smelt, which should be protected from entrainment by the fish screens.

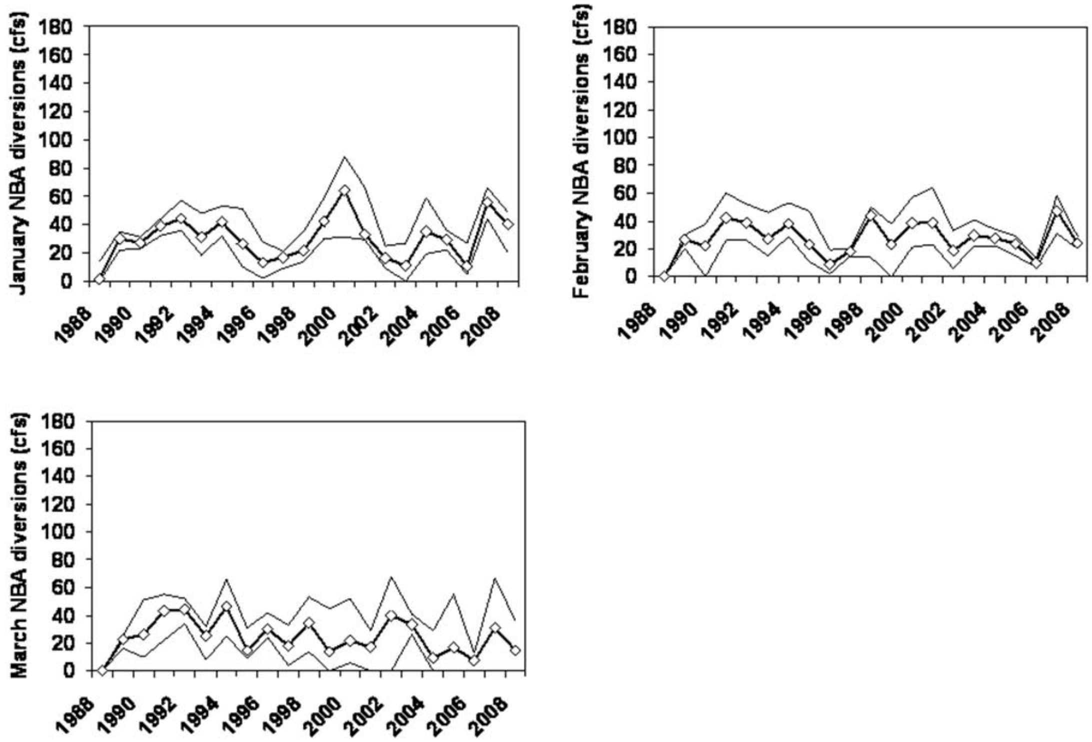

Figure 60. Time series of January-March State Water Project exports at Barker Slough Pumping Plant, 1988-2008. The thin lines depict minima and maxima, the thick lines with diamond symbols are the monthly averages. Data source: Dayflow database

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 by up to 200 cfs during winter.

Rock Slough

The Rock Slough Intake is presently screened and will be operational after August 2011.

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, therefore adult delta smelt entrainment is not likely to be above de minimis levels. In addition, Rock Slough is a dead-end slough with poor habitat for delta smelt. It can be assumed that the numbers of delta smelt using Rock Slough are likely very low.

Alternative Intake

Total entrainment at CCWD's facilities is likely to be reduced when the CCWD's Alternative Intake Project is completed. The project contractor achieved "substantial completion" and CCWD began making diversions in July 2010. Operational testing of the intake lasted a month or more beyond July 2010. 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 and has generally declined over time (Figure 61). 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. For instance, from 2006-2008 the gates were operated only 10-20 days annually. It is expected that this level of operational frequency (10-20 days per year) will continue in the future.

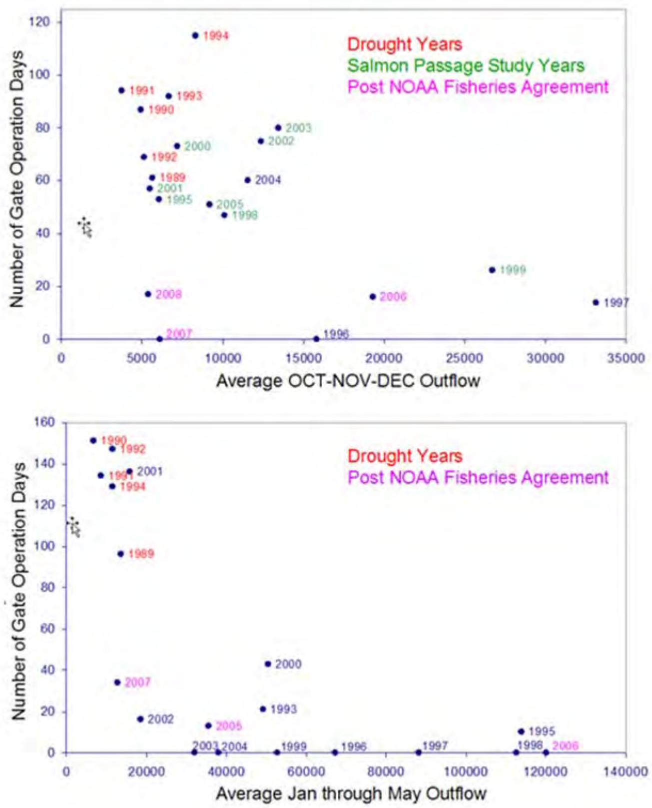

Figure 61. Scatterplots of Delta outflow versus number of days of operation of the Suisun Marsh Salinity Control Gates, 1989-2008. Data points are color-coded according to the Figure legend. Source: DFG (2009).

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 possible that if delta smelt were entrained into Montezuma Slough and Suisun Marsh by operations of the SMSCG that they may be vulnerable to water diversions (Culberson et al. 2004). The two Project diversions in the marsh are the Roaring River and Morrow Island distribution systems (RRDS and MIDS, respectively). The RRDS has a positive barrier fish screen operated to 0.2 feet/second approach velocities, therefore it is unlikely to entrain or impinge adult delta smelt. Entrainment into MIDS appears to be unlikely. No adult delta smelt were observed during entrainment monitoring at MIDS from 2004-2006 (and only one larva in 2.3 million m^3 of water sampled) 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. However, many adult delta smelt are collected in Montezuma Slough during SKTS sampling (Figure 40). This reinforces previous assumptions that Suisun Marsh is an important delta smelt spawning habitat (Moyle 2002).

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 shift as far as 3 km upstream while the gates are operating. Thus, depending on the tidal conditions during and after gate operations, X2 may be nominally transported upstream about 20 days per year. This shift has the potential to transiently decrease the delta smelt habitat suitability (see delta smelt habitat effects section below for rationale).

During January through March, most delta smelt move into spawning areas in the Delta. Grimaldo et al. (2009) 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 that moves X2 east of 80 km may contribute to increased entrainment of delta smelt at the CVP and SWP, especially during years of low outflow or periods of high CVP/SWP exports. However, adult entrainment should be more effectively controlled by the OMR targets described in the RPA.

1. The South Delta Temporary Barriers are not operated during the winter months thus they will not impact adult delta smelt during migration and spawning.
2. DCC operations are negligible to delta smelt because the DCC does not substantively affect entrainment risk based on PTM simulations (Kimmerer and Nobriga 2008; Table E-4. Factors affecting delta smelt entrainment and salvage).

Larvae (~ March-June)

Delta smelt are "larvae" from the time they hatch and enter the estuary's planktonic community until they reach lengths of 23-25 mm (Mager et al. 2004). However, the Service is using a definition of "larvae" in this section that relates to delta smelt's vulnerability to Project diversions rather than their morphology. Specifically, this section of the Effects Analysis considers age-0[14] delta smelt to be "larvae" during the period they are vulnerable to SWP and CVP water diversions even though many individuals are morphologically "juveniles" by the end of May. This was done only for organizational convenience. The period of entrainment vulnerability extends from larval emergence through the end of June or the first week of July each year (Kimmerer 2008; Figure 85). The next section of this Effects Analysis titled "Juveniles and Adults" covers the remainder of delta smelt's first calendar year of life from about July-December.

Delta smelt can hatch into pelagic larvae from February-June, but peak hatching usually occurs in April. The distribution of delta smelt larvae initially follows that of the spawners because larvae emerge near where they were spawned. Thus, larvae are

[14] The term 'age-0' refers to fish that are less than a year old. It is synonymous with terms like 'young-of-the-year' and 'larval-juvenile'.

distributed more widely during high outflow periods because the spawning range extends further west when Delta outflows are high (Hobbs et al. 2007). The survival of delta smelt larvae is probably driven mainly by the interaction of their bioenergetic environment[15] and entrainment, but only mortality rates associated with the latter have been estimated (Kimmerer 2008).

The distribution of larval delta smelt

Delta smelt larvae are generally open-water and planktonic, but they can and do swim (Bennett et al. 2002; Baskerville-Bridges et al. 2004; Mager et al. 2004). They also generally manage to maintain positions within favorable habitats (Bennett et al. 2002; Hobbs et al. 2006). The distribution of age-0 delta smelt collected in the Department of Fish and Game's 20-mm Survey has been analyzed relative to concurrent water quality conditions using the generalized additive modeling framework described by Feyrer et al. (2007). The results are shown alongside the results from other surveys in Figure 27. The analysis shows that larvae tend to be distributed in fresher water than juveniles. This is consistent with the findings of Dege and Brown (2004). These authors noted that delta smelt larvae (< 20 mm) were centered 5-20 km upstream of X2; delta smelt > 20 mm were distributed closer to X2. Delta smelt larvae are less sensitive to water transparency than juveniles (Figure E-X6). Miller (2011) showed that the influence of water transparency on proportional catch increases as the larvae grow larger. Thus, as the larvae transition to the juvenile stage, they tend to occupy more brackish water and limit their distribution more strongly to the most turbid waters available. The distribution of larvae relative to water temperature is similar to juveniles, with a peak probability of capture near 20^{o}C (Figure 27).

It has recently been documented that substantial numbers of delta smelt spawn in Liberty Island and the immediately adjacent region including the Sacramento Deep Water Shipping Channel (http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp). Subsequent catches of larvae in this region have also been high at times (http://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp) and have comprised an increasing proportion of total larval catch over time (Kimmerer 2011). The permanent flooding of Liberty Island in the latter 1990s changed north Delta hydrodynamics (Lehman et al. 2010b) and opened up a large area of shallow and turbid open-water habitat that is used by spawning delta smelt and their progeny (Figure 62). Turbidity is the most likely explanation for a shift in delta smelt distribution to the north (Feyrer et al. 2007; Miller 2011; Kimmerer 2011). Water transparency, an index of turbidity (Shoup and Wahl 2009[16]), is lower in the north Delta than the south Delta (Figure 63). Further, water transparency has trended upward in the south, but not in the north.

The south Delta is also warmer than the north Delta (Figure 64). However, the median difference has tended to be only about 1^{o}C in any given year (Figure 64, upper panel),

[15] The bioenergetic environment refers to the interaction of food quality/quantity and water temperature. The interaction occurs because delta smelt, like most fishes, require higher amounts of food to maintain any given growth rate at higher temperatures.

[16] These authors provided a statistical translation between Secchi disk depth (water transparency in cm) and turbidity in nephelometric turbidity units (NTU): NTU = 1761 · (Secchi depth$^{-1.514}$); $r^2 = 0.99$.

with most of that difference occurring in June-July (Figure 64, lower panel). In contrast to Secchi depth, the 20-mm Survey data do not show evidence of a time trend in water temperature in either region.

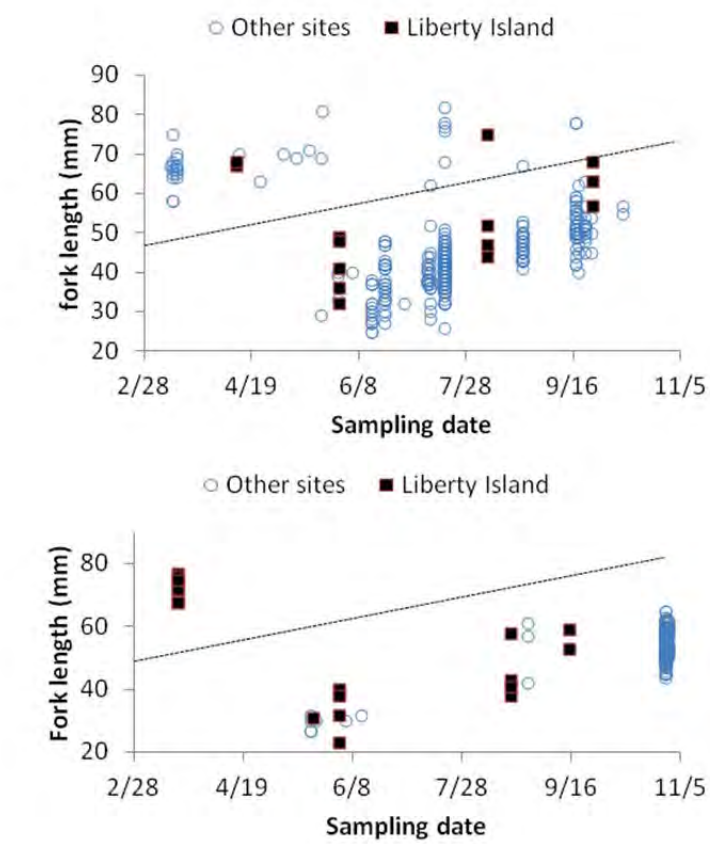

Figure 62. Scatterplots showing the sizes of delta smelt collected in beach seine sampling during 2001 and 2003 (see Nobriga et al. 2005 for details). The dashed lines separate delta smelt year classes; older fish occur above the lines. Thus, the data above the line in the top graph are year class 2000 and below the line they are the age-0 fish born in 2001. Similarly in the bottom plot, fish above the line are year class 2002 and below the line they are the age-0 fish born in 2003. Note that all four cohorts were collected in Liberty Island. Catches were much lower in 2003 than 2001 consistent with previous descriptions of the "Pelagic Organism Decline" (Sommer et al. 2007).

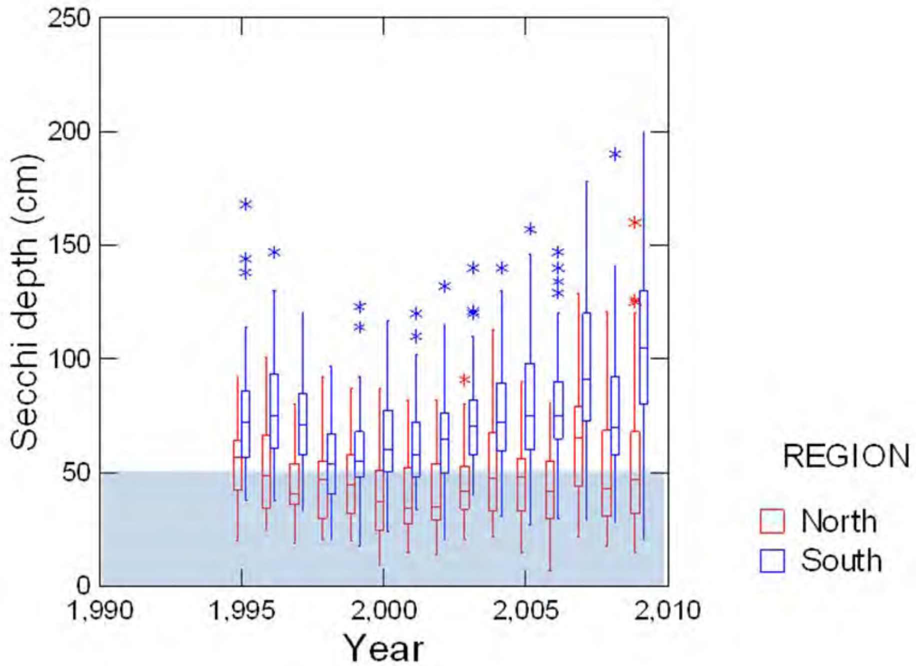

Figure 63. Boxplot time series of Secchi disk depth measurements in the California Department of Fish and Game's 20-mm Survey, 1995-2009. The red boxes are for 'north' Delta stations, which are the stations numbered from 704-799 in the 20-mm Survey (http://www.dfg.ca.gov/delta/data/20mm/stations.asp). The blue boxes are for 'south' Delta stations, which are the stations numbered 809-919 in the 20-mm Survey. The boxplots are as follows: rectangular box = interquartile range of observations; horizontal line in the box = median; vertical lines = 95% confidence intervals; asterisks = individual data points the Systat software program determined were "outliers". The blue shaded box denotes the region of Secchi disk depths ≤ 50 cm. This is an approximate level of Secchi disk depth below which delta smelt capture probability is somewhat higher based on analysis of the 20-mm Survey data set (see Figure 27).

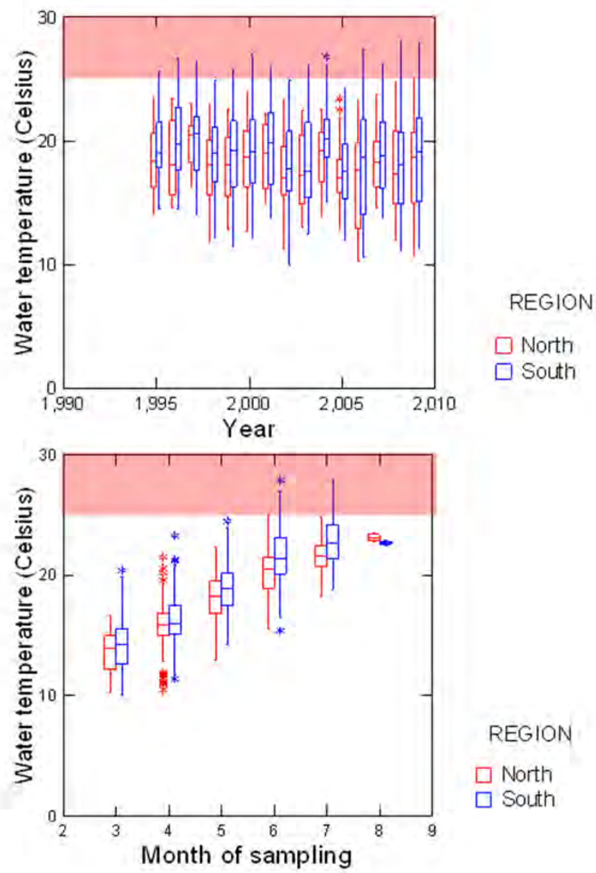

Figure 64. Boxplot time series of water temperature measurements in the California Department of Fish and Game's 20-mm Survey, 1995-2009. The red boxes are for 'north' Delta stations, which are the stations numbered from 704-799 in the 20-mm Survey (http://www.dfg.ca.gov/delta/data/20mm/stations.asp). The blue boxes are for 'south' Delta stations, which are the stations numbered 809-919 in the 20-mm Survey. The boxplots are as follows: rectangular box = interquartile range of observations; horizontal line in the box = median; vertical lines = 95% confidence intervals; asterisks = individual data points the Systat software program determined were "outliers". The shaded red box in each panel denotes water temperatures ≥ 25ºC. This is an approximate upper lethal water temperature limit for young delta smelt (Swanson et al. 2000).

Delta smelt life cycle models

There were no published life cycle models (LCMs) for delta smelt when the previous OCAP Biological Opinion was finished in December 2008. However, several have been developed and published since (Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011). The Mac Nally and Thomson models evaluate delta smelt population dynamics on an annual time step from one Fall Midwater Trawl Survey (FMWT) to the next. Maunder and Deriso (2011) developed a more sophisticated LCM framework. Their model evaluates population dynamics at three life stages represented by the FMWT, 20-mm, and Summer Townet (STNS) surveys. All of these authors developed statistical LCMs meaning models based on correlations of field observations rather than equations that explicitly describe delta smelt vital rates in terms of environmental variation. All of them correlate delta smelt abundance to prior abundance and to "covariates" that are physical and biological variables that are generally thought to affect delta smelt because they are the kinds of things that affect all organisms (predators, prey, temperature) or they are factors of local management importance (X2, exports, salvage).

The basic approach and findings of these LCMs are summarized in Table 28. If there is a 'big picture' conclusion to be gleaned from these studies, it is that the results depend *very strongly on how the model is set up and what covariates are considered*. Mac Nally et al. (2010) and Thomson et al. (2010) used two variables that index the entrainment of larval delta smelt. These were spring exports and spring X2, both averaged for March-May. Thomson et al. (2010) developed an LCM that searched for abrupt changes in delta smelt abundance and attempted to correlate the timing of those changes with environmental variables. They found no evidence for an effect of either spring exports or X_2 on delta smelt. Mac Nally et al. (2010) developed an LCM that considered delta smelt in the context of a partial estuarine food web model. They found weak statistical support for an influence of spring exports, and no evidence for an effect of spring X2. Maunder and Deriso (2011) appear to have used an approach similar to the Service (2008) to estimate age-0 delta smelt entrainment for their LCM: "The entrainment mortality rates are calculated based on Kimmerer (2008);…his larval-juvenile entrainment estimates were fitted to a multiple linear regression model with spring Old Middle River flow and spring low salinity zone (as measured by *X*[17])". These authors did not find evidence for an effect of spring entrainment on delta smelt's long-term population dynamics.

These findings from LCMs are not surprising because it has been shown for many years that spring X_2 is not a statistically significant predictor of delta smelt abundance (Jassby et al. 1995; Kimmerer 2002; Bennett 2005). However, the LCM results, and the earlier single factor correlations, are all tempered by a recent modeling simulation. Kimmerer (2011) noted that compensatory density-dependence is not likely to occur in the delta smelt population given its current very low abundance. The Service agrees. That means that an impact to the population at one life stage will carry through to the next. Kimmerer showed that (1) an entrainment loss lower than the levels he estimated in 2008 would cause a substantial population decline when density-dependence does not occur in a later life stage, and (2) correlative analyses like all of those reviewed above would be unlikely to ever detect the effect (Figure 41). Thus, although there are now numerous published studies that have not found a statistically significant influence of spring flow conditions/entrainment on delta smelt's abundance index time series, it is possible that a very detrimental effect has still occurred (Kimmerer 2011).

Springtime hydrodynamics

The freshwater flows that enter the Delta as inflow and pass through it as outflow influence habitat volume for delta smelt during the spring (Kimmerer et al. 2009). They also influence proportional entrainment of the larval delta smelt population (Kimmerer and Nobriga 2008). The combined CVP and SWP water systems began diverting water year-around from the Delta in 1968. Thus, the following analysis considers historical

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[17] This is presumably a typo in which the authors meant X2, the 2 psu isohaline.

flow conditions based on summaries of the DAYFLOW database for the period 1968-2010. Delta inflows vary among years due largely to interannual differences in precipitation (Kimmerer 2004; Figure 65). Inflows are thus highly correlated among months in the springtime, but decline with each successive month as snowmelt and runoff recede. The Projects can have considerable control over Delta inflows during springs with low precipitation. They also tend to have higher control over inflows by early summer (e.g., June) than earlier in the winter and spring.

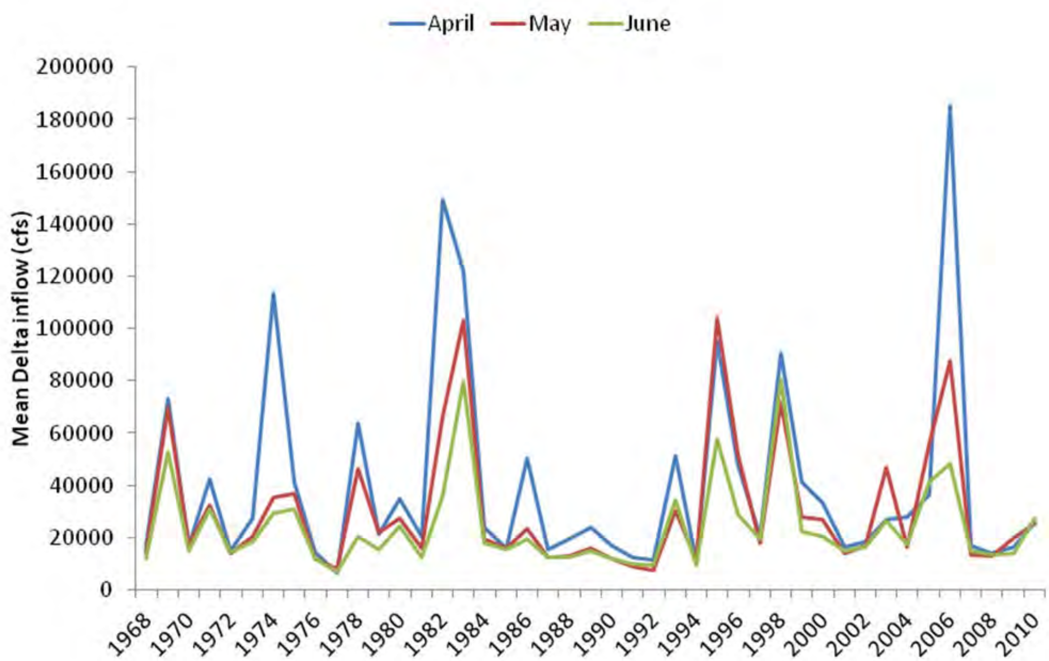

Figure 65. Time series of total Delta inflow for April-June, 1968-2010. Source: Dayflow database

April-May exports underwent a step-decline starting in the early 1990s (Figure 66). This was initially due to several years of successive drought but the lower export levels have continued because the State of California implemented the X2 standard and the VAMP experiment. Project exports frequently exceeded 300 TAF during April-May 1968-1988, but they have only infrequently exceeded that threshold since. Project exports are higher in June, sometimes exceeding 400 TAF per month, but there is no evidence of a long-term trend. Overall, Project exports are usually lower during April-June than other times of year (compare y-axis scale of Figure 66 and Figure 74). The trends in the E:I ratio for the spring months mirror the export trend; step-declines in April-May and no trend in June (Figure 76). The State of California's X2 standard has also shifted the upstream limit of X2 further to the west during April-June (Figure 77).

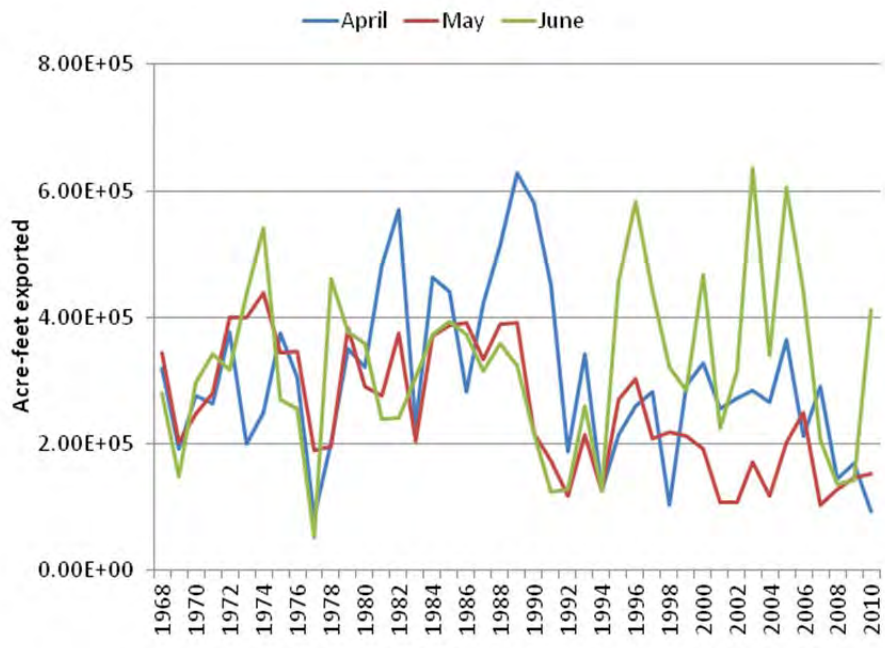

Figure 66. Time series of monthly SWP and CVP exports for April-June, 1968-2010. Source: Dayflow database

Conceptual background for south Delta entrainment risk

Most age-0 delta smelt *entrainment* at Banks and Jones happens during the true larval stage and is not observed and counted (Kimmerer 2008). The *salvage* of age-0 delta smelt reflects the tail end of the entrainment of age-0 cohorts that started before the fish were large enough to be observed in the fish salvage facilities. Delta smelt are not counted in fish salvage until they reach a minimum length of 20 mm. It's unlikely that they are collected efficiently (Bowen et al. 2004; Castillo et al. 2010), but Kimmerer (2008) showed that delta smelt salvage was inefficient, even by delta smelt standards, until the fish were 30 mm long (by which time they are morphologically juveniles; Mager et al. 2004). They typically reach 20-30 mm in May and June. Thus, April is typically the month of highest Project entrainment of age-0 delta smelt, while May-June are the months of highest salvage (Kimmerer 2008).

Previously, the Service (2008) translated Kimmerer's (2008) data-intensive age-0 delta smelt entrainment estimates into a multiple linear regression equation using multi-month averages of X2 and OMR flow as predictor variables. This allowed the Service to hindcast and forecast proportional entrainment (Figure 67). The regression was a quantitative representation of the following conceptual model: (1) the geographic distribution of the population is strongly associated with Delta outflow (or its surrogate, X2; Dege and Brown 2004). Thus, Delta outflow determines how much of the age-0 delta smelt population rears in the Delta during the spring and early summer where it is potentially vulnerable to entrainment, and (2) OMR reflects the hydrodynamic influence of the water projects' diversions on the southern half of the Delta and thus the degree of entrainment risk for fishes in that region (Kimmerer 2008; Grimaldo et al. 2009). The long-term declines in April-May exports and E:I ratio, and April-June X2 location are all indications that the proportional entrainment of age-0 delta smelt has declined. In addition, proportional entrainment may be continuing to decline due to a general shift in delta smelt spawning distribution toward the north Delta (Miller 2011; Kimmerer 2011).

This conceptual model remains valid. The Service notes that Kimmerer's (2008) estimates have recently been criticized on numerous grounds (Miller 2011). However, most of Miller's criticisms are unfounded, incorrectly cast, or beyond the scope of currently available data sets to address (Kimmerer 2011). The Service recognizes that the shift in delta smelt distribution toward the north affects the accuracy of the translation of hydrodynamic conditions into specific predictions of proportional entrainment (Miller 2011; Kimmerer 2011) (Figure 68).

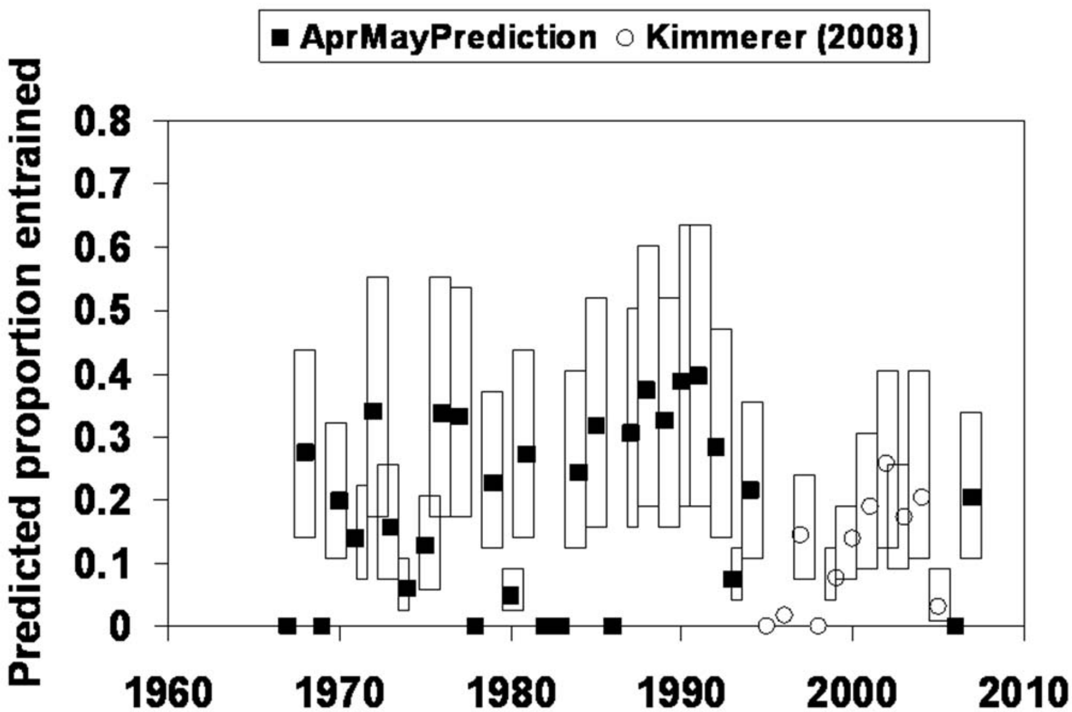

Figure 67. Copy of Figure E-16 from Service (2008). Time series of estimated proportion of the age-0 delta smelt population entrained at Banks and Jones. Open symbols are the empirical estimates made by Kimmerer (2008). Solid symbols were estimated using the linear regression equation developed by the Service (2008). The rectangles depict the approximate 95% confidence intervals on the estimates.

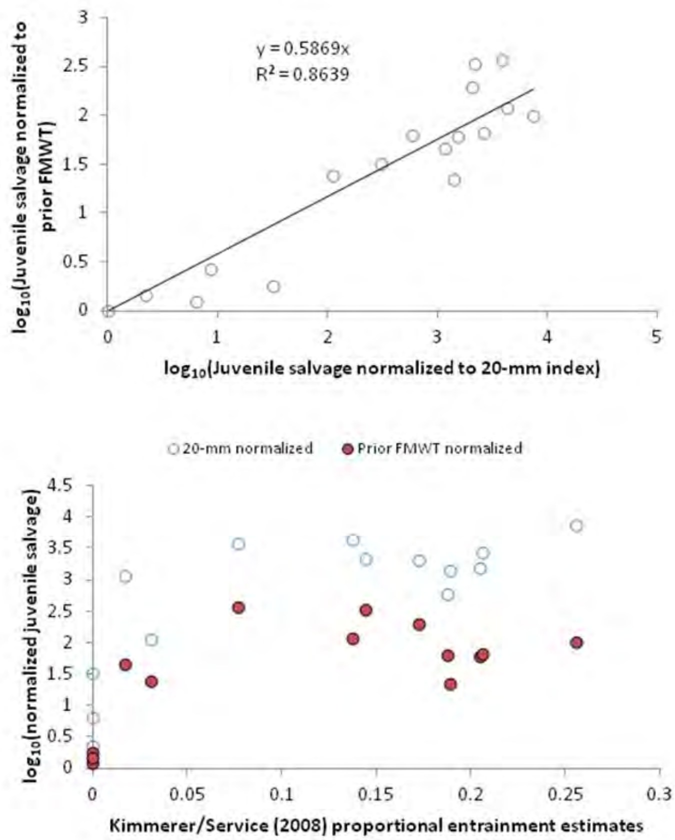

Figure 68. Top panel: scatterplot showing the close relationship between two different versions of normalized juvenile salvage. The x-axis is juvenile salvage (April-July total) divided by the same year 20-mm Survey abundance index. The y-axis is the same salvage summary divided by the previous year's Fall Midwater Trawl abundance index. Bottom panel: scatterplots showing the lack of linear relationships between the Service's (2008) proportional entrainment estimates and the two normalized salvage metrics compared in the top panel. The implication is that (1) it does not matter very much which delta smelt abundance index is used to normalize the age-0 salvage data to account for interannual variation in abundance, and (2) the salvage data and entrainment estimates derived using independent data sets only agree with each other in years when entrainment is very low.

The potential for entrainment of fishes rearing in the lower San Joaquin River can be visualized with particle tracking model (PTM) results based on neutrally buoyant particles. The Service understands that these results reflect predictions about water movement in the Delta rather than fish movement per se. However, the water movement data provide the best available indication of entrainment risk. In fact, Kimmerer (2008) showed that the entrainment estimates he derived from empirical flow and 20-mm data matched predictions of entrainment based on PTM simulations very well[18] (Figure 69). Thus, PTM provides a reliable estimate of entrainment for fish inhabiting the San Joaquin River and south Delta.

[18] Note that the ptm results were not used to develop the proportional entrainment estimates. Thus, the data shown in Figure 68 are not depicting a circular argument.

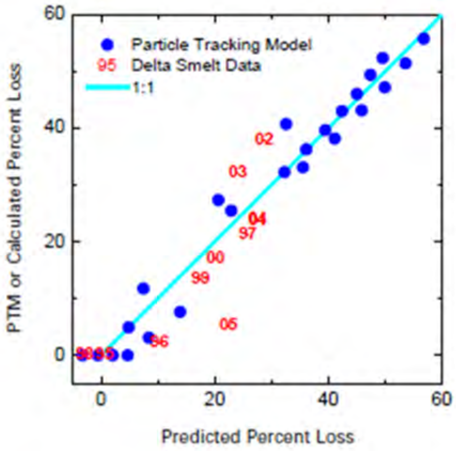

Figure 16. Larval/juvenile delta smelt. Predicted percent loss to the population by regression using log of Delta inflow and log of export flow as predictors (with interaction), and particle-tracking model results as the dependent variable (circles), with the line indicating a 1:1 relationship. The regression is: log (y) = 4.29 – (0.36 ± 0.17) log(inflow) – (0.90 ± 0.11) log(export flow) + (0.10 ± 0.03) log(inflow) × log(export flow), parameters with 95% confidence limits. Estimates of delta smelt losses from Figure 15 with no natural mortality (to match the particle tracking model results) are plotted against predictions from the above statistical model using mean flow conditions during the hatch period; numbers indicate years.

Figure 69. Copy of Figure 16 from Kimmerer (2008). The Figure compares the empirically derived age-0 delta smelt entrainment estimates for Banks and Jones (combined) against estimates of neutrally buoyant particle entrainment entrainment into those facilities based on DSM2 particle tracking modeling.

Based on existing summaries of PTM results, it appears that delta smelt cannot be protected from entrainment once they enter Old or Middle Rivers (Figure 70). Figure 70 shows that particle fluxes into Old and Middle rivers are proportional to predicted entrainment into Banks and Jones. The relationship deviates from the one to one line when loss to agricultural irrigation diversions is high. Thus, PTM indicates that almost all particles, and by extension larval fishes, that enter Old and Middle Rivers will eventually be entrained somewhere. Larval fishes will be entrainedeither at Banks, Jones, or one of numerous smaller agricultural irrigation diversions en route to Banks and Jones. Thus, currently available scientific evidence indicates that OMR flow limits cannot be used to ‘help’ fish migrate out of Old and Middle Rivers if they are already there. Rather, OMR flow limits will be most effective if they minimize the hydrodynamic conditions that entrain young delta smelt into Old and Middle Rivers from the mainstem San Joaquin River.

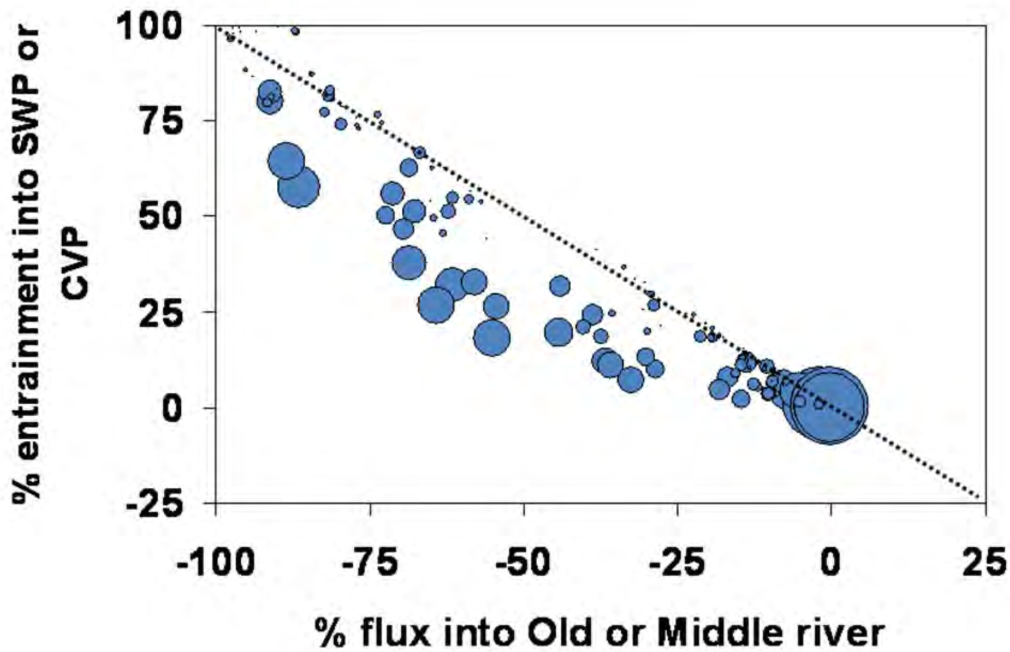

Figure 70. Scatterplot showing the relationship between flux into Old and Middle rivers and entrainment based on simulations using the DSM-2 particle tracking model. The plot demonstrates that particle flux into Old and Middle rivers is strongly linked to entrainment risk. Note that DSM-2 codes fluxes into Old and Middle rivers from elsewhere as negative percentages. The individual data points are sized according to their predicted entrainment into agricultural irrigation diversions. The dotted line is an approximate 1:1 line. Note that large bubbles at Old and Middle river fluxes ranging from about 25% to 90% are often associated with deviations from the 1:1 line. This occurs because particles can be lost to agricultural irrigation diversions in Old and Middle rivers before being transported all the way to Banks and Jones Pumping Plants. Data source: particle tracking model runs done to support the State Water Project's CESA Incidental Take authorization for longfin smelt.

The PTM results also suggest that OMR flow limits should be applied proactively because (1) there are no available data on the distribution of delta smelt eggs; (2) the net efficiency of the 20-mm Survey is very low for hatch sized larvae (Kimmerer 2008); and (3) PTM simulations show that the ultimate entrainment of particles is closely tied to OMR flows during particle release (Figure 1Figure 71). In other words, 'after the fact' OMR adjustments are either not necessary or 'too little, too late'.

In addition to variability in salvage caused by interannual differences in population distribution and environmental conditions, delta smelt that are entrained into the Projects are subject to variable collection efficiency and predation rates (Table 30). The pre-screen loss of adult delta smelt in Clifton Court Forebay has been estimated at nearly 100%[19] during recent pilot studies (Castillo et al. in review). However, the experiments used captive-bred fish and the experimental design cannot feasibly include a control outside the forebay. Thus, it is uncertain how accurately these preliminary estimates represent wild fish mortality rates in the forebay. Nonetheless, the occurrence and

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[19] The pre-screen loss estimates ranged from 89.9% to 100% in six experiments. The mean loss was 95.9%.

variability of pre-screen loss adds additional statistical uncertainty or "noise" to the salvage data. This further affects the precision of conclusions that can be drawn from these data. All of this measurement imprecision is reflected in the Service's use of round number OMR flow criteria like -2000 cfs and -5000 cfs.

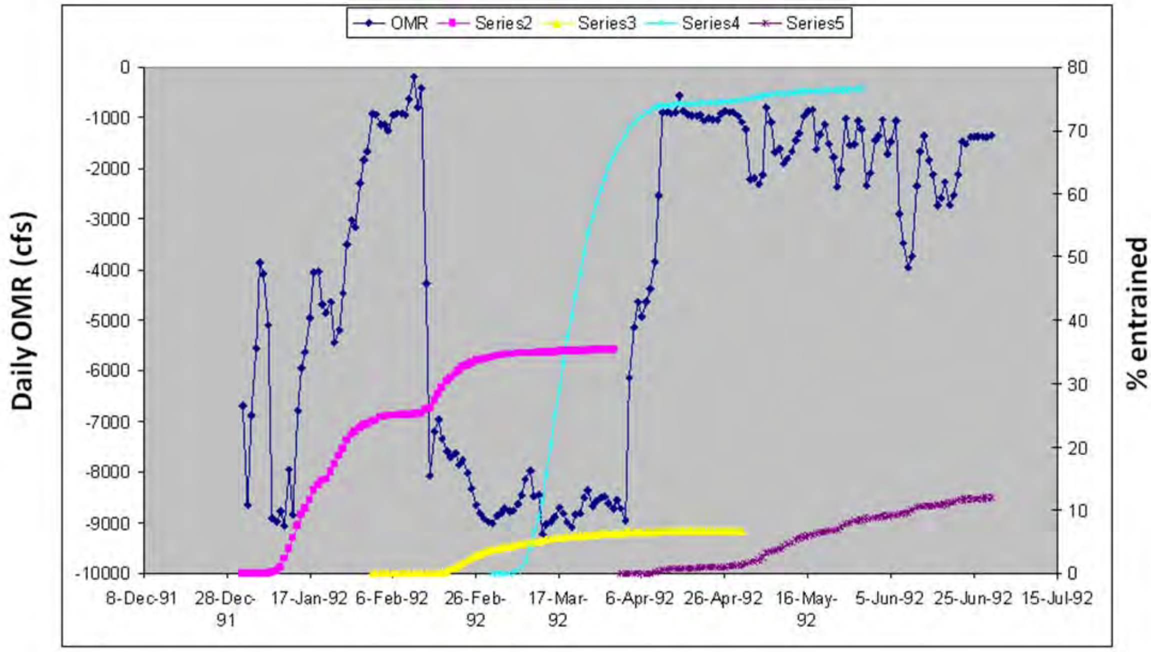

Figure 71. Time series plots of daily particle fate predicted from the DSM-2 particle tracking model for four different particle releases at trawl station 812 (see Figure 35 for location). The simulations used the actual hydrology from winter-spring, 1992, a dry year with a lot of variation in OMR flows. Particles were released on January 1, February 1, March 1, and April 1 and each of the four simulations was run for a total of 90 days. The dark blue line shows the daily mean OMR flow. The other lines show the accumulation of particles entrained at Banks and Jones. Note that the general magnitude of final particle loss was apparent in much less than 90 days and was closely associated with OMR flow at or very near the time of initial particle release. Data source: particle tracking model runs done to support the State Water Project's CESA Incidental Take authorization for longfin smelt.

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 reducing habitat suitability, as discussed below in the habitat suitability section.

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 during the spring. 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. This facility is fully screened to meet delta smelt fish screening criteria. Diversion from this facility may affect OMR flows by up to 200 cfs.

Rock Slough

The Rock Slough Intake is presently screened and will be operational after August 2011. 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, therefore adult delta smelt entrainment is not likely to be above de minimis levels. In addition, Rock Slough is a dead-end slough with poor habitat for delta smelt. It can be assumed that the numbers of delta smelt using Rock Slough are likely very low.

Alternative Intake

Total entrainment at CCWD's facilities is likely to be reduced when the CCWD's Alternative Intake Project is completed. The project contractor achieved “substantial completion” and CCWD began making diversions in July 2010. Operational testing of the intake lasted a month or more beyond July 2010. 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 Suisun Marsh. The number of days the SMSCG are operated in any given year varies, but has generally declined over time (Figure E-30). Historically, the SMSCG were operated 60-120 days between October and May (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. For instance, from 2006-2008 the gates were operated only 10-20 days annually. It is expected that this level of operational frequency (10-20 days per year) will continue in the future. This change has an unquantified mix of risk and benefit.

Based on PTM simulations, a reduced frequency of SMSCG operation is expected to reduce the flux of delta smelt larvae spawned outside of Suisun Marsh into the marsh (Figure E-Y9). The risk of entrainment into water diversions in Suisun Marsh increases with proximity to the diversions (Culberson et al. 2004). Therefore, lower flux of delta smelt larvae into the marsh may reduce cumulative entrainment loss. The two Project diversions in the marsh are the Roaring River and Morrow Island distribution systems (RRDS and MIDS, respectively). The RRDS has a positive barrier fish screen operated to 0.2 feet/second approach velocities so it should not entrain or impinge delta smelt – at least once they reach the juvenile stage (e.g., Nobriga et al. 2004). Entrainment into MIDS appears to be unlikely. Only one larva was collected in 2.3 million m^3 of water sampled during a two-year study of the MIDS diversion (Enos et al. 2007). The likely reason was that salinity in Suisun Slough was usually too high for delta smelt during periods the the MIDS diversion needed to operate.

With regard to potential benefits, large fractions of delta smelt are collected in Suisun Marsh (Montezuma Slough) by the Department of Fish and Game's Spring Kodiak Trawl (Figure 36). Thus, Suisun Marsh may be an important spawning habitat. If it is also an important larval rearing habitat, then less frequent operation will result in fewer larvae benefitting from co-location with the marsh (Figure 70) unless they are able to find their own way into it. Delta smelt larvae are known to occur in Suisun Marsh (Meng and Matern 2001; http://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp), but it is not known if they gain a benefit relative to larvae rearing elsewhere in the estuary. However, it has been shown that delta smelt larvae show evidence of improved feeding and condition when they are located in shallow embayments adjacent to Suisun Marsh (Hobbs et al. 2006).

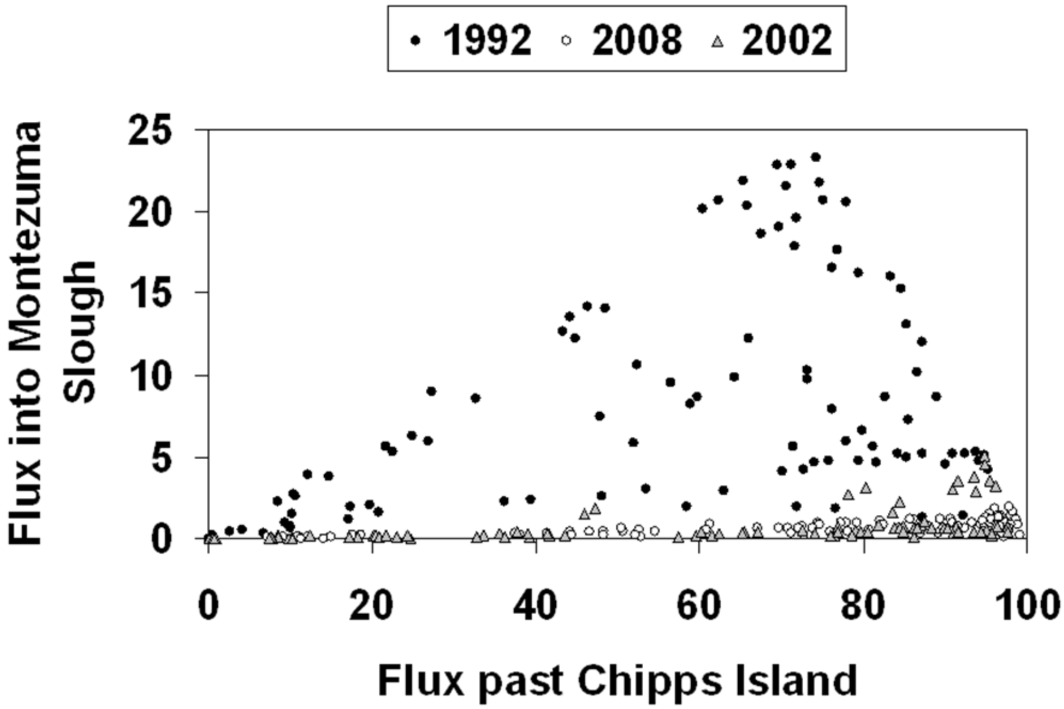

Figure 72. Scatterplot showing DSM2 particle tracking model results for Suisun Bay and marsh. The x-axis depicts the percentage of particles that passed Chipps Island for the three years of simulations shown in the legend. The y-axis depicts the percentage of particles that entered Suisun Marsh (Montezuma Slough) via the Suisun Marsh Salinity Control Gates. Note that the gates were operated much more frequently in 1992 than 2002 or 2008 to pump freshwater from the Sacramento River into the marsh. Particle release times varied; see DFG (2009) for details.

1. The South Delta Temporary Barriers are not operated during the spring months so they will not impact adult delta smelt during migration and spawning.
2. We do not care how DCC gets operated; defer to NMFS because it does not substantively affect entrainment risk based on PTM simulations (Kimmerer and Nobriga 2008).Table E-4. Factors affecting delta smelt entrainment and salvage.

Juveniles and Adults (~ July-December)

Conceptual background for juvenile rearing

Delta smelt larvae are present in the estuary in July (http://www.dfg.ca.gov/delta/data/20mm/Length_frequency.asp). However, by this time most individuals are morphologically juveniles (Table 31). These juveniles are pelagic with a spatial distribution that varies with salinity, turbidity, water temperature, and possibly other habitat features (Sweetnam 1999; Dege and Brown 2004; Bennett 2005; Feyrer et al. 2007; Nobriga et al. 2008; Sommer et al. 2011). Most of them will be 60-70 mm long by December. They are still considered juveniles at that time because their reproductive organs are not functional, but the delta smelt collected in the fall are often referred to as “adults” or pre-adults”. The center of the juvenile delta smelt population during summer-fall is typically very near the 2 psu isohaline, X2 (Moyle et al. 1992; Sweetnam 1999; Dege and Brown 2004; Sommer et al. 2011). However, some individuals continue to rear in fresher water in the Liberty Island- Sacramento River Deep Water Shipping Channel area (Sommer et al. 2011). This is probably due in large part to the comparatively turbid water in this region (Nobriga et al. 2005). A few individuals are also collected at salinities higher than 6 psu but these are low probability events (Feyrer et al. 2007; Nobriga et al. 2008). It is not known how long individual delta smelt occupy waters seaward of the low-salinity zone.

Table 31. Summary of mean delta smeltlengths in the 20 mm Survey for the sampling dates nearest to July 1, 1995-2011. Note that no July sampling occurred 2000-2002. Delta smelt are beyond the larval stage by the time they reach about 23-25 mm in length (Mager et al. 2004). Data source: http://www.dfg.ca.gov/delta/data/20mm/Length_frequency.asp

Year	Survey Number	Sampling dates	Mean Length (mm)
1995	6	July 3-10	30.5
1996	7	July 8-13	30.4
1997	8	July 8-13	36.9
1998	7	June 28-July 3	33.0
1999	7	July 6-10	25.7
2000	8	June 26-30	25.9
2001	8	June 25-30	30.0
2002	8	June 24-29	38.5
2003	8	June 30-July 3	29.7
2004	8	July 6-10	36.5
2005	9	July 5-9	37.1
2006	8	June 26-July 1	28.1
2007	9	July 2-7	41.2
2008	9	July 7-11	41.7
2009	9	June 29-July 2	31.8
2010	9	July 6-9	26.0
2011	9	July 5-8	24.9

Delta smelt’s juvenile rearing habitat has undergone profound changes which have led to increasingly degraded habitat conditions over time. These changes were described in detail in the *Environmental Baseline/Critical Habitat* section and are not repeated here. Many of these baseline changes are not attributable to Project operations. Those that are, are analyzed below.

Habitat suitability

Summer-fall hydrodynamics

The freshwater flows that enter the Delta as inflow and pass through it as outflow influence habitat suitability for delta smelt (Kimmerer et al. 2009; Feyrer et al. 2011). The combined CVP and SWP water systems began diverting water year-around from the Delta in 1968. Thus, the following analysis considers historical flow conditions based on summaries of the DAYFLOW database for the period 1968-2009/2010[20]. Delta inflows vary among years due largely to interannual differences in precipitation (Kimmerer 2004). However, the Projects often have considerable control over Delta inflows during most of delta smelt's juvenile life stage – particularly July-October, which are the 'base flow' months in the watershed (Kimmerer 2002; 2004). Inflows have been variable during July-August, but with consistently higher minima since the mid-1990s (Figure 73). In contrast, inflows during September-December have been lower since the mid-1980s than they were prior. This is particularly apparent in November-December because peak flows are so much larger than low flows in these months due to occasional large autumn storms.

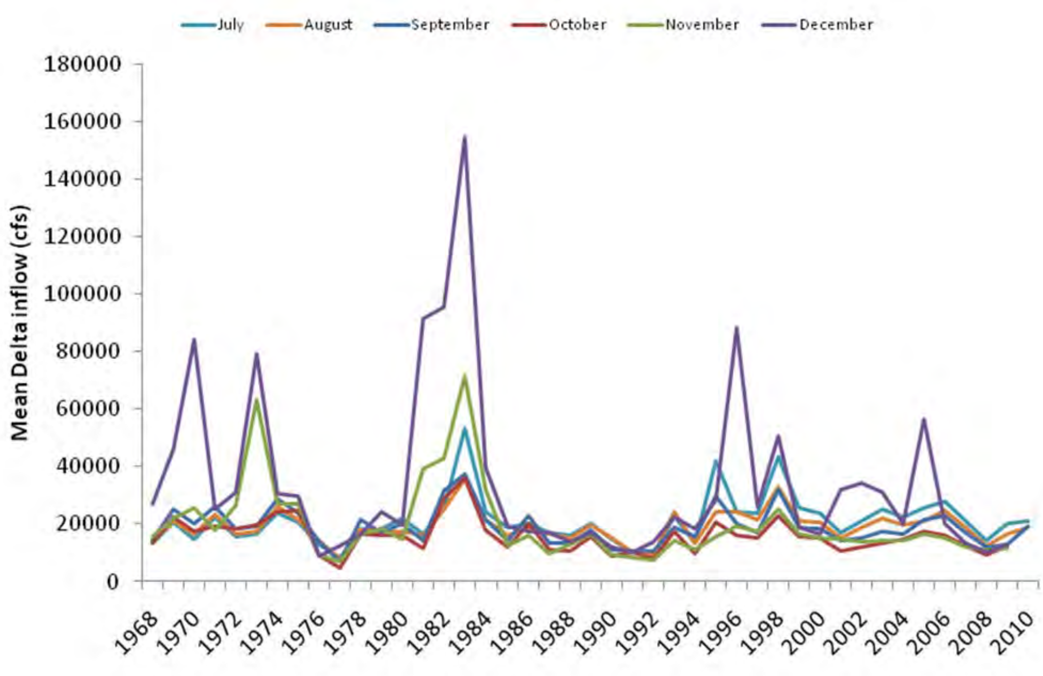

Figure 73. Time series of total Delta inflow forJuly-September, 1968-2010 and October-December, 1968-2009. Source: Dayflow database

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[20] At this writing, official DAYFLOW data were available through water year 2010 (i.e., September 2010).

As was the case for the winter months of January-March, Project exports have generally increased during July-December (Figure 74). Monthly exports first reached 400 TAF in July 1971. They first reached 500 and 600 TAF in July and August 1974. September exports specifically, first reached 500 and 600 TAF in 1976 and 1985. July-December exports have often ranged between 400-600 TAF per month since 1980. Monthly exports exceeded 700 TAF a few times during the mid-2000s. Summer-fall exports are typically less than 400-600 TAF per month during droughts (1976-1977; 1990-1992; 2007-2009).

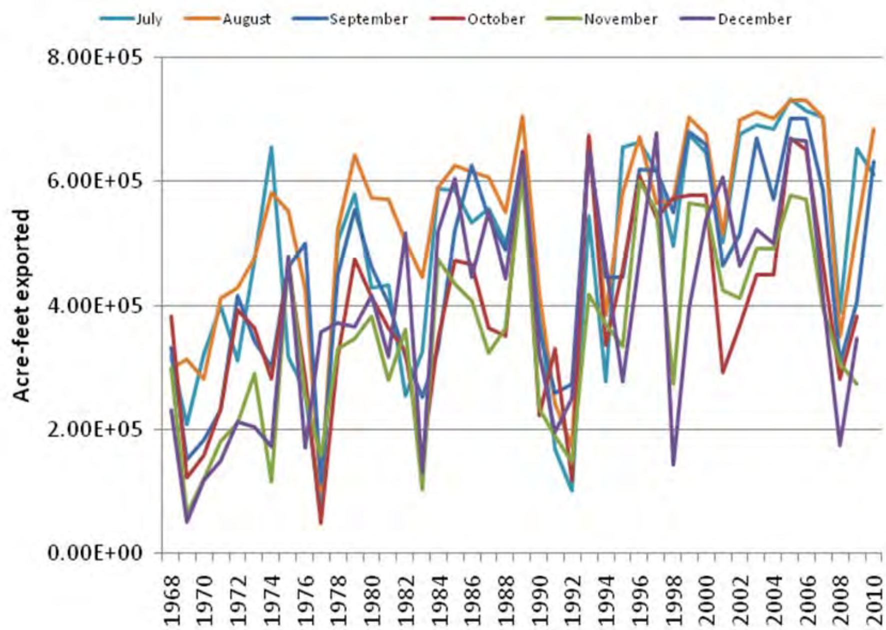

Figure 74. Time series of combined Project exports for July-September, 1968-2010 and October-December, 1968-2009. Source: converted from cfs data in Dayflow database

The net effect of these inflow and export trends is clearer when plotted as the export to inflow ratio (E:I; Figure 75). The E:I is highly variable among months and years because both exports and inflows vary considerably. Nonetheless, with the possible exception of December, summer-fall E:I has generally been higher since the mid-1980s than it was prior. Since 2000, it has only dropped below 0.40 once during the months of July-November. These trends are very different than what has occurred during other times of the year (Figure 76). During January-March, E:I has not had any trend except to increase temporarily during droughts (1976-1977, 1987-1992). The E:I has decreased during April-May because of the Vernalis Adaptive Management Plan (VAMP), and it has shown no obvious long-term trend during June.

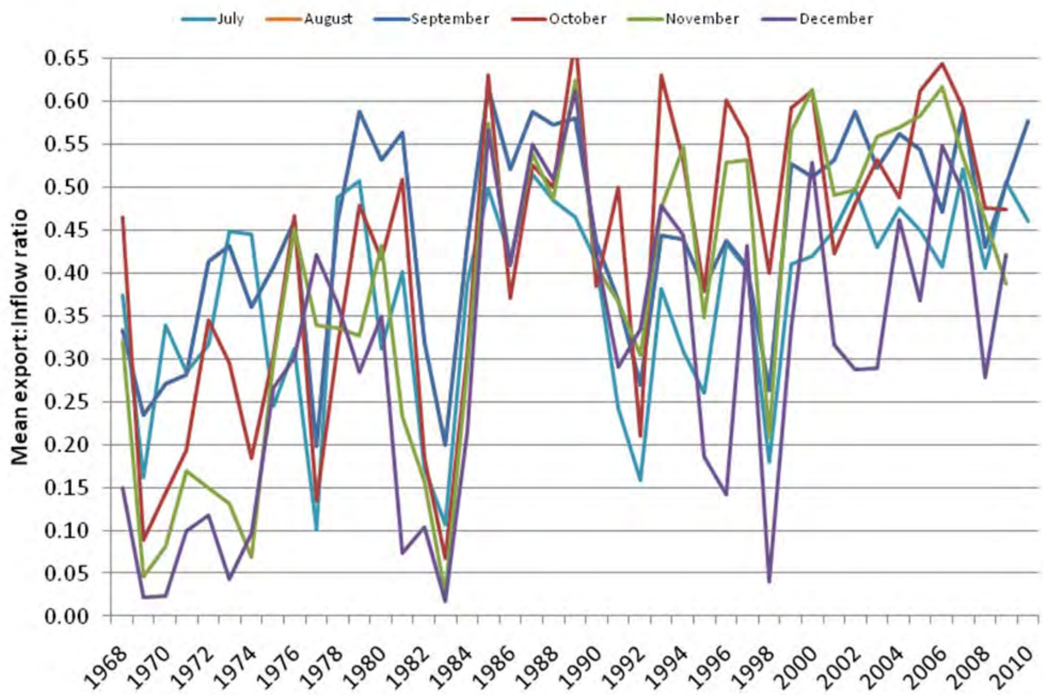

Figure 75. Time series of the monthly mean Exportto Inflow ratio for July-September, 1968-2010 and October-December, 1968-2009. The upper limit of the y-axis (0.65) is the upper limit for this ratio set by the State Water Resources Control Board. Source: Dayflow database

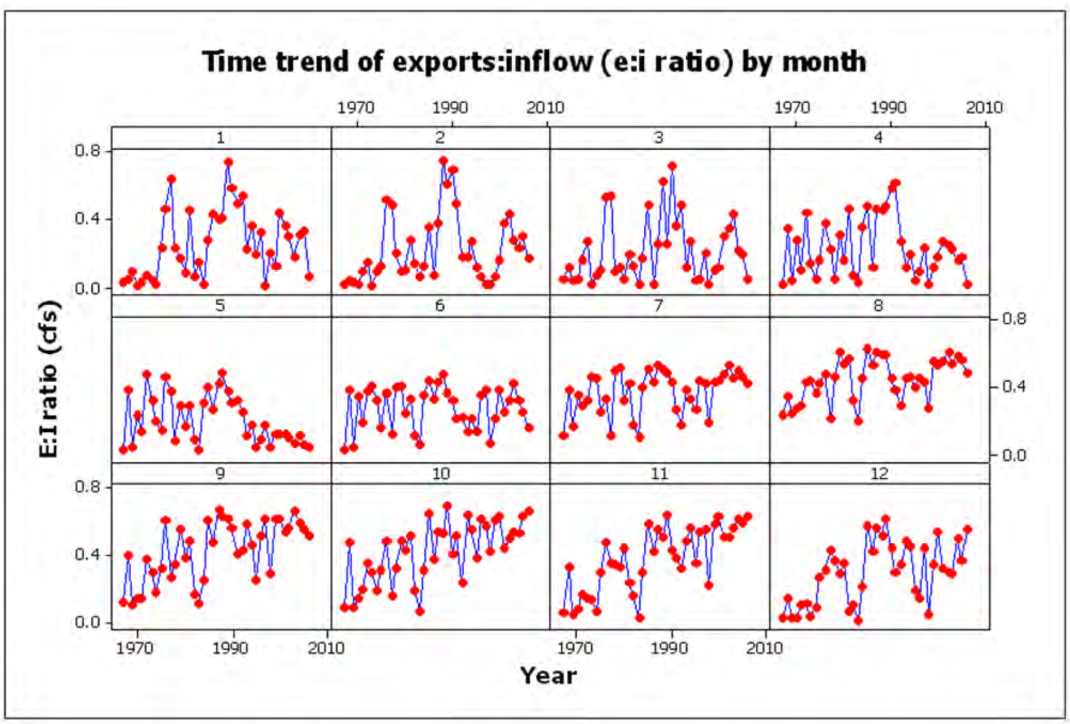

Figure 76. Time series of the monthly mean Export to Inflow ratio, January-December, 1968-2006. Source: Dayflow database

The increased export flows relative to inflows translate into lower Delta outflow (Kimmerer 2004). This in turn allows the estuarine salinity distribution to move upstream. The salinity distribution of the San Francisco Estuary is often indexed using X2, the distance (km) from the Golden Gate Bridge to the location where the average salinity at the bottom of the water is 2 parts per thousand or “psu” (Jassby et al. 1995). The State of California enacted a salinity standard that can be met using X2 location during February-June (SWRCB 1995). The Projects began operating to the standard in the mid-1990s. This can be seen in monthly time series of X2 (Figure 77). Since the mid-1990s, X2 has not migrated as far upstream as it did prior during February-June[21]; it’s also true of January and July even though the salinity standard does not apply in these months. This is likely due to inertia in the location of X2; its average location does not move as quickly as Delta outflow changes (Jassby et al. 1995). It takes more Delta outflow to move X2 from a starting location to a downstream location than it takes to maintain it at the downstream location once it is there. Thus, the Projects may sometimes need to start moving X2 downstream in January to meet the February standard if precipitation is not sufficient to provide the needed outflow. The interia also works in reverse. If Delta outflow decreases in July, a month in which the Projects usually have a substantial influence on Delta outflow, then X2 will not immediately move upstream. Project influence is probably why upstream limits of July X2 have remained seaward of historical locations even though the Projects are not required to meet an X2 standard in July.

[21] Note that downstream limits of X2 during winter and spring are driven by flood flows and are thus not under substantive control of the Projects.

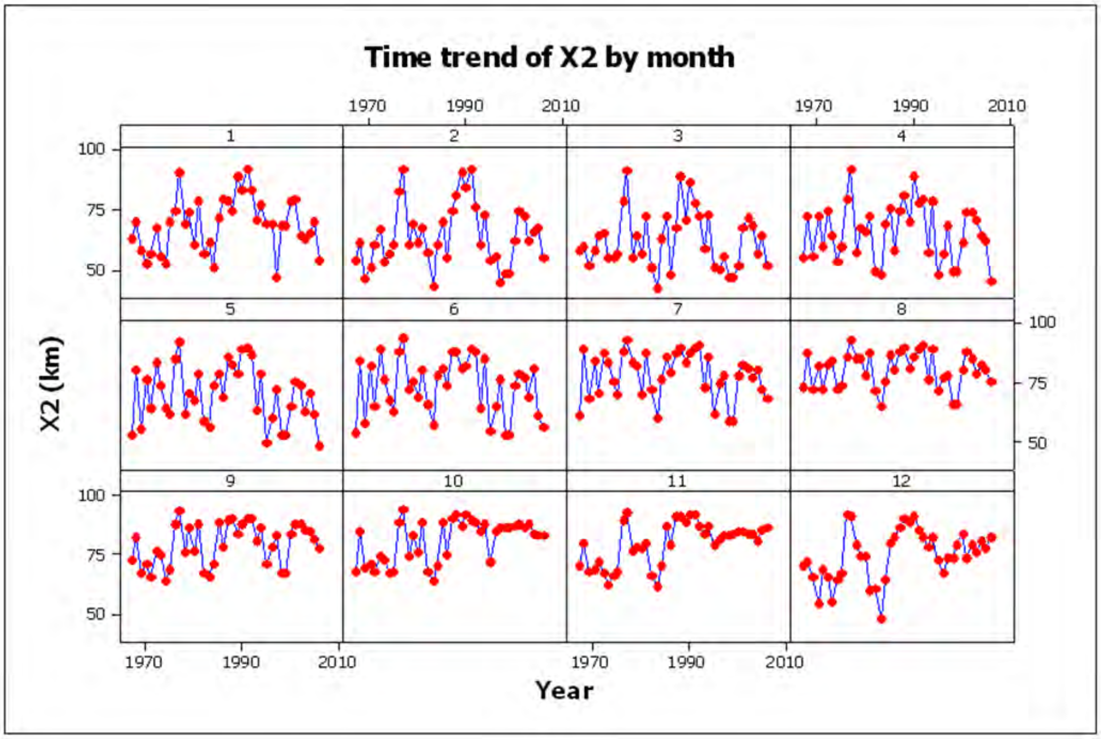

Figure 77. Time series of X2 January-December, 1967-2008. Source: Dayflow database

By August, present-day X2 locations are more comparable to what they were prior to the mid-1990s (Figure 77). In contrast, September-December X2 locations have recently been skewed toward the upstream end of where they occurred in the early years of combined Project pumping. This trend is particularly pronounced during October-December, during which the historical interannual variability in fall X2 location had largely disappeared by the mid-1980s. The trend toward increasing exports with decreasing inflows shown in Figure 73 to Figure 75 is a proximal cause of this change in X2 and is thus at least somewhat attributable to Project operations.

The linkage of fall hydrodynamics to delta smelt habitat suitability

The changes in Delta hydrodynamics during the fall have been linked to declining habitat suitability for delta smelt (Feyrer et al. 2007; 2011). When the POD studies were initiated by the Interagency Ecological Program (IEP) in 2005, the IEP's extensive fish data sets had already been used for many scientific purposes in numerous publications. A few of the best known examples included the development of "fish-flow" relationships (e.g., Stevens and Miller 1983; Jassby et al. 1995), and the documentation of step-declines[22] of some species (e.g., Kimmerer 2002; Kimmerer 2006; Sommer et al. 2007).

[22] A step-decline is a sudden, severe drop in a species' abundance.

However, no entity had ever undertaken a comprehensive data analysis to evaluate fish and water quality variables, which had been collected concurrently for several decades. The water quality variables meaured during the fishery monitoring surveys had not been studied to explain the relationship with variation in fish catches within years, and over time. The first of these analyses resulted in habitat suitability indices[23] for several pelagic fishes collected in the Department of Fish and Game's Fall Midwater Trawl Survey (FMWT; Feyrer et al. 2007). Several additional studies based on the same generalized additive modeling (GAM) framework were published thereafter (Nobriga et al. 2008; Kimmerer et al. 2009; Feyrer et al. 2011).

The Department of Fish and Game collects data on three water quality variables along with its trawl surveys: specific conductance, which is a surrogate for salinity; Secchi disk depth, which is a measure of water transparency, and water temperature. Feyrer et al. (2007) showed that the FMWT had most frequently collected delta smelt in water that had very low transparency and specific conductances that ranged from fresh water to about 10,000 microseimens per centimeter or 6 psu. The approximate conversion between these salinity units is provided in Table 32. The Feyrer et al. (2007) analysis is reproduced in Figure 78 along with equivalent analyses for spring (20mm Survey) and summer (Townet Survey). Feyrer et al. showed the water quality conditions that were historically associated with the highest chances of catching delta smelt were occurring at progressively fewer locations over time in the FMWT. This decline in the mixture of water quality conditions that provided the best chances of catching a delta smelt had occurred because the water transparency had been generally increasing, particularly in the south Delta, and because specific conductance had been generally increasing in Suisun Bay. The latter was due to the hydrodynamic changes discussed above.

[23] Dubbed "EQ" at the time, which is short-hand for environmental quality following Rose (2000).

Table 32. Approximate translation of specific conductance into oceanic salinity based on Obrebski et al. XXXX. Note that a full conversion requires a correction for water temperature.

Specific conductance (µS/cm)	Approximately salinity (psu or parts per thousand)
187	0.105
910	0.5
1750	1.0
3400	2.0
5075	3.0
6750	4.0
8400	5.0
10,000	6.0

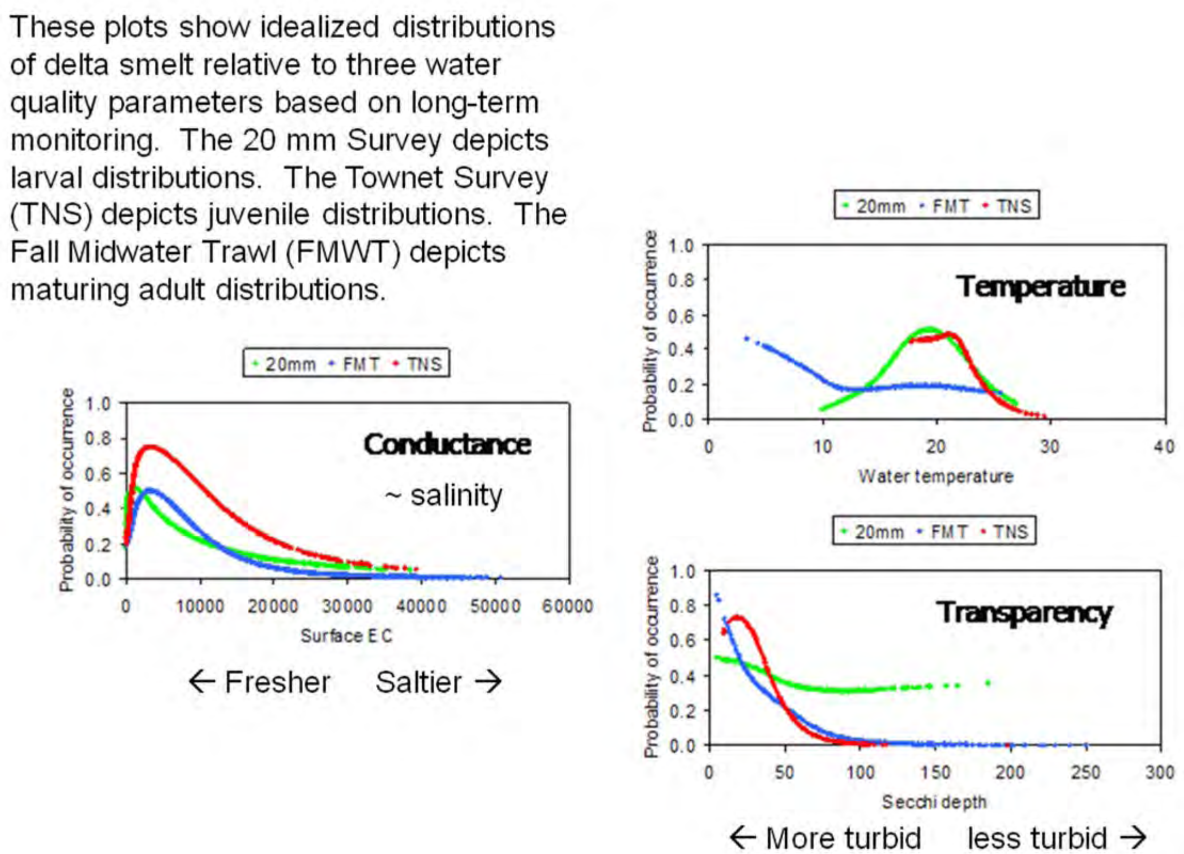

Figure 78. Predicted probabilities of catching a delta smelt relative to several concurrently measured water quality variables for three fishery surveys of the upper San Francisco Estuary. The predictions are based on binomial generalized additive modeling. See Feyrer et al. (2007), Nobriga et al. (2008), and Kimmerer et al. (2009) for details. The 20 mm Survey (20mm) collects larval and early juvenile delta smelt from March-July. The Summer Townet Survey (TNS) collects juvenile delta smelt during June-August. The Fall Midwater Trawl Survey (FMT) collects late stage juvenile delta smelt during September-December.

The correspondence of declining delta smelt capture probabilities and changing water quality is an indicator of declining habitat suitability. This linkage was made more explicit by Feyrer et al. (2011). Feyrer et al. (2011) showed how the predicted probability of capturing a delta smelt in the FMWT varied for each year of the survey (1967-2008; Figure 79; top panel). The cluster of lines with the higher probabilities of [delta smelt] occurrence represent years of relatively high FMWT indices; the cluster with lower probabilities are years of relatively low FMWT indices. This analysis showed that historical capture probabilities reached about 0.5 or 50 percent at a specific conductance between 3 and 3.5 on a $\log_{10}$ scale. This is about 1000-3200 microseimens per centimeter or about 0.5 to 2 psu (Figure 74). During years of lower abundance, there is less evidence of a peak in catch relative to salinity, but there is a slight increase in capture probability at $\log_{10}$ specific conductance between 3.5 and 4.0, or 3200 to 10,000 microseimens per centimeter; about 2-6 psu. The chances of catching a delta smelt decrease rapidly at specific conductances corresponding to more than about 6 psu.

Probabilities of delta smelt occurrence are higher where the Secchi disk depths are lowest (Figure 79; bottom panel). This is most pronounced in high abundance years, but still apparent in most low abundance years as well. As with specific conductance, the high and low abundance years converged on near zero chance of delta smelt detection where Secchi depths approach 1 meter (0 on a log scale). The basic reason for these combined trends is that water transparency has increased the most at the freshwater sampling stations (Feyrer et al. 2007).

Next, Feyrer et al. (2011) developed a unitless delta smelt habitat suitability index based on the FMWT (copied here as Figure 80). This was an improvement over the Feyrer et al. (2007) version which did not factor geography into the index. Each year's index is the predicted chance of catching a delta smelt based on specific conductance and Secchi depth at each of 73 FMWT sampling stations multiplied by a corresponding areal estimate represented by each station. These areas can be seen as polygons in Figure 80. The Figure provides an example of how much predicted habitat suitability for delta smelt improves in Suisun Bay when X2 is downstream of the Sacramento-San Joaquin river confluence.

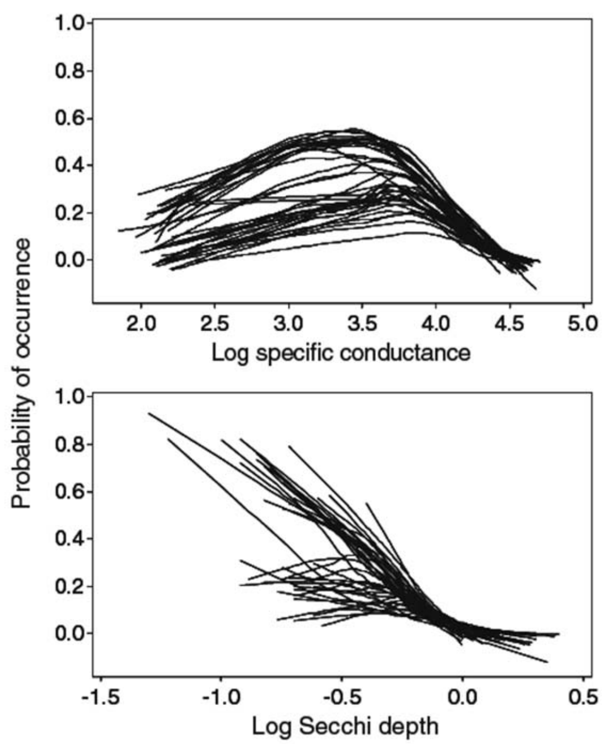

Fig. 1 Plot of the GAM response predictions (probability of occurrence) against specific conductance and Secchi depth. Individual lines are LOESS smooths drawn through the points for individual years

Figure 79. Source: Feyrer et al. (2011); GAM refers to generalized addtive modeling of the Fall Midwater Trawl data for delta smelt, 1967-2008.

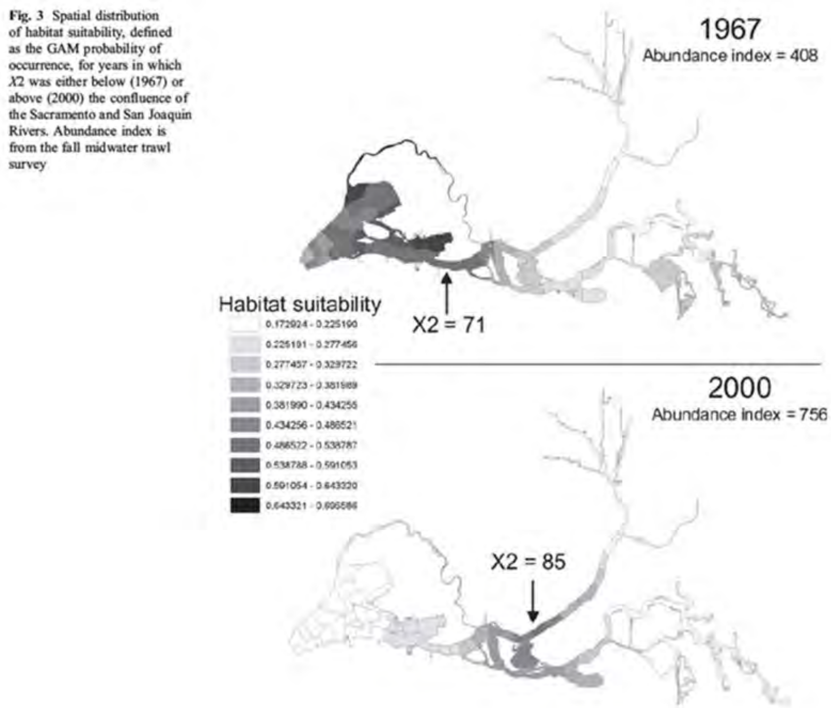

Figure 80. Maps showing the spatial distribution of estimateddelta smelt habitat suitability for two example years in the Department of Fish and Game's Fall Midwater Trawl Survey. 1967 was a high outflow fall with an average fall X2 location of 71 km; 2000 was a low outflow fall with an average X2 location of 85 km.

The fall habitat suitability index showed evidence of a step-decline in the mid-1980s (Figure 81; top panel "A"). This corresponded in time with the hydrodynamic changes discussed above (Figure 74 and Figure 75). The habitat index reflects long-term trends in both salinity and water transparency. The former is strongly influenced by Project operations in the fall. The latter is partly due to Project infrastructure as described in the *Environmental Baseline/Critical Habitat* section. However, it is not known whether it is substantively influenced by Project operations during the fall. Feyrer et al. (2011) plotted their habitat index versus average September-December X2 as a means of determining how strongly Project operations can influence delta smelt habitat suitability (Figure 81; middle panel "B"). The rationale was that because the Projects can control X2 location during periods of low Delta outflow (SWRCB 1995), this would test how well the Projects could control abiotic habitat suitability for delta smelt. The habitat index is related to fall X2, but in a nonlinear way. Generally speaking, the habitat index is low whenever X2 is upstream of 80 km (near Broad Slough at the confluence of the Sacramento and San Joaquin rivers). The habitat index increases when X2 is downstream of 80 km, but the rate of increase per km of X2 appears to slow down considerably once X2 move seaward of about 75 km.

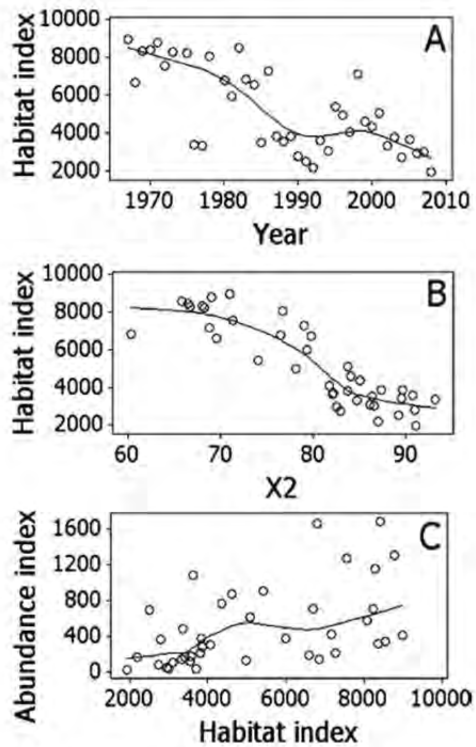

Fig. 2 Plots of the habitat index time series (a), relationship between X2 (km) and the habitat index (b), and relationship between the habitat index and delta smelt abundance measured as the fall midwater trawl index. Curves are LOESS smooths

Figure 81. Time series of a delta smelt habitat index based on the Department of Fish and Game's Fall Midwater Trawl Survey, 1967-2008, and relationships of the index with the geographic location of the 2 psu salinity isohaline (X2) and and FMWT abundance index for delta smelt. Figure copied from Feyrer et al. (2011).

The GAM analyses performed by Feyrer et al. (2007; 2011) and others (e.g., Nobriga et al. 2008; Kimmerer et al. 2009) are reporting concurrent associations of fish catches and water quality. Thus, they show that some of the variation in delta smelt catch is explained by environmental conditions that occurred during the sampling. Feyrer et al. (2011) showed that despite being based on presence or absence of delta smelt, their resultant habitat index was correlated with the FMWT abundance index (Pearson r = 0.51; $P = 0.001$; Figure 81; bottom panel "C"). However, this is an expected outcome because abundance and presence-absence are correlated. Therefore, it is not appropriate to apply a hypothesis test to these data to determine how much variation in delta smelt abundance is explained by the habitat index. That is why Feyrer et al. (2011) reported a Pearson correlation coefficient (r) and showed with a spline that the relationship was close to linear rather than analyzing the data inappropriately with linear regression.

Feyrer et al. (2011) showed that the CALSIM II modeling done to support this consultation provides an imperfect representation of present-day hydrodynamic conditions. Nonetheless, the modeling shows that the combination of a 2030 level of development and the sea-level rise that is predicted to occur by 2030 due to climate change decrease predicted habitat suitability for delta smelt in all but critical water years (Figure 82). The comparison between Scenarios A and B isolates the influence of Project operations on delta smelt's habitat index because it compares the Projects' modeled baseline to a predicted 2030 operation without including the climate changes explored in Scenarios C-G. Note that Feyrer et al. (2011) estimated future values of the index by using the predicted X2 locations output by the CALSIM II model and predicting the habitat index from X2 using the relationship shown in Figure 81 panel "B".

The comparison of Scenarios A and B shows that Project induced changes in X2 cause most of the predicted change in the habitat index. In wet years, the median habitat index in Scenario B is just over 4000, which is about half the value of the median in Scenario A (just under 8000). In above-normal, below-normal, and dry water year types, not only do predicted median habitat indices decline, but the variability that occurs in Scenario A is greatly reduced in Scenario B.

Fig. 5 Box plots of the habitat index values for each scenario across water year types. The *box plots* show medians and first and third quartiles. *Whiskers* show the highest or lowest values in the upper or lower limits, respectively. Table 1 provides details on the modeled outflow scenarios

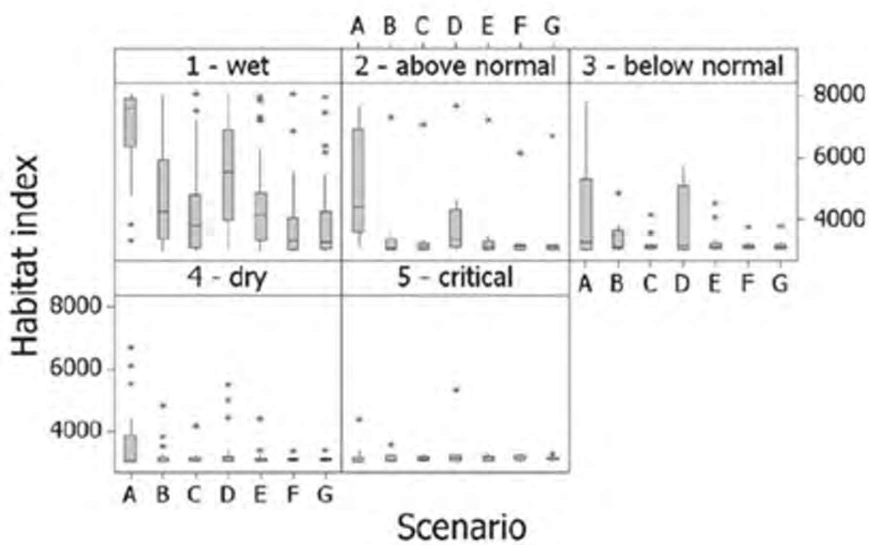

Figure 82. Comparisons of CALSIMII simulation results for delta smelt fall habitat index by water year type from Feyrer et al. (2011). Scenario A = 2005 level of development, current sea level; Scenario B = 2030 level of development, current sea level; Scenario C = 2030 level of development, 0.33 m increase in sea level and 10% increase in tidal range; Scenarios D-G, same as Scenario C except, Scenario D = higher mean precipitation and somewhat warmer weather than present; Scenario E = higher mean precipitation and warmer weather than Scenario D; Scenario F = lower mean precipitation and temperatures equivalent to Scenario D; Scenario G = lower mean precipitation and temperatures equivalent to Scenario E.

Limitations of the habitat index

The delta smelt habitat index discussed above is based on two abiotic habitat characteristics (salinity and water transparency). Two other abiotic habitat attributes have been evaluated in the generalized additive modeling framework. Water temperature is an important aspect of delta smelt habitat suitability in the summer (Nobriga et al. 2008), but not in the fall (Feyrer et al. 2007). This is likely because lethal temperatures do not often occur in the estuary during September-December so there is little opportunity for temperature to constrain delta smelt distribution. Additionally, water depth is not an important aspect of delta smelt's summer habitat (Kimmerer et al. 2009). However, including it did improve the fit of Kimmerer et al.'s (2009) fall habitat model. The caveat to this statement is that Kimmerer's FMWT analysis explained less than or equal to 4 percent of the variability in delta smelt catch. When so little variance is explained, any increment of variability makes a difference. Note that the Feyrer et al. (2007; 2009) analyses of the same data explain up to 25 percent of the variance. The Service does not know why this discrepency exists between these two analyses of the FMWT data.

Delta smelt habitat suitability is also influenced by biotic variables (food supply, predation, and disease). The degree to which biotic habitat attributes might confound conclusions based on the abiotic habitat index is unknown. The reason that Feyrer et al. (2007; 2011) did not explicitly include any biotic variables in their analyses is simple and was acknowledged by the authors – biotic variables like zooplankton prey data have not historically been taken concurrently with the FMWT. Further, there are no existing data that can be used to quantify predation rates or disease trends during summer-fall. However, it should be noted that biotic and abiotic habitat attributes cannot always be easily separated. For instance, the prey density needed for delta smelt to grow at a given rate is affected by water temperature (e.g., Lantry and Stewart 1993). As a second example, the predation rates on delta smelt are hypothesized to be influenced by both water temperature and water transparency based on studies of salmonid fishes (e.g., Gregory and Levings 1998; Marine and Cech 2004).

Life cycle models

There were no published life cycle models (LCMs) for delta smelt when the previous OCAP Biological Opinion was finished in December 2008. However, several have been developed and published since (Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011). The Mac Nally and Thomson models evaluate delta smelt population dynamics on an annual time step from one FMWT to the next. Maunder and Deriso (2011) developed a more sophisticated LCM framework. Their model evaluates population dynamics at three life stages represented by the FMWT, 20mm, and Summer Townet (STNS) surveys. The basic approach and findings of these LCMs are summarized in Table 23. The Service notes that fall X2 was tested as a covariate by Mac Nally et al. (2010) and Thomson et al. (2010) and was tested using the Maunder and Deriso (2011) LCM by Deriso (2011). It was not retained as a strong predictor variable in any of these studies.

There are reasonable explanations for why currently available LCMs have not found fall X2 to be a strong predictor of long-term delta smelt population dynamics. As explained below, the population-level effect of fall X2 appears to only be statistically discernable (1) within the fall period the data are collected, and (2) possibly in the subsequent year's STNS index. As mentioned above, the Mac Nally and Thomson models evaluate delta smelt population dynamics on an annual time step from one FMWT to the next. This time step may therefore just be too long to track the population-level effects of fall habitat conditions – especially since the concurrent habitat influence on each year's FMWT index is already encompassed in the indices themselves. Maunder and Deriso (2011) did not include any covariate in their LCM explorations that described or indexed fall habitat conditions. Thus, no indicator of fall habitat was used to discern among possible alternative LCMs.

This lack of support for an influence of fall habitat conditions on delta smelt population dynamics in the existing LCMs contrasts with results for partial life cycle analyses. As described above, Feyrer et al. (2007; 2011) have shown that some of the variation in delta smelt's distribution and FMWT indices can be explained by concurrent water quality measurements or the habitat index they developed from these data. Thus, fall habitat appears to have some effect on fall abundance. Feyrer et al. (2007) also showed that including the average September-December specific conductance in a stock-recruit analysis for delta smelt improved the fit of the stock-recruit model – at least for years following the overbite clam invasion. The same was not true for years prior to the overbite clam invasion or for the entire index time series. In lay terms, this analysis assumed that delta smelt have been chronically food-limited since 1987 and that since that time, the number of juveniles produced per adult has been higher when salinity was comparatively low during the adult fishes' fall rearing period. This analysis has been challenged for two primary reasons. One criticism was that a linear stock-recruit model was not appropriate because the intercept did not go through the origin and/or it would not correctly account for density-dependence. This was an unnecessary criticism on both counts. First, there is no evidence that density-dependence has occurred between generations since the overbite clam invasion (Future placement of Figure E-X). The reason for this conclusion is that a spline through the stock-recruit data does not suggest that the rate of juvenile production per adult slowed down when abundance was comparatively high the previous fall. Note also that the spline comes very close to going through the origin of this plot. Thus a linear model can describe this relationship appropriately. The second criticism was that the statistical significance (at α less than 0.05) was driven by a single data point.

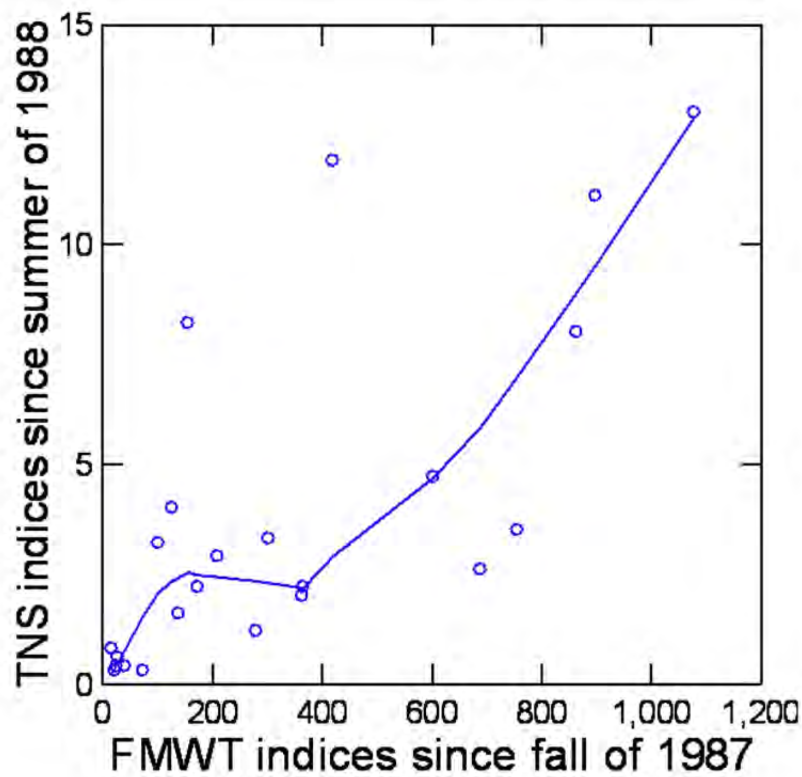

Figure 83. Scatterplot depicting a stock-recruit relationship for delta smelt, based on Fall Midwater Trawl indices for 1987-2009 versus the subsequent Summer Townet Survey indices for 1988-2010. The spline is a LOWESS smooth with tension = 0.5. This is the default setting in the Systat software program.

The Feyrer et al. (2007) stock-recruit analysis used the FMWT data through 2004 and used the average specific conductance data from the FMWT rather than fall X2. The Service repeated their analysis using FMWT data through 2009 and TNS data through 2010. We also substituted the average September-December X2 for specific conductance to avoid having to imply a translation between these two salinity variables.

We applied a linear regression analysis to the data shown in Figure 83. The data were $\log_{10}$-transformed before the statistical analysis to help normalize the variance. The linear regression showed that fall relative abundance is a highly significant predictor of the next generation's relative abundance (logTNS = 0.742*logFMWT – 1.34; $r^2 = 0.65$; $P < 0.000001$; $AIC_c = 16.21$). Then, we re-ran the linear regression including fall X_2 as a covariate. Consistent with Feyrer et al. (2007), the analysis indicated that both fall relative abundance and fall X2 were significant predictors[24] of the relative abundance of juveniles the next summer (logTNS = 0.703*logFMWT – 0.0252*X_2 + 0.872; $P < 0.000001$; $AIC_c = 14.20$). Note that the AIC_c for the stock-recruit model including fall X_2 is two units lower than the model without it, suggesting the regression model that includes X2 provides a better fit to the data (Burnham and Anderson 1998 as cited by Maunder and Deriso 2011).

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[24] The *P*-value of the fall X2 term was 0.04.

The potential influence of fall X2 on individual data points in the stock-recruit relationship can be seen in Figure 84. The spline shows that the data point labeled '1999' has a strong influence. It also shows that the points labeled '1993' '2010' and '1995' also have a strong influence because they create a 'bump' in what would otherwise be a negative linear association. These three years all reflect a situation where the prior falls (1992, 1994, and 2009) had very low outflow, but outflows were above average during the spring that the generation of smelt indexed by the TNS was spawned. Thus, it is possible that high spring outflows may sometimes compensate for low fall outflows.

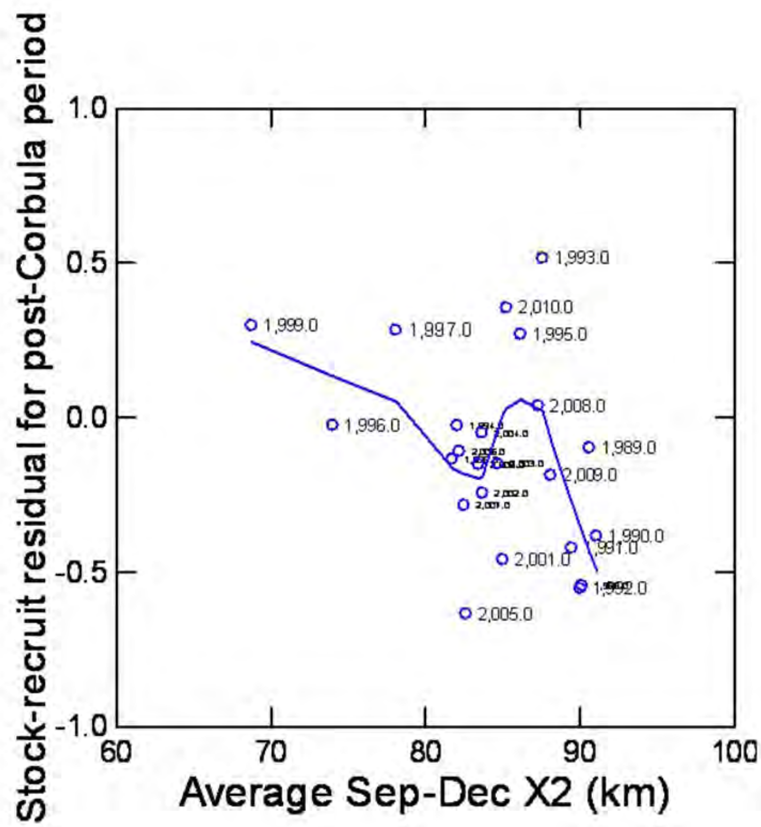

Figure 84. Scatterplot of the average location of the 2 psu isohaline in the fall versus the residuals of a stock-recruit relationship for delta smelt, based on Fall Midwater Trawl indices for 1987-2009. The individual 'recruit years' are labeled. The recruit years are the calendar year following the FMWT index; for example, the data point labeled '1,999.0' is the data point showing the association of the 1998 FMWT index and the 1999 TNS index. The spline is a LOWESS smooth with tension = 0.5. This is the default setting in the Systat software program.

In conclusion, analyses conducted over portions of the delta smelt life cycle provide support for a population-level effect of fall habitat conditions or indices of those conditions. Thus far however, full life cycle modeling frameworks do not.

Entrainment Effects to Delta Smelt Larvae and Juveniles

Water Diversions and Reservoir Operations

Banks and Jones

The entrainment of larvae and juveniles into Banks and Jones can extend into July and beyond. However, entrainment after June is comparatively very low (Kimmerer 2008; Grimaldo et al. 2009; Figure 85) and not considered to represent anything more than a de minimis effect. The Projects entrain lower trophic level organisms all year (e.g., Jassby et al. 2002). However, this does not appear to affect planktonic production nearly as much as the grazing pressure of non-native clams (Jassby et al. 2002). Planktonic production also may be impaired by wastewater treatment inputs of ammonium (Wilkerson et al. 2006; Dugdale et al. 2007), loading of pesticides from the watershed (Werner et al. 2010), and blooms of the toxic cyanobacterium *Microcystis aeruginosa* (Ger et al. 2009). These are issues of water toxicity that are not attributable to Project operations.

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.

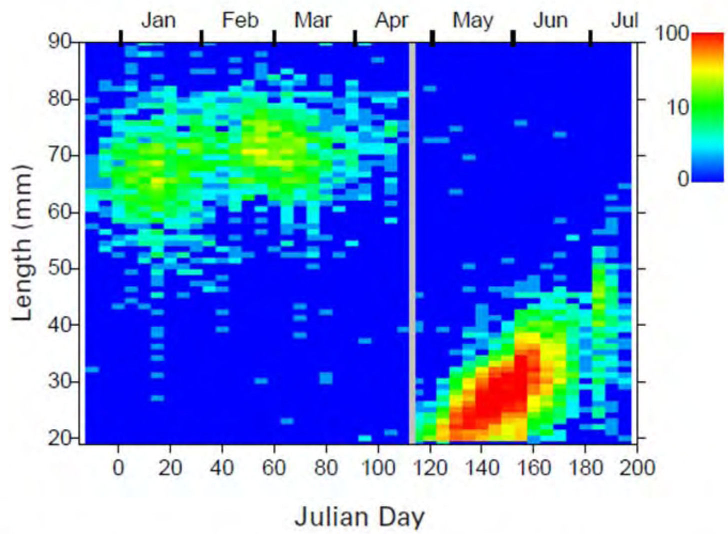

Figure 3. Delta smelt. Combined salvage at south Delta fish facilities for 1997–2005. Image plot showing numbers of fish by length and day, according to log scale at right. Larger fish are adults, and small ones are larvae and juveniles, roughly separated by the vertical line. Larvae smaller than 20 mm are generally not counted. Very few fish were caught between July and mid-December.

Figure 85. Image plot showing timing of delta smelt salvage at Banks and Jones. Source: Kimmerer (2008).

Water Transfers

Water transfers would increase Delta exports by 0 to 360 TAF in most years (the wettest 80 percent of years) and by up to 600 TAF 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 the assessment would occur only in the months July-September. Delta smelt are rarely present in the south Delta in these months, so no increase in salvage due to water transfers during these months is anticipated.

Post-processing of Model Data for Transfers

This section shows results from post-processed available pumping capacity at Banks and Jones for 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 opportunities for transfers. 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 (65%) 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 a maximum of about 90 TAF of additional export for the July-September period, although 60 TAF is a better estimate of the practical maximum available from that 500 cfs of capacity because it allows for some unforeseeable operations contingencies.

- (Future placement of Figures from 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.

(Future placement of Figures from 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 that, 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 ((Future placement of Figures from 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 available transfer capacity 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 it 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 State Board's limits on E:I ratio or Delta salinity standards. 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 TAF
Consecutive Dry	up to 600 TAF
Dry after Critical	up to 600 TAF
All other Years	up to 360 TAF

During July-September, water transfers are not expected to have more than a de minimis entrainment effect on delta smelt since the proposed transfer window is a time when low habitat suitability largely precludes use of the south Delta by delta smelt (Kimmerer 2008; Nobriga et al. 2008). However, water transfers could have adverse effects to delta smelt habitat if the increased pumping affects the location of X2. These habitat effects are captured in CALSIM II modeling and analyzed in 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.

North Bay Aqueduct (NBA) Diversion

The Barker Slough pumping plant diverts water into the NBA during all months of the year. During July-November exports into the NBA have increased since the facility came online in 1988. However, NBA exports have not consistently increased in December (Figure 86). Prior to 1995 NBA diversions were almost always less than 80 cfs per month during the summer-fall. Since that time, they have frequently exceeded 100 cfs during July-September, but are typically lower during the fall. These historical numbers are similar to those predicted for July by CALSIM II Study 7.1, but lower than predictions from Study 8.0, which includes a 2030 level of demand (Figure 87). There is a possibility for larvae to be entrained at the Barker Slough Pumping Plant during July. This was analyzed in the larval delta smelt section. However, the Barker Slough Pumping Plant is screened with fish screens that operate at approach velocities of 0.2 feet/second. Thus, after July all delta smelt have reached lengths that should be protected from impingement by the approach velocity operating criterion and from entrainment by the fish screens.

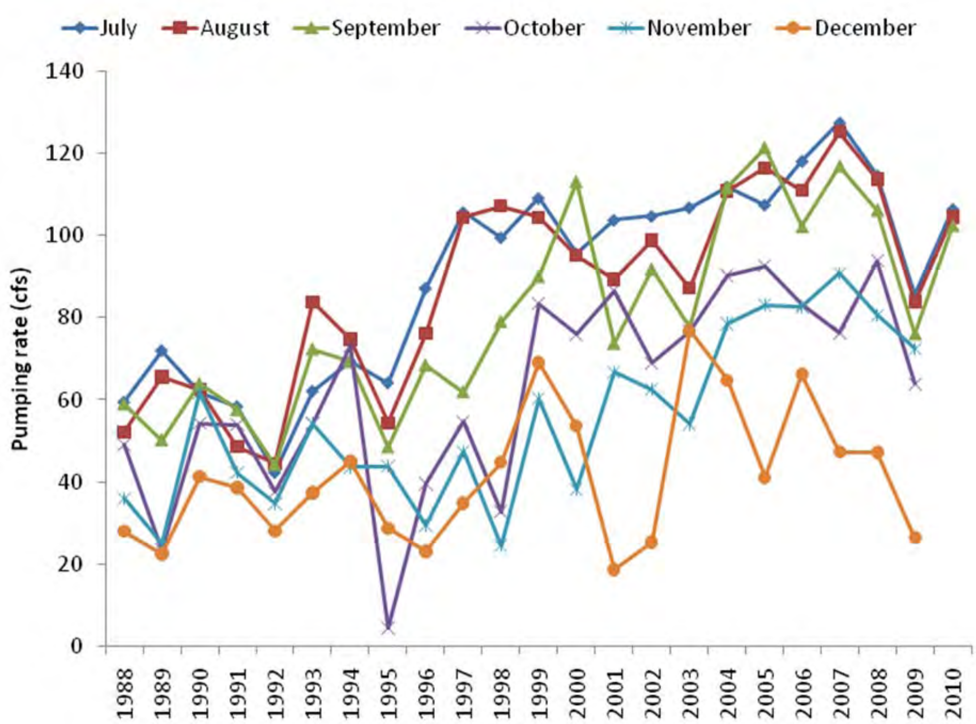

Figure 86. Time series of monthly mean water diversion rate (cfs) into the North Bay Aqueduct from the Barker Slough Pumping Plant, July-December, 1988-2009 and through 2010 for July-September.

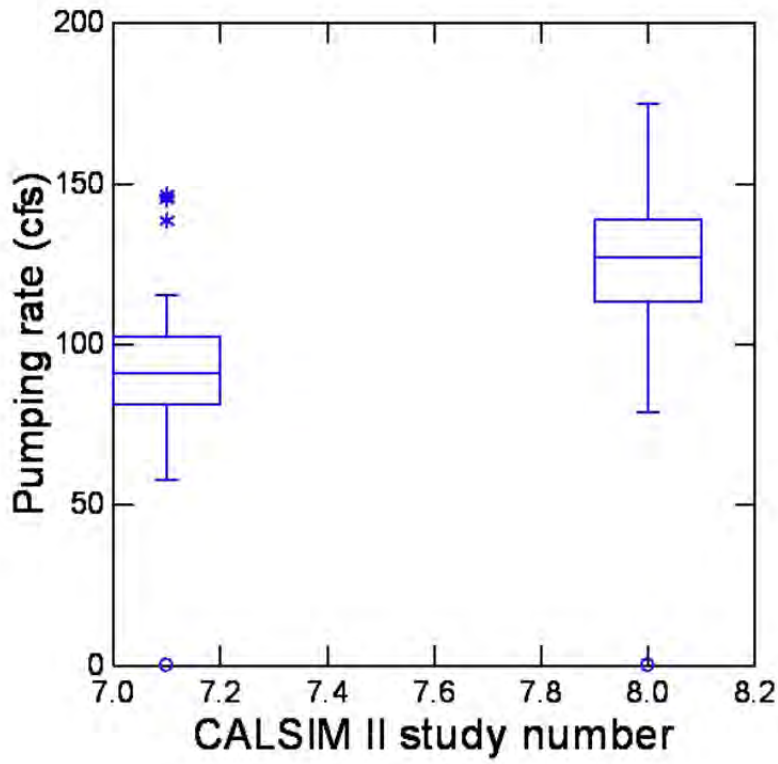

Figure 87. Boxplot summary of July pumping rates predicted for Barker Slough Pumping Plant for CALSIM II studies 7.1 and 8.0. The boxplots are as follows: rectangular box = interquartile range of observations; horizontal line in the box = median; vertical lines = 95% confidence intervals; open circles and asterisks = individual data points the Systat software program determined were "outliers".

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 of 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 (September-December)

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 first draft 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). Compensatory density-dependence usually happens because of one or more of the following mechanisms. When an organism occurs at high density, its growth rate may slow down because competition for food is increased. In addition, high densities of organisms also tend to attract predators and transmit disease more readily, both of which increase the rate of mortality. These mechanisms interact to limit an organism's population growth rate and by extension, create a 'ceiling' on its abundance. That ceiling is the carrying capacity. 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 have been hypothesized to be important in delta smelt population dynamics. Compensatory density-dependence has been statistically detected in delta smelt at high population levels (Bennett 2005). In contrast, the current record low levels of abundance of delta smelt could 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, 2011). 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.

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 48). 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 48) 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 $\geq$ 10 percent, $\geq$ 25 percent, and $\geq$ 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 49.

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 50). 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 50), 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 51). 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 51). 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 52). 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 52) 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 53). 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 53). 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 54). 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 55). 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 56). 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 57).

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, and
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 *Egeria densa* Control Program Environmental Impact Report (EDCP EIR ; DBW 2006) for a two-year, Komeen® research trial in the Delta. A second addendum to the 2001 EIR was finalized in 2006 describing project operations from 2001-2010 (DBW 2006). The 2001 EDCP EIR evaluated the potential impacts of Komeen® for trials. The herbicide was never used as part of the EDCP from 2001 to 2005; Sonar® and Reward® were used instead.

Komeen® was only used for two limited research trials, occurring two days in 2002, and two days in 2003. DBW removed Komeen® entirely from the EDCP because chelated copper, the active ingredient, is not biodegradeable and could accumulate in sediments, violating toxicity standards per the Central Valley Regional Water Quality Control Board's Delta Basin Plan. Even at moderate toxic levels, Komeen® could present adverse effects to fish, wetland vegetation and aquatic invertebrates (DBW 2006).

The DWR controls *Egeria densa* in CCF using Komeen® and Sonar® (DBW 2006). In 2005, no fish mortality or stressed fish were reported during or after the treatment. The contractor, Clean Lakes, Inc., searched for dead fishduring 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 3:00 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 Komeen® impacts to fish that may be in CCF, we will assume that all delta smelt in CCF at the time of application are taken. The daily loss values vary greatly within treatments, between months and between years. 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 CCF 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. Many of the effects described below for the PCEs are difficult to separate. Therefore some effects are repeated for multiple PCEs.

Spawning Habitat

PCE #1 – Physical Habitat

Delta smelt require physical habitat only during spawning. The major effect 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 effect is expected to remain relatively unchanged for delta smelt. The TBP will affect the physical habitat during the construction of the barriers which again is not covered within this first draft 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 effect 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 *Environmental 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 affecting 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 effect 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 affecting 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 effect on delta smelt migration. The South Delta Permanent Operable Gates should have less of an effect 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.

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 first draft 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.

Conclusion

Delta Smelt

The development of a draft conclusion regarding project action effects is incomplete, pending expected revisions to the project description by Reclamation and DWR

Delta Smelt Critical Habitat

The development of a draft conclusion regarding project action effects to delta smelt critical habitat is incomplete, pending expected revisions to the project description by Reclamation and DWR

Incidental Take Statement

The development of a draft incidental take statement is incomplete, pending expected revisions to the project description by Reclamation and DWR. Reasonable and Prudent Measures

Reasonable and Prudent Measures

The development of a draft reasonable and prudent measures to minimize incidental take of delta smelt is incomplete, pending expected revisions to the project description by Reclamation and DWR.

Reinitiation-Closing Statement

The development of a draft reinitiation and closing statement is incomplete, pending expected revisions to the project description by Reclamation and DWR

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