United States Department of the Interior

FISH AND WILDLIFE SERVICE
California and Nevada Region
2800 Cottage Way, Room W-2606
Sacramento, California 95825-1846

In reply refer to:
81420-2008-F-1481-5

DEC 15 2008

Memorandum

To: Operation Manager, Bureau of Reclamation, Central Valley Operations Office, Sacramento, California

From: Regional Director, ~~U.S.~~ Fish and Wildlife Service, Region 8, Sacramento, California

Subject: Transmittal of Formal Endangered Species Act Consultation on the Coordinated Operations of the Central Valley Project and State Water Project

With this memorandum, the U.S. Fish and Wildlife Service (Service) is transmitting the biological opinion on the coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP) in California. We transmitted the official draft biological opinion on November 21, 2008, and subsequently refined the opinion based on input and comments from the Service's Internal Peer Review Team, our contracted peer review, the California Department of Water Resources (DWR), and the Bureau of Reclamation (Reclamation). Additionally, we additionally met numerous times with DWR, Reclamation, the California Department of Fish and Game (DFG) and the National Marine Fisheries Service on development of the biological opinion.

We want to extend our appreciation to Reclamation and DFG for their technical assistance in developing the biological opinion.

If you have any questions, please contact Susan Moore, Cay C. Goude, Steven Detwiler, or Ryan Olah of our Sacramento Fish and Wildlife Office at 414-6600.

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81420-2008-F-1481-5

DEC 15 2008

Memorandum

To: Operation Manager, Bureau of Reclamation, Central Valley Operations Office Sacramento, California

From: Regional Director, Fish and Wildlife Service, Region 8, Sacramento, California

Subject: Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP)

This is in response to the Bureau of Reclamation's (Reclamation) May 16, 2008, request for formal consultation with the Fish and Wildlife Service (Service) on the coordinated operations of the CVP and SWP in California. Reclamation is the lead Federal agency and the California Department of Water Resources (DWR) is the Applicant for this consultation. Your revised biological assessment was received in our office on August 20, 2008. This document represents the Service's biological opinion on the effects of the subject action to the threatened delta smelt (*Hypomesus transpacificus*) and its designated critical habitat. This response is provided in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

Reclamation also requested consultation on the effects of the proposed action 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 concurs with Reclamation's determination that the coordinated operations of the CVP and SWP are not likely to adversely affect these species.

The Service conducted a comprehensive peer review of this biological opinion. We formed an Internal Peer Review Team (IPRT), which consisted of individuals from throughout the Service who are experts in the development of complex biological opinions under the ESA. The IPRT reviewed the biological opinion and provided substantive input and comments. Additionally, the Service assembled a team of delta smelt experts from within the Service, California Department of Fish and Game, Environmental Protection Agency, Reclamation and other academics to provide scientific and technical expertise into the review of the biological assessment and the development of the biological opinion. The Service also contracted with PBS&J, an environmental consulting firm, who formed an independent review team consisting of experts on aquatic ecology and fishery biology to conduct a concurrent review of the draft Effects Section of the biological opinion at the same that we provided the Effects Section to Reclamation and DWR for their review. The Service received the results of the independent review of the draft Effects Section on October 23, 2008; DWR and Reclamation provided the results of their review on October 24, 2008. The Service modified the Effects Section of the biological opinion, as appropriate, based on the comments received from the IPRT, the independent review team, Reclamation and DWR. The Service also contracted with PBS&J to conduct an independent review of the draft Actions (Final shown in Attachment B), as well as a review of DWR's proposed actions. The Service simultaneously provided the draft Actions to Reclamation and DWR for their review. The Service received Reclamation's and DWR's comments on the draft Actions on November 5, 2008. The Service received the results of the independent review of both the Service's and DWR's draft Actions on November 19, 2008. The Service's actions were then modified to respond to comments from the independent review team and in consideration of comments received from DWR. A draft biological opinion was provided to Reclamation on November 21, 2008. Comments were received back from Reclamation and DWR on December 2, 2008. The Service has incorporated all comments and edits, as appropriate, into this biological opinion.

This biological opinion is based on information provided in Reclamation's biological assessment dated August 20, 2008, associated appendices, and input from the various internal and external review processes that the Service has utilized in this consultation, described immediately above. A complete administrative record is on file at the Sacramento Fish and Wildlife Office (SFWO).

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 # 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 # 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.
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.

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Project Description

The proposed action is the continued long-term operation of the CVP and SWP. The proposed action includes the operation of the temporary barriers project in the South Delta and the 500 cubic feet per second (cfs) increase in SWP Delta export limit from July through September. In addition to current day 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) the operation of permanent gates that will replace the temporary barriers in the South Delta, (4) changes in the operation of the Red Bluff Diversion Dam (RBDD), and (5) Alternative Intake Project for the Contra Costa Water District (CCWD). A detailed summary of all operational components and associated modeling assumptions are included in the biological assessment in Chapter 9.

Table P-1 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 ANALYTICAL	Study 8.0 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), Limited EWA**	**Future - (b)(2), Limited EWA**	**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	Same	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.)								
	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	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	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	
Federal									
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	
	River	New Melones Interim Operations Plan	Same	Same	Same	Draft Transitional Operations Plan[r]	Same	Same	Initial storage conditions for New Melones Reservoir were

Stanislaus

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
									increase d.
South of Delta									
	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	
(CVP/SWP	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 accuratel y 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 all months	Same	Same	Up to 314 TAF/month from December to March, total of demands up to 214 TAF/month in all other months[e,jw]	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	American River	No project	Same	Same	PCWA American River pump station[k]	Same	Same	Same	
	River Water Reliability	No project	Same	Same	Same	Same	American/Sacramento River Diversions[t]	Same	
Upper	Lower Sacramento River	No project	Same	Same	Same	Freeport Regional Water Project (Full Demand)[l]	Same	Same	
Delta Region									
Sacramento	SWP Banks Pumping Plant	South Delta Improvements Program Temporary Barriers, 6,680 cfs capacity in all months and an additional 1/3 of Vernalis flow from Dec 15 through Mar 15[a]	Same	Same	Same	South Delta Improvements Program Permanent Operable Gates (Stage 1). 6,680 cfs capacity in all months and an additional 1/3 of Vernalis flow from Dec 15 through	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
						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									
	Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/year)	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	Minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	Same	Same	Same	Same	Same	Same	
Yuba River									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Minimum flow below Daguerre Point Dam	Available Yuba River Data[p]	D-1644 Interim Operations[p]	Same	Yuba Accord Adjusted Data[p]	Same	Same	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 managemen t[s]	Same	American River Flow Management [s]	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 use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
	dissolved oxygen	SWRCB D-1422	Same	Same	Same	Same	Same	Same	
Merced River									

Minimum

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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									
	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									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	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 Plan	Same	Same	Same	Draft Transitional Operations Plan[r]	Same	Same	
Sacramento **San Joaquin River**	Flow at Vernalis	D1641	Same	Same	Same	Same	Same[q]	Same	
OPERATIONS CRITERIA: SYSTEMWIDE									
CVP water allocation									
	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	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	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									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	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	
	Sharing of export capacity for lesser priority and wheeling related pumping	Cross Valley Canal wheeling (max of 128 TAF/year), CALFED ROD 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									

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
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	
Study assumptions from above apply			**Study 6b**	**Study 7b**	**Study 7b**	**Study 7.1b**	**Study 8b**	**NA**	
CALFED Environmental Water Account / Limited Environmental Water Account									
	Actions	Dec-Feb reduce total exports by 50 TAF/mon relative to total exports without EWA; VAMP (Apr 15 - May 16) export restriction on SWP; Post (May 16-31) VAMP export restriction on SWP and potentially on CVP if B2 Post-VAMP action is not taken; Ramping of exports (Jun)	Dec/Jan 50 TAF/mon export reduction, Feb 50 TAF export reduction in Wet/AN years, Feb/Mar 100, 75, or 50 TAF reduction dependent on species habitat conditions; VAMP (Apr 15 - May 16) export restriction on SWP; Pre (Apr 1-14) VAMP export reduction in Dry/Crit years; Post (May 16-31) export restriction; June ramping restriction if PostVAMP action was done. Pre- and Post-VAMP and June actions done if foreseeable October debt at San Luis does not exceed 150 TAF.	NA	Same	VAMP (Apr 15 - May 16) 31-day export restriction on SWP; If stored assets and purchases from the Yuba are sufficient, Post (May 16-31) VAMP export restrictions apply to SWP[pq]	Same	NA	The EWA actions, assets, and debt were revised and vetted as part of the Long Term Environmental Water Account EIS/R project

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
Assets	Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. The purchases range from 0 TAF in Wet years to approximately 153 TAF in Critical years NOD, and 57 TAF in Critical years to 250 TAF in Wet years SOD. Variable assets include the following: use of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta E/I Ratio (post-processed from CalSim-II results), additional 500 CFS pumping capacity at Banks in Jul-Sep	Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. NOD share of annual purchase target ranges from 90% to 50% based on SWP Ag Allocation as an indicator of conveyance capacity. Variable/operational assets include use of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, additional 500 CFS pumping capacity at Banks in Jul-Sep, source shifting, Semitropic Groundwater Bank, "spill" of San Luis carryover debt, and backed-up stored water from Spring EWA actions.	NA	Same	Purchase of Yuba River stored water under the Lower Yuba River Accord (average of 48 TAF/yr), use of 50% of any CVPIA 3406 (b)(2) releases pumped by SWP, additional 500 CFS pumping capacity at Banks in Jul-Sep.	Same	NA	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Debt	Delivery debt paid back in full upon assessment; Storage debt paid back over time based on asset/action priorities; SOD and NOD debt carryover is explicitly managed or spilled; NOD debt carryover must be spilled; SOD and NOD asset carryover is allowed	Same	NA	Same	No Carryover Debt	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}	available capacity	Same	NA	Same	Same	Same		
	Refuge Level 4 water Evaluate	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 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II

[a] The OCAP 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 availablity 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 ANALYTICAL	Study 8.0 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 Alternate Intake Project (AIP), an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir is not included in Study 8.0. AIP is included as a separate consultation. AIP will be further evaluated after regulatory and operational managment assumptions have been determined.

[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). For Study 8.0 the American River Flow Management is assumed to be the new minimum instream flow.

[t] OCAP 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 P-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. 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

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

conditions interspersed with excess water conditions. Account balances continue from one 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 P-2 and Figure P-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 P-2 (Summary Bay-Delta Standards), Figure P-3 (Footnotes for Summary Bay-Delta Standards), and Figure P-4 (CVP/SWP Map).

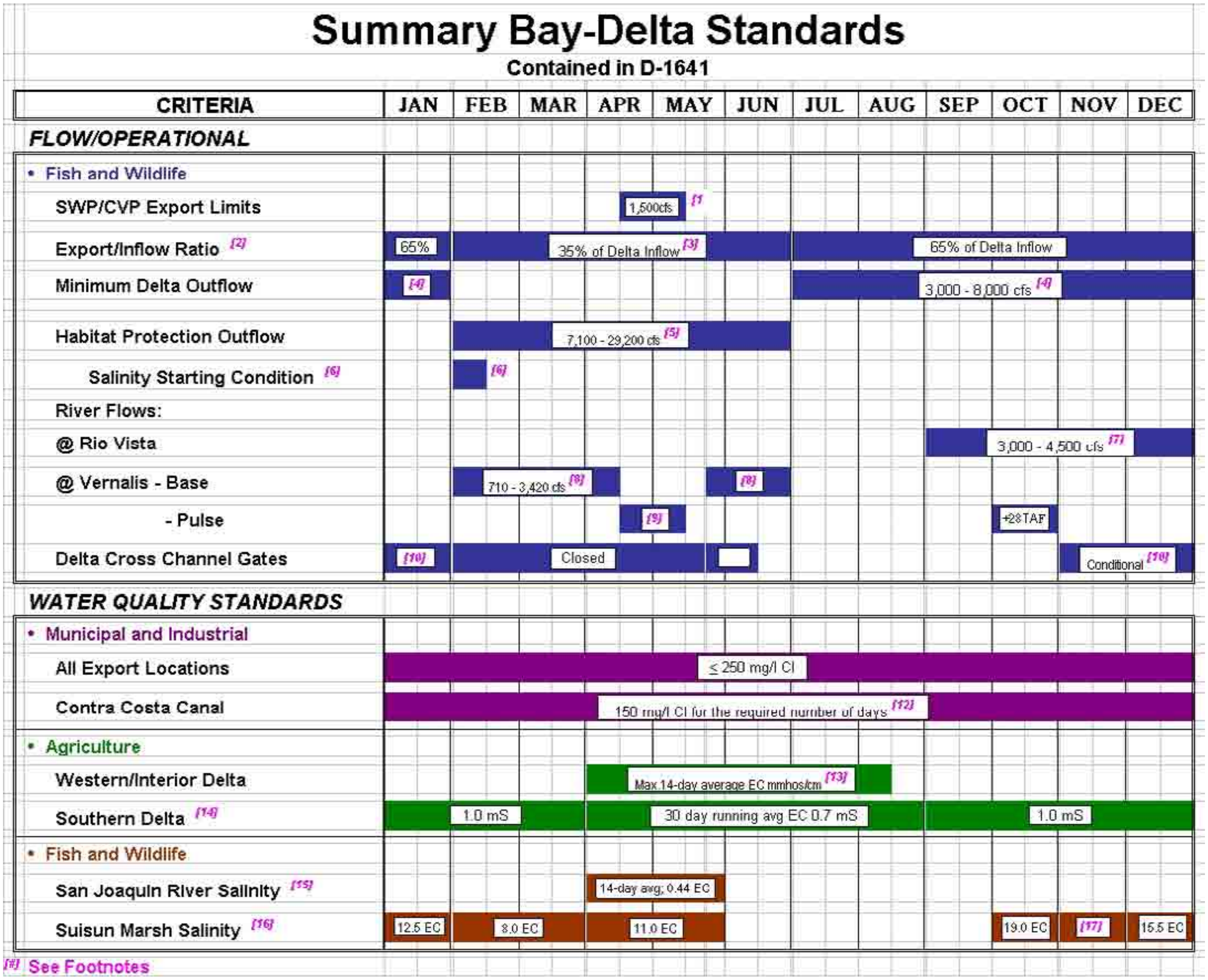

Figure P-2 Summary Bay Delta Standards (See Footnotes below)

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 P-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

	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
Year Type	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 fro date shown 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 ≤ 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	Chipps Island (Chipps Island Station D10)				
(TAF)	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 20 days.

PMI	Port Chicago (continuous recorder at Port Chicago)				
(TAF)	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	20
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	20	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 P-3 Footnotes for Summary Bay Delta Standards

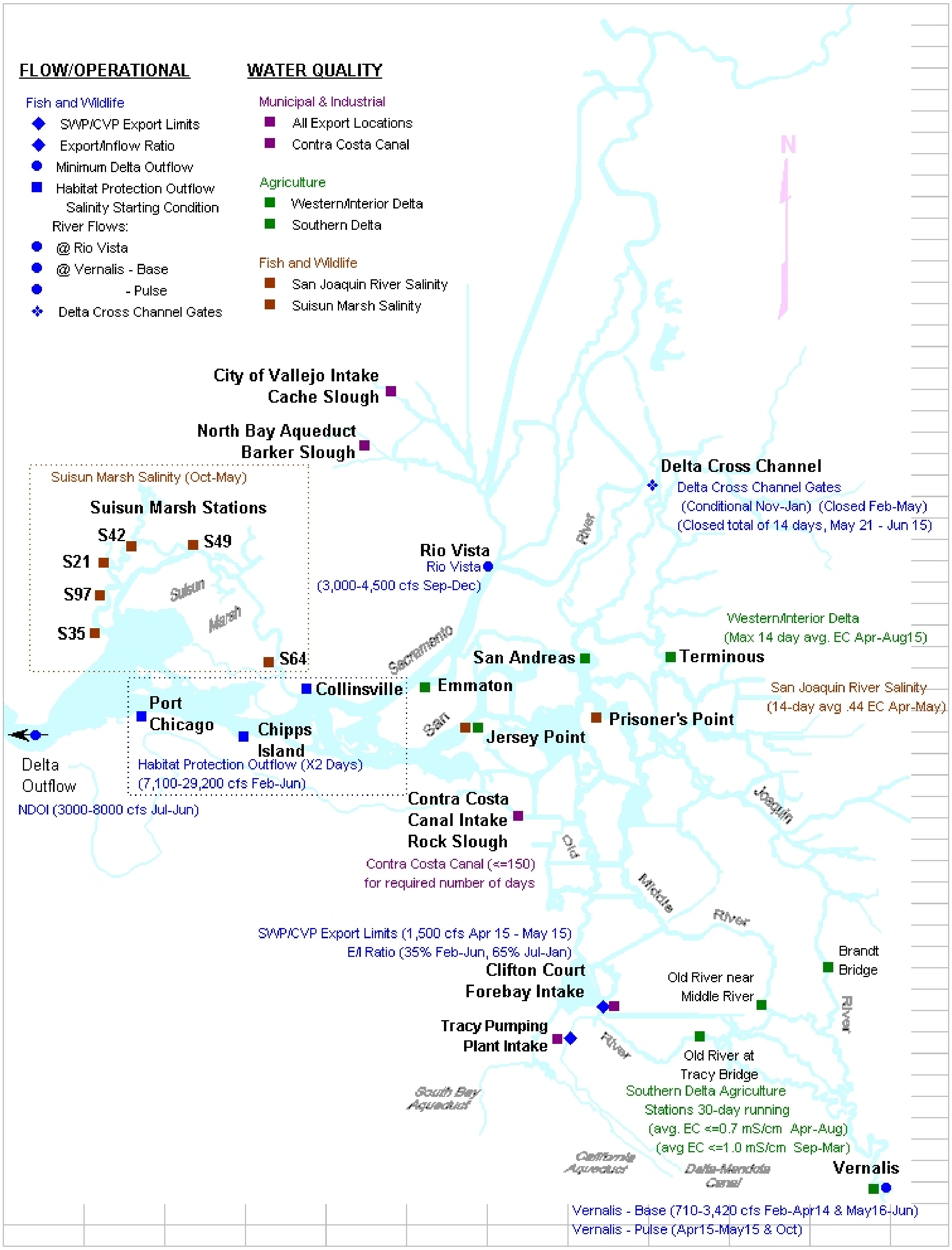

Figure P-4 CVP/SWP Delta Map

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 since it relied on the 2004 and 2005 biological opinions, the Fisheries Response Plan will need to 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. Concurrently, under the CALFED Record of Decision (ROD), JPOD may be used to create additional water supplies for the Environmental Water Account (EWA) or reduce debt for previous EWA actions.

- 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 eleven times a year in a public setting so that the agencies can inform each other and stakeholders about current the 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.

Integrated Water Operations and Fisheries Forum

The Integrated Water Operations and Fisheries Forum (IWOFF) provides the forum for executives and managers of Reclamation, DWR, DFG, the Service, NMFS, USEPA and the SWRCB to meet and discuss current and proposed action planning, permitting, funding, and Endangered Species Act compliance, which affect the workloads and activities of these organizations. IWOFF provides a forum for elevation of these matters if staff is unable to reach resolution on process/procedures requiring interagency coordination. IWOFF may also elevate such decisions up to the Director level at their discretion.

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

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 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.

The Salmon Decision Process

The Salmon Decision Process is used by the fishery agencies and Project agencies 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. The coordination process has worked well during the recent fall and winter DCC operations in recent years and is expected to be used in the present or modified form in the future.

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.

San Joaquin River Technical Committee (SJRTC)

The SJRTC meets for the purposes of planning and implementing the Vernalis Adaptive Management Plan (VAMP) each year and oversees two subgroups: the Biology subgroup, and the Hydrology subgroup. These two groups are charged with certain responsibilities, and must also coordinate their activities within the San Joaquin River Agreement (SJRA) Technical Committee.

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 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.

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.

Reclamation will provide Townsend with up to 6,000 AF of water annually. If the full 6,000 AF is delivered, then 900 AF will be dedicated to (b)(2) according to the August 2000 agreement.

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 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 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 as shown in the IPO. 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.

Environmental Water Account

The original Environmental Water Account (EWA) was established in 2000 by the CALFED ROD, and operating criteria area described in detail in the EWA Operating Principles Agreement attachment to the ROD. In 2004, the EWA was extended to operate through the end of 2007. Reclamation, the Service, and NMFS have received Congressional authorization to participate in the EWA at least through September 30, 2010, per the CALFED Bay-Delta Authorization Act (PL-108-361). However, for these Federal agencies to continue participation in the EWA beyond 2010, additional authorization will be required.

The original purpose of the EWA was to enable diversion of water by the SWP and CVP from the Delta to be reduced at times when at risk fish species may be harmed while preventing the uncompensated loss of water to SWP and CVP contractors. Typically the EWA replaced water loss 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. Under past operations, from 2001 through 2007, when there were pumping curtailments at Banks Pumping Plant to protect Delta fish the EWA often owed a debt of water to the SWP, usually reflected in San Luis Reservoir.

The EWA agencies (the Project and fisheries agencies) are currently undertaking environmental review to determine the future of EWA. Because no decision has yet been made regarding EWA, for the purposes of this project description, EWA is analyzed with limited assets, focusing on providing assets to support VAMP and in some years, the "post – VAMP shoulder". The EWA assets include the following:

- Implementation of the Yuba Accord Component 1 Water, which is an average 60,000 AF of water released annually from the Yuba River to the Delta, is an EWA asset through 2015, with a possible extension through 2025. The 60,000 AF is expected to be reduced by carriage water costs in most years, estimated at 20 percent, leaving an EWA asset of 48,000 AF per year. The SWP will provide the 48,000 AF per year asset from Project supplies beyond 2015 in the event that Yuba Accord Component 1 Water is not extended.

- Purchases of assets to the extent funds are available.
- Operational assets granted the EWA in the CALFED ROD:
  - A 50 percent share of SWP export pumping of (b)(2) water and ERP water from upstream releases;
  - A share of the use of SWP pumping capacity in excess of the SWP's needs to meet contractor requirements with the CVP on an equal basis, as needed (such use may be under Joint Point of Diversion);
  - Any water acquired through export/inflow ratio flexibility; and
  - Use of 500 cubic-feet per second (cfs) increase in authorized Banks Pumping Plant capacity in July through September (from 6,680 to 7,180 cfs).
  - Storage in Project reservoirs upstream of the Delta as well as in San Luis Reservoir, with a lower priority than Project water. Such stored water will share storage priority with water acquired for Level 4 refuge needs.

Operational assets averaged 82,000 AF from 2001-2006, with a range from 0 to 150,000 AF.

500 cfs Diversion Increase During July, August, and September

Under this operation, the maximum allowable daily diversion rate into Clifton Court Forebay (CCF) during the months of July, August, and September increases 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 expired on September 30, 2008. An application has been made to the U.S. Army Corps of Engineers (Corps) for permitting the implementation of this operation. The description of the 500 cfs increased diversion in the permit application to the Corps will be consistent with the following description:

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 asset will be held in the SWP share of San Luis Reservoir, as long as space is available, to be applied to an export reduction specified by the fish agencies for the immediate water year (WY). For example, if 58 TAF were exported under the increased diversion during July through September, then 10 TAF of additional asset would be in San Luis Reservoir on September 30. The fish agencies may choose to apply this asset to an export reduction during the early winter or take a risk that space for storing the asset will remain in the SWP share of San Luis Reservoir and be available to be applied to the VAMP or post-VAMP export reduction in the spring. If the asset remains available for the VAMP and post-VAMP shoulder, it would increase the export reduction during that period by an equal amount. In this example, the export would be reduced an additional 10 TAF.

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. When the temporary barriers are replaced by the permanent operable flow-control gates, proposed as Stage 1 of the South Delta Improvements Program, the gates must be operating to their specified criteria.

4. Between July 1 and September 30, prior to the start of or during any time at which the SWP has increased its diversion rate in accordance with the approved operations plan, if the combined salvage of listed fish species reaches a level of concern, real-time decision making will be implemented. 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 P-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.

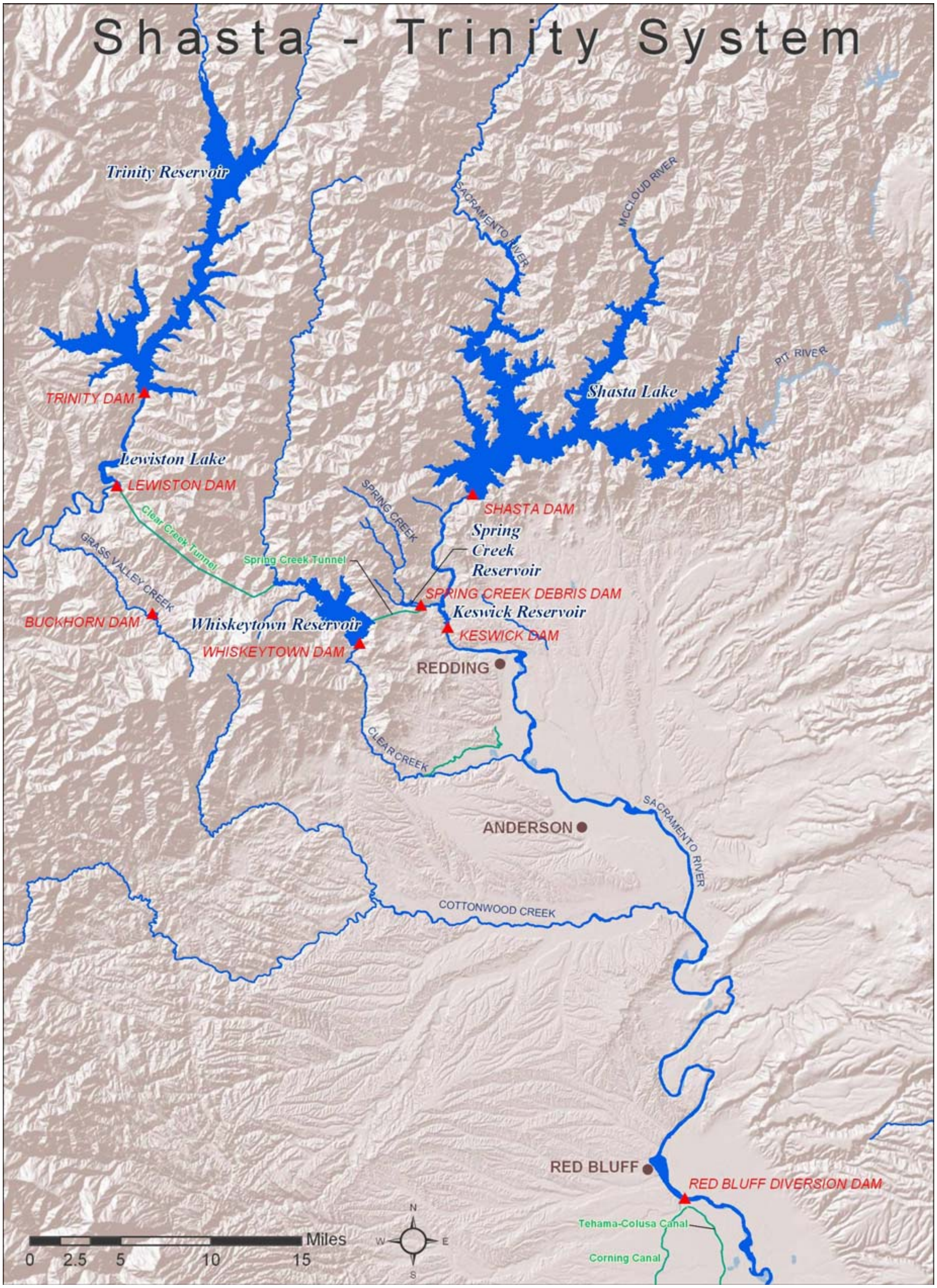

Figure P-5 Shasta-Trinity System

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 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 below 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, 368,600 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 (Also see Table P-2 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 October 1. 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 lower temperature water releases into the Trinity River.

Table P-2 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 P-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.

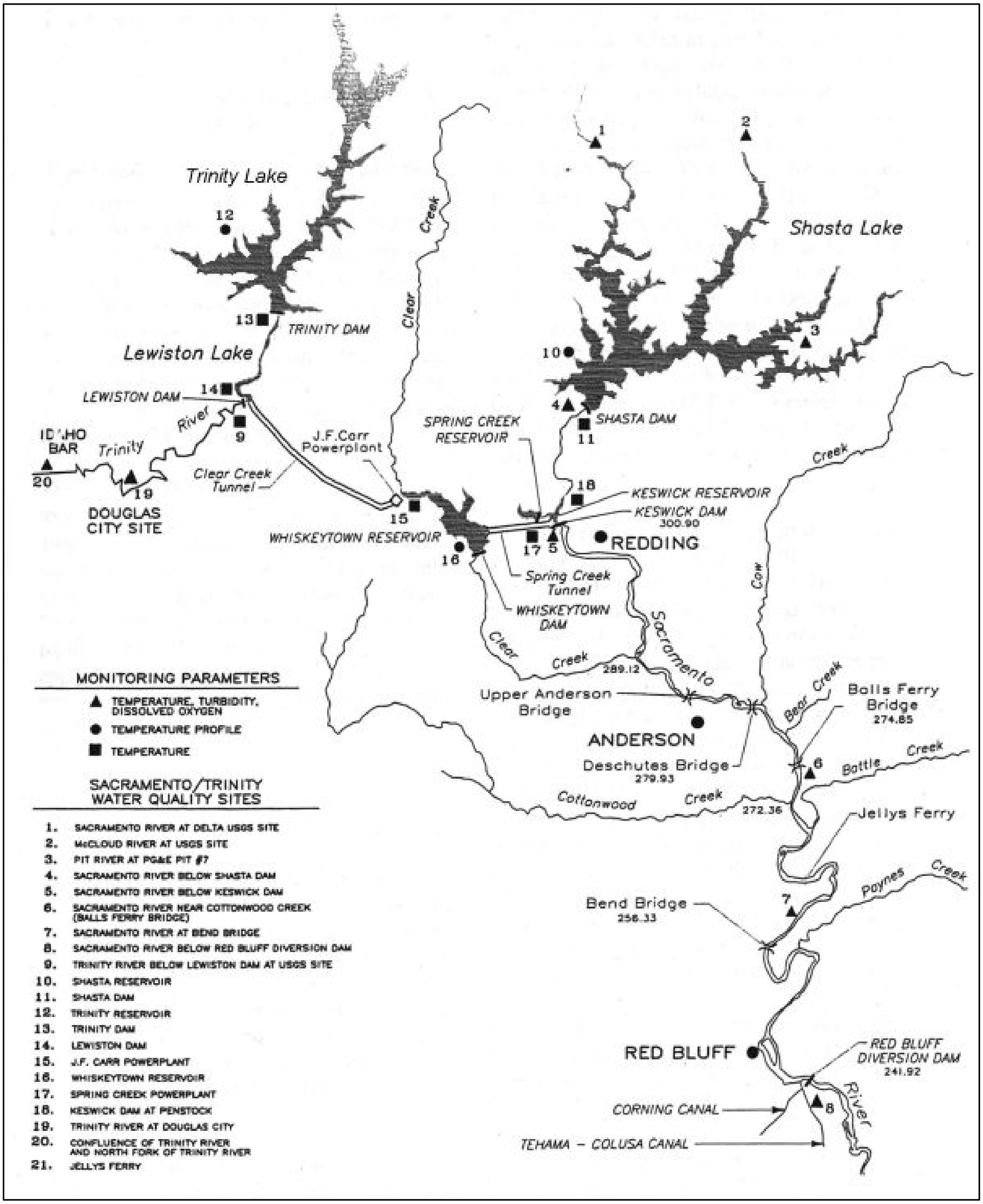

Figure P-6 Sacramento-Trinity Water Quality Network (with river miles [RM])

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 is a temperature curtain in Whiskeytown Reservoir.

Spillway Flows below Whiskeytown Lake

Whiskeytown Lake is 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 P-3 below.

Table P-3 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

Water Year	Days of Spilling	40-30-30 Index
1986	17	W
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

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 P-4 .
- 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 P-4 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.

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 P-5). 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 P-5 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 P-6). 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 P-6 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

The Red Bluff Diversion Dam (RBDD), located on the Sacramento River approximately two miles southeast of Red Bluff, is a gated structure with fish ladders at each abutment. When the gates are lowered, the impounded water rises about 13 feet, creating Lake Red Bluff and allowing gravity diversions through a set of drum fish screens into the stilling basin servicing the Tehama-Colusa and Corning canals. Construction of RBDD was completed in 1964.

The Tehama-Colusa Canal is a lined canal extending 111 miles south from the RBDD and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. Construction of the Tehama-Colusa Canal began in 1965, and it was completed in 1980.

The Corning Pumping Plant lifts water approximately 56 feet from the screened portion of the settling basin into the unlined, 21 mile-long Corning Canal. The Corning Canal was completed in 1959, to provide water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. The Tehama-Colusa Canal Authority (TCCA) operates both the Tehama-Colusa and Corning canals.

Since 1986, the RBDD gates have been raised during winter months to allow passage of winter-run Chinook salmon. As documented in the 2004 NMFS biological opinion addressing the long-term CVP and SWP operations, the gates are raised from approximately September 15 through May 14, each year. In the near term, Reclamation proposes the continued operation of the RBDD using the eight-month gate-open procedures of the past ten years, and to use the research pumping plant to provide water to the canals during times when the gates-out configuration precludes gravity diversions during the irrigation season. Additionally, although covered under a separate NMFS biological opinion, Reclamation proposes the continued use of rediversions of CVP water stored in Black Butte Reservoir to supplement the water pumped at RBDD during the gates-out period. This water is rediverted with the aid of temporary gravel berms through an unscreened, constant head orifice (CHO) into the Tehama-Colusa Canal.

In addition to proposing to operate the RBDD with the gates in for 8 months annually to enable gravity diversion of water into the Tehama-Colusa Canal, Reclamation proposes retention of the provision for a 10-day emergency gate closure, as necessary, contingent upon a case-by-case consultation with NMFS. Reclamation most recently coordinated such an emergency gate closure with NMFS in the spring of 2007. Around that time, dead green sturgeon were discovered in the vicinity of the dam, and Reclamation worked with the other resource agencies to review the gate operation protocol to try and reduce future potential adverse affects to adult green sturgeon that pass the dam. The resulting, new protocol for all gates in operation is to open individual gates to a minimum height of 12 inches to substantially reduce the possibility of injury should adult green sturgeon pass beneath the gates.

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 P-7.

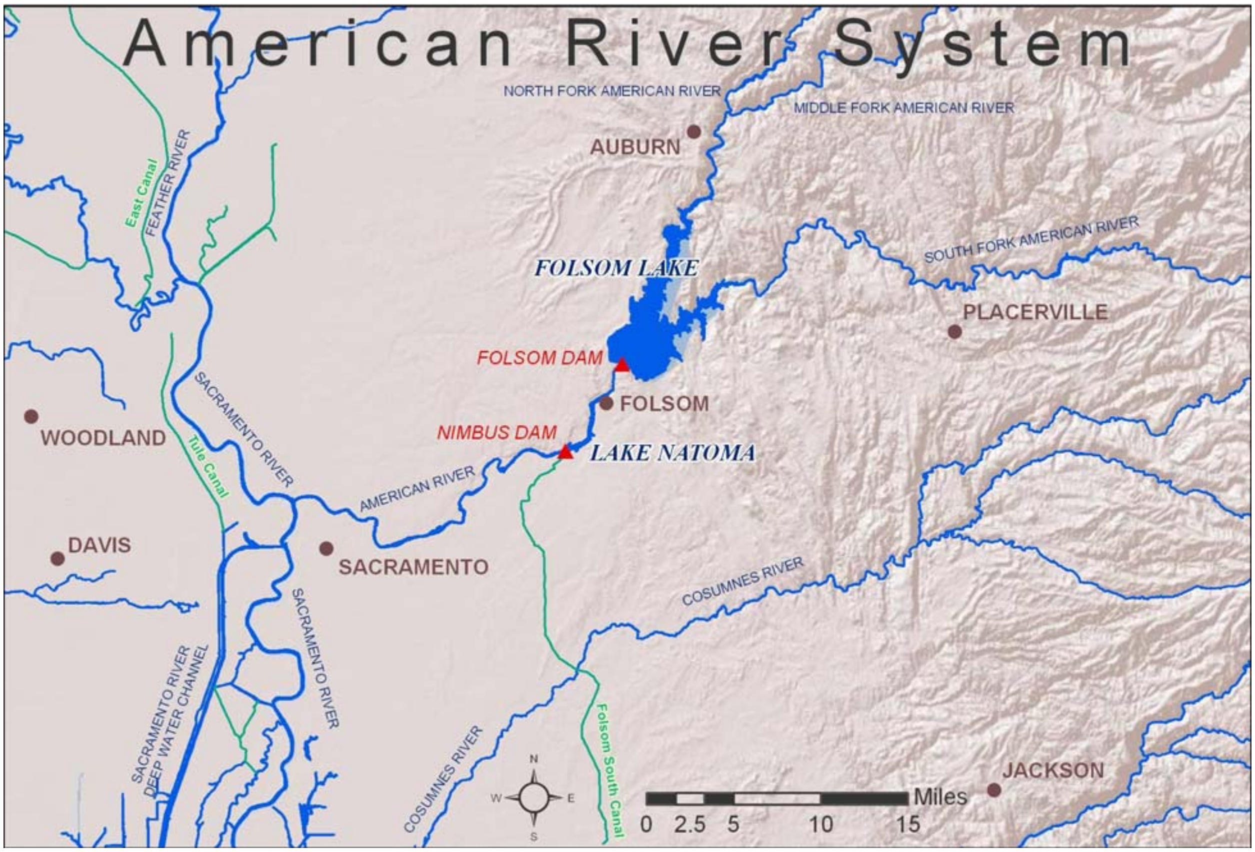

Figure P-7 American River System

Table P-7 provides Reclamation's annual water deliveries for the period 2000 through 2006 in the American River Division. The totals reveal an increasing trend in water deliveries over that period. Present level of American River Division water demands are 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 P-7 Annual Water Delivery - American River Division

Year	Water Delivery (TAF)
2000	196
2001	206
2002	238
2003	271
2004	266
2005	297
2006	282

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, the 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 the 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 Folsom 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 TAF 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 storage permitted to fill completely on June 1.

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 WY 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.

Reclamation continues to work with the Sacramento Water Forum, the Service, NMFS, DFG, and other interested parties to integrate a revised flow management standard for the Lower American River into CVP operations and water rights. This project description and modeling assumptions include the operational components of the recommended Lower American River flows and is consistent with the proposed flow management standard. 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. Use of additional (b)(2) flows above the proposed flow standard is envisioned 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 WY. 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.

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 operational 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.

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, standard operations of Folsom calls for 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 temperature conditions, and the benefits to the cold water pool and determined that it could use the spillway gates to make the incremental releases above powerplant capacity, thereby conserving cold water for later use. The ability to take similar actions (as needed in the future) 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 Urban Water Supply TCD operations

A series of shutter management scenarios are then incorporated into the model to gain a better understanding of the potential for meeting both summer steelhead and fall salmon temperature needs. Most annual strategies contain significant tradeoffs and risks for water temperature management for steelhead and fall–run salmon goals and needs due to the frequently limited cold water 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 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 temperature target at the downstream end of the compliance reach (Watt Avenue Bridge) while at the same time reserving the final shutter pull for salmon, or in some cases, continue to meet steelhead 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 Urban Water Supply TCD has provided additional flexibility to conserve cold water for later use. Initial studies are being conducted evaluating the impact of warmer water deliveries to the water treatment plants receiving the water. It is expected that the TCD will be operated during the summer months and deliver 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. 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. When temperatures climb into the 60°F to 70°F range, hatchery personnel with Reclamation to determine a compromise operation of the temperature shutter at Folsom Dam for the release of cooler water.

Reclamation operates Nimbus to maintain the health of the hatchery fish while minimizing the loss of the cold water pool for fish spawning in the river during fall. This is done on a case-by-case basis and is different in various months and year types. Temperatures above 70°F in the hatchery usually mean the fish need to be moved to another hatchery. 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 Service, NMFS, and DFG through B2IT when these types of difficult decisions are needed. In addition, Reclamation communicates with ARG on real time data and operational trade offs.

A fish diversion weir at the hatchery 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.

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 P-8.

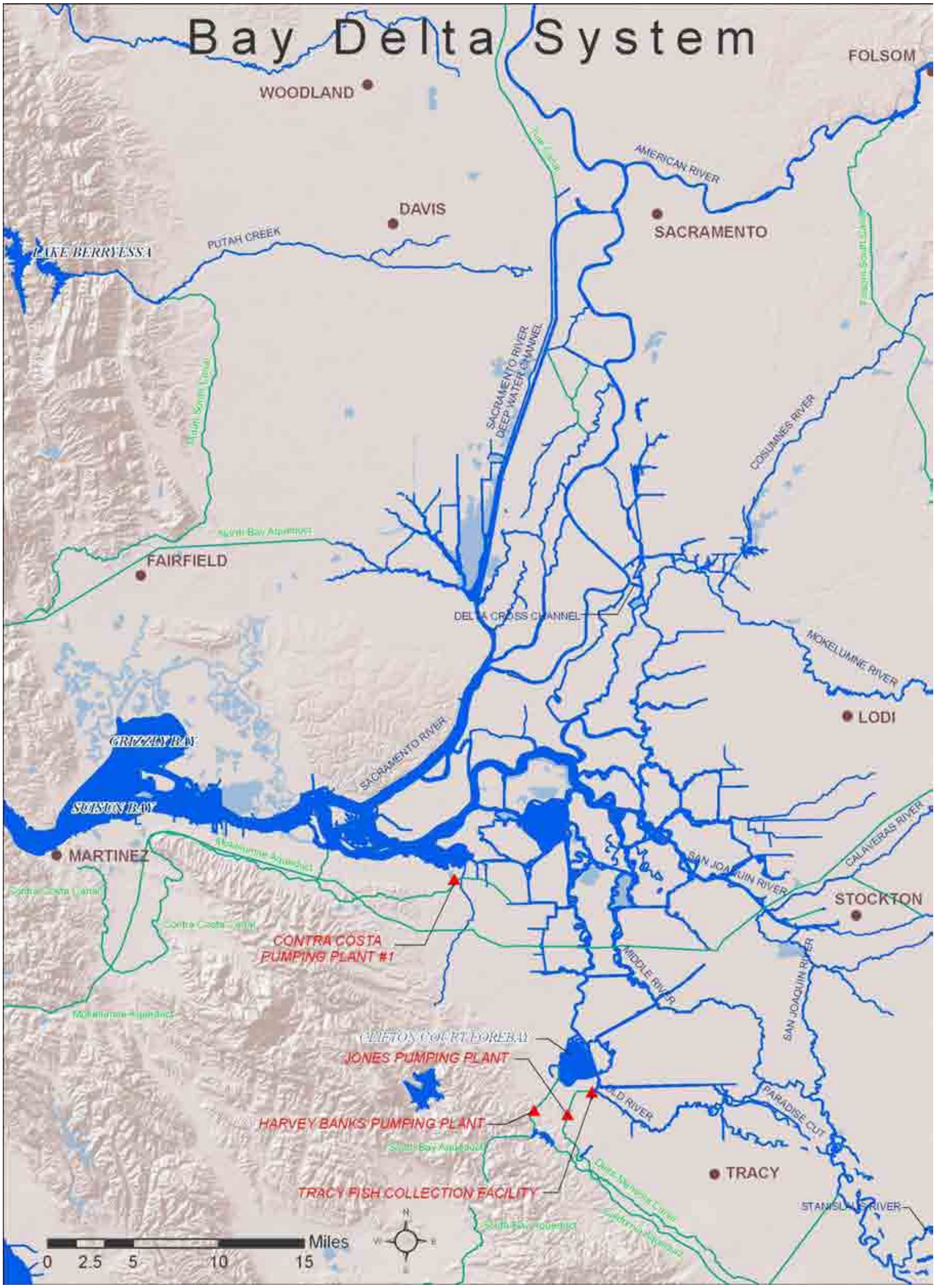

Figure P-8 Bay Delta System

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 near 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 P-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.

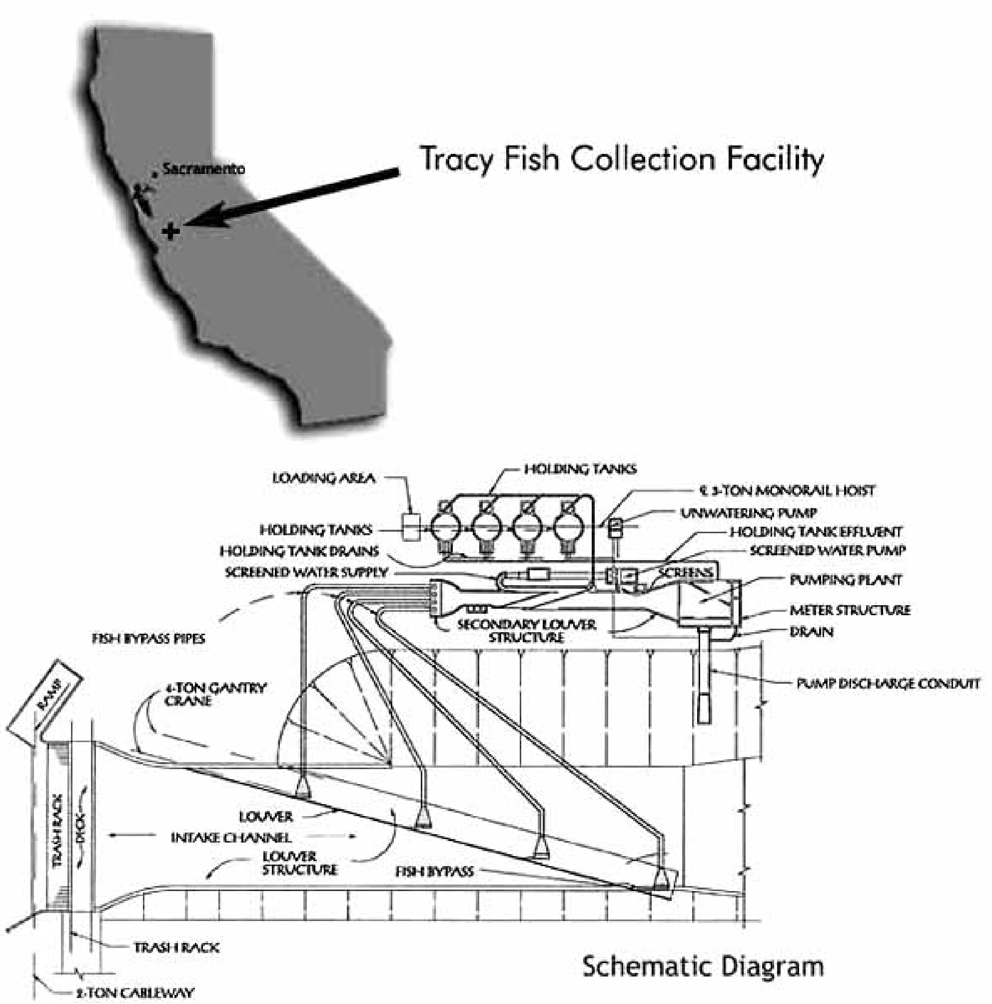

Figure P-9 Tracy Fish Collection Facility Diagram

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

CCWD diverts water from the Delta for irrigation and M&I uses under CVP contract, under its own permit and license at Mallard Slough, and under its own Los Vaqueros water right permit at Old River near State Route 4. 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. CCWD will be adding a fourth diversion point on Victoria Canal (the Alternative Intake Project described below) to help meet its water quality goals. 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. 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 due 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 permit issued by the SWRCB authorizes 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, primarily at the Rock Slough Intake.

The Rock Slough Intake is located about four miles southeast of Oakley, where water flows through a trash rack into the earth-lined portion of the Contra Costa Canal. This section of the canal is open to tidal influence and continues for four miles to Pumping Plant 1, which has capacity to pump up to 350 cfs into the concrete-lined portion of the canal. Prior to completion of the Los Vaqueros Project in 1997, this was CCWD's primary diversion point. Pumping Plant 1 is not screened. Reclamation, in collaboration with CCWD, is responsible for constructing a fish screen as authorized by CVPIA and required by the 1993 Service biological opinion for the Los Vaqueros Project. Reclamation has received an extension on fish screen construction until December 2008, and is preparing to request a further extension until 2013 because the requirements for screen design will change when CCWD completes the Contra Costa Canal Replacement Project, which will replace the earth-lined section of canal from Rock Slough to Pumping Plant 1 with a pipeline. When completed, the Canal Replacement project will eliminate tidal flows into the Canal intake section and should significantly reduce entrainment impacts and improve the feasibility of screening Rock Slough. Typically, CCWD diverts about 17 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. It 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. Pumping to storage in Los Vaqueros Reservoir is limited to 200 cfs by the terms of the Los Vaqueros Project biological opinions and by D-1629, the State Board water right decision for the Project. Typically, CCWD diverts about 80 percent of its total supply through the Old River Intake.

As described above, the first four miles of the Contra Costa Canal is earth-lined; after Pumping Plant 1, the Contra Costa Canal is concrete-lined and continues for 44 miles to its termination point in Martinez Reservoir. Pumping Plants 1 through 4 lift the water to an elevation of 127 feet. A blending facility just downstream of Pumping Plant 4 allows water from the Los Vaqueros Project pipeline and water from the Contra Costa Canal to mix to maintain CCWD’s delivered water quality goals for salinity. Canal capacity is 350 cfs at this blending facility and decreases to 22 cfs at the terminus at Martinez Reservoir, which provides flow regulation. The Contra Loma Reservoir is connected to the Canal and provides flow regulation and emergency storage. Two short canals, Clayton Canal and Ygnacio Canal, are integrated into the distribution system. The Clayton Canal is no longer in service.

Los Vaqueros Reservoir is an off-stream reservoir with a capacity of 100 thousand acre-feet (TAF). Construction was completed and filling started in 1998 as part of the Los Vaqueros Project to improve delivered water quality and emergency storage reliability for CCWD’s customers. Releases from Los Vaqueros Reservoir are conveyed to the Contra Costa Canal via a pipeline.

CCWD diverts approximately 127 TAF per year in total, of which approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), demand is supplied 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. However, the biological opinions for the Los Vaqueros Project and the Alternative Intake Project, CCWD’s memorandum of understanding with the 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 Service, NMFS and DFG can change these dates to best protect the subject species. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir.

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.

In addition to the existing 75-day no-fill period (March 15-May 31) and the concurrent no-diversion 30-day period , beginning in the February following the first operation of the Alternative Intake Project, 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 Feb 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.

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 P-10.

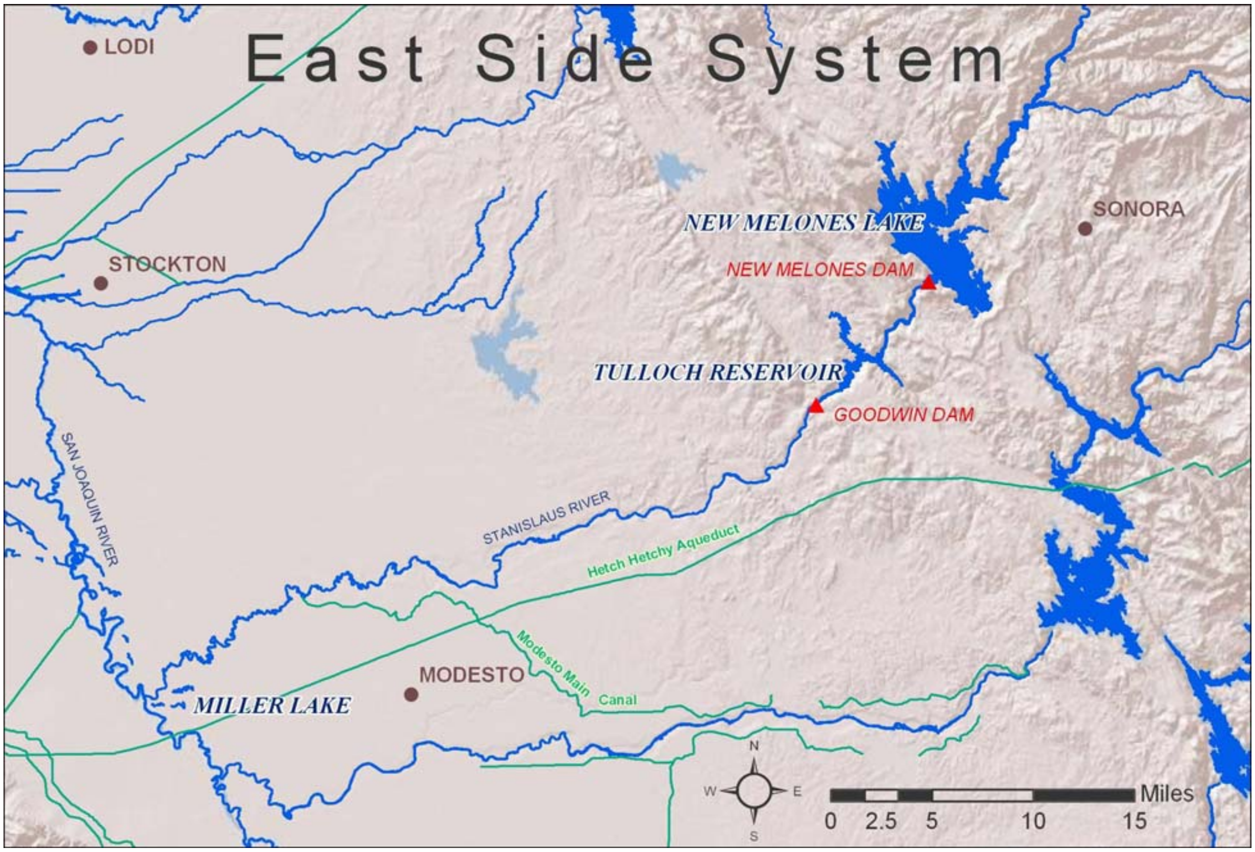

Figure P-10 East Side System

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 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 P-8 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 that provided for in the Interim Plan of Operation (IPO).

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 CVP operations on the Stanislaus River. 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 defines categories of water supply based on storage and projected inflow. It then allocates annual water quantities 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 P-9 Inflow 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 P-10 New Melones 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	59
2500	3000	345	467	175	250	75	75	90	90
3000	6000	467	467	250	250	75	75	90	90

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 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 to CVPIA (b)(2) uses or CVP Eastside contracts.

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.

New Melones Reservoir – Future Operations

To provide a basis to develop a long-term operating plan, Reclamation sponsored updates to the San Joaquin River Basin component of CALSIM II to better represent and model how river flows and water quality in the San Joaquin River are likely to affect operations at New Melones Reservoir.

This new information and the resulting CALSIM II model improvements were peer reviewed in 2004 and additional refinements were made to the model based on that review. The resulting model is considered by Reclamation to be the best representation of the significant hydrologic and water quality dynamics that currently affect New Melones operations.

The relationships developed for the current model are significantly different than the assumptions used to develop the 1997 IPO. Given that the 1997 IPO was only meant to be a temporary management tool and that water quality conditions are changing in the basin, the fundamental operating assumptions of the 1997 IPO are not entirely consistent with the improved CALSIM II model.

As an important first step in evaluating the effects of a permanent operating plan for New Melones, Reclamation concludes that the following general assumptions best represents future New Melones operations for the purpose of this consultation. These operational parameters recognize existing priorities in beneficial uses, and the 1928 to 1934 drought is used as the basis to evaluate risks associated with successive dry years. The current analysis of future New Melones operations is based on two sets of project beneficial uses: a primary set of uses tied to pre-existing water rights and long-standing permit terms, and a secondary set of uses that came into effect after the primary set.

The operational parameters for allocation to Eastside Division water service contracts and CVPIA (b)(2) are based on available yield over the 1928-34 drought period. The available project quantity is allocated between water service contracts and CVPIA (b)(2) use.

Table P-11 Fundamental considerations used to define the New Melones Reservoir operations parameters.

CVP Beneficial Uses (Prior to 1992). The pre-1992 long-term beneficial uses for Reclamation's water supply/water rights at New Melones Reservoir are as follows:

- Existing OID/SSJID Settlement Contract
- D-1641 Vernalis Salinity Objective
- Stanislaus River Dissolved Oxygen
- 1987 DFG Fishery Agreement

CVP Beneficial Uses (After 1992). The beneficial uses for Reclamation's water supply/water rights at New Melones Reservoir established after 1992 are as follows:

- D-1641 Vernalis Feb-June Base Flow objective
- CVPIA (b)(2) water to increase Goodwin Dam releases for AFRP instream flow objectives
- CVP Eastside Division water services contracts

Basic Allocation Bands. Similar to the 1997 IPO, the representation of future New Melones operations defines categories of water supply based on projected storage and inflows.

1) High Allocation Years (Projected New Melones Carryover Storage greater than 1.7 MAF End of September)

- DFG allocation is 302 TAF
- Vernalis flow objectives are met
- CVPIA (b)(2) water allocation is 155 TAF
- CVP Eastside contract allocation is 155 TAF
- Vernalis Salinity and Stanislaus River DO objectives are met

2) Mid-Allocation Years

- DFG allocation is 98.3 TAF
- Vernalis flow objectives are met
- CVPIA B2 water allocation to meet instream fishery needs is to be determined in coordination with USFWS, DFG and NMFS in a collaborative planning process
- Vernalis Salinity and Stanislaus River DO objectives are met
- CVP Eastside contract allocation is to be determined after all the instream needs are met

3) "Conference Year" conditions - New Melones Index is less than 1.0 MAF.

- As with the IPO, if the projected end of September New Melones Index (i.e. projected inflow plus storage) is less than 1.0 MAF, Reclamation would meet with USFWS stakeholders, DFG, and NMFS to coordinate a practical strategy to guide New Melones Reservoir operations to meet the most basic needs associated with Stanislaus River instream flows, DO, and Vernalis salinity. Allocation for CVPIA (b)(2) flows would be determined in coordination with USFWS, DFG and NMFS.

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

Adopted by the SWRCB in D-1641, the San Joaquin River Agreement (SJRA) includes 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 provides 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 indicates that VAMP experimental data will be used to create permanent objectives for the pulse flow period. 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. 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 the VAMP operations for a period of time after the expiration of SJRA 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 VAMP targets could be provided using CVPIA section 3406 (b)(1), (b)(2), and (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 VAMP objectives in most years. Chapter 9 of the biological assessment contains an analysis of the capability of DWR to provide for export reduction during the VAMP pulse flow period, using the 48,000 acre feet of substitute supply assumed to be available from the Yuba Accord.

Within the SJRA, the 1997 IPO has been assumed as the baseline operation for New Melones Reservoir, which forms part of the existing flow condition. The existing flow condition is used to compute the supplemental flows which will be provided on the San Joaquin River to meet the target flows for the 31-day pulse during April and May. These supplemental flows that will be provided from other sources in the San Joaquin River Basin under the control of the parties to the SJRA.

The parties to the SJRA include several agencies that contribute flow to the San Joaquin, divert from or store water on the tributaries to the San Joaquin, or have an element of control over the flows in the lower San Joaquin River. These include Reclamation; OID; SSJID; Modesto ID; Turlock ID; Merced ID; and the San Joaquin River Exchange Contractors. The VAMP is based on coordination among these participating agencies in carrying out their operations to meet a steady target flow objective at Vernalis.

The target flow at Vernalis for the spring pulse flow period is determined each year according to the specifications contained in the SJRA. The target flow is determined prior to the spring pulse flows as an increase above the existing flows, and so “adapts” to the prevailing hydrologic conditions. Possible target flows specified in the agreement are (1) 2000 cfs, (2) 3200 cfs, (3) 4450 cfs, (4) 5700 cfs, and (5) 7000 cfs.

The Hydrology Group of the SJRTC develops forecasts of flow at Vernalis, determines the appropriate target flow, devises an operations plan including flow schedules for each contributing agency, coordinates implementation of the VAMP flows, monitors conditions that may affect the objective of meeting the target flow, updates and adjusts the planned flow contributions as needed, and accounts for the flow contributions. The Hydrology Group includes designees with technical expertise from each agency that contributes water to the VAMP. During VAMP, the Hydrology group communicates via regular conference calls, shares current information and forecasts via e-mail and an internet website. The Hydrology group has two lead coordinators, one from Reclamation and one designated by the SJRG. Subsequent to the end of the VAMP, a group similar to the Hydrology Group, with the same or similar role, will be maintained as part of the ongoing coordination of operations in the San Joaquin River basin.

CVP-SWP operations forecasts include Vernalis flows that meet the appropriate pulse flow targets for the predicted hydrologic conditions. The flows in the San Joaquin River upstream of the Stanislaus River are forecasted for the assumed hydrologic conditions. The upstream of the Stanislaus River flows are then adjusted so when combined with the forecasted Stanislaus River flow based on the 1997 IPO, the combined flow would provide the appropriate Vernalis flows consistent with the pulse flow target identified in the SJRA. An analysis of how the flows are produced upstream of the Stanislaus River is included in the SJRA Environmental Impact Statement /Environmental Impact Report. For purposes of CVP/SWP operations forecasts, the VAMP target flows are simply assumed to exist at the confluence of the Stanislaus and San Joaquin Rivers. The assessment of the effects of CVP/SWP operations in the Delta begins downstream of that point.

The VAMP program has two distinct components, a flow objective and an export restriction. The flow objectives were designed to provide similar protection to those defined in the WQCP. Fishery releases on the Stanislaus above that called for in the 1987 DFG Agreement are typically considered WQCP (b)(2) releases. The export reduction involves a combined State and Federal pumping limitation on the Delta pumps. The combined export targets for the 31 days of VAMP are specified in the SJRA: 1500 cfs (when target flows are 2000, 3200, 4450, or 7000 cfs), and 2250 cfs (when target flow is 5700 cfs, or 3000 cfs [alternate export target when flow target is 7000 cfs]). Pumping reductions which cannot be recovered by adjustments in CVP operations are considered a WQCP (b)(2) expense. Reductions of SWP pumping are limited to the amount that can be recovered through operations adjustments and the export of up to 48 TAF of transferred water made available from the Yuba Accord.

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, as well as residence time in Tulloch Reservoir, as affected by local irrigation demand.

Reclamation intends to plan and manage flows to meet a 65° F water temperature objective 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 objective cannot be met. The Service, in coordination with NMFS and DFG, identifies the schedule for Reclamation to provide fall pulse attraction flows for salmon. The pulse flows are a combination of water purchased under the San Joaquin River Agreement 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 P-11). 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

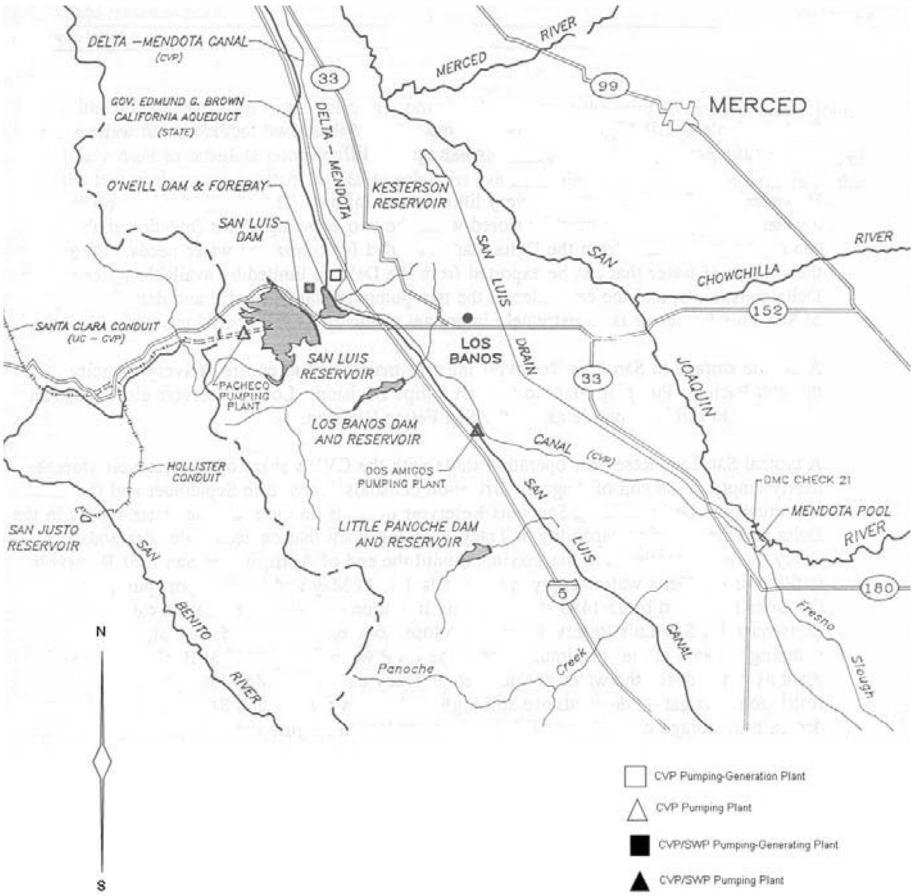

Figure P-11 West San Joaquin Division and San Felipe Division

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.

Friant Division

This division operates separately from the rest of the CVP and is 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 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.

Flood control storage space in Millerton Lake is based on a complex formula, which considers upstream storage in the Southern California Edison reservoirs. 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.

At this time, the Friant Division is generally hydrologically disconnected from the Delta as the San Joaquin River is dewatered in two reaches between Friant Dam and the confluence of the Merced River, except in extremely wet years. Under flood conditions, water is diverted into two bypass channels that carry flood flows to the confluence of the Merced River.

In 2006, parties to NRDC v. Rodgers executed a stipulation of settlement that calls for, among other things, restoration of flows from Friant Dam to the confluence of the Merced River. Implementation of the settlement is not included in this consultation as it is a large project which has not been sufficiently developed to allow for analysis of the effects of implementation of settlement action on listed aquatic species at this time. At some point in the future, consultation may need to be reinitiated to evaluate the effects of the Restoration Program on continued CVP and SWP operations.

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 Clifton Court Forebay (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 users, and a more detailed discussion of these operations and agreement will follow under CCF and JPOD sections.

Banks 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 Banks operations are demand limited, and Banks is able to pump 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. This has been less likely in recent years, where the contractors request all or nearly all of their contract Table A amount every year. Consequently, current Banks operations are more often supply limited. Under these current full demand conditions, Banks pumping plant 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 21 water 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[3]. 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

[3]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…”

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[4] of San Luis Reservoir is physically full, or projected to be physically full within approximately one week at permitted pumping rates; 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 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. Article 21 water will not be offered until State storage in San Luis Reservoir is either physically full or projected to be physically full within approximately one week at permitted pumping rates. Also, any carried-over EWA water asset stored in the State share of San Luis Reservoir (whether it be from the use of the 500 cfs or other operational assets) will not be considered part of the SWP storage when determining the availability of Article 21. This will ensure that the carried-over EWA water asset does not result in increased Article 21 deliveries.

During parts of April and May, the VAMP takes effect as described in the CVP section above. The state and federal pumps reduce their export pumping to benefit fish in the San Joaquin River system. Around this same time, water demands from both agricultural and M&I contractors are increasing, Article 21 water is usually discontinued, and San Luis supplies are released to the SWP facilities to supplement Delta pumping at Banks, thereby meeting contractor demands. The SWP intends to continue VAMP-type export reductions through 2030 to the extent that the limited EWA assets, (as described in an earlier section) will meet the associated water costs. Chapter 9 of the biological assessment includes an analysis of modeling results that illustrates the frequency on which assets are available under a limited EWA to meet the SWP portion of VAMP.

Immediately following VAMP, a “post –VAMP shoulder” may occur. This action is an extension of the reduced pumping levels that occur during VAMP depending on the availability of EWA and limited EWA assets. Chapter 9 includes an analysis of modeling results that illustrates the frequency on which assets are available under a limited EWA to meet the “post – VAMP shoulder”.

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

After VAMP and the “post-VAMP shoulder”, Delta pumping at Banks can be increased depending on Delta inflow and Delta standards. By late May, demands usually exceed the restored pumping rate at Banks, and continued releases from San Luis Reservoir are needed 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 conditions
- 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 agreed to a set of principles known as the Monterey Agreement, to settle long-term water allocation disputes, and to establish a new water management strategy for the SWP. This project description only includes the system-wide water operations consistent with the Monterey Agreement and not the specific actions by DWR and State Water Contractors needed to implement the agreement.

The Monterey Agreement resulted in 27 of the 29 SWP contractors signing amendments to their long-term water supply contracts in 1995, and the Monterey Amendment has been implemented as part of SWP operations for these 27 SWP contractors since 1996. The original Environmental Impact Report prepared for the Monterey Agreement was challenged, and the EIR was required to be decertified. DWR is currently preparing an EIR on the Monterey Amendment following that litigation and approval of a settlement agreement with the plaintiffs in May 2003. A draft of the new EIR was released in October 2007, the comment period closed in January 2008, and a final EIR is scheduled for completion in the fall of 2008.

The alternatives evaluated in the EIR include continuation of the Monterey Amendment, certain No Project alternatives that would revert some contract terms to pre-Monterey Amendment terms, and two “court ordered no-project” alternatives that would impose a reduction in Table A supplies by implementing a permanent shortage provision together with an offsetting increase in the supply of Article 21 water.

Adoption of any of the alternatives would not measurably change SWP Delta operations, although the internal classification of water provided to SWP contractors could change as to the balance between Table A and Article 21 water, as could the relative allocation of water between urban and agricultural contractors. The Monterey Amendment provides for certain transfers of water from agricultural to urban contractors; impacts from those transfers are all south of the Delta and have no effect on the Delta.

The only impact of Monterey Amendment operations on Delta exports is identified in the draft EIR as the facilitation of approval for out-of-service-area storage programs. Because DWR had previously approved water storage programs outside of individual SWP contractor's service areas and many such storage programs now exist, this water management method is unlikely to be voided by future actions of DWR. These increased exports can only occur if they are within the diversions permitted at the time. None of the alternatives being considered would result in demand for added Delta diversions above currently assumed levels and all are subject to whatever regulatory restrictions are in force at the time.

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

The Monterey Amendment revised 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 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 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 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 interruptible water among 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 P-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 P-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	1,541,816	1,303,148	2,844,964
2001	Dry	1,023,169	1,253,579	2,276,748
2002	Dry	1,408,919	1,241,088	2,650,007
2003	Above Normal	1,686,973	688,043	2,375,016
2004	Below Normal	1,724,380	733,095	2,457,475
2005	Above Normal	1,616,710	839,704	2,456,414
2006	Wet	1,521,681*	594,544	2,116,225
2007	Dry	1,395,827*	713,456*	2,109,283

* - These figures are preliminary.

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 P-12. 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.

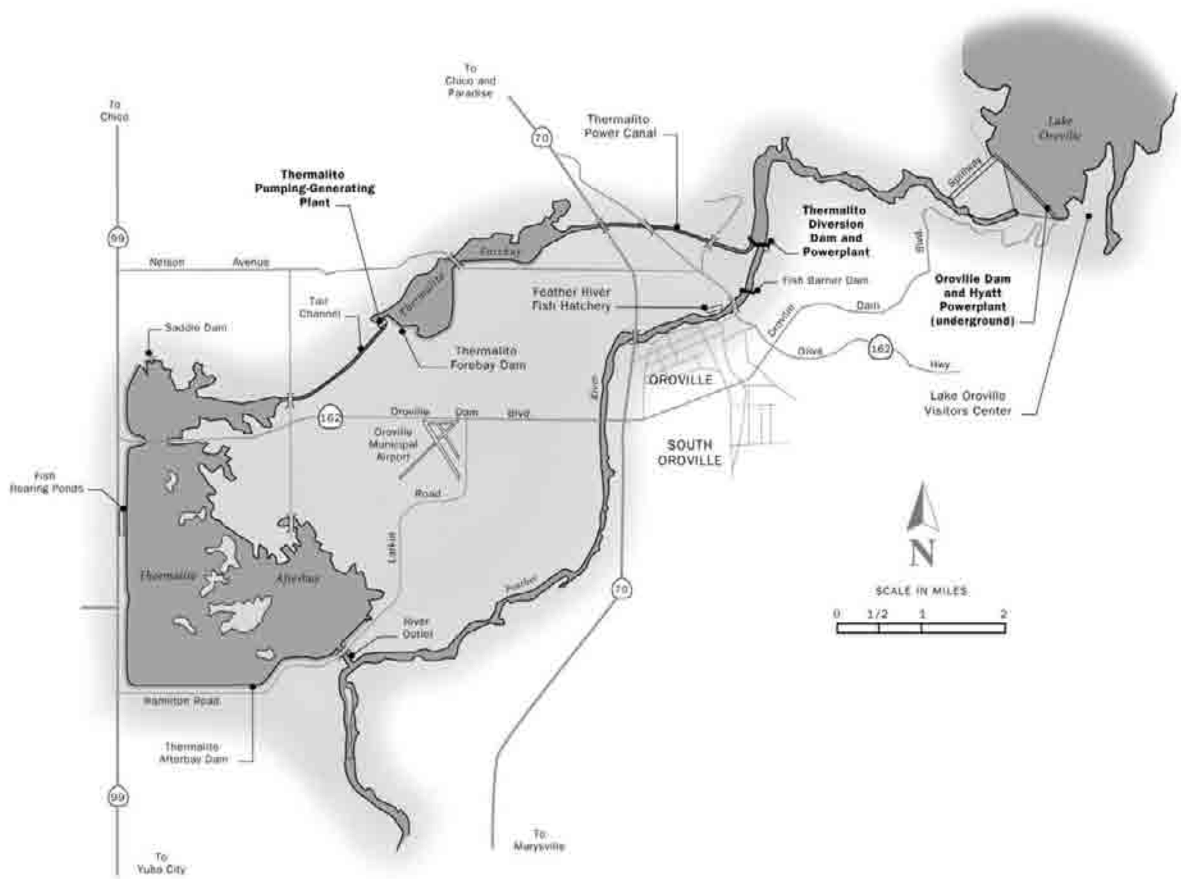

Figure P-12 Oroville Facilities on the Feather River

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 Feather River Fish Hatchery.

Current Operations - Minimum Flows and Temperature Requirements

Operation of Oroville will continue under existing criteria, consistent with past project descriptions, until a final decision is made in the FERC relicensing process. The release temperatures from Oroville Dam are designed to meet Feather River Fish Hatchery 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 Feather River Fish Hatchery 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 LFC rather than releasing colder water.

Additionally, DWR maintains a minimum flow of 600 cfs within the Feather River Low Flow Channel (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 P-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 P-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 twice for temperature control: in 2001 and 2002. To ensure that the river valves will operate reliably, DWR exercises them annually. When operated to meet temperature criteria, DWR can and does operate the river valves at a flow rate up to the 1,500 cfs needed for FRFH temperature management purposes.

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.

Table P-14 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.

Table P-14 Historical Records of Releases from the Oroville Facilities in 2001 and 2002, by Downstream Use

Downstream Use	Water Year 2001 Release		Water Year 2002 Release	
	Volume (TAF)	Percentage	Volume (TAF)	Percentage
Feather River Service Area	1,024	46	925	34
Instream and Delta Requirements	1,099	50	1,043	38
Flood Management	0	0	0	0
Support of Exports	93	4	773	28
Total	2,216	100	2,741	100

Source: DWR SWP Operations Control Office

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. 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 P-15 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 P-15 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

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.

Key:

cfs – cubic feet per second

HFC – High Flow Channel

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 are in Table P-16.

Table P-16 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 P-17 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 P-17 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.

Type of Measure	Title	Description
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.
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.

Table P-18 Water Year/Days in Flood Control/40-30-30 Index

Water Year	Days in Flood Control	40-30-30 Index
1981	0	D
1982	35	W
1983	51	W
1984	16	W
1985	0	D
1986	25	W
1987	0	D
1988	0	C
1989	0	D
1990	0	C
1991	0	C
1992	0	C
1993	8	AN
1994	0	C
1995	35	W
1996	22	W
1997	57	W
1998	0	W
1999	58	W
2000	0	AN
2001	0	D
2002	0	D

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 P-19.

Table P-19 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.

There is a great deal of uncertainty as to when the license will be issued and what conditions will be imposed by FERC and the State Water Resources Control Board (SWRCB). The process that DWR has to go through to get the new license is as follows: DWR will finalize the Final Environment Impact Report in May 2008, the SWRCB will prepare the Clean Water Act Section 401 Certification (401 Cert) for the project which may take up to a year and the 401 Cert may have additional requirements for DWR operations of Oroville. Once the 401 Cert is issued, FERC can issue the new license; however, in the interim, the documents or process may be challenged in court. When the new FERC license is issued, additional flow or temperature requirements may be required. At this time, DWR can only assume that the flow and temperature conditions required will be those in the FERC Settlement Agreement (SA); therefore, those are what DWR proposes for the near-term and future Oroville operations.

The proposed future operations in the SA described in the Project Description include 100-200 cfs increase in flows in the LFC of the Lower Feather River and reduced water temperatures at the Feather River Hatchery and in the Low Flow and High Flow channels, after further analysis of alternatives and construction of one or more temperature control facilities. These are described in more detail in the SA. The flows in the HFC downstream of the TAO will not change. It is unlikely that either the proposed minor flow changes in the LFC or the reduced water temperatures will affect conditions in the Sacramento River downstream of the confluence but if they were detectable, they would be beneficial to anadromous fish in the Sacramento River.

The original FERC license to operate the Oroville Project expired in January 2007 and until a new license is issued, DWR will operate to the existing FERC license. FERC has and will continue 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 with State, federal and local agencies, State Water Contractors, Non-Governmental Organizations, and Tribal governments 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 Settlement Agreement signed in 2006, a Habitat Expansion Agreement was negotiated to address the fish passage issue over Oroville Dam and NMFS and the Service' Section 18 Authority under the Federal Power Act. FERC prepared an EIS for the proposed license and DWR prepared and EIR and biological assessments for FERC based on the terms and conditions in the Settlement Agreement. The SWRCB is working on the Section 401 Certification process and when all the environmental documents and permits are complete, the new 50-year FERC license will be issued for the Oroville Project, possibly in 2009.

FERC requested consultation with NMFS on the Oroville Project SA and DWR prepared and submitted the FERC biological assessment in June 2007 to NMFS and FERC. 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 and the FERC biological assessment provide substantial detail on the 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.

Minimum Flows in the Low Flow and High Flow Channels

When the FERC license is issued, DWR will release a minimum flow of 700 cfs into the 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, the Service, 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.

Water Temperatures for the Feather River Fish Hatchery

When the FERC license is issued, DWR will use the temperatures in Table P-20 as targets, and will seek to achieve them through the use of operational measures described below.

Table P-20 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 P-20 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 P-20 temperatures shall become requirements, and DWR shall not exceed the Maximum Mean Daily Temperatures in Table P-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 Table P-21. 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 P-21 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 P-21. 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 P-22 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 P-22 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 P-22, 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 P-22 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 P-22 temperatures are exceeded. DWR shall operate the project to meet temperature requirements in Table P-22 in the LFC, unless it is a Conference Year as described in Article 108.6. The proposed water temperature objectives in Table P-23 (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 P-23 temperatures will require the phased development of the Table P-23 water temperature objective and likely, a revision to Table P-23 prior to Table P-23 becoming a compliance obligation.

Table P-23 HFC as measured at Downstream Project Boundary

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

Month	Temperature
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.

Delta Field Division

SWP facilities in the southern Delta include Clifton Court Forebay, 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. 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 California Aqueduct (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. 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 plant provides the initial lift of water 244 feet into the CA. 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 of these facilities is discussed further in later sections.

Clifton Court Forebay Aquatic Weed Control Program

DWR will apply copper based herbicide complexes including copper sulfate pentahydrate, Komeen,® and Nautique® on an as-needed basis to control aquatic weeds and algal blooms in Clifton Court Forebay (Forebay). Komeen® is a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique® is a copper carbonate compound (see Sepro product labels). These products are used to control algal blooms so that such algae blooms do not degrade drinking water quality through tastes and odors and production of algal toxins. Dense growth of submerged aquatic weeds, predominantly *Egeria densa*, can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free 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 pumping rate of water to prevent potential equipment damage through cavitation at the pumps. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the State Water Project.

Herbicide treatments will occur only in July and August on an as needed basis in the Forebay dependent upon the level of vegetation biomass in the enclosure. However, the frequency of herbicide applications is not expected to occur more than twice per year. 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. Past use of aquatic herbicides is presented in Table P-24.

Table P-24 Aquatic herbicide applications in Clifton Court Forebay, 1995- Present.

Note: The past applications are provided to give the reader an indication of the frequency of herbicide applications in the past (baseline).

Year	Date	Aquatic Herbicide
1995	5/15/1995	Komeen®
1995	8/21/1995	Komeen®
1996	6/11/1996	Komeen®
1996	9/10/1996	Komeen®

Year	Date	Aquatic Herbicide
1997	5/23/1997	Komeen®
1997	7/14/1997	Komeen®
1998	7/13/1998	Komeen®
1999	6/11/1999	Komeen®
2000	7/31/2000	Komeen®
2001	6/29/2001	Nautique
2002	6/24/2002	Komeen®
2003	5/12/2003	Nautique
2003	8/13/2003	Copper Sulfate
2004	6/3/2004	Komeen®
2004	7/22/2004	Copper Sulfate
2005	5/3/2005	Komeen®
2005	6/21/2005	Komeen®
2006	6/1/2006	Komeen®
2006	6/29/2006	Komeen®

Additionally, copper sulfate pentahydrate was applied once in 2003 and 2004 by helicopter to control taste and odor producing benthic cyanobacteria.

Aquatic weed management problems in the Forebay have to date been limited to about 700 acres of the 2,180 total water surface acres. Application of the herbicide is limited to only those areas in the Forebay that require treatment. The copper based herbicides, Komeen® or Nautique, are applied by helicopter or boat to only those portions where aquatic weeds present a management problem to the State.

To date, algal problems in the Forebay 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 the Forebay 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. Annually, application areas may vary considerably based on the extent of the algal infestation in the Forebay.

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 when necessary to achieve management goals. The State Board functions as the 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) and 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. .

Proposed Measures to Reduce Fish Mortality

Komeen® will be applied according to the product label directions as required by state and federal law. The Forebay 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). 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 specimen 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®. Clifton Court Forebay has a mean depth of 6 feet at 2 feet above mean sea level; thus the volume treated is 4620 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 Clifton Court Forebay aquatic plant community) is 0.5 - 0.75 mg/L Cu^{2+}. Source: Komeen® Specimen Label.

Prior to application of copper based herbicides, toxicity testing and literature review of LC-50 levels for salmon, steelhead, delta smelt, and green sturgeon may be conducted. Once applied, the initial stock copper concentration is reduced rapidly (hours) by dilution (Komeen® applied according to the Specimen Label (SePro Corporation) of the product in the receiving water to achieve final concentration levels. Based on the treatment elevation of +2 feet, only about 20 percent (4,630 AF) of the 22,665 AF Forebay will be treated (AF = Acre-feet= volume). The copper will be applied beginning on one side of the Forebay 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.

In 2006 DWR proposed the following actions to reduce fish mortality in coordination with DFG and NMFS. Also, the hydroacoustical aquatic plant survey was continued in 2007 when no Komeen application was done. A survey in 2008 is also planned. These actions will continue to be followed in the future.

1. Komeen® or copper sulfate will only be applied in July and August.

2. The salvage of listed fish species at Skinner Fish Facility will be monitored prior to the Komeen® application.

3. The intake (radial) gates at Clifton Court Forebay will be closed 24 hours prior to the scheduled application to improve fish passage out of the designated treatment areas.

4. The radial gates will not be re-opened to allow inflow into the Forebay for 24 hours following the end of the aquatic herbicide application. The Clifton Court intake gates will therefore be closed for 48 hours. The Komeen® Specimen Label recommends a 12-24 hours contact with target weeds to provide effective control. Twenty-four hours is at the high end for recommended contact time according to the Komeen® Specimen Label.

5. Komeen® will be applied by boat, first to the nearshore areas and then outwards in transects away from the shore. The application will be conducted by a private contractor and supervised by a California Certified Pest Control Advisor.

6. The herbicide treatment will be scheduled and planned for minimizing the treatment area by using hydroacoustical plant mapping technology to locate and estimate the area of submerged vegetation beds. The smallest possible area will be treated to minimize both the volume of aquatic herbicide applied and lessen the impacts to fish in the Forebay. Examples of figures from the 2005 hydroacoustical survey are enclosed.

7. Copper monitoring and analysis will follow the procedures described in the DWR Quality Assurance Project Plan submitted to the State Water Resources Control Board in February 2002. There are no plans to measure sediment and detrial copper concentrations. The Quality Assurance Plan was submitted to the SWRCB on February 26, 2002 and no comments were received.

North Bay Aqueduct Intake at Barker Slough

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (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 required 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, each of 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 the biological opinion 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 will be replaced by an expanded 20-mm survey (described at http://www.delta.dfg.ca.gov/data/20mm) that has proven to be fairly effective at 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. The gear type was a surface boom tow, 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 P-13), 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.

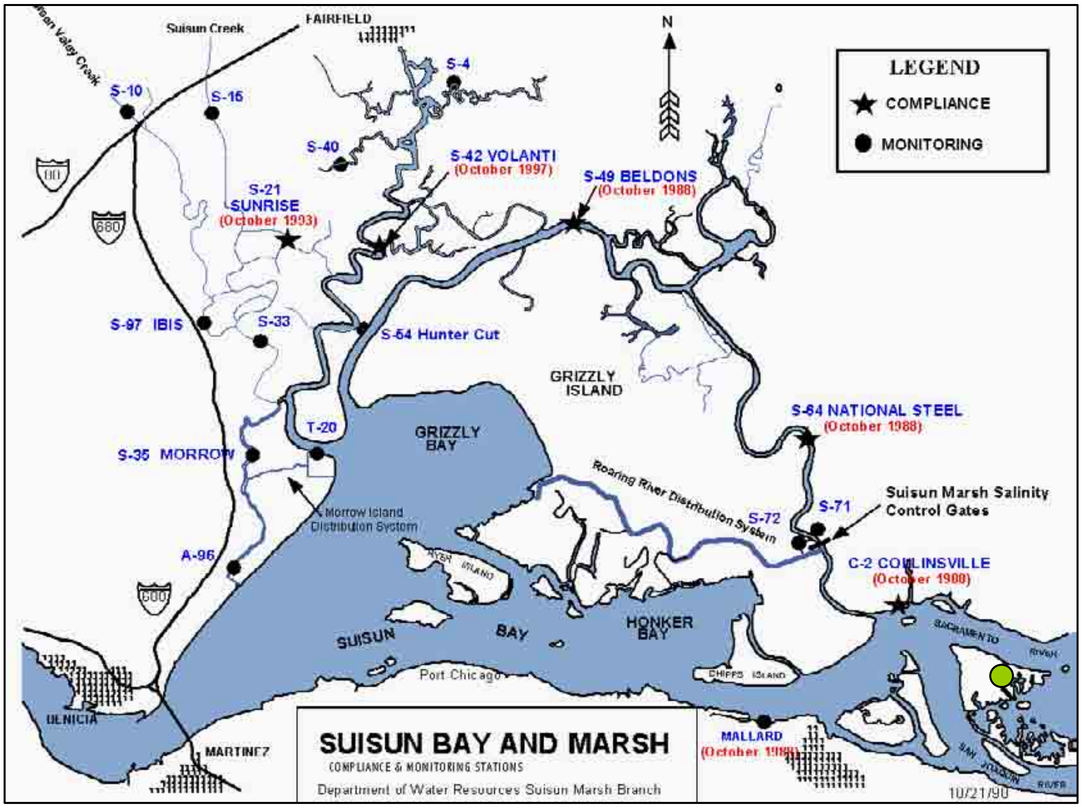

Figure P-13 Compliance and monitoring stations and salinity control facilities in Suisun Marsh.

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.

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 P-14). Net outflow through Carquinez Strait is not affected. Figure P-14 indicates the approximate position of X2 and how is transported upstream when the gate is operated.

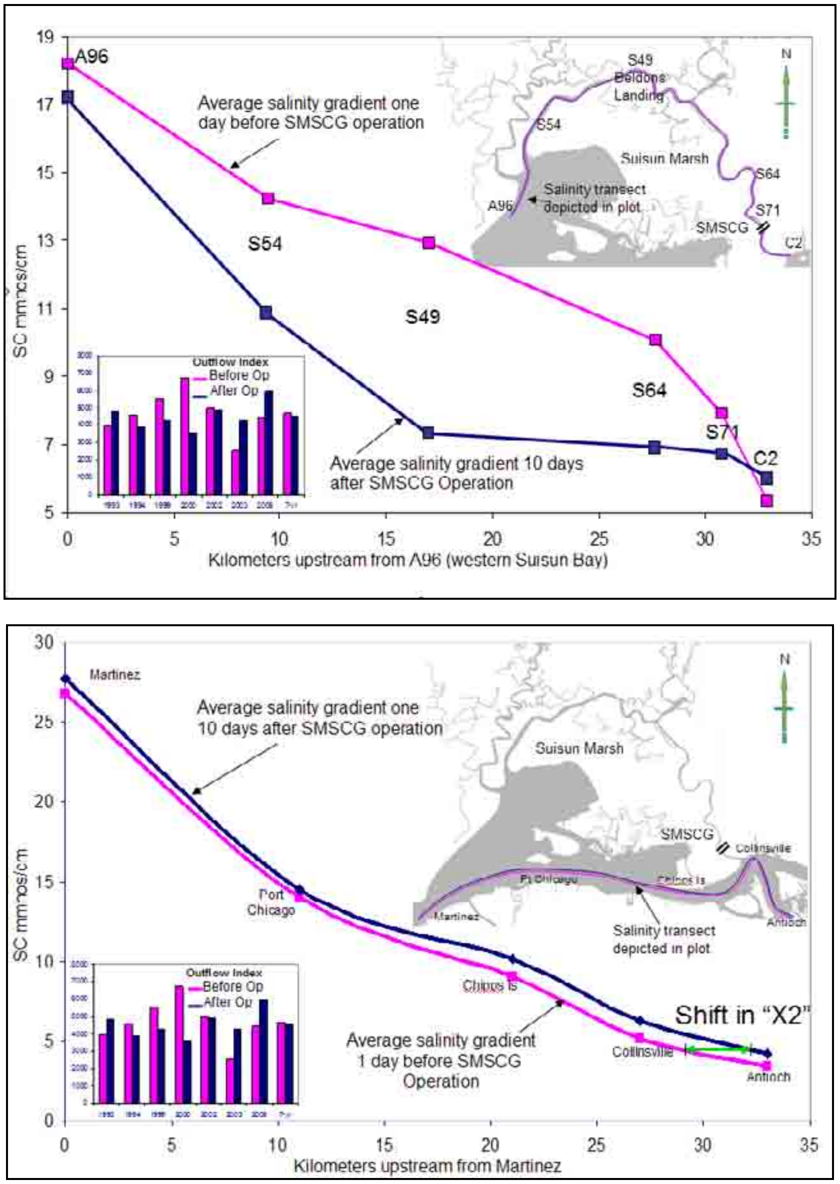

Figure P-14 Average of seven years salinity response to SMSCG gate operation in Montezuma Slough and Suisun Bay.

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. Figure P-15 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. Assuming no significant, long-term changes in the drivers mentioned above, this level of operational frequency (10 – 20 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.

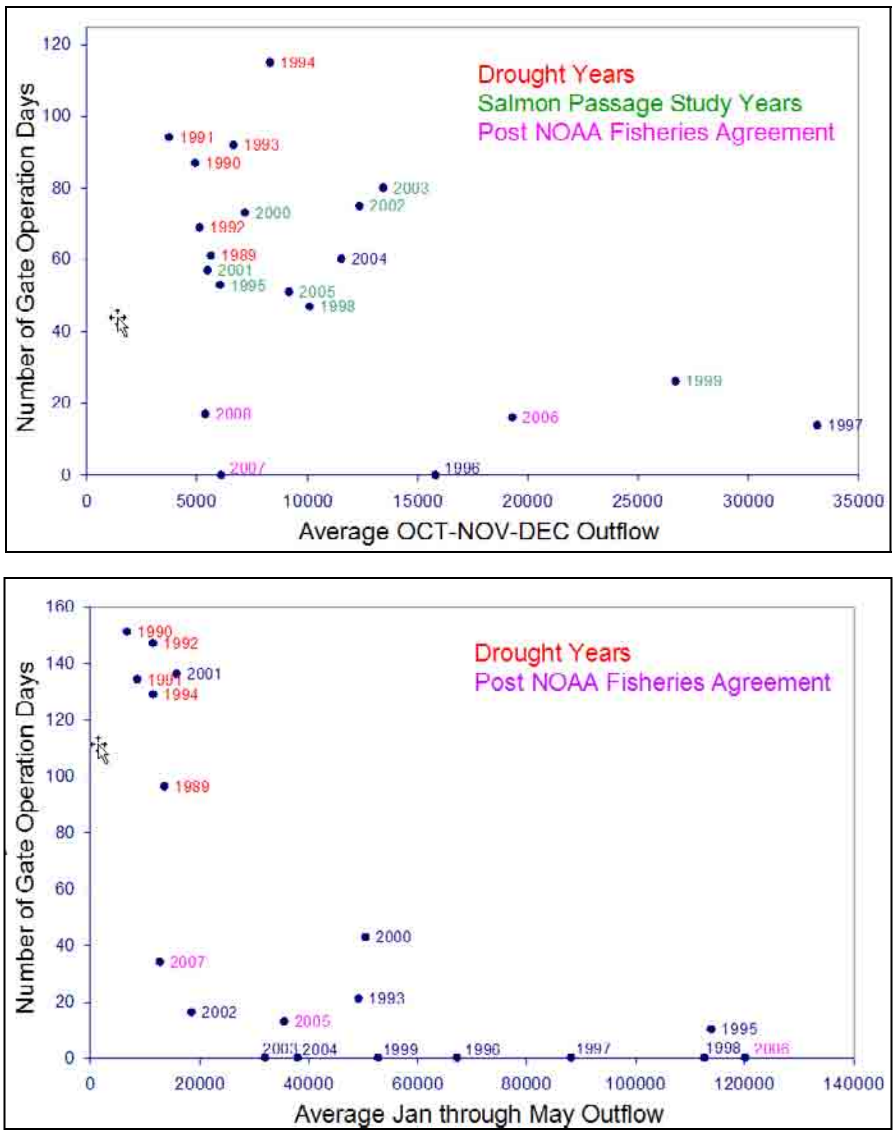

Figure P-15 SMSCG operation frequency versus outflow since 1988.

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 Roaring River Distribution System (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.

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 and again in 2001, when DWR obtained permits to extend the Temporary Barriers Project through 2007. The Service has approved the extension of the permits through 2008. Continued coverage by the Service for the TBP will be assessed under this biological opinion for the operational effects and under a separate Section 7 consultation for the construction and demolition effects. The NMFS recently submitted a biological opinion to the Corps which provides incidental take coverage for the continuation of the TBP through 2010.

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 growing season. Under the Service biological opinion 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 also depends on San Joaquin flow conditions.

Proposed Installation and Operations of the Temporary Barriers

The installation and operation of the TBP will continue until the permanent gates are constructed. 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 was prohibited in 2008. As a result, the agricultural barriers installations were delayed according to the current permits until mid-May.

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 quality. Adjusting the barrier weir heights is being considered to improve water quality and circulation. DWR will consult with the Service and NMFS if changes in the height of any or all of the weirs is sought.

As the permanent gates are being constructed, temporary barrier operations 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

Various measures and conditions required by regulatory agencies under past and current permits to avoid, minimize, and compensate for the TBP impacts 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, Head of Old River fish entrainment and Kodiak trawling study, 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 at Sherman Island.

San Luis Complex

Water in the mainstem of the California Aqueduct flows south by gravity into the San Luis Joint-Use Complex (Figure P-16), 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.

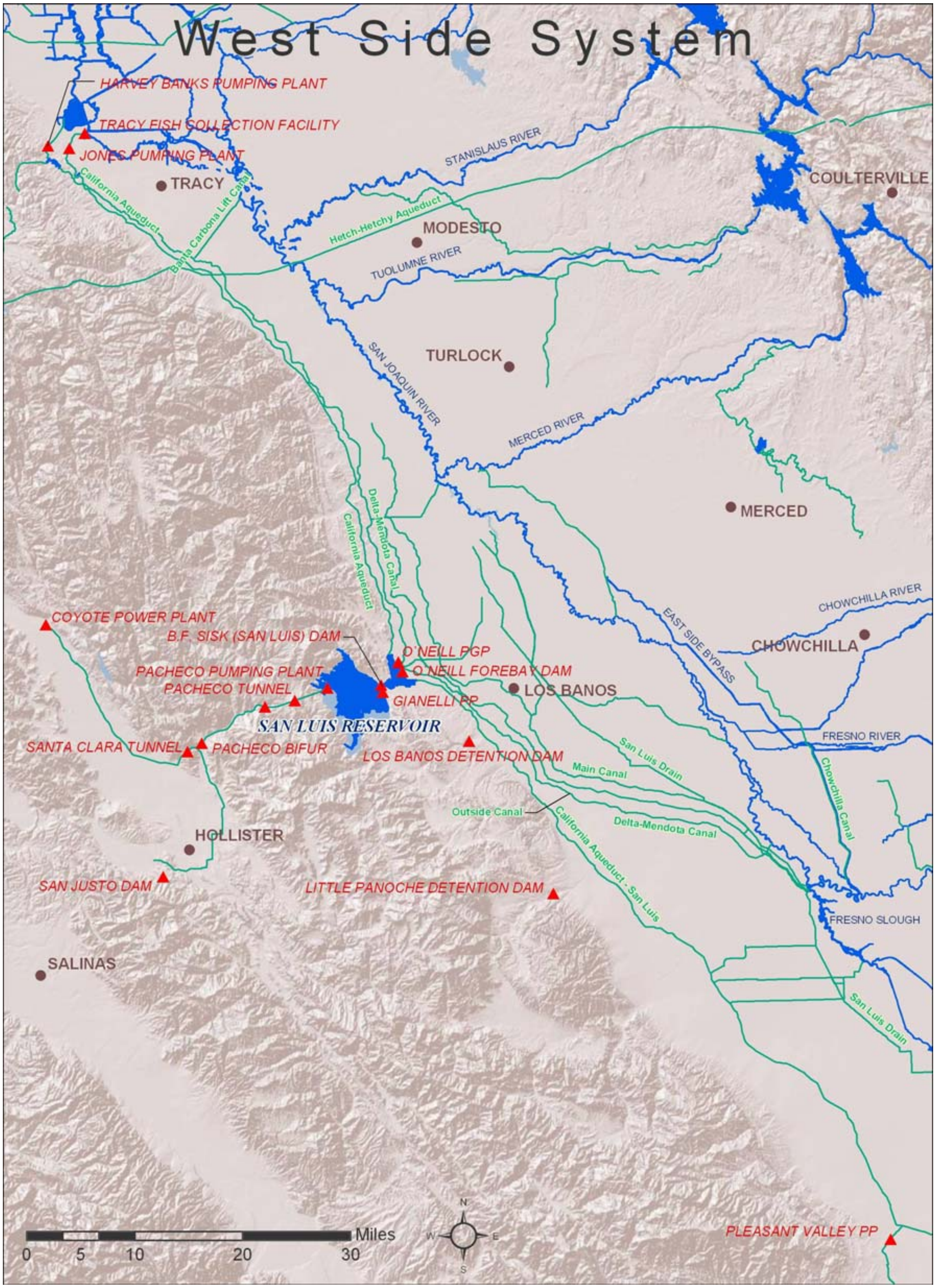

Figure P-16 San Luis Complex

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.

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.

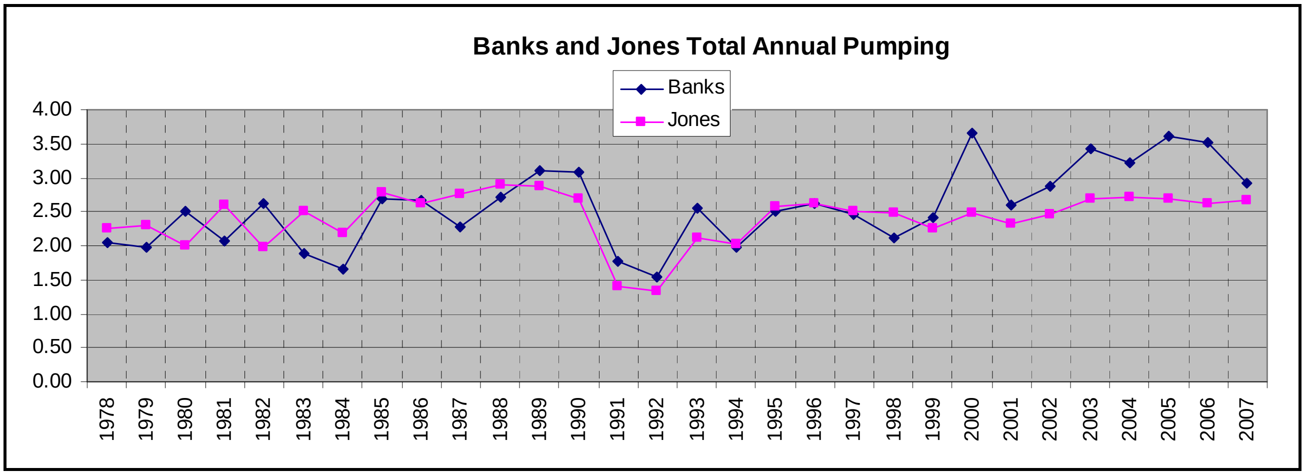

Figure P-17 Total Annual Pumping at Banks and Jones Pumping Plant 1978-2007 (MAF)

Table P-25 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%	

WY	Hydrologic Index 40-30-30	Banks			Jones			Contra Costa	CVP Total Delta Pumping	SWP Total Delta Pumping	CVP SOD-Ag Allocation	Shasta Index Critical
		SWP	CVP	Total	SWP	CVP	Total					
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

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 Delta or Sacramento-San Joaquin watershed undertakes actions to make water available for transfer by export from the Delta. With the exception of the Component 1 water pursuant to the Yuba River Accord, this biological opinion 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. The flows for the Yuba River Accord may provide up to 60,000 acre feet annually for EWA, in the lower Yuba River (estimated to provide up to 48,000 acre feet of additional Delta export), and may provide additional water to the CVP and SWP and their contractors in drier years. The upstream effects of other transfers and effects to terrestrial species would require a separate ESA consultation.

Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at Banks or Jones is available to move the water. Additionally, operations to accomplish these transfers must be carried out in 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 water transfers may include Reclamation, DWR, SWP contractors, CVP 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. The DWR programs include the 1991, 1992, and 1994 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. The CALFED Ecosystem Restoration Program will, in the future, acquire water for fishery and ecosystem restoration. DWR, and potentially Reclamation in the future, has agreed to participate in a 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. It is anticipated that Reclamation will join in the Accord and fully participate in the Yuba Accord upon completion of this consultation. The Yuba River Accord water would be transferred to offset VAMP water costs.

Also in the past, CVP and SWP contractors have also independently acquired water and arranged for pumping and conveyance through SWP facilities. State Water Code provisions grant other parties access to unused conveyance capacity, although SWP contractors have priority access to capacity not being used by the DWR to meet SWP contract amounts.

The Yuba River Accord includes three separate but interrelated agreements that would protect and enhance fisheries resources in the lower Yuba River, increase local water supply reliability, and provide DWR with increased operational flexibility for protection of Delta fisheries resources through Project re-operation, and provision of added dry-year water supplies to state and federal water contractors. These proposed agreements are the:

- Principles of Agreement for Proposed Lower Yuba River Fisheries Agreement (Fisheries Agreement)
- Principles of Agreement for Proposed Conjunctive Use Agreements (Conjunctive Use Agreements)
- Principles of Agreement for Proposed Long-term Transfer Agreement (Water Purchase Agreement)

The Fisheries Agreement was developed by state, federal, and consulting fisheries biologists, fisheries advocates, and policy representatives. Compared to the interim flow requirements of the SWRCB Revised Water Right Decision 1644, the Fisheries Agreement would establish higher minimum instream flows during most months of most WYs.

To assure that Yuba County Water Agency's (YCWA) water supply reliability would not be reduced by the higher minimum instream flows, YCWA and its participating Member Units would implement the Conjunctive Use Agreements. These agreements would establish a comprehensive conjunctive use program that would integrate the surface water and groundwater supplies of the local irrigation districts and mutual water companies that

YCWA serves in Yuba County. Integration of surface water and groundwater would allow YCWA to increase the efficiency of its water management.

Under the Water Purchase Agreement, DWR would enter into an agreement with YCWA to purchase water from YCWA to off-set water costs resulting from VAMP as long as operational and hydrological conditions allow. Additional water purchased by DWR would be available for south-of-Delta CVP and SWP contractors in drier years. The limited EWA would take delivery of 60,000 AF (48,000 AF export) of water in every year; the CVP/SWP would receive additional water in the drier years. In the future Reclamation may become a party to the Water Purchase Agreement.

The Fisheries Agreement is the cornerstone of the Yuba Accord Alternative. To become effective, however, all three agreements (Fisheries, Conjunctive Use, and Water Purchase) must undergo CEQA and NEPA review and be fully approved and executed by the individual parties to each agreement. Also, implementation of the Yuba Accord Alternative would require appropriate SWRCB amendments of YCWA's water-right permits and SWRCB D-1644.

Transfer Capacity

Reclamation assumes as part of the project description that the 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, with no forebay for pumped diversions and with limited capability to fine tune rates of pumping, 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 a broad middle range of hydrologic conditions, and some surplus again in some above normal and wet years when demands may be lower because contractors have alternative supplies.

The availability of water for transfer and the demand for transfer 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 recent history, the expectations for the future limited EWA, and the needs of other transfer programs suggest a growing reliance on transfers.

Under both the present and future conditions, capability to export transfers will often be capacity-limited, except in Critical and some Dry years. In these Critical and some Dry years, both Banks and Jones have more available capacity for transfers, so export capacity is less likely to limit transfers. Rather, either supply or demand for transfers may be a limiting factor. 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, proposed exports for transfers apply only to 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 TAF
Dry (following Critical)	up to 600 TAF
Dry (following Dry)	up to 600 TAF
All other Years	up to 360 TAF

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.

DMC/CA Intertie Proposed Action

The proposed action, known as the DMC and CA Intertie (DMC/CA Intertie), consists of construction and operation of a pumping plant and pipeline connections between the

DMC and the CA. The DMC/CA Intertie alignment is proposed for DMC milepost 7.2 where the DMC and the CA are about 500 feet apart.

The DMC/CA Intertie would 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 would allow flow in both directions, which would provide additional flexibility to both CVP and SWP operations. The Intertie includes a 467 cfs pumping plant at the DMC that would allow up to 467 cfs to be pumped from the DMC to the CA. Up to 900 cfs flow could be conveyed from the CA to the DMC using gravity flow. The intertie will not be used to increase total CVP exports until certain criteria are in place.

The DMC/CA Intertie will be operated by the San Luis and Delta-Mendota Water Authority (Authority). A three-way agreement among Reclamation, DWR, and the Authority would identify the responsibilities and procedures for operating the Intertie. The Intertie would be owned by Reclamation. A permanent easement would be obtained by Reclamation where the Intertie alignment crossed State property.

Location

The site of the proposed action is an unincorporated area of Alameda County, west of the City of Tracy. The site is situated in a rural area zoned for general agriculture and is under Federal and State ownership. The DMC/CA Intertie would be located at milepost 7.2 of the DMC, connecting with milepost 9.0 of the CA.

Operations

The Intertie would be used under three different scenarios:

1. Up to 467 cfs would be pumped from the DMC to the CA to help meet water supply demands of CVP contractors. This would allow Jones Pumping Plant to pump to its authorized 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 would 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 would 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 would 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 could 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 could 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 would be transferred to the CA via the Intertie. Water diverted through the Intertie would 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 the unscreened Rock Slough Intake will decrease while 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.[5]

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),

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[5] 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.

- 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 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

Delta Smelt Species Description and Taxonomy

The Service proposed to list the delta smelt 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). A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004); that review affirmed the need to retain the delta smelt as a threatened species. The Service is currently considering information to determine if the listing status of delta smelt should be upgraded from threatened to endangered.

The delta smelt is a member of the Osmeridae family (northern smelts) (Moyle 2002) and is one of six species currently recognized in the *Hypomesus* genus (Bennett 2005). 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 S-1). 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.

The delta smelt is a slender-bodied fish, generally about 60 to 70 millimeters (mm) (2 to 3 inches (in)) long, although they can reach lengths of up to 120 mm (4.7 in) (Moyle 2002). Live delta smelt are nearly translucent and have a steely blue sheen to their sides. Delta smelt usually aggregate but do not appear to be a strongly schooling species.

Genetic analyses have confirmed that *H. transpacificus* presently exists as a single intermixing population (Stanley et al. 1995; Trenham et al. 1998). The most closely-related species is the surf smelt (*H. pretiosis*), a marine species common along the western coast of North America. Despite its morphological similarity, the delta smelt is less-closely related to wakasagi (*H. nipponensis*), an anadromous western Pacific species introduced into California Central Valley reservoirs in 1959 and now distributed in the historic range of the delta smelt (Trenham et al. 1998). Genetic introgression among *H. transpacificus* and *H. nipponensis* is low.

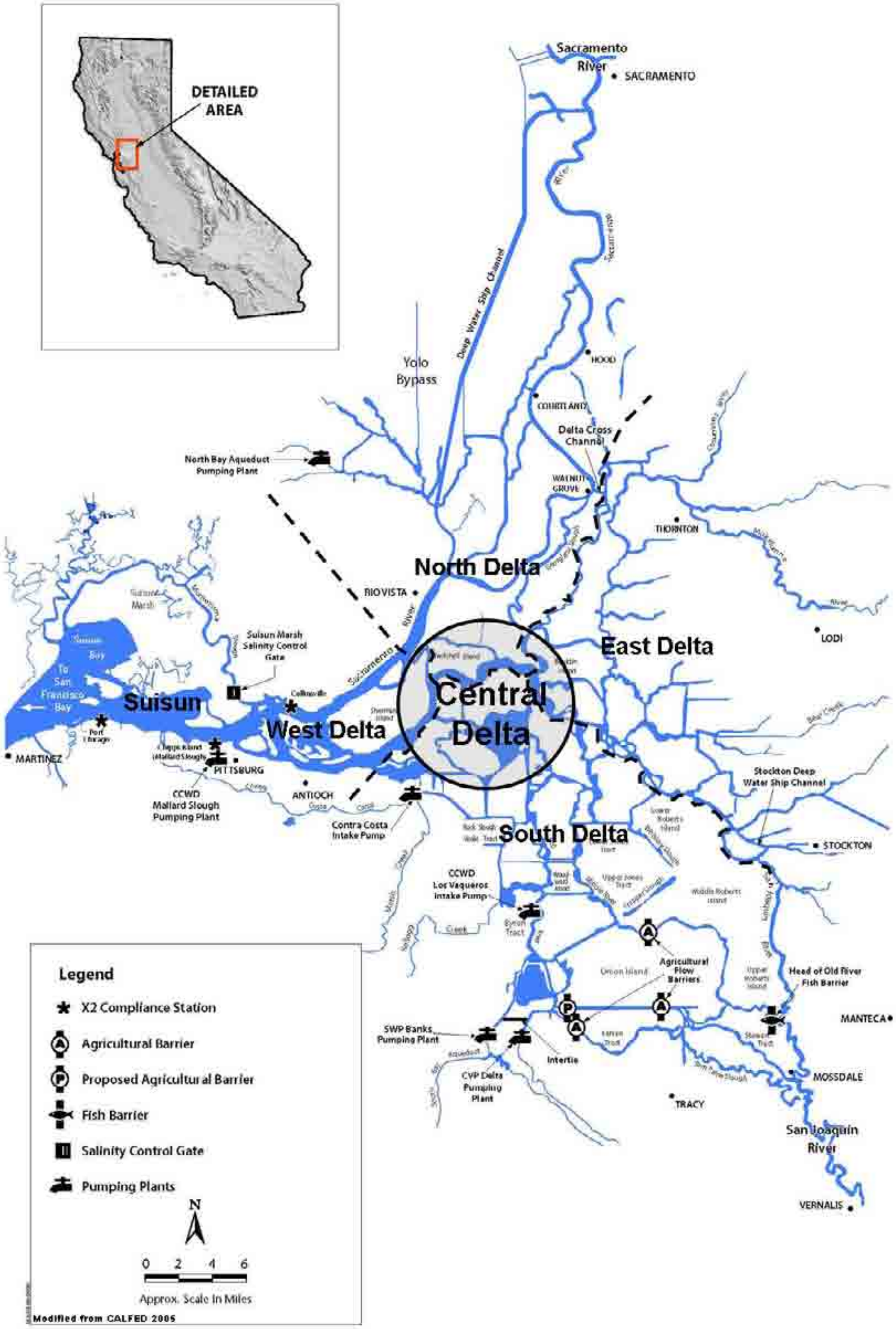


Figure S-1 Map of the Delta with Delta Regions Identified

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 S-2 shows the monitoring stations that are sampled in the Bay-Delta Estuary. Each of these programs captures delta smelt to some degree, 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 Fall Midwater Trawl Survey (FMWT) and the Summer Townet Survey (TNS) are the two longest running IEP fish monitoring programs that are used to index delta smelt abundance. They work well because they were originally designed to target age-0 striped bass, which have similar habitat requirements to delta smelt. Two more recent programs, the 20-mm Survey and the Spring Kodiak Trawl Survey (SKT), 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 different life stages and encompasses the entire distribution of delta smelt for the given life stage and time of year. 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 Bay-Delta. 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 a subset of 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 (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 young 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 though June. This survey also simultaneously samples zooplankton with a Clarke-Bumpus net during one of the three sampling tows at each site.

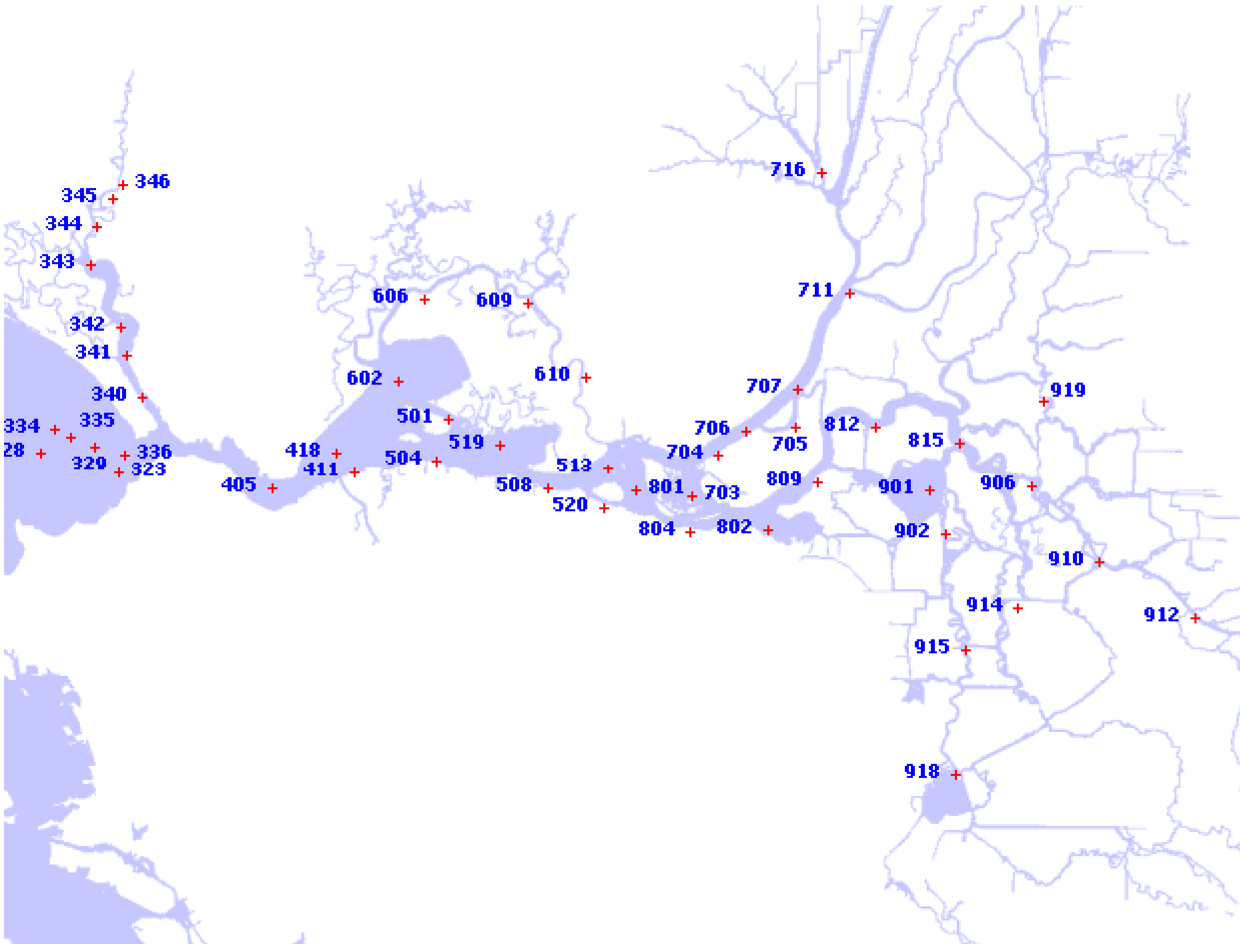


Figure S-2 Map of Bay Delta Estuary Sampling Locations for the TNS and 20-mm Survey (DFG Bay Delta website 2008)

Data from the SKT are used to monitor and provide information on the pre-spawning and spawning distributions of delta smelt. The survey also quantifies the reproductive maturity status of all adult delta smelt collected. SKT sampling has been done since 2002 at approximately 39 stations. Sampling at each station is completed five or more times per year from January to May. Supplemental surveys are often completed 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 fish facilities. 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 commonly acknowledged that delta smelt often do not survive the salvage process. Data on the salvage of delta smelt 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.

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 S-3 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).

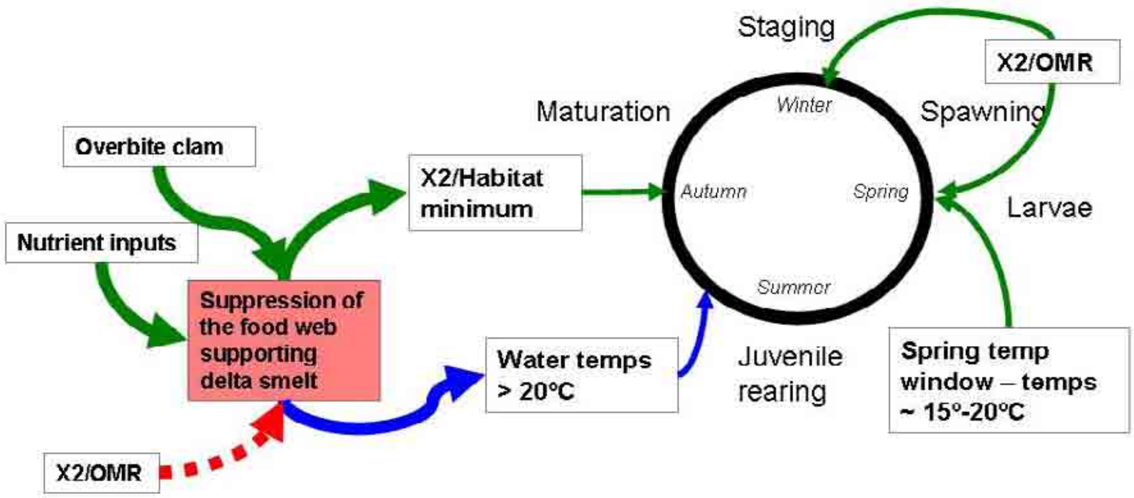


Figure S-3 Lifecycle Conceptual Model For Delta Smelt. The Larger the Arrow Size, the Stronger the Influence on the Process Box

Delta smelt are weakly anadromous and undergo a spawning migration from brackish water to freshwater annually (Moyle 2002). 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. In winters featuring high Delta outflow, the spawning range of delta smelt shifts west to include the Napa River (Hobbs et al. 2007).

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 or cued by abrupt changes in flow and turbidity associated with the first flush of winter precipitation (Grimaldo et al, accepted manuscript) but can also occur after very high flood flows have receded. Grimaldo et al (accepted manuscript) 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 (Moyle 2002). Most adult delta smelt die after spawning (Moyle 2002). However, some fraction of the population may hold over as two-year-old fish and spawn in the subsequent year.

During and after a variable period of larval development, the young fish migrate downstream until they reach the low-salinity zone (LSZ) (indexed as X2) where they reside until the following winter (Moyle 2002). The location of the delta smelt population follows changes in the location of the LSZ which depends primarily on delta outflow.

Biology and Life History

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 SL) 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 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).

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.

Presence of newly hatched larvae likely indicates regions where spawning has occurred. The 20-mm trawl has captured small (~5 mm Standard Length [SL]) 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 SL), 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.

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.

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).

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).

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 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.

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 but 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 LSZ from late spring through fall and early winter. Once in the rearing area growth is rapid, and juvenile fish are 40-50 mm SL long by early August (Erkkila *et al.* 1950; Ganssle 1966; Radtke 1966). They reach adult size (55-70 mm SL) 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).

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 biological opinion, there is evidence that X2 in the fall influences delta smelt population dynamics.

Delta smelt seem to prefer water with high turbidity, based on 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. The delta smelt’s preference for turbid water may be related to increased foraging efficiency (Baskerville-Bridges et al. 2004) and reduced risk of predation.

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).

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 into 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 a 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 inland 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 (in press) showed that inland 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).

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 2002b). 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).

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. Though not restricting spawning *per se*, based on particle tracking modeling, export of water by the CVP and SWP would usually restrict reproductive success of spawners in the San Joaquin River by entraining most larvae during downstream transport from spawning sites to rearing areas (Kimmerer and Nobriga 2008). There is one, non-wet year exception to this generalization: in 2008, delta smelt entrainment was managed under a unique system of restrictions imposed by the Court in NRDC v Kempthorne. In 2008, CVP/SWP operations were constrained in accordance with recommendations formulated by the Service expressly to limit entrainment of delta smelt from the Central Delta.

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 Hyalella azteca (Werner et al. 2008). 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 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).

The position of the LSZ where delta smelt rear has also changed over the years. 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).

Delta Smelt Population Dynamics and Abundance Trends

The FMWT provides the best available long-term index of the relative abundance of delta smelt (Moyle et al. 1992; Sweetnam 1999). The indices derived from these surveys closely mirror trends in catch per unit effort (Kimmerer and Nobriga 2005), but do not at present support statistically reliable population abundance estimates, though substantial progress has recently been made (Newman 2008). FMWT derived data are generally accepted as providing a reasonable basis for detecting and roughly scaling interannual trends in delta smelt abundance.

The FMWT derived indices have ranged from a low of 27 in 2005 to 1,653 in 1970 (Figure S-5). For comparison, TNS-derived indices have ranged from a low of 0.3 in 2005 to a high of 62.5 in 1978 (Figure S-4). Although the peak high and low values have occurred in different year, the TNS and FMWT indices show a similar pattern of delta smelt relative abundance; higher prior to the mid-1980s and very low in the past seven years.

From 1969-1981, the mean delta smelt TNS and FMWT indices were 22.5 and 894, respectively. Both indices suggest the delta smelt population declined abruptly in the early 1980s (Moyle et al. 1992). From 1982-1992, the mean delta smelt TNS and FMWT indices dropped to 3.2 and 272 respectively. The population rebounded somewhat in the mid-1990s (Sweetnam 1999); the mean TNS and FMWT indices were 7.1 and 529, respectively, during the 1993-2002 period. However, delta smelt numbers have trended precipitously downward since about 2000.

Figure S-4. TNS abundance indices for delta smelt.

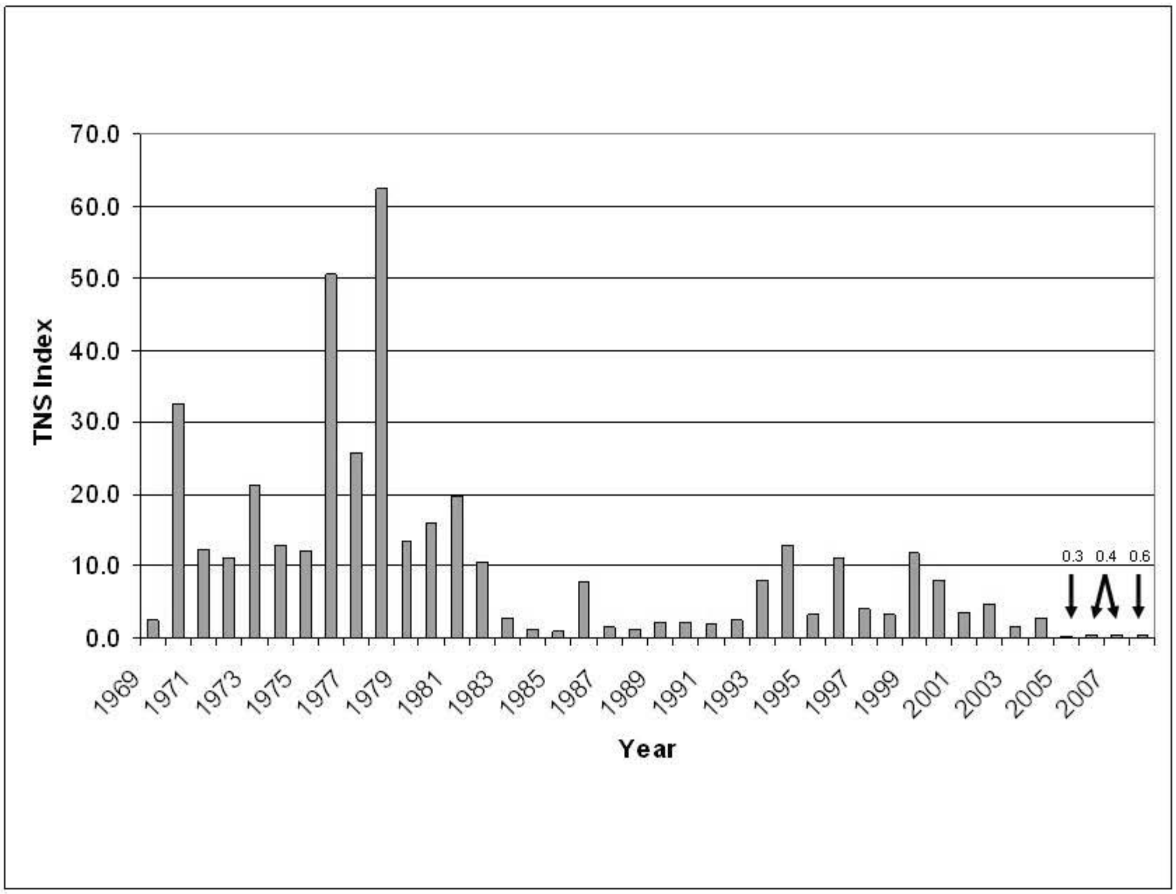
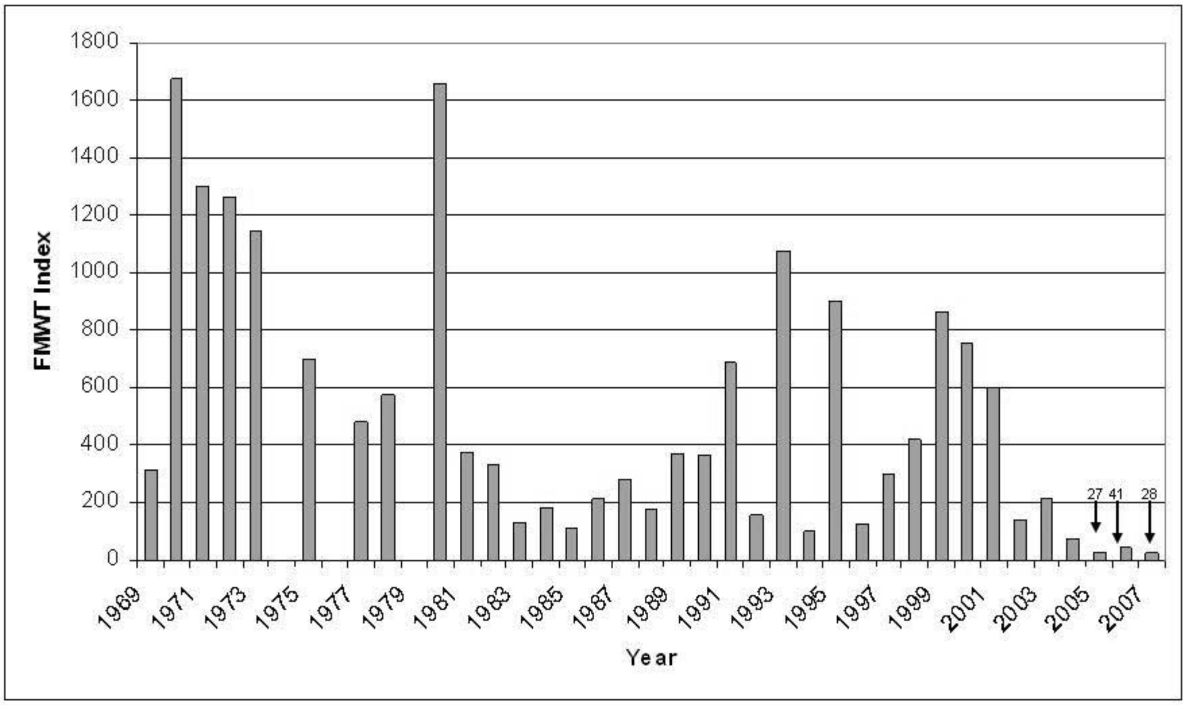


Figure S-4. FMWT abundance indices for delta smelt.



Currently, the delta smelt population indices are two orders of magnitude smaller than historical highs (Figures S-4 and S-5) and recent population abundance estimates are up to three orders of magnitude below historical highs (Newman 2008). After 1999 both the FMWT and the TNS population indices showed declines, and from 2000 through 2007 the median FMWT index was 106.5. The lowest FMWT abundance indices ever obtained were recorded during 2004-2007 (74, 27, 41, and 28, respectively; Figure S-5). The median TNS index during the period from 2000 through 2008 fell similarly to 1.6, and has also dropped to its lowest levels during the last four years with indexes of 0.3, 0.4, 0.4, and 0.6 during 2005 through 2008, respectively (Figure S-4). It is highly unlikely that the indices from 2004-2007 can be considered statistically different from one another (see Sommer et al. 2007), but they are very likely lower than at any time prior in the period of record.

The total number of delta smelt collected in the 20-mm Survey decreased substantially during the years from 2002 to 2008 (4917 to 587 fish) compared to the period 1995 through 2001 (98 to 1084 fish) (Figure S-6). Similarly, the number of delta smelt caught in the SKT has decreased steadily since the survey started in 2002 (Figure S-6)

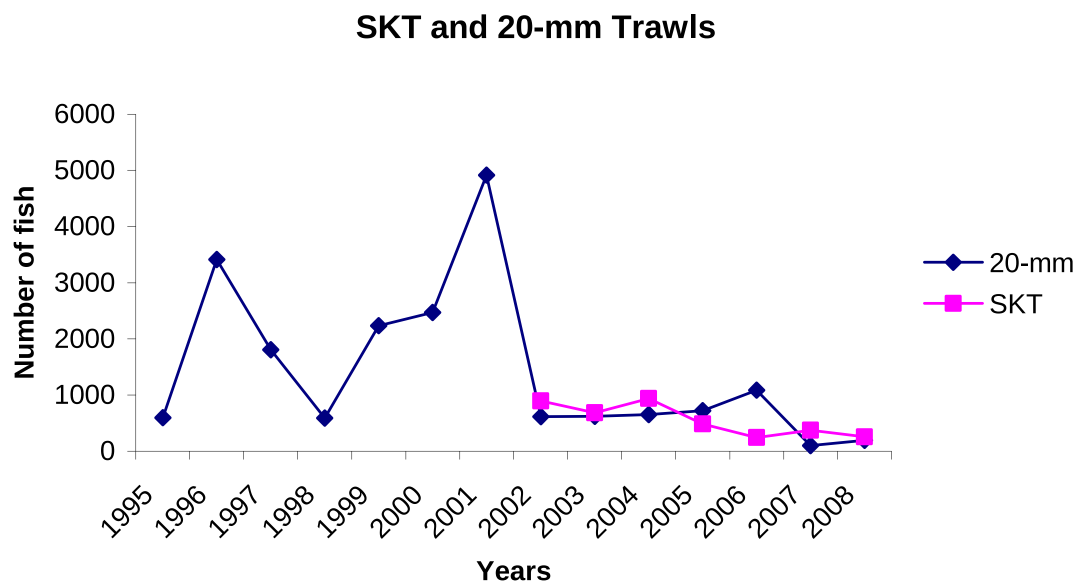


Figure S-6. Number of fish collected in the Spring Kodiak Trawl and the 20-mm surveys. Only the eight first 20-mm trawl surveys are included and only data from the four first full surveys of the SKT. SKT data from DFG at http://www.delta.dfg.ca.gov/ and 20-mm trawl catch data provided by DFG.

Since about 2002, delta smelt is one of four pelagic fish species subject to what has been termed the Pelagic Organism Decline or POD (Sommer et al. 2007). The POD denotes the sudden, overlapping declines of San Francisco Estuary pelagic fishes first recognized in data collected from 2002-2004. The POD species include delta smelt, longfin smelt, threadfin shad (*Dorosoma petenense*), and (age-0) striped bass (*Morone saxatillis*), which together account for the bulk of the resident pelagic fish biomass in the tidal water upstream of X2. The year 2002 is often recognized as the start of the POD because of the striking declines of three of the four POD species between 2001 and 2002; however, statistical review of the data (e.g., Manly and Chotkowski 2006) has revealed that for at least delta smelt, the POD downtrend really began earlier (around 1999). Post-2001 abundance indices for the POD species have included record lows for all but threadfin shad. The causes of the POD and earlier declines are not fully understood, but appear to be layered and multifactorial (Baxter et al. 2008). Several analyses have concluded that the shift in pelagic fish species abundance in the early 1980s was caused by a decrease in habitat carrying capacity or production potential (Moyle et al. 1992, Bennett 2005; Feyrer et al. 2007).

There is some evidence that the recruitment of delta smelt may have sometimes responded to springtime flow variation (Herbold et al. 1992; Kimmerer 2002). However, the weight of evidence suggests that delta smelt abundance does not (statistically) respond to springtime flow like the abundance of the species mentioned above (Stevens and Miller 1983; Jassby et al. 1995; Bennett 2005). The number of days of suitable spawning temperature during spring is correlated with subsequent abundance indices in the autumn (Bennett 2005). This is evidence that cool springs, which allow for multiple larval cohorts, can contribute to population resilience. However, these relationships do not explain a large proportion of variance in autumn abundance. Depending on which abundance index is used, the r^2 are 0.24-0.29.

The relationship between numbers of spawning fish and the numbers of young subsequently recruiting to the adult population is known as a stock-recruit relationship. Analysis of stock-recruit relationships using delta smelt survey data indicate that a weak density dependent effect has occurred during late summer/fall (Bennett 2005, Reclamation 2008), suggesting that delta smelt year-class strength has often been set during late summer and fall. This is supported by studies suggesting that the delta smelt is food limited (Bennett 2005; IEP 2005) and evidence for density dependent mortality has been presented by Brown and Kimmerer (2001). However, the number of days during the spring that water temperature remained between 15 ºC and 20 ºC, with a density-dependence term to correct for the saturating TNS-FMWT relationship (described above), predicts FMWT indices fairly well ($r^2 \approx 0.70$; $p < 0.05$; Bennett, unpublished presentation at the 2003 CALFED Science Conference). This result shows that of the quantity of young delta smelt produced also contributes to future spawner abundance. Bennett (2005) analyzed the relationship between delta smelt spawner population and spawner recruits using data before and after the 1980s decline. He concluded that density dependence pre-1982 may have occurred at FMWT values of 600 to 800 and at FMWT values of 400 to 500 for the period 1982 through 2002.

Bennett (2005) also conducted extensive stock-recruit analyses using the TNS and FMWT indices. He provided statistical evidence that survival from summer to fall is nonlinear (= density-dependent). He also noted that carrying capacity had declined. Bennett (2005) surmised that density-dependence and lower carrying capacity during the summer and fall could happen in a small population if habitat space was smaller than it was historically. This hypothesis was recently demonstrated to be true (Feyrer et al. 2007). Reduced Delta outflow during autumn has led to higher salinity in Suisun Bay and the Western Delta while the proliferation of submerged vegetation has reduced turbidity in the South Delta. Together, these mechanisms have led to a long-term decline in habitat suitability for delta smelt. High summer water temperatures also limit delta smelt distribution (Nobriga et al. 2008) and impair health (Bennett et al. 2008).

A minimum amount of suitable habitat during summer-autumn may interact with a suppressed pelagic food web to create a bottleneck for delta smelt (Bennett 2005; Feyrer et al. 2007; Bennett et al. 2008). Prior to the overbite clam invasion, the relative abundance of maturing adults collected during autumn was unrelated to the relative abundance of juveniles recruiting the following summer (i.e., the stock-recruit relationship was density-vague). Since the overbite clam became established, autumn relative abundance explains 40 percent of the variability in subsequent juvenile abundance (Feyrer et al. 2007). When autumn salinity is factored in, 60 percent of the variance in subsequent juvenile abundance is accounted for statistically.

Since 2000, the stock-recruit relationship for delta smelt has been stronger still ($r^2 = 0.88$ without autumn habitat metrics factored in; Baxter et al. 2008). This has led to speculation about Allee effects. Allee effects occur when reproductive output per fish declines at low population levels (Allee 1931, Berec et al. 2006). Below a certain threshold the individuals in a population can no longer reproduce rapidly enough to replace themselves and the population spirals to extinction. For delta smelt, possible mechanisms for Allee effects include mechanisms directly related to reproduction and genetic fitness such as difficulty finding enough males to maximize egg fertilization during spawning (e.g., Purchase et al. 2007). Genetic problems arising from small population sizes like inbreeding and genetic drift also can contribute to Allee effects, but genetic bottlenecks occur after demographic problems like the example of finding enough mates (Lande 1988). Other mechanisms related to survival such as increased vulnerability to predation are also possible based on studies of other species.

These data provide evidence that factors affecting juvenile delta smelt during summer-autumn are also impairing delta smelt reproductive success. Thus, the interaction of warm summer water temperatures, suppression of the food web supporting delta smelt, and spatially restricted suitable habitat during autumn affect delta smelt health and ultimately survival and realized fecundity (Figure S-3).

Another possible contributing driver of reduced delta smelt survival, health, fecundity, and resilience that occurs during winter is the “Big Mama Hypothesis” (Bill Bennett, UC Davis, pers. comm. and various oral presentations). As a result of his synthesis of a variety of studies, Bennett proposed that the largest delta smelt (whether the fastest growing age-1 fish or fish that manage to spawn at age-2) could have a large influence on population trends. Delta smelt larvae spawned in the South Delta have high risk of entrainment under most hydrologic conditions (Kimmerer 2008), but water temperatures often warm earlier in the South Delta than the Sacramento River (Nobriga and Herbold 2008). Thus, delta smelt spawning often starts and ends earlier in the Central and South Delta than elsewhere. This differential warming may contribute to the “Big Mama Hypothesis” by causing the earliest ripening females to spawn disproportionately in the South Delta, putting their offspring at high risk of entrainment. Although water diversion strategies have been changed to better protect the ‘average’ larva, the resilience historically provided by variable spawn timing may be reduced by water diversions and other factors that covary with Delta inflows and outflows.

Substantial increases in winter salvage at Banks and Jones that occurred contemporaneously with recent declines in delta smelt and other POD species (Kimmerer 2008, Grimaldo et al. accepted manuscript) support the interpretation that entrainment played a role in the POD-era depression of delta smelt numbers. Increased winter entrainment of delta smelt represents a loss of pre-spawning adults and all their potential progeny (Sommer et al. 2007). Note that winter salvage levels subsequently decreased to very low levels for all POD species during the winters of 2005-2006 and 2006-2007, possibly due to the very low population sizes during those periods. Reduced pumping for protection of delta smelt also substantially reduced OMR flow towards the pumps and subsequently reduced number of delta smelt entrained during the winters of 2006-2007 and 2007-2008.

The hydrologic and statistical analyses of relationships between OMR flows and salvage suggest a reasonable mechanism by which winter entrainment increased with increased exports during the POD years; however, entrainment is not a substantial source of mortality every year. Manly and Chotkowski (2006; IEP 2005) found that monthly or semi-monthly measures of exports or Old and Middle rivers flow had a reliable, statistically significant effect on delta smelt abundance; however, individually they explained a small portion (no more than a few percent) of the variability in the fall abundance index of delta smelt across the entire survey area and time period. Kimmerer (2008) addressed delta smelt entrainment by means of particle tracking, and estimated historical entrainment rates for larvae and juvenile delta smelt to be as high as 40 percent; however, he concluded that non-entrainment mortality in the summer had effects on FMWT delta smelt numbers. Hence, there are other factors that often mask the effect of entrainment loss on delta smelt fall abundance in these analyses. Among them, availability and quality of summer and fall habitat (see Effects section) are clearly affected by CVP/SWP operations.

We conclude that entrainment and habitat availability/quality jointly contribute to downward pressure on spawner recruitment in and one or both of these general mechanisms is operating throughout the year. The intensity of constraints of the other threats affecting the delta smelt carrying capacity varies between years, and the importance of contributing stressors changes as outflow, export operations, weather, and the abundances of other ecosystem elements vary. For instance, Bennett (2005) noted that seasonally low outflow and warmer water temperatures may concentrate delta smelt and other planktivorous fishes into relatively small patches of habitat during late summer. This would increase competition and limit food availability during low outflow. Higher outflow that expands and moves delta smelt habitat downstream of the Delta is expected to improve conditions for delta smelt (Feyrer et al. 2007). The high proportion of the delta smelt population that has been entrained during some years (Kimmerer 2008) would be expected to reduce the ability of delta smelt to respond to the improved conditions, thereby limiting the potential for increased spawner recruitment. Further, the smaller sizes of maturing adults during fall may have affected delta smelt fecundity (Bennett, 2005). This would further reduce the species' ability to respond to years with improved conditions.

Factors Affecting the Species

Water Diversions and Reservoir Operations

Banks and Jones Export Facilities

In 1951, the Tracy Pumping Plant (now referred to as the Jones Pumping Plant), with a capacity of 4,600 cfs, was completed along with the Delta Mendota Canal which conveys water from the Jones Pumping Plant (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 the Jones Pumping Plant. 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, not as a grouping of 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 Clifton Court Forebay was completed. In 1991 an additional four pumping units were added, increasing Banks Pumping plant capacity to 10,300 cfs. However, this diversion rate has historically been 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, pumping in excess of 6680 at a rate equal to one-third of the San Joaquin River flow at Vernalis has historically been permissible. Furthermore, under the EWA, the SWP has been 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. 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 (Figure P-18).

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 calculated as "Qwest" (Dayflow at http://www.iep.ca.gov/dayflow/). Flow towards the pumps is characterized as negative flow for both measurements. Further, 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, water exports and fish entrainment at Jones and Banks are 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. For Banks in particular, it does not account for high rates of predation on fish in CCF (Gingras 1997). Fish less than 30 mm forklength (FL) are not efficiently collected by the fish screens (Kimmerer 2008).

The entrainment of adult delta smelt at Jones and Banks occurs mainly during their upstream spawning migration between December and April (Figure S-7). Entrainment risk depends on the location of the fish relative to the export facilities and the level of exports (Grimaldo et al. accepted manuscript). The spawning distribution of adult delta smelt varies widely among years. In some years a large proportion of the adult population migrates 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.

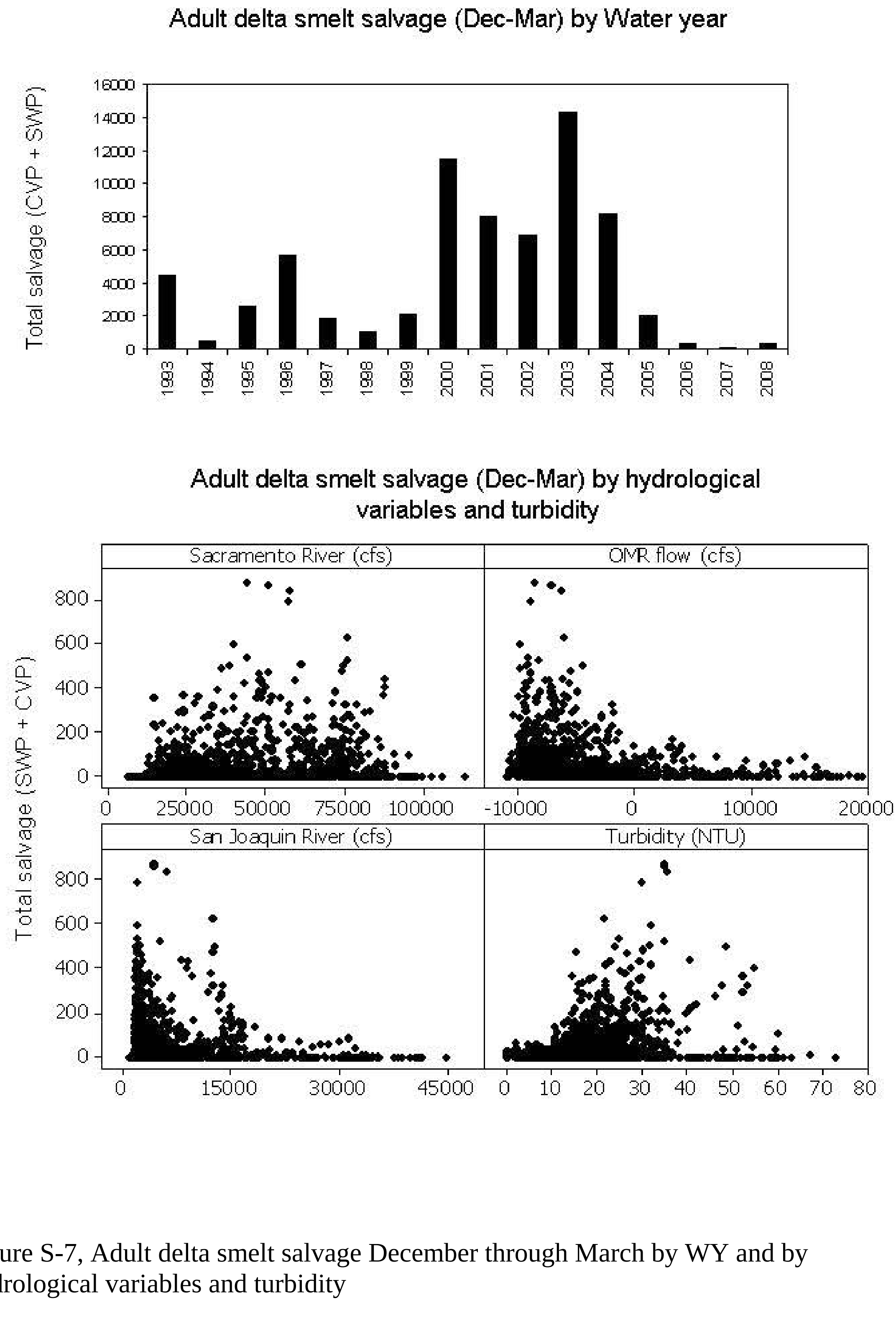
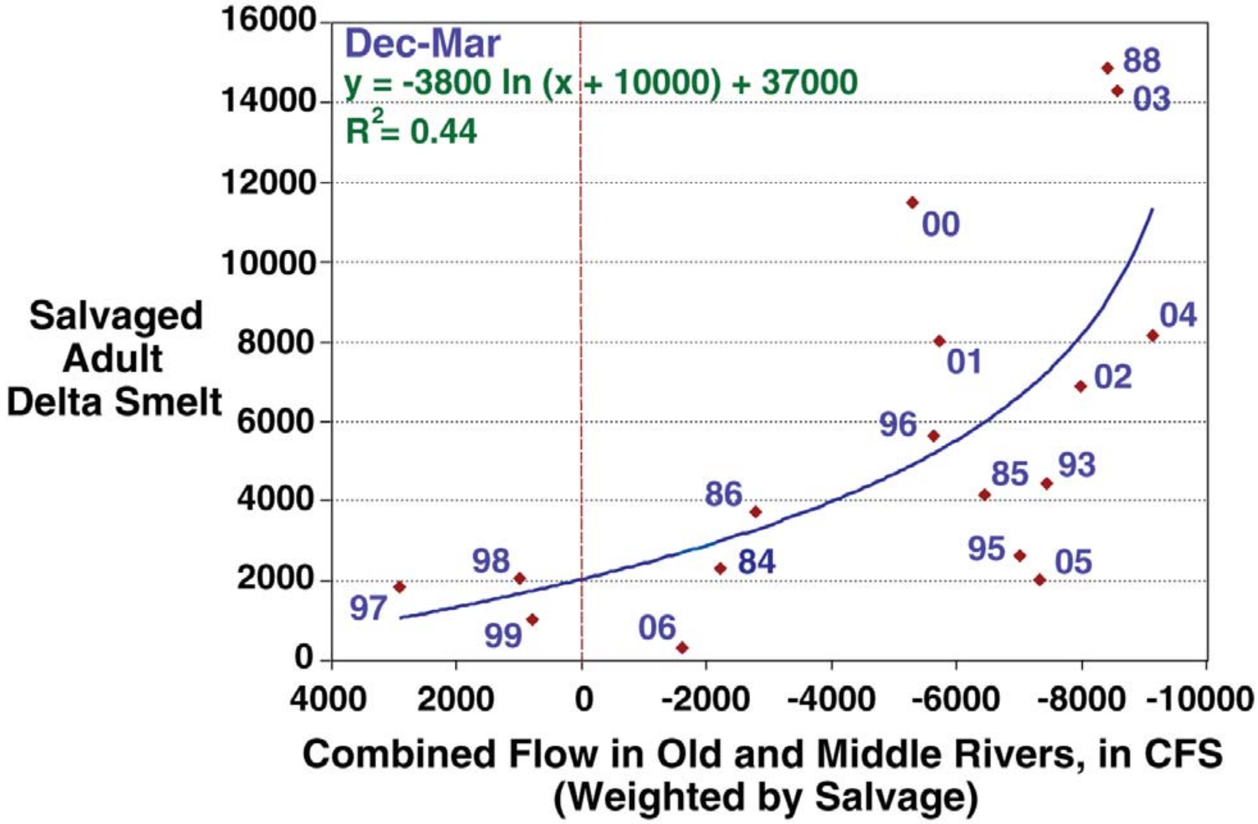


Figure S-7, Adult delta smelt salvage December through March by WY and by hydrological variables and turbidity

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, accepted manuscript).

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 (Figure P-17). 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 (Figure 7-12, 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 (Fig. 7-6 in Reclamation 2008; P. Smith, unpublished data; Grimaldo et al accepted manuscript; Kimmerer 2008) (See Figure S-8). 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.



Note: Data shown are for the period 1984-2007, excluding years 1987, 1989-92, 1994, and 2007 that had low (<12ntu) average water turbidity during Jan-Feb at Clifton Court Forebay.

Figure S-8 – Relationship for the total number of adult delta smelt salvaged at the State and Federal fish facilities in the south Delta during the winter months of December through March with the combined, tidally averaged flow in Old and Middle Rivers near Bacon Island (AVG_OMR_i).

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 by coupling PTM with 20-mm survey results to estimate historical larval entrainment. These approaches suggest that larval entrainment losses could exceed 50 percent 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 serve reduction in that year's production. 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 young of the year (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., accepted manuscript: 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 (Figure S-9). 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 biological opinions (Brown and Kimmerer 2002).

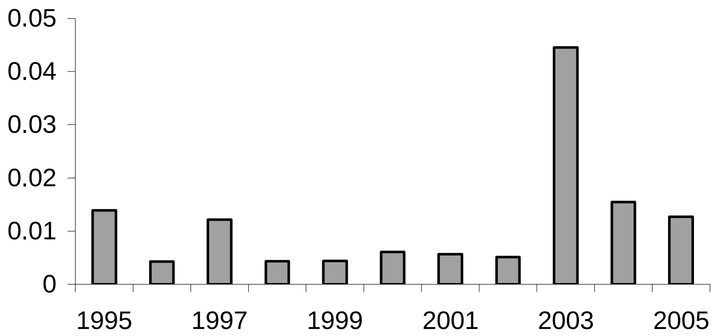


Figure S-9. Ratio of salvage density to the previous FMWT index.

In 2007 and 2008, 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 two years estimated number of delta smelt salvaged decreased considerably. Estimated adult salvage was 60 and 350 in 2007 and 2008, respectively. Total (adults and young-of-the-year) estimated salvage was 2,327 and 2,038 delta smelt, respectively. These were down from a high of 14,338 in 2003.

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 and 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 (Wanger Order)

For the 2008 WY, a dry WY, the Service, Reclamation and DWR implemented the direction contained in the Wanger 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. Starting in 2009, an expanded larval survey in the Delta will be conducted. 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. There may be years, however, that large numbers of delta smelt are in the Cache Slough complex and could be subject the 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. To date, the Rock Slough Intake is not screened. Reclamation, as described in the Project Description, is responsible for constructing a fish screen at this facility under the authority of the CVPIA. Reclamation has received an extension for construction of the screen until 2008 and is seeking a further extension until 2013. 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

In 2006, the Service issued a biological opinion on the construction and operation of the Stockton Delta Water Supply Facility located on Empire Tract along the San Joaquin River. This facility is expected to be completed and online by 2010. The maximum diversion rate for this facility will be 101 AF per day. Fish screens and pumping restrictions in the spring are expected to considerably limit entrainment of delta smelt. However, limited pumping will occur during the spring and the fish screens are not expected to fully exclude fish smaller than 20 mm TL, so delta smelt may be entrained at this facility.

There are 2,209 known agricultural diversions in the Delta and an additional 366 diversions in Suisun Marsh used for enhancement of waterfowl habitat (Herren and Kawasaki 2001). The vast majority of these diversions do not have fish screens to protect fish from entrainment. It has been recognized for many years that delta smelt are entrained in these diversions (Hallock and Van Woert 1959). Determining the effect of this entrainment has been limited because previous studies either (1) did not quantify the volumes of water diverted (Hallock and Van Woert 1959, Pickard et al. 1982) or (2) did not sample at times when, or locations where, delta smelt were abundant (Spaar 1994, Cook and Buffaloe 1998). Delta smelt primarily occur in large open-water habitats, but early life stages move downstream through Delta channels where irrigation diversions are concentrated (Herren and Kawasaki 2001). At smaller spatial scales, delta smelt distribution can be influenced by tidal and diel cycles (Bennett et al. 2002), which also may influence vulnerability to shore-based diversions.

In the early 1980s, delta smelt were commonly entrained in the Roaring River diversion in Suisun Marsh (Pickard et al. 1982), suggesting that it and similar diversions can adversely affect delta smelt. However, delta smelt may not be especially vulnerable to many Delta agricultural diversions for several reasons. First, adult delta smelt move into the Delta to spawn during winter-early spring when agricultural diversion operations are at a minimum. Second, larval delta smelt only occur transiently in most of the Delta and now avoid the South Delta during summer when diversion demand peaks. Third, Nobriga et al. (2004) examined delta smelt entrainment at an agricultural diversion in Horseshoe Bend during July 2000 and 2001, when much of the YOY population was rearing within one tidal excursion of the diversion. Delta smelt entrainment was an order of magnitude lower than density estimates from the DFG 20-mm Survey. Low entrainment was attributed to the offshore distribution of delta smelt, and the extremely small hydrodynamic influence of the diversion relative to the channel it was in. Because Delta agricultural diversions are typically close to shore and probably take small amounts of water relative to what is in the channels they draw water from, delta smelt vulnerability may be low despite their small size and their poor performance near simulated fish screens in laboratory settings (Swanson et al. 1998; White et al. 2007).

The impact on fish populations of individual diversions is likely highly variable and depends upon size, location, and operations (Moyle and Israel 2005). Given that few studies have evaluated the effectiveness of screens in preventing losses of fish, much less declines in fish populations, further research is needed to examine the likely population-level effects of delta smelt mortality attributed to agricultural diversions (Nobriga et al.

2004; Moyle and Israel 2005). Note however, that most of the irrigation diversions are in the Delta, so low flow conditions that compel delta smelt to rear in the Delta fundamentally mediate loss to these irrigation diversions. PTM evidence for this covariation of Delta hydrodynamics and cumulative loss to irrigation diversions was provided by Kimmerer and Nobriga (2008).

Delta Power Plants

There are two major power plants located near the confluence of the Sacramento and San Joaquin Rivers. The upstream-most facility is commonly referred to as the Contra Costa Power Plant while the downstream-most facility is commonly referred to as the Pittsburg Power Plant. Both facilities are located in the low salinity rearing habitats of delta smelt. The following assessment of the Contra Costa and Pittsburg Power Plants comes from information collected by Matica and Sommer (2005).

The Contra Costa Power Plant is located 2.5 miles upstream from the city of Antioch. The first units were operational in June 1951. By 1975, with expansions, the power plant incorporated 7 main power-generating units and 3 smaller house units. In 1995, Units 1-5 were decommissioned. When all units were operating, the cooling water flows into Units 1-5 and Units 6-7 were up to 946 and 681 cfs, respectively. Cooling water was diverted by two separate intake arrangements. Water for Units 1-5 was taken from near the river bottom 410 feet offshore and for Units 6-7 from a shoreline intake system. Water was carried at 3.8 ft/sec to five recessed onshore traveling trash screens, with 3/8-inch square-opening wire mesh. Calculated screen approach velocities averaged about 1.3 ft/sec with velocities of 2.0 ft/sec through the mesh. Discharge canals return the heated water to the river. For Units 1-5 water was returned 750 ft west of its uptake and for Units 6-7 it is returned 750 ft east of its uptake. Under normal full-load operation the temperature of the discharge water was raised a mean of 16.2 °F and at peak loads the maximum differential between intake and discharge temperature was 21 °F, creating a thermal plume, concentrated near the surface and shoreline, extending over an area of approximately 100 acres.

The Pittsburg Power Plant is located on the south shore of Suisun Bay just west of Pittsburg. This steam generation plant consists of 7 power generating units. Construction began in 1953 and the 7 units were commissioned in 3 phases: Units 1-4 in 1954; Units 5 and 6 in 1960; and Unit 7 in 1961. Units 1-6 withdraw and return cooling water to Suisun Bay. Their intake structures are located on the shoreline about 1,000 feet to the west of the discharge structure. Discharge is located 10-30 feet offshore in about 10 feet of water. Total cooling water flow for Units 1-6 when all pumps are running is 1,612 cfs. Entrainment effects may occur at the plants from large pressure decreases across the condenser at both power plants, and impingement on fish screens.

Overall, the total maximum non-consumptive intake of cooling water for the two facilities is 3,240 cfs, which can exceed 10 percent of the total net outflow of the Sacramento and San Joaquin rivers, depending on hydrology. However, pumping rates are often significantly lower under normal operation. Potential impacts to aquatic species include chemical and thermal pollution, and entrainment. Chemical impacts may occur as a result of chlorination for control of “condenser slime”, which was historically conducted weekly. This treatment at Contra Costa Power Plant consumed a little over 1 ton of chlorine a month, or 13 tons per year. The discharge water was not historically dechlorinated or subject to regular monitoring for residual chlorine.

Thermal pollution represents an additional concern for aquatic species. Temperature objectives set by the California Regional Water Quality Control Board include: "No discharge shall cause a surface water temperature rise greater than 4 ºF above the natural temperature of the receiving water at any time or place"; and "The maximum temperature of thermal waste discharge shall not exceed 86 ºF." Both plants discharge water at temperatures in excess of 86 °F 10 percent of the time, and surface water temperature plumes in the receiving water at each plant exceed +4 °F for areas up to 100 acres. The previous owner of these two plants, Pacific Gas and Electric (PG&E), sought and received exemptions to the above limitations.

In 1951, DFG recognized the power plants presented a potential issue for the salmon and striped bass resources of the area as both plants were originally equipped with inefficient fish barriers. At the time, DFG estimated that as many as 19 million small striped bass might pass through the Contra Costa plant and be killed each year between April and mid-August. As a result of these concerns, DFG and PG&E conducted a monitoring study to evaluate entrainment. In 1979, consultants estimated the total average annual entrainment to be 86 million smelt (delta smelt and longfin smelt not differentiated). The total average annual impingement was estimated to be 178,000 smelt. It's unclear whether these numbers are relevant to current entrainment trends. Further, power plant operations have been reduced such that the plants only operate to meet peak power needs. The current owner of the power plants, Mirant, is currently undergoing a monitoring program that is sampling entrainment and impingement at the Contra Costa and Pittsburg powerplants to compile more recent information on how many delta smelt are affected by the two plants.

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

The SDTB 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 the Project through 2007. The Service has approved the extension of the permits through 2008. Continued coverage by Service for the SDTB will be assessed in this biological opinion for the operational effects and under a separate Section 7 consultation for the construction and demolition effects.

Under the Service's 2001 biological opinion for the SDTB, 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. The SDTB 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.

Trinity River

The Trinity River Division includes facilities to divert water to the Sacramento River Basin. 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).

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 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.

The diversions from the Trinity River have been reduced in recent years after the Trinity River Main-stem Fishery Restoration ROD, dated December 19, 2000, which mandated 368,600 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. These higher flows in the Trinity River system mean less water diverted to the Sacramento River. This reduced water results in less flexibility in releases for Sacramento River flows and can result in increased releases from Shasta Lake.

Seasonal Life History of Delta Smelt

Winter (December-February)

Adult delta smelt are generally distributed in low salinity habitats of the greater Suisun Bay region and the Sacramento and San Joaquin River confluence during fall. Variation in outflow appears to initiate their migration from Suisun Bay upstream to freshwater habitats for spawning. This is because initial catches upstream normally occur in close association with increased turbidity associated with the first strong flow pulse of the winter (Grimaldo et al. accepted manuscript). As a result, entrainment of adult delta smelt at Banks and Jones is also closely associated with factors controlled by outflow or X2 (Grimaldo et al. accepted manuscript). Specifically, salvage of adult delta smelt is significantly negatively associated with flows in OMR flows, and when the flows are highly negative the starting location of the fish indexed by X2 the month prior to entrainment also has an effect (Grimaldo et al. accepted manuscript).
Outflow during winter also affects the entrainment of early-spawned larvae when their distribution is within the hydrodynamic zone affected by pumping operations (Kimmerer 2008). Winter outflow also affects the distribution of spawning fish in major regions. For example, the Napa River is used for spawning only in years when outflow is sufficient to connect the Napa River with low salinity habitat in the estuary (Hobbs et al. 2007).

Spring (March-May)

During spring, YOY delta smelt generally move from upstream spawning locations downstream into low salinity rearing habitats. There is some evidence that recruitment variability of delta smelt may have sometimes responded to springtime flow variation (Herbold et al. 1992; Kimmerer 2002). For example, the number of days X2 is in Suisun Bay during spring is weakly positively correlated with abundance as measured by the FMWT index. However, the weight of evidence suggests that delta smelt abundance does not statistically respond to springtime flow in a similar manner to other species for which the spring X2 requirements were developed (Stevens and Miller 1983; Jassby et al. 1995; Bennett 2005).

However, studies have demonstrated that outflow has a strong effect on the distribution of YOY delta smelt (Dege and Brown 2004) and that it therefore also ultimately influences entrainment at Jones and Banks (Kimmerer 2008). Dege and Brown (2004) found that X2 had a strong influence on the geographic distribution of delta smelt, but distribution with respect to X2 was not affected, indicating that distribution is closely associated with habitat conditions proximal to X2. YOY delta smelt are consistently located just upstream of X2 in freshwater until they become juveniles and enter the low salinity habitats of Suisun Bay later in the year.

Outflow affects the entrainment of YOY delta smelt at the Jones and Banks facilities in several ways. First, because outflow affects adult spawning migration and juvenile distribution, it affects their position relative to the hydrodynamic influence of the diversions (Kimmerer 2008). Second, OMR is the best predictor of salvage and entrainment for adult delta smelt and it is also relevant to larval and juvenile entrainment when considered in the context of X2 (see effects section). In general, the more water that is exported relative to that which is dedicated to outflow enhances negative flows in OMR flow towards the diversions, which in turn increases salvage (Baxter et al. 2008; Kimmerer 2008; Grimaldo et al accepted manuscript).

Summer (June-August)

Summer represents a primary growing season for delta smelt while they are distributed in low salinity habitats of the estuary. X2 affects delta smelt distribution during summer (Sweetnam 1999). Food supply and habitat suitability are currently believed to be important factors for delta smelt during summer (Bennett 2005; Baxter et al. 2008; Nobriga and Herbold 2008). The CVP/SWP affect summer habitat suitability and might affect summer prey co-occurrence through their effect on Delta hydrodynamics.

Fall

During fall, delta smelt are typically fully distributed in low salinity rearing habitats located around the confluence of the Sacramento and San Joaquin Rivers. Suitable abiotic habitat for delta smelt during fall has been defined as relatively turbid water (Secchi depths < 1.0 m) with a salinity of approximately 0.6-3.0 psu (Feyrer et al. 2007). The amount of suitable abiotic habitat available for delta smelt, measured as hectares of surface area, is negatively related to X2 (see effects section). The average X2 during fall has exhibited a long-term increasing trend (movement further upstream), which has resulted in a corresponding reduction the amount and location of suitable abiotic habitat (Feyrer et al. 2007, 2008).

The available data provide evidence to suggest that the amount of suitable abiotic habitat available for delta smelt during fall affects the population in a measurable way. There is a statistically significant stock-recruit relationship for delta smelt in which pre-adult abundance measured by the FMWT positively affects the abundance of juveniles the following year in the TNS (Bennett 2005; Feyrer et al. 2007). Incorporating suitable abiotic habitat into the stock-recruit model as a covariate improves the model by increasing the amount of variability explained by 43 percent, r-squared values improved from 46 percent to 66 percent (Feyrer et al. 2007).

It is likely that changes in X2 and the corresponding amount of suitable abiotic habitat are important to the long-term decline of delta smelt but may have been of lesser importance in the more recent POD. Over the long-term, the amount of suitable abiotic habitat for delta smelt during fall has decreased anywhere from 28 percent to 78 percent, depending on the specific habitat definitions that are considered (Feyrer et al. 2008). The majority of this habitat loss has occurred along the periphery, limiting the distribution of delta smelt mainly to a core region in the vicinity of the confluence of the Sacramento and San Joaquin Rivers (Feyrer et al. 2007). Concurrently, delta smelt abundance as measured by the FMWT decreased by 63 percent. This correspondence and the significant stock-recruit relationship with the habitat covariate strongly suggest that delta smelt have been negatively affected by long-term changes in X2 and habitat. However, at the onset of the POD, delta smelt abundance and suitable abiotic habitat had already declined to a point where it was unlikely that Feyrer's two variable definition of habitat was the primary limiting factor constraining the population.

Nevertheless, X2 (Figure S-10) and inflow-corrected X2 (Figure S-11) during fall in the years following the POD (2000-2005) was several km upstream compared to that for the pre-pod years (1995-1999). This suggests that operations in the Delta have exported more water relative to inflow, which has had a negative effect on X2 by moving it upstream. This is confirmed by a long-term positive trend in the E:I ratio for all months from June through December (Figure S-12). In fact, long-term trends in X2 (Figure S-13), inflow-corrected X2 Figure S-14), and the E:I ratio (Figure S-12) indicate this pattern has been in effect for many years and likely one of the factors responsible for the long-term decline in habitat suitability for delta smelt.

Figure S-10. X2 in years preceding and immediately following the Pelagic Organism Decline.

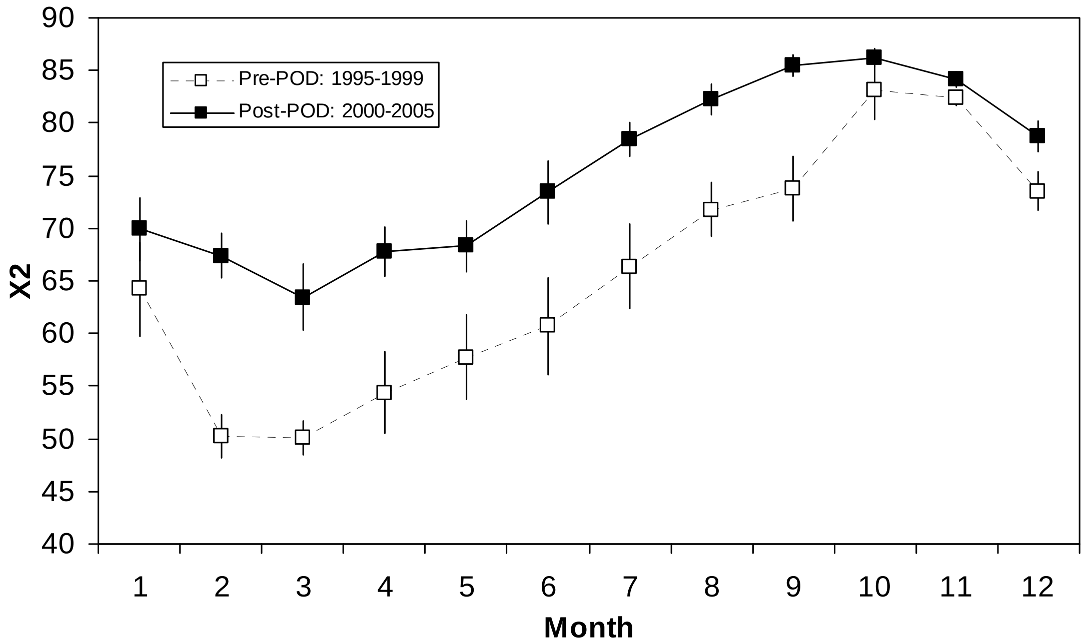


Figure S-11. Inflow-corrected X2 in years preceding and immediately following the Pelagic Organism Decline.

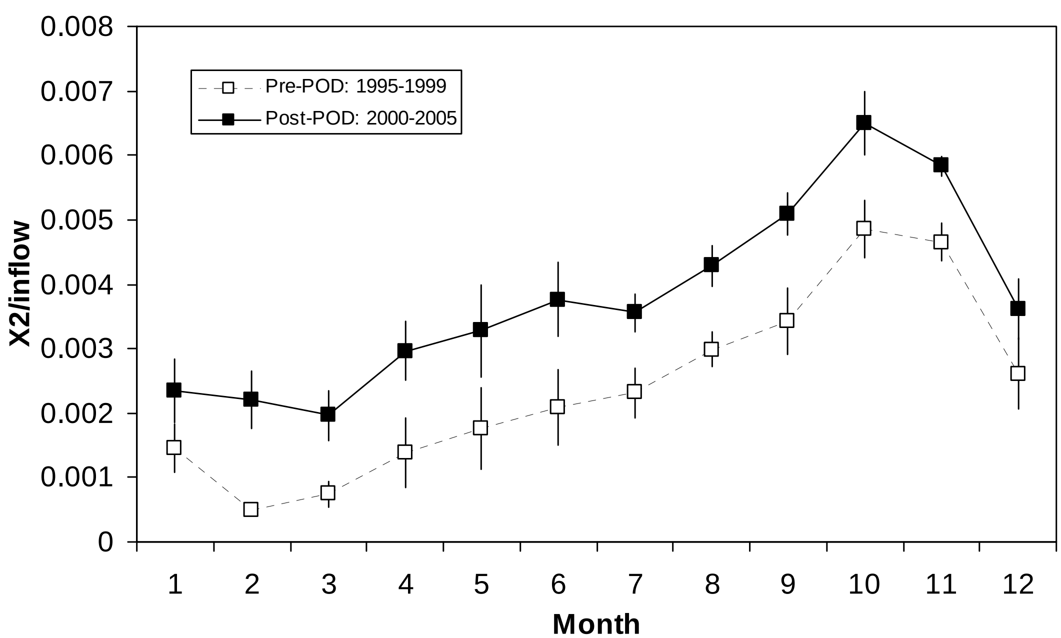


Figure S-12. Monthly time trends of the ratio of project exports to Delta inflow.

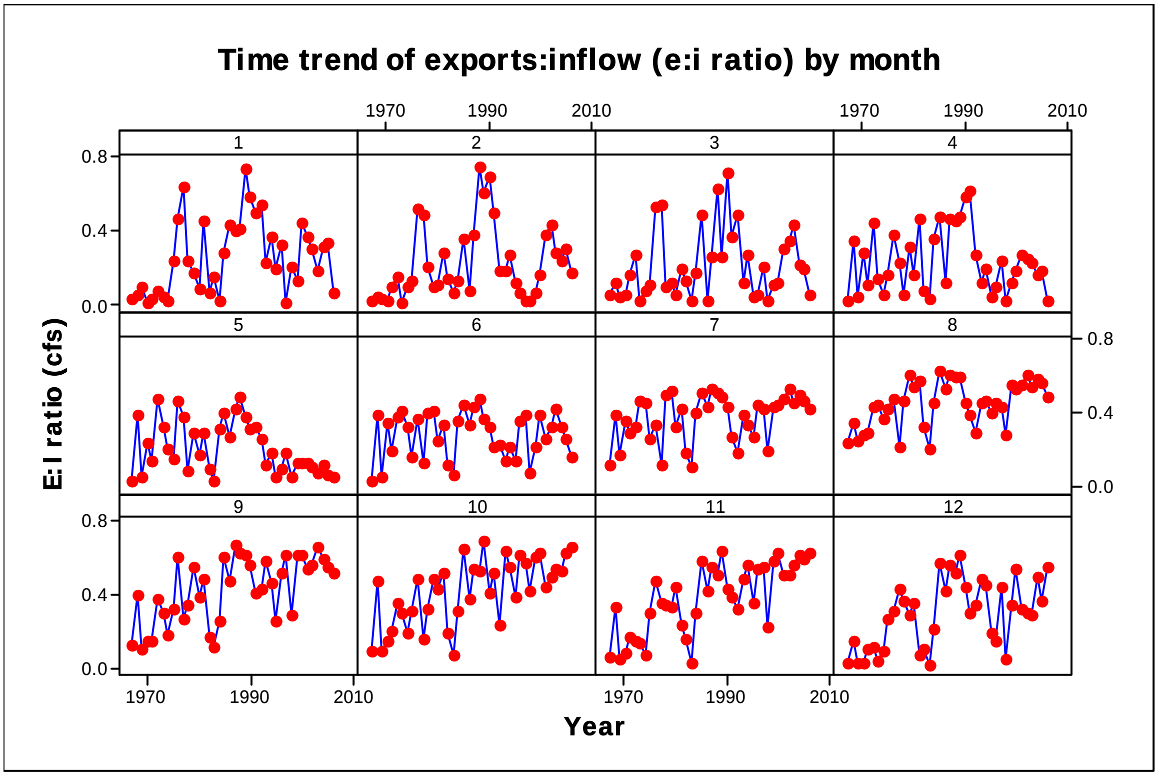


Figure S-13. Monthly time trends of X2.

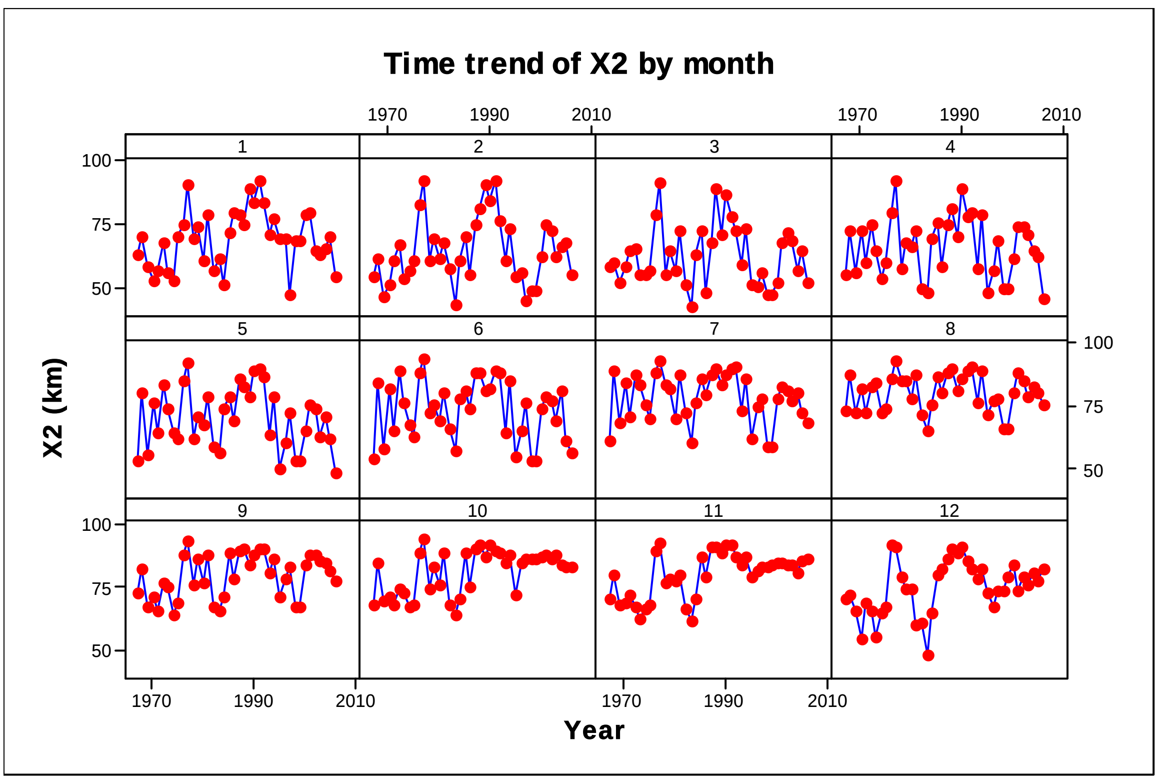
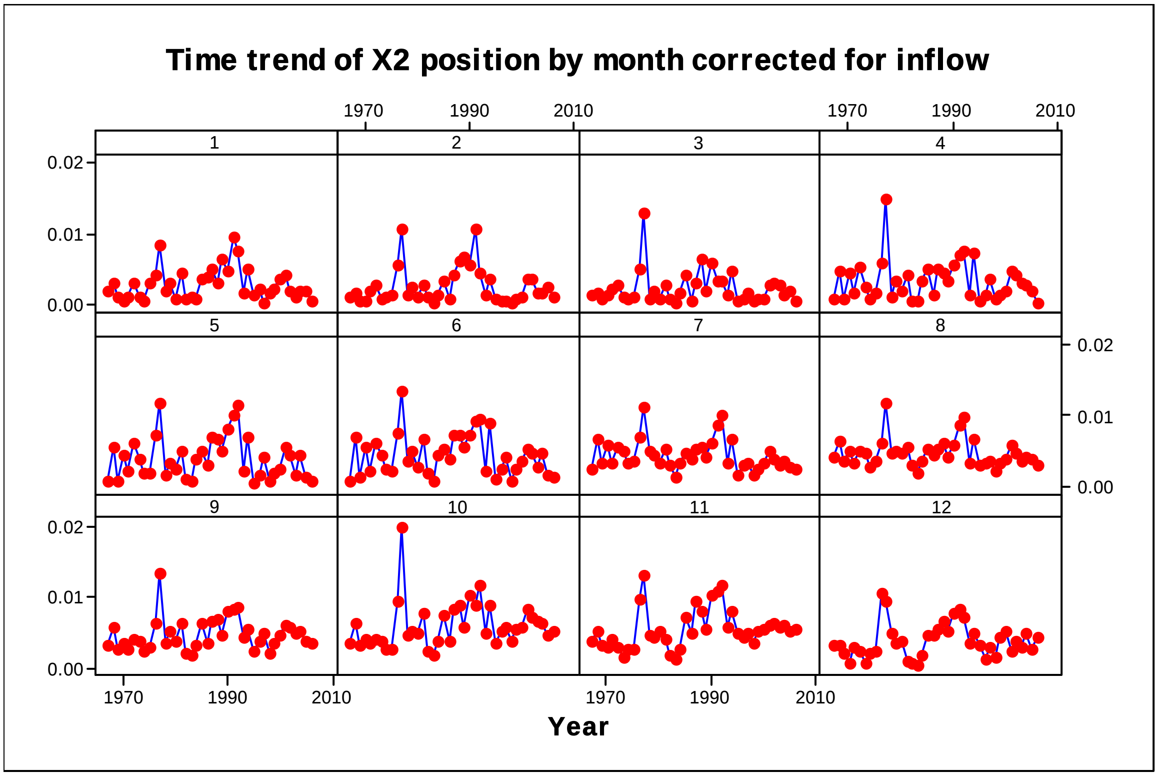


Figure S-14. Monthly time trends of inflow-corrected X2.



Other Stressors

Aquatic Macrophytes

In the last two decades, the interior Delta has been extensively colonized by submerged aquatic vegetation. The dominant submerged aquatic vegetation is *Egeria densa*, a non-native from South America that thrives under warm water conditions. Research suggests that *Egeria densa* has altered fish community dynamics in the Delta, including increasing habitat for centrarchid fishes including largemouth bass (Nobriga et al. 2005; Brown and Michniuk 2007), reducing habitat for native fishes (Brown 2003; Nobriga et al. 2005; Brown and Michniuk 2007), and supporting a food web pathway for centrarchids and other littoral fishes (Grimaldo et al in review). *Egeria densa* has increased its surface area coverage by up to 10 percent per year depending on hydrologic conditions and water temperature (Erin Hestir personal communication University of California Davis).

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.

Delta smelt may experience high predation mortality around water diversions where smelt are entrained and predators aggregate. The eggs and newly-hatched larvae of delta smelt are thought to be prey for inland 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.

The Delta-wide increase in water transparency may have intensified predation pressures on delta smelt and other pelagic fishes in recent years. 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). There has been limited research to address predation of pelagic fishes in offshore habitats. Stevens (1966) examined diets of striped bass in pelagic habitats, finding that they varied by geographical area and prey abundance but no information was provided on the physical variables that may have influenced predation rates. Research is underway to determine the specific factors responsible for increased water transparency in the Delta (David Schoelhammer, personal communication, University of California at Davis) but recent findings suggest the trend is related to the submerged aquatic vegetation invasion in recent years.

Competition

It has been hypothesized that delta smelt are adversely affected by competition from other introduced fish species that use overlapping habitats, including inland silversides, (Bennett and Moyle 1995) striped bass, and wakasagi (Sweetnam 1999). Laboratory studies show that delta smelt growth is inhibited when reared with inland 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.

Delta Smelt Feeding

The DRERIP conceptual model for delta smelt (summarized in figure S-3) provides a thorough summary of delta smelt feeding behavior (Nobriga and Herbold 2008), much of which is described in this section and the Delta food web section. Delta smelt are visual feeders that select prey individually rather than by filtering-feeding. Juvenile and adult smelt primarily eat copepods, but they are also known to prey on cladocerans, mysids, amphipods, and larval fish (Moyle et al. 1992; Lott 1998; Feyrer et al. 2003). During the 1970s and 1980s, delta smelt diets were dominated by *Eurytemora affinis, Neomysis mercedis,* and *Bosmina longirostus* (Moyle et al. 1992; Feyrer et al. 2003), however, none of these are important prey now (Steve Slater personal communication California Department of Fish and Game). When delta smelt diets were examined again between 1988 and 1996, they were consistently dominated by the copepod *Pseudodiaptomus forbesi*, which was introduced and became abundant following the overbite clam invasion (Lott 1998). *Pseudodiaptomus forbesi* was introduced into the San Francisco Bay-Delta in 1988 and became a significant part of the summertime zooplankton assemblage and is now an important prey item for Delta smelt and other small fishes (Kimmerer and Orsi 1996; Nobriga 2002; Hobbs et al. 2006; Bryant and Arnold 2007). Recent diet studies have shown that *Pseudodiaptomus forbesi* (all lifestages) remains an important prey for juvenile delta smelt during summer, but that several other copepods introduced into the system in the mid-1990s, are also frequently being eaten (Steven Slater unpublished data California Department of Fish and Game).

Delta Food Web

Suisun Bay Region

Following the introduction of the overbite clam into the lower Estuary in 1986, a dramatic decline in primary production in the Estuary was documented (Alpine and Cloern 1992; Jassby et al 2002). The overbite clam is a highly efficient grazer with a wide salinity range. It does not encroach into freshwater but its grazing effect does, presumably due to tides (Jassby et al. 2002). With a high metabolism, the overbite clam has been able to reduced standing stocks of phytoplankton to fractions of historic levels. As a consequence, many zooplankton and fish species experienced sharp declines in abundance (Kimmerer and Orsi 1996, Kimmerer 2002, Kimmerer 2007). Clam grazing on copepod nauplii also may affect copepods directly. Despite its impact on the estuarine pelagic food web, to date, there is no direct evidence linking the effects of overbite clam grazing to adverse effects to delta smelt (Kimmerer 2002; Bennett 2005). It has been noted that delta smelt fork lengths have decreased since 1990, but it is uncertain whether this is a direct consequence of the overbite clam. The Feyrer (2007) effect of fall habitat assumes delta smelt have been chronically food-limited since the overbite clam invasion.

There have been two notable zooplankton introductions into the estuarine food web in recent years that have the potential to adversely affect delta smelt trophic dynamics. In the mid 1990s, the estuary was invaded by *Limnoithona tetraspina* and *Acartiella* *sinensis*, both which originated from Asia and are believed to have been introduced via ballast water. *Limnoithona tetraspina* is now the most abundant copepod in the LSZ but evidence suggests that it is not an important food item for delta smelt and other pelagic fishes because of its small size, generally sedentary behavior, and predator-avoidance capability (Bouley and Kimmerer 2006). The consequences of these copepod invasions on the diet of delta smelt feeding remains unknown, but the likely effect is fewer calories per unit when delta smelt prey on *Limnoithona tetraspina*. Experimental studies are currently under way to determine the feeding dynamics of delta smelt on the newly introduced invaders in relation to the current zooplankton fauna of the Delta/Estuary (Lindsay Sullivan RTC 2008 CALFED Science Conference Presentation).

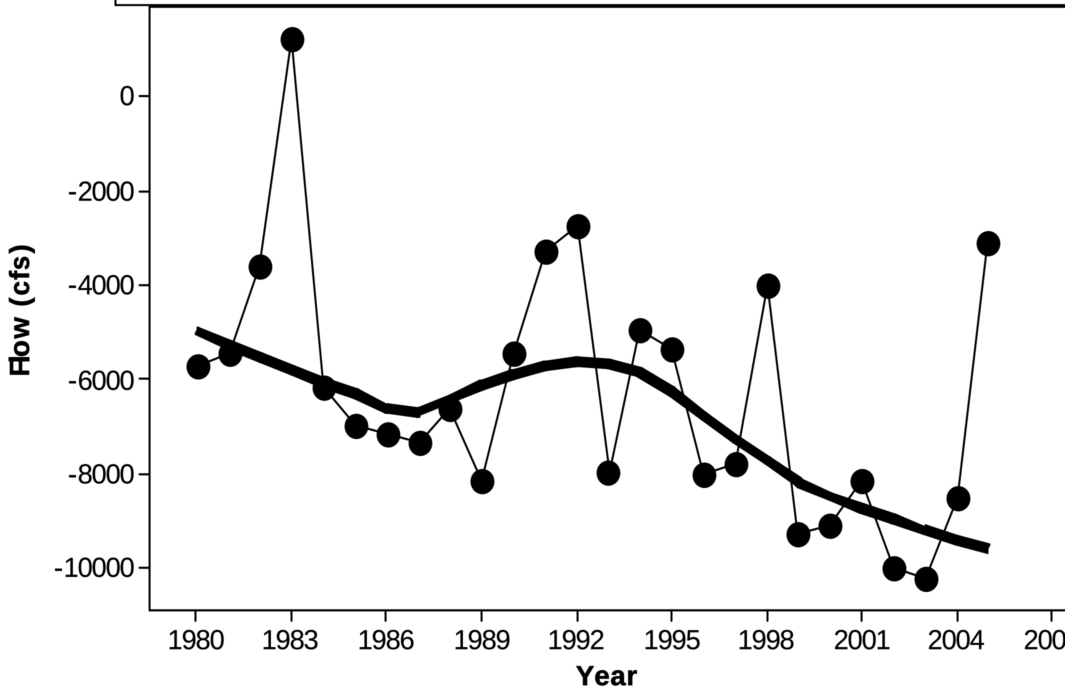
Delta

Water diversions represent one of the major factors controlling lower trophic level production in the Delta (Jassby et al. 2002). Water diversions directly entrain zooplankton and phytoplankton biomass which might impact food availability to delta smelt. Entrainment impacts to lower trophic level production are of concern during the spring and summer when newly hatched delta smelt larvae and juveniles are vulnerable to starvation and thermal stress; food limitation may lead to disease, poor growth, or death (Bennett 2005; Bennett et al. 2008).

Water diversions can also influence the residence time of water in the Eastern and Central Delta that can greatly influence phytoplankton production (Jassby 2005). Low export conditions can result in a doubling of primary production in the Eastern Delta. However, during periods of high exports, such as the summer (Figure S-15), much of the lower trophic level production is entrained rather than dispersed downstream to Suisun Bay. Summer entrainment of phytoplankton and zooplankton could therefore adversely affect delta smelt if food supplies are not transported to the LSZ. Preliminary evidence shows that the abundance of *Pseudodiaptomus forbesi*, a dominant prey of delta smelt in the summer, has steadily declined in the lower Estuary since 1995, while its numbers have increased in the South Delta (Figure 7-19 in the biological assessment; Kimmerer et al. in prep.). This copepod has blooms that originate in the Delta. Thus, its availability to delta smelt rearing to the west of the summer blooms may be impaired by high export to inflow ratios.

As stated above, clam grazing represents another major factor influencing primary and secondary production in the Delta. In the Western Delta, the food web may be compromised by overgrazing effects of the overbite clam (Kimmerer and Orsi 1996, Jassby et al. 2002). Within the Central Delta, grazing by the introduced river clam (*Corbicula fluminea*) can deplete resident phytoplankton biomass, especially in flooded island areas (Lucas et al 2002; Lopez et al 2006). Given that the food web supporting delta smelt depends on phytoplankton, these effects are likely to adversely affect its survival and reproduction by limiting food resources.

Figure S-15 Combined OMR flow (June-August)



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.

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). However, preliminary results from 2007, a dry year, suggest the incidence of toxic events was higher than in the previous (wetter) years. 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. 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.

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. 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., unpublished data). However, there was some evidence of low frequency endocrine disruption. In 2005, 9 of 144 (6 percent) of adult delta smelt males sampled were intersex, having immature oocytes in their testes (Teh et al., unpublished data).

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 inland 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).

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

Given the long list of stressors discussed, the rangewide status of the delta smelt is currently declining and abundance levels are the lowest ever recorded. This abundance trend has been influenced by multiple factors, some of which are affected or controlled by CVP and SWP operations and others that are not. Although it is becoming increasingly clear that the long-term decline of the delta smelt was very strongly affected by ecosystem changes caused by non-indigenous species invasions and other factors influenced, but not controlled by CVP and SWP operations, The CVP and SWP have played an important direct role in that decline, especially in terms of entrainment and habitat-related impacts that add increments of additional mortality to the stressed delta smelt population. Further, past CVP and SWP operations have played an indirect role in the decline of the delta smelt by creating an altered environment in the Delta that has fostered both the establishment of non-indigenous species and habitat conditions that exacerbate their adverse influence on delta smelt population dynamics. Past CVP and SWP operations have been a primary factor influencing delta smelt abiotic and biotic habitat suitability, health, and mortality.

Survival and Recovery Needs of 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 nearly 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 in this document.

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) (USFWS 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).

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. 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.

Overview of Delta Smelt Habitat Requirements and the Primary Constituent Elements

As previously described in the Status of the Species/Environmental Baseline section, Delta smelt live their entire lives in the tidally-influenced fresh- and brackish waters of the San Francisco Estuary (Moyle 2002). Delta smelt are an open-water, or pelagic, species. They do not associate strongly with structure. They may use nearshore habitats for spawning (PCE #1), but free-swimming life stages mainly occupy offshore waters (PCE #2). Thus, the distribution of the population is strongly influenced by river flows through the estuary (PCE #3) because the quantity of fresh water flowing through the estuary changes the amount and location of suitable low-salinity, open-water habitat (PCE #4). This is true for all life stages. During periods of high river flow into the estuary, delta smelt distribution can transiently extend as far west as the Napa River and San Pablo Bay. Delta smelt distribution is highly constricted near the Sacramento-San Joaquin river confluence during periods of low river flow into the estuary (Feyrer et al. 2007).

In the 1994 designation of critical habitat, the best available science held that the delta smelt population was responding to variation in spring X2. In the intervening 14 years, the scientific understanding of delta smelt habitat has improved. The current understanding is that X2 and OMR both must be considered to manage entrainment and that X2 indexes important habitat characteristics throughout the year.

Conservation Function of Primary Constituent Elements by Life History Stage

The conservation function and important attributes of each constituent element in each life stage are further described below.

Spawning

Spawning delta smelt require all four PCEs, but spawners and embryos are the only life stages of delta smelt that are known to require specific structural components of habitat (PCE # 1; see Biology and Life History section). Spawning delta smelt require sandy or small gravel substrates for egg deposition. Migrating, staging, and spawning delta smelt also require low-salinity and freshwater habitats, turbidity, and water temperatures less than 20ºC (68ºF) (attributes of PCE #2 and #4 for spawning). The developing embryos likewise may remain associated with sandy substrate until they hatch. Hatching success is only about 20 percent at 20ºC in the laboratory and declines to zero at higher temperatures (Bennett 2005).

Laboratory observations indicate that delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand or pebble (DWR and Reclamation 1994; Lindberg et al. 2003; Wang 2007). Rather than stick to immobile substrates, the adhesive eggs might adhere to sand particles, which keeps them negatively buoyant but not immobile (Hay 2007).

Spawning occurs primarily during April through mid-May (Moyle 2002) in sloughs and shallow edge areas in the Delta. Spawning also has been recorded in Suisun Marsh and the Napa River (Hobbs et al. 2007). Historically, delta smelt ranged as far up the San Joaquin River as Mossdale, indicating that areas of the lower San Joaquin and its tributaries support conditions appropriate for spawning. Little data exists on delta smelt spawning activity in the lower San Joaquin region. Larval and young juvenile delta smelt collected at South Delta stations in DFG's 20-mm Survey, indicate that appropriate spawning conditions exist there. However, the few delta smelt that are collected in the lower San Joaquin region is a likely indicator that changes in flow patterns entrain spawning adults and newly-hatched larvae into water diversions (Moyle et al 1992).

Once the eggs have hatched, larval distribution depends on both the spawning area from which they originate (PCE#1 and PCE#2) and the effect of Delta hydrodynamics on transport (PCE#3). Larval distribution is further affected by salinity and temperature (attributes of PCE#4 and #3). 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), which in some cases might result in rapid dispersal of larvae away from spawning sites.

In the laboratory, a turbid environment (>25 NTU) was necessary to elicit a first feeding response (Baskerville-Bridges et al. 2000; Baskerville-Bridges 2004) (attribute of PCE#2). Successful feeding depends on a high density of food organisms and turbidity. The ability of delta smelt larvae to see prey in the water is enhanced by turbidity (Baskerville-Bridges et al. 2004). Their diet is comprised of small planktonic crustaceans that inhabit the estuary's turbid, low-salinity, open-water habitats (attribute of PCE#2).

Larval and Juvenile Transport

Delta smelt larvae require PCEs # 2-4. The distribution of delta smelt larvae follows that of the spawners; larvae emerge near where they are spawned. Thus, they are distributed more widely during high outflow periods. Delta smelt larvae mainly inhabit tidal freshwater at temperatures between 10ºC-20ºC (Bennett 2005). The center of distribution for delta smelt larvae < 20 mm is usually 5-20 km upstream of X2, but larvae move closer to X2 as the spring progresses into summer (Dege and Brown 2004). The primary influences the water projects have on larval delta smelt critical habitat are that they influence water quality, the extent of the LSZ, and larval transport via capture of runoff in reservoirs and subsequent manipulation of Delta inflows and exports that affect OMR flows, and resultant Delta outflows that affect X2.

Changes to delta smelt larval and juvenile transport attributable to the SWP and CVP include water diversions that create net reverse flows in the Delta that entrain larval and juvenile delta smelt; permanent and temporary barrier installations and operation that change Delta hydrology and salinity and increase entrainment risk; and diminished river inflows that seasonally bring the LSZ into the Delta for increasingly longer periods of time, resulting in lower quality and quantity of rearing habitat.

Juvenile Rearing

Rearing juvenile delta smelt mainly require PCEs # 2 and # 4. Juvenile delta smelt are most abundant in the LSZ, specifically at the upstream edge of the LSZ where salinity is < 3 psu, water transparency is low (Secchi disk depth < 0.5 m), and water temperatures are cool (< 24ºC) (Feyrer et al. 2007; Nobriga et al. 2008). Because high freshwater inflows that push X_2 well into Suisun Bay are not sustained through the juvenile stage (July-December), many juvenile delta smelt rear near the Sacramento-San Joaquin river confluence. This reflects a long-term change in distribution. During surveys in the latter 1940s, juvenile delta smelt reared throughout the Delta during summer (Erkkila 1950). Currently, young delta smelt rear throughout the Delta into June or the first week of July, but thereafter, distribution shifts to the Sacramento-San Joaquin river confluence where water temperatures are cooler and water transparencies are lower (Feyrer et al. 2007; Nobriga et al. 2008). Note that this change in distribution has often been mischaracterized as a migration into brackish water.

- The primary influences the water projects have on juvenile delta smelt critical habitat are that they influence water quality, the extent of the LSZ, and early summer (June) transport via capture of runoff in reservoirs and subsequent manipulation of Delta inflows and exports that affect OMR flows, and resultant Delta outflows that affect X2. The projects are the primary influence on freshwater inflows and outflows during the juvenile stage. The SWP and CVP control almost all Delta inflow during summer-fall. The primary effects these highly controlled flows have on juvenile delta smelt are a possible impact on summertime prey availability in the LSZ and a strong effect on the extent of the LSZ and dilution flows and thus, habitat suitability during fall (see Effects section).

- Estuarine turbidity varies with Delta outflow and it is higher during periods of high outflow (Kimmerer 2004). The interannual variation in peak flows to the estuary is not always controlled by the projects, so they have little effect on interannual variation in estuary turbidity during delta smelt's spawning season. The CVP/SWP have had a long-term influence on turbidity in the estuary because project dams have retained sediment originating in project tributaries, especially in the Sacramento River basin (Wright and Schoelhamer 2004). However, the CVP/SWP have not been shown to have influenced shorter-term decreases in turbidity due to the proliferation of aquatic plants like *Egeria densa*.

- The water projects have little if any ability to affect water temperatures in the Estuary (Kimmerer 2004). Estuarine and Delta water temperatures are driven by air temperature. Water temperatures at Freeport can be cooled up to about 3ºC by high Sacramento River flows, but only by very high river flows that cannot be sustained by the projects. Note also that the cooling effect of the Sacramento

River is not visible in data from the west Delta at Antioch (Kimmerer 2004) so the area of influence is limited.

Adult Migration

Successful delta smelt adult migration habitat is characterized by conditions that attract migrating adult delta smelt, attributes of PCE #2, #3, and #4, and that help them migrate to spawning habitats (PCE #3). Delta smelt are weakly anadromous and move from the LSZ into freshwater to spawn, beginning in late fall or early winter and likely extending at least though May (see Delta Smelt Life Cycle section in the Status and Baseline). Although the physiological trigger for the movement of delta smelt up the Estuary is unknown, movement is associated with pulses of freshwater inflow, which are cool, less saline and turbid (attributes of PCE #2 and #4 for adult migration). As they migrate, delta smelt increase their vulnerability to entrainment if they move closer to Banks and Jones (Grimaldo et al accepted manuscript). Analyses indicate that delta smelt become less vulnerable to entrainment when reverse flows in the Delta are minimized. Inflows in early winter must be of sufficient magnitude to provide the cool, fresh and highly turbid conditions needed to attract migrating adults and of sufficient duration to allow connectivity with the Sacramento and San Joaquin river channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries (attributes of PCE #2 for adult migration). These areas are vulnerable to physical disturbance and flow disruption during migratory periods. Once adults have moved into the Delta, freshwater inflows must remain of sufficient magnitude to minimize their vulnerability to entrainment.

Changes to delta smelt adult migration habitat include water diversions that have increased net negative OMR flows that entrain migrating adult smelt and reservoir operations that reduce seasonal inflow that provides flow and turbidity cues for migration. In addition, the proliferation of nonnative aquatic plants that trap sediment has reduced overall turbidity and may have increased the deposition of fine sediments in historical spawning habitats.

Current Condition of Delta Smelt Critical Habitat and Factors that Contribute to that Condition

As stated in the previous section on the status of the delta smelt, the physical appearance, salinity, water clarity, and hydrology of the Delta have been modified significantly by channelization, conversion of Delta islands to agriculture, and water operations. 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, Baxter et al. 2008).

In general, the CVP/SWP operations have decreased springtime flows (PCE #3) relative to the natural hydrograph, as reservoir operations change over from flood management to water storage (Kimmerer 2004). Further, summer and early fall inflows (PCE #2, #3, and #4) may be increased over the natural hydrograph as reservoirs release stored water to support export operations. Changes in inflow affect the location of the historically highly-productive LSZ, affecting habitat volume and quality (effect on PCE #2, #3 and

#4). The combined influence of these changes since the 1980s and earlier has had the effect of distributing delta smelt narrowly and in areas with high risk of mortality from many known sources (e.g., entrainment in water diversions large and small) and plausible sources (intensified predation loss, sublethal contaminant exposure, etc.) (combined effect on the condition of PCE #2, #3, and #4). Second, a more upstream distribution of maturing adult delta smelt places them at greater vulnerability to entrainment by CVP and SWP export operations once they begin their spawning migration (Grimaldo et al, accepted manuscript) (combined effect on the condition of PCE #2, #3, and #4).

PCE #1 - Physical Habitat for Spawning

We are aware of no conditions attributable to SWP and CVP operations that limit the availability of spawning substrate.

Routine dredging of various Delta channels to facilitate shipping periodically may disrupt or eliminate spawning substrate availability, but is not known to substantially modify location, extent, or quality of available spawning substrate (PCE #1) for delta smelt.

Nonnative submerged aquatic vegetation, particularly *Egeria densa*, overwhelms littoral habitats (inter-tidal shoals and beaches) where delta smelt spawn, possibly making them unsuitable for spawning.

The cumulative effects of locally small or isolated losses or degradations of physical habitat associated with construction and maintenance of water conveyance facilities, together with increasing exposure in physical habitat to chemical pollutants from other sources, and the increase of nonnative submerged aquatic vegetation likely have reduced both the quality and extent of physical habitat. Overall, this primary constituent element remains capable of fulfilling its intended conservation function, but the trend is downward and will likely remain so unless ways are found to control *Egeria*.

PCE #2 - Water for All Life Stages (Suitable Quality)

The condition of PCE #2 has been substantially reduced. Pelagic habitat in the Delta has been highly altered and degraded by many factors discussed in the Baseline and Effects Sections. The historic Delta consisted primarily of tidal freshwater marshes, tributary river channels and their associated floodplains, and sloughs. The current Delta has little (< 1 percent) of its historic intertidal marsh habitat, its patterns of sloughs and channels have been modified, changing its hydrodynamic characteristics, and the pattern and quantity and inflow to, through and out of the estuary has been altered. When compared to estuaries around the world, the Delta is unique in its low levels of productivity (Clipperton and Kratville, in review). Current conditions for larval and juvenile transport, rearing, and adult migration in particular have been modified to an extent that this primary constituent element is substantially impaired in its ability to fulfill its conservation function at least seasonally in all water year-types. Special management is needed to address the degraded condition of this primary constituent element. Many factors that have contributed to the current condition are described below.

Factors that Impair/Degrade the Function of PCE #2

CVP and SWP

Operations of the Banks and Jones (inclusive of 500 cfs diversion at Banks, Article 21, upstream diversion and reservoir operations, North Bay Aqueduct, South Delta Temporary Barriers and Permanent Operable Gates, pumping plants water transfers) have diminished the ability of PCE #2 to fulfill its intended conservation purpose. Disconnecting inflow and outflow via water exports in the South Delta probably represents the single largest stressor for this primary constituent element. The manipulation of inflow and outflow with a goal of maintaining “balanced conditions” also has adversely affected the functionality of the other primary constituent elements and is discussed in more detail under each of the primary constituent elements. Though not restricting spawning *per se*, export of water by the CVP and SWP has usually restricted reproductive success of spawners in the San Joaquin River portion of the Delta as many adults and most larvae have been entrained and lost during transport to and from spawning sites to rearing areas (see Effects Section). Persistent confinement of the effective spawning population of delta smelt to the Sacramento River increases the likelihood that a substantial portion of the spawning population could be adversely affected by catastrophic event or localized chronic threat, such as localized contaminant releases.

The additional interaction of PCE #2 with salinity, PCE #4, has resulted in a lengthening seasonal shift in the distribution of delta smelt to areas that are generally upstream of where they once occurred. See additional discussion below in the section on Rearing.

Preliminary evidence shows that the abundance of *Pseudodiaptomus forbesi*, a dominant prey of delta smelt in the summer, has steadily declined in the lower Estuary since 1995, while its numbers have increased in the Southern Delta (Kimmerer et al. in prep.). This copepod has blooms that originate in the Delta. Its availability to delta smelt rearing to the west of the summer blooms may be impaired by pumping at Banks and Jones.

The operation of upstream diversions and reservoirs can, depending on how they are managed, substantially influence the pelagic environment in the Delta by controlling timing and volume of releases. Over time, the operation of project dams and diversions has had the additional effect of making water in the Delta more clear by trapping sediment behind dams and diverting sediment that otherwise would be transported to the Delta (effect on the condition of PCE #2). Delta smelt seem to prefer water with high turbidity (see Baseline Section). In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin River was highly seasonal and more strongly and reliably affected by precipitation that it is today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of Delta water was larger then than now (Kimmerer 2002b). 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, but through time more and more of the summer-fall inflow and been exported, reducing outflows.

Aquatic Macrophytes

As stated in the Status and Baseline Section, research suggests that the nonnative South American aquatic plant *Egeria densa* has altered fish community dynamics in the Delta. In addition to the above-mentioned effect of overwhelming spawning habitat (PCE #1), *Egeria* and other submerged aquatic vegetation decreases turbidity by trapping suspended sediment, thereby decreasing juvenile and adult smelt habitat (Feyrer et al. 2007; Nobriga et al. 2008). Increased water transparency may also make delta smelt more susceptible to predation. It appears that aquatic macrophytes may have a role in degrading pelagic habitat to the extent that the Delta's ability to fulfill its intended conservation purpose continues to diminish. *Egeria* has the additional effect of decreasing turbidity, described above as important to successful feeding of newly-hatched larval delta smelt. However, there is still enough turbidity in the Central and South Delta to initiate larval feeding responses because larvae collected in the South Delta have comparatively high growth rates. So while *Egeria* may reduce or eliminate the extent and quality of spawning habitat for delta smelt, it is not at this time considered to have detectable effects on spawning or early feeding success.

Contaminants

While contaminants are thought to reduce habitat quality and thus reduce the ability of PCE #2 to fulfill its intended conservation function, contaminant loading and its ecosystem effects within the Delta are still not well understood. There are long-standing concerns related to methyl mercury and selenium levels in the watershed, Delta, and San Francisco Bay (Linville et al. 2002; Davis et al. 2003). There is evidence that contaminants may inhibit phytoplankton growth rates at times (Wilkerson et al. 2006; Dugdale et al. 2007). Pulses of sediment-bound pesticides can co-occur in space and time with delta smelt reproduction (Kuivila and Moon 2004). There is also recent evidence of low frequency of intersex delta smelt suggesting exposure to estrogenic chemicals (Teh 2008).

Nonnative Species

Within the Delta, grazing by the introduced clams *Corbula amurensis* and *Corbicula fluminea* can deplete resident phytoplankton biomass (Jassby et al. 2002; Lucas et al. 2002; Lopez et al. 2006). The former has had a demonstrable effect on phytoplankton standing stock and zooplankton abundance throughout the estuary (Kimmerer and Orsi 1996), but the effect of the latter is mainly limited to freshwater flooded island areas (Lucas et al. 2002; Lopez et al. 2006). Given that phytoplankton help support the production of prey items eaten by delta smelt, these nonnative species are likely to adversely affect the ability of PCE #2 to fulfill its intended conservation function, which results in degraded condition.

PCE #3 - River Flow for Larval and Juvenile Transport, Rearing, and Adult Migration

Management of Delta inflows results in conditions for river flow that frequently do not meet the intended conservation function of this primary constituent element in certain

WYs. PCE #3 is probably the most significantly degraded of all the PCEs, and requires the most intensive management in order for it to continue to fulfill its intended conservation role. The primary factors that have contributed to this condition are discussed below.

Factors that Impair/Degrade the Function of PCE #3

CVP and SWP

Operations of the CVP and SWP manipulate inflows, outflows and OMR flows. This probably represents the single largest stressor for PCE #3. Banks and Jones entrain delta smelt and delta smelt food items, thereby affecting the quality of PCE #2 as well. While tides and climate affect flow into and within the Delta, Banks and Jones are the single most prominent factor in determining whether transport flows are sufficient to allow larval and juvenile delta smelt to move out of the Central and South Delta before water temperatures reach lethal levels. Baseline operation of the CVP/SWP represents a downward trend in the ability of this primary constituent element to fulfill its intended conservation function.

Management of Article 21 water at the SWP has changed since 2000. The result is more water exported than historically during the late fall and winter months, and increasing SWP exports overall relative to historic conditions (Table P-12). This additional pumping has contributed to the downward trend in the ability of PCE #3 to meet its intended conservation function by increasing the entrainment risk of adults migrating upstream to spawn.

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. Reservoir operations have played a significant role in modifying conditions in the Delta to the extent that this primary constituent element is unable to fulfill its intended conservation purpose in most years. The SWRCB D-1641 has helped provide Delta outflow during the spring, but outflows are reduced during other times by increased pumping at Jones and Banks.

Environmental Water Account

Implementation of the EWA provided brief export cutbacks in winter and spring, but also increased exports during early winter and summer, and it contributed to increased exports in summer and fall to levels that would not have occurred if EWA assets had not been purchased. This may have negatively affected habitat suitability and prey availability for delta smelt (see Effects Section). So while EWA was intended to moderate effects of CVP and SWP operations, its ability to do so measured over time was small (Brown et al. 2008). While EWA may have provided short-term transport opportunities in the early part of the year, it contributed to low outflows during other times of the year, which diminished the ability of this primary constituent element to fulfill its intended conservation purpose.

Special Management for PCE #3

Vernalis Adaptive Management Plan

VAMP represents one of the management measures that has been applied to CVP and SWP operations to assist this primary constituent element in fulfilling its intended conservation role. VAMP flows are thought to have selectively enhanced survival of delta smelt larvae that emerge in the Central Delta during VAMP by reducing entrainment. VAMP has enhanced the ability of this primary constituent element to fulfill its intended conservation purpose for 31 days each year.

PCE #4 - Salinity for Rearing

Summer and fall environmental quality, represented by PCE #4, has decreased overall in the Delta, but less so for the Sacramento River-San Joaquin River confluence. The rivers' confluence has, as a result, become increasingly important as a rearing location, as delta smelt's range has been restricted to an increasingly small area (Feyrer et al. 2007; Nobriga et al. 2008). This has increased the likelihood that juvenile and maturing adult delta smelt are exposed to chronic and cyclic environmental stressors, or localized catastrophic events. The many changes imposed on the Delta have had the effect of concentrating the distribution of delta smelt to an area that is generally upstream of where they once were. This upstream location of rearing habitat has reduced habitat quantity and quality, making larval and juvenile delta smelt more susceptible to marginal water temperatures, cyanobacterium blooms, and other habitat-related effects.

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 historical delta smelt prey in the LSZ. A minimum amount of suitable habitat during summer-autumn may interact with a suppressed pelagic food web to create a bottleneck for delta smelt (Bennett 2005; Feyrer et al. 2007; Bennett et al. 2008). As discussed in the preceding section on Population Dynamics-Abundance Trends, there is evidence that factors affecting juvenile delta smelt during summer-autumn are strongly impairing delta smelt reproductive success. The interaction of warm summer water temperatures, suppression of the food web supporting delta smelt, and spatially restricted suitable habitat during autumn all affect delta smelt health and ultimately survival and realized fecundity. The preceding factors have contributed to the current condition of seasonally low outflow and the inability of PCE #4 to fulfill its intended conservation purpose in most years.

Factors that Impair/Degrade the Function of PCE #4

CVP and SWP

Operations of the CVP and SWP pumping plants manipulate outflow and represent probably the single largest factor affecting the condition of this primary constituent element. The facilities entrain delta smelt and delta smelt food items. While tides and climate affect flow into and within the Delta, the export facilities are the single most prominent factor in determining whether transport flows for migrating larvae, juveniles, and adults are sufficient to move fish out of the Central Delta before water temperatures reach lethal levels, are sufficient to maintain rearing habitat at a more downstream position where smelt also are not at risk of entrainment from export facilities, and are sufficient to cue adults to migrate to upstream spawning habitat without being entrained at the export facilities. Baseline operation of these facilities represents a downward trend in the ability of this primary constituent element to fulfill its intended conservation purpose with the possible exception of specific actions taken recently, the results of which, however, remain uncertain.

Management of Article 21 water at the SWP has changed since 2000. The result is more water exported than historically during the late fall and winter months when Article 21 water normally is moved, and increasing SWP exports overall relative to historic conditions. This additional pumping has contributed considerably to the downward trend in the ability of this primary constituent element to meet its intended conservation purpose.

Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage and in some years may increase late summer and fall inflows. Reservoir operations have played a significant role in modifying conditions in the Delta to the extent that this primary constituent element is unable to fulfill its intended conservation purpose in most years.

Environmental Water Account

Implementation of the EWA provided brief export cutbacks in winter and spring, but also increased exports during early winter and summer, and it contributed to increased exports in summer and fall to levels that would not have occurred if EWA assets had not been purchased. This may have negatively affected habitat suitability and prey availability for delta smelt (see Effects Section). So while EWA was intended to moderate effects of CVP and SWP operations, its ability to do so measured over time was small (Brown et al. 2008). While EWA may have provided short-term transport opportunities in the early part of the year, it contributed to low outflows during other times of the year, which diminished the ability of this primary constituent element to fulfill its intended conservation purpose.

Other Factors that May Influence the Condition of PCE #4

Aquatic Macrophytes

As stated in the preceding section on Other Stressors, research suggests that the nonnative South American aquatic plant *Egeria densa* has altered fish community dynamics in the Delta. However, we are not aware of evidence that aquatic macrophytes such as *Egeria*, affect flows. Thus, this factor is considered to have no influence on the current condition of PCE #4

Nonnative Species

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

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

Climate Change

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

Effects of the Proposed Action

Introduction

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

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

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

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

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

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

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

[a] Historical hydrodynamic data are DAYFLOW 1967-2007; OMR was measured 1993-2007 and estimated using regression on DAYFLOW variables by Cathy Ruhl (USGS) for 1967-1992; historical delta smelt salvage data are 1993-2007, the period when the data are considered most reliable.
[b] Historical hydrodynamic data are DAYFLOW 1967-2007 (except OMR as noted in the previous footnote); direct estimates of larval-juvenile entrainment are 1995-2005. (Kimmerer 2008); Entrainment was estimated statistically for 1967-1994 and 2006-2007
[c] Historical hydrodynamic data (DAYFLOW; except OMR 1988-1992, see footnote a) and Pseudodiaptomus density data (IEP monitoring) are 1988-2006 because Pseudodiaptomus was introduced in 1988.
[d] Historical hydrodynamic data are DAYFLOW 1967-2007.

Data and Models used in the Analysis

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Effects Analysis Methods

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

Migrating and Spawning Adults (~ December through March)

Water Diversions and Reservoir Operations

Upstream Reservoirs and Diversions

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

Banks and Jones Pumping Plants

Entrainment

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

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

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

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

Adult Entrainment

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

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

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

OMR Flows

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

Salvage and Entrainment Loss Predictions

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

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

Predicted Salvage and Entrainment

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

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

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

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

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

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

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

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

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

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

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

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

Article 21

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

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

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

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

DMC-CA Intertie

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

NBA Diversion

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

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

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

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

CCWD Diversions

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

Old River intake

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

Rock Slough

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

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

Alternative Intake

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

Suisun Marsh Salinity Control Gates

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

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

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

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

Larval and Juvenile Delta Smelt (~ March-June)

Water Diversions and Reservoir Operations

Banks and Jones

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

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

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

Historical Data (1967-2007)

Combined Old and Middle River Flow

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

Delta Outflow

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

Predicted entrainment

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

Proposed Action

Combined Old and Middle River Flow

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

X2

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

Effects of Forecasted Operations

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

Article 21

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

VAMP

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

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

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

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

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

Intertie

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

NBA Diversion

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

CCWD Diversions

Old River Intake

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

Rock Slough

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

Alternative Intake

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

South Delta Temporary Barriers

Hydrodynamic Effects

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

The varying proposed operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables limit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. In 1996, the installation of the spring HORB caused a sharp reversal of net flow in the South Delta to the upstream direction. Coincident with this change was a strong peak in delta smelt salvage (Nobriga et al. 2000). This observation indicates that short-term salvage can significantly increase when the HORB is installed in such a manner that it causes a sharp change or reversal of positive net daily flow in the South and Central Delta. The physical presence of the TBP may attract piscivorous fishes and influence predation on delta smelt. However, past studies by the DFG TBP Fish Monitoring Program indicated that such predation is negligible (DWR 2000a).

Vulnerability to Local Agricultural Diversions

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

Effects to Potential Fish Prey Items

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

South Delta Permanent Operable Gates

Hydrodynamic Effects

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

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

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

Vulnerability to Local Agricultural Diversions

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

Effects to Potential Fish Prey Items

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

Suisun Marsh Salinity Control Gates

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

American River Demands

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

Delta Cross Channel

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

Juveniles and Adults (~ July-December)

Entrainment of *Pseudodiaptomus forbesi* (June-September)

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

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

Water Transfers

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

Post-processing of Model Data for Transfers

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

- Capacities are for the Late-Summer period July through September total.
- The pumping capacity calculated is up to the allowable E:I ratio and is limited by either the total physical or permitted capacity, and does not include restrictions due to ANN salinity requirements with consideration of carriage water costs.
- The quantities displayed on the graph do not include the additional 500 cfs of pumping capacity at Banks (up to 7,180 cfs) that is proposed to offset reductions previously taken for fish protection. This could provide up to a maximum about 90 TAF of additional capacity for the July-September period, although 60 TAF is a better estimate of the practical maximum available from that 500 cfs of capacity, allowing for some operations contingencies.
- Figure 13-59 and Figure 13-60 in the biological assessment show the available export capacity from Study 8.0 (Future Conditions-2030) at Banks and Jones, respectively, with the 40-30-30 WY type on the x-axis and the WY labeled on the bars. The SWP allocation or the CVP south of Delta Agriculture allocation is the allocation from CALSIM II output from the WY.

From Figure 13-59 of the biological assessment, Banks will have the most ability to move water for transfers in Critical and certain Dry years (driest 20 percent of study years) which generally have the lowest water supply allocations, and reflect years when transfers may be higher to augment water supply to export contractors. For all other study years (generally the wettest 80 percent) the available capacity at Banks for transfer ranges from about 0 to 500 TAF (not including the additional 60 TAF accruing from the proposed permitted increase of 500 cfs at Banks. But, over the course of the three months July-September other operations constraints on pumping and occasional contingencies would tend to reduce capacity for transfers. In consideration of those factors, proposed transfers would be up to 360 TAF in most years when capacity is limiting. In Critical and some Dry years, when capacity would not be a limiting factor, exports for transfers could be up to 600 TAF (at Banks and Jones combined). Transfers at Jones (Figure 13-60 of the biological assessment) are probably most likely to occur only in the driest of years (Critical years and some Dry years) when there is available capacity and low allocations.

Limitations

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

Proposed Exports for Transfers

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

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

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

JPOD

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

500 cfs at Banks

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

NBA Diversion

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

CCWD Diversions

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

Temporary Agricultural Barriers

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

Permanent Operable Gates

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

American River Demands

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

Delta Cross Channel

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

Entrainment Effects

Water Diversions and Reservoir Operations

Banks and Jones

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

Intertie

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

Suisun Marsh Salinity Control Gates

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

Habitat Suitability (Sept-Dec)

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

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

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

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

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

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

X2

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

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

Area of Suitable Abiotic Habitat

The second step of the evaluation used the modeled X2 to estimate the total surface area of suitable abiotic habitat available for delta smelt. Feyrer et al. (2008) examined three different definitions of habitat suitability for delta smelt that were subsequently used to generate the hectares (ha) of suitable abiotic habitat. The three habitat criteria examined by Feyrer et al. (2008) were based on the statistical probability of delta smelt occurring in a sample due to water salinity and clarity characteristics at the time of sampling. The probabilities of occurrence they examined and compared were $\geq$ 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 E-20.

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

Effect on Delta Smelt Abundance

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

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

Additional Long-term Trends and Potential Mechanisms

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

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

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

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

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

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

American River Demands

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

Komeen Treatment

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

In 2005, no fish mortality or stressed fish were reported during or after the treatment. The contractor, Clean Lakes, Inc was looking for dead fish during the Komeen application. In addition, no fish mortality was reported in any of the previous Komeen or Nautique applications. In 2005, catfish were observed feeding in the treatment zone at about 3 PM on the day of the application (Scott Schuler, SePro). No dead fish were observed. DWR complied with the NPDES permit that requires visual monitoring assessment. Due to the uncertainty of the impact of Komeen on fish that may be in the Forebay, we will assume that all delta smelt in the Forebay at the time of application are taken. The daily loss values vary greatly within treatments, between months and between years. Figure E-29 illustrates the presence of delta smelt in the Forebay during treatments. There are no loss estimates for delta smelt, so the relationship between salvage and true loss of delta smelt in the Forebay in unknown. However, since the treatments will only be during July and August, delta smelt are not expected to be present in the Forebay during this time, so adverse effects to delta smelt are unlikely.

Effects to Delta Smelt Critical Habitat

Primary Constituent Elements

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

Spawning Habitat

PCE 1 – Physical Habitat

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

PCE 2 – Water

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

PCE 3 – River Flow

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

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

PCE 4 – Salinity

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

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

Larval and Juvenile Transport

PCE 1 – Physical Habitat

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

PCE 2 – Water

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

PCE 3 – River Flows

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

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

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

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

PCE 4 – Salinity

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

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

Rearing Habitat

PCE 1 – Physical Habitat

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

PCE 2 – Water

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

PCE 3 – River Flows

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

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

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

Slough and Suisun Marsh when the SMSCG is closed.

PCE 4 – Salinity

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

Adult Migration

PCE 1 – Physical Habitat

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

PCE 2 – Water

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

PCE 3 – River Flows

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

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

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

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

PCE 4 – Salinity

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

Summary of Effects of the Action on Delta Smelt Critical Habitat

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

Cumulative Effects

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

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

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

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

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

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

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

Figures referenced in the Effects Section

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

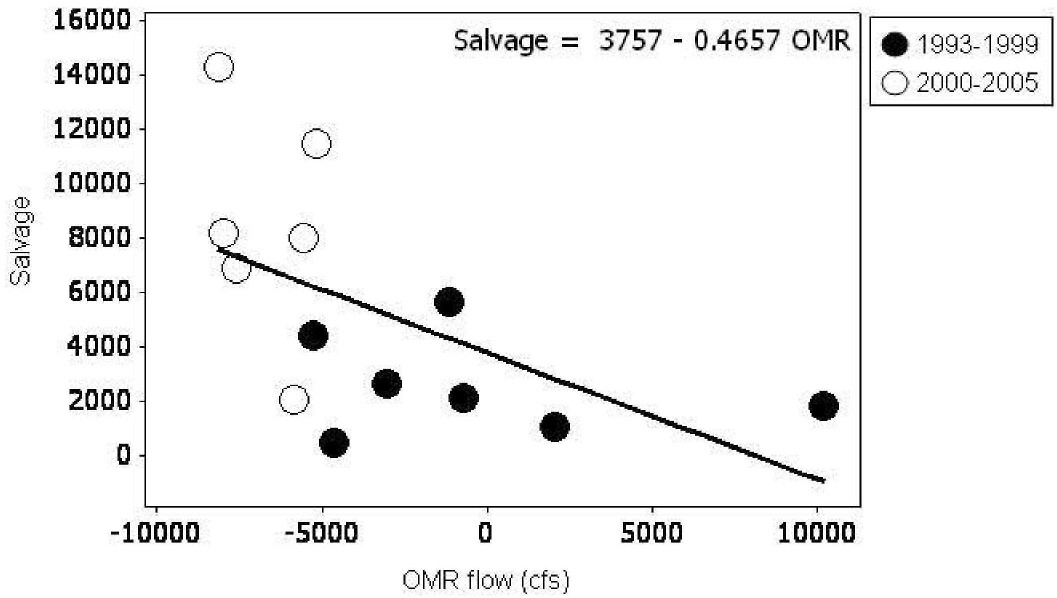


Figure E-2. Average winter (Dec-Mar) OMR flow (A), total Delta inflow (B), and combined SWP/CVP exports (C) by year. The data were fitted with lowess splines to show trends.

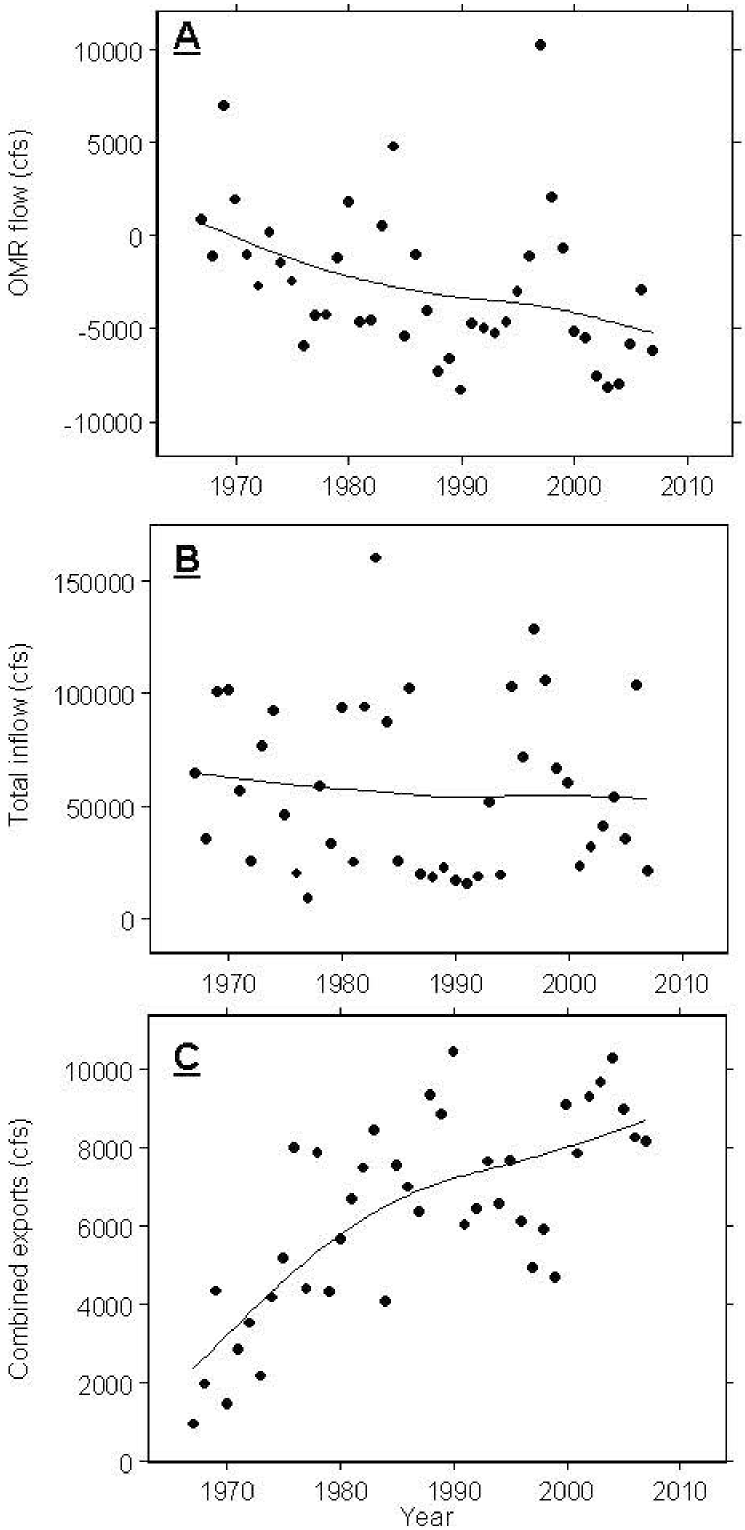


Figure E-3. Boxplot summary of CALSIM II operations study outputs of average winter (Dec-Mar) OMR flow for five water year types and the actual historic data (1967-2007). The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles.

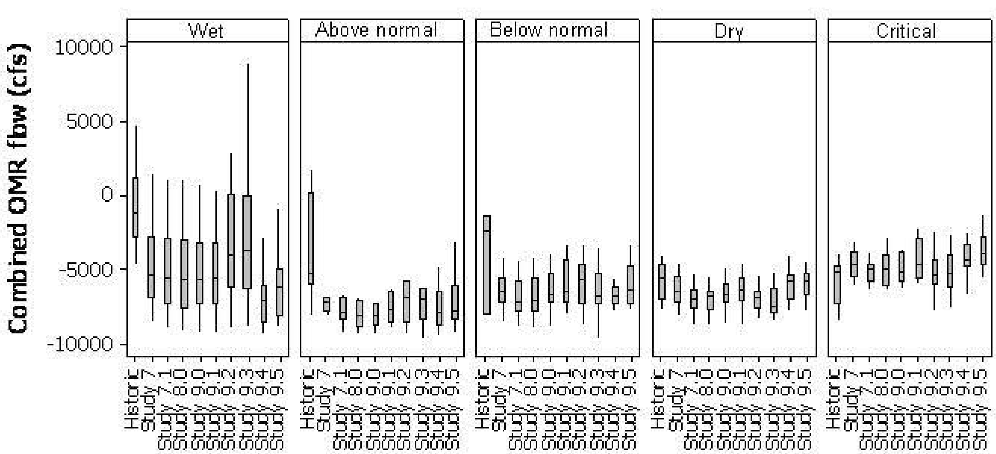


Figure E-4. Time series of estimated percentages (with 95 percent error bars) of the adult delta smelt population entrained in the SWP and CVP South Delta water export diversion facilities estimated from Kimmerer (2008). OMR flow is plotted on the secondary y-axis.

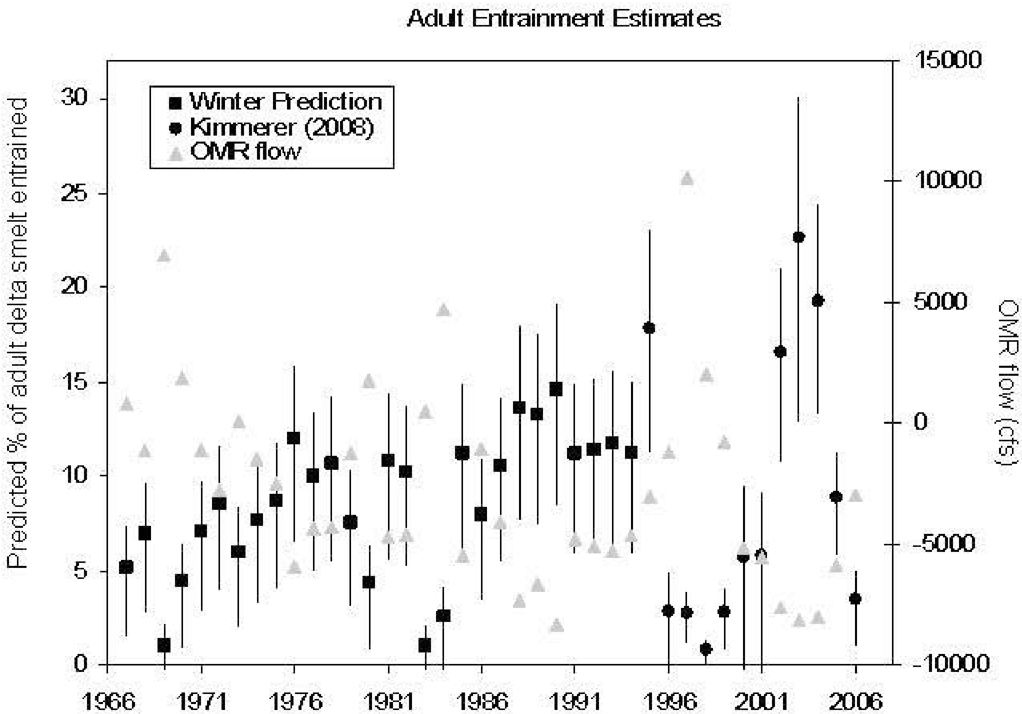


Figure E-5. Frequency distribution of predicted adult delta smelt entrained at Banks and Jones for predicted estimates from historic data (1967-1994), actual estimates from Kimmerer (2008) for years 1995-2006, and those estimated from CALSIM II model data by study.

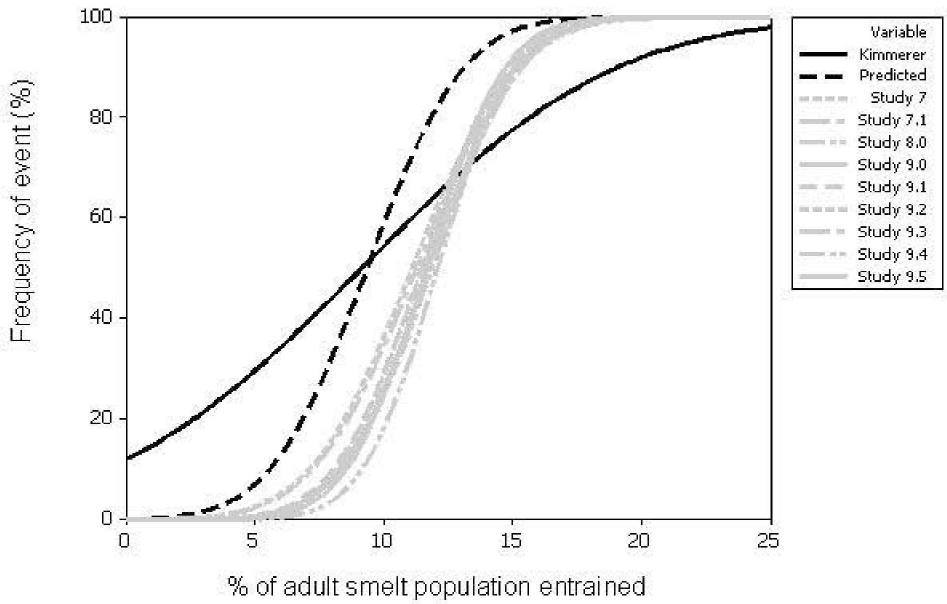


Figure E-6. Same as E-5 but by water year type. Kimmerer (2008) estimates did not include below normal or critical dry water year types.

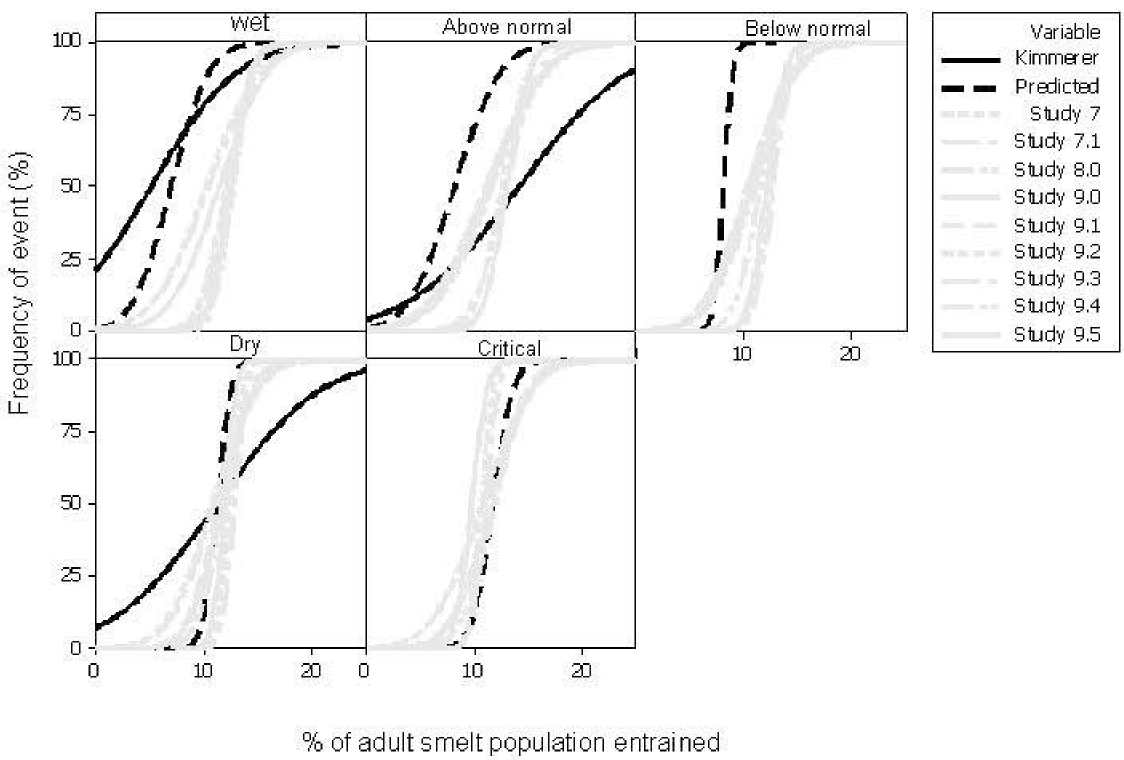


Figure E-7. Scatterplot of average flow in Old and Middle rivers (upper panel = March – June; lower panel = April – May) and the percentage of the larval and juvenile delta smelt population entrained in the SWP and CVP export pumps. The entrainment estimates were taken from Kimmerer (2008). The bubble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

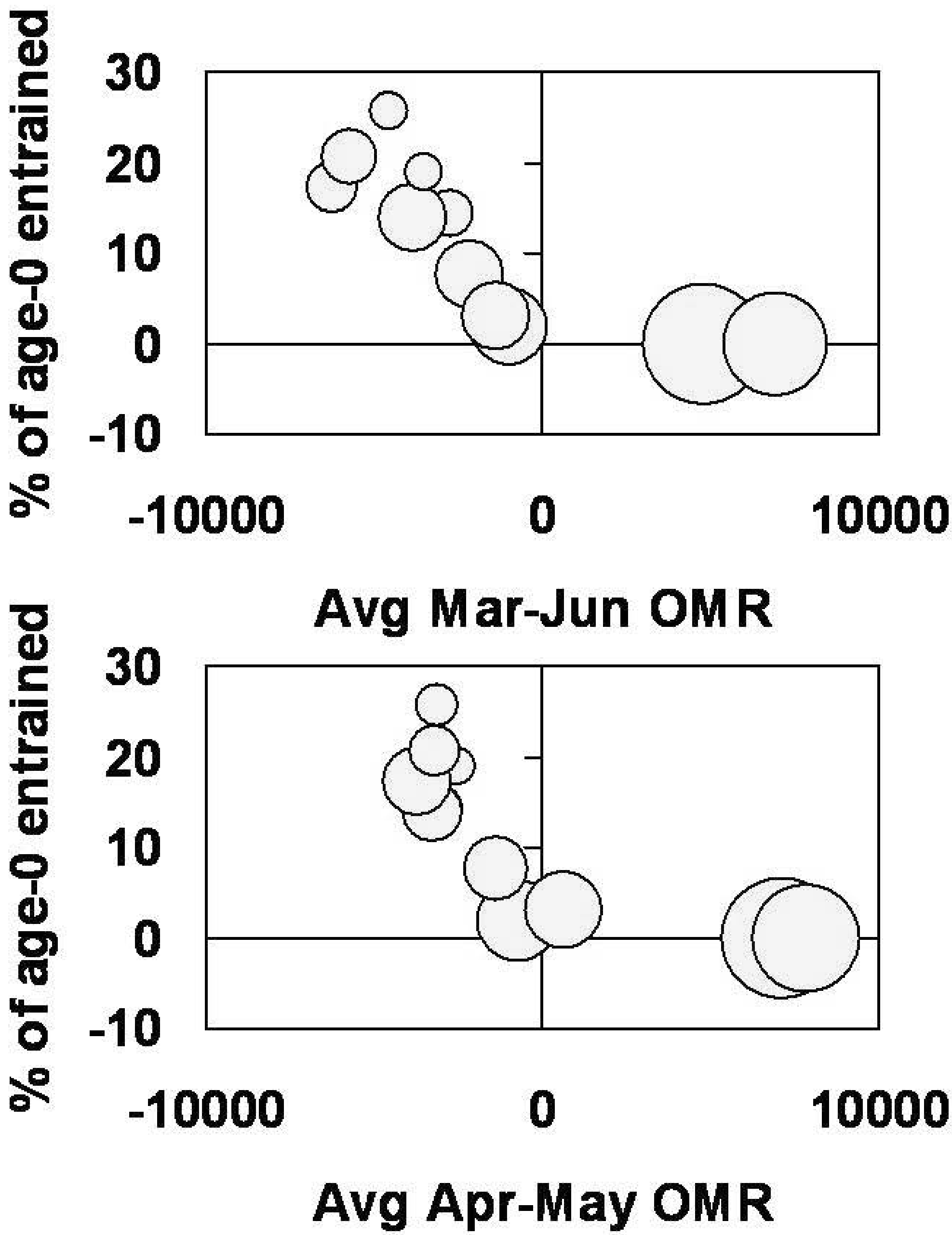


Figure E-8. Time trend in average March – June flow Old and Middle river flow, 1967-2007. Data for 1980-2006 are empirical data based on ADCP measurements. Data for 1967-1979 and 2007 are estimated as described in the text. The spline is a LOWESS regression
line.

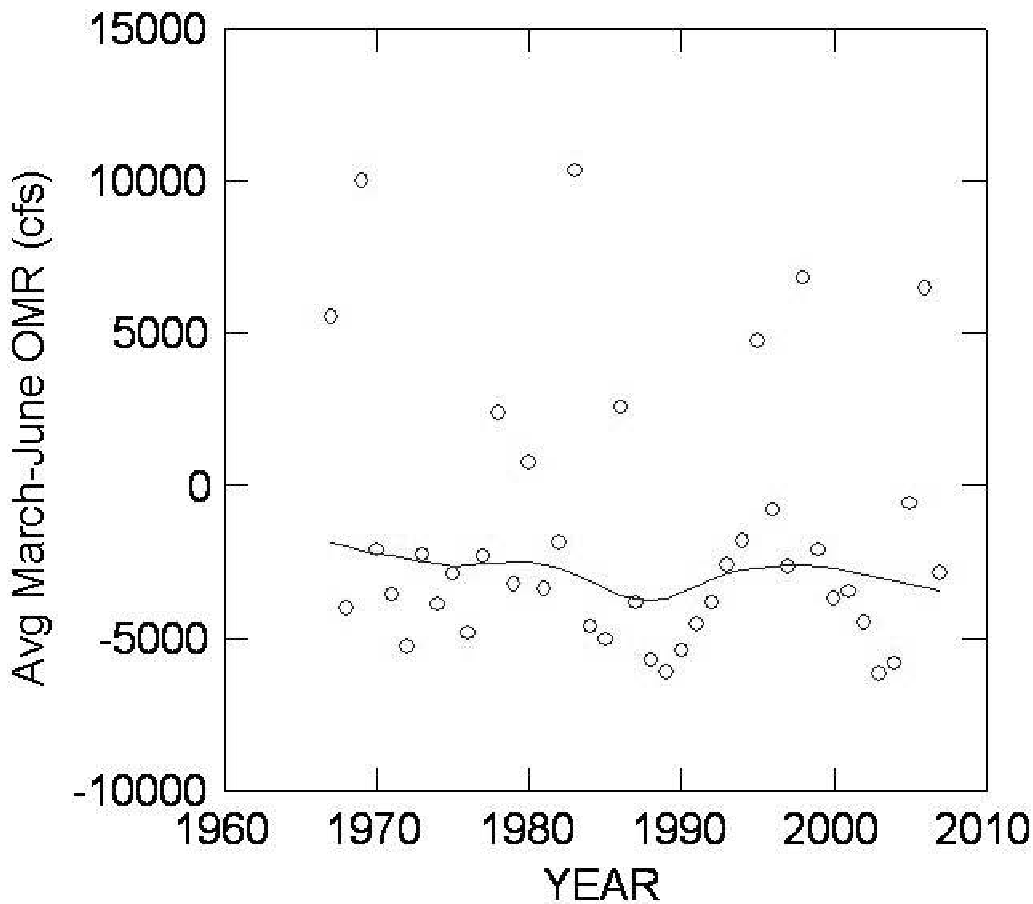


Figure E-9. Time trend in average April-May OMR flow, 1967-2007. Data for 1980-2006 are empirical data based on ADCP measurements. Data for 1967-1979 and 2007 are estimated as described in the text. The spline is a LOWESS regression line.

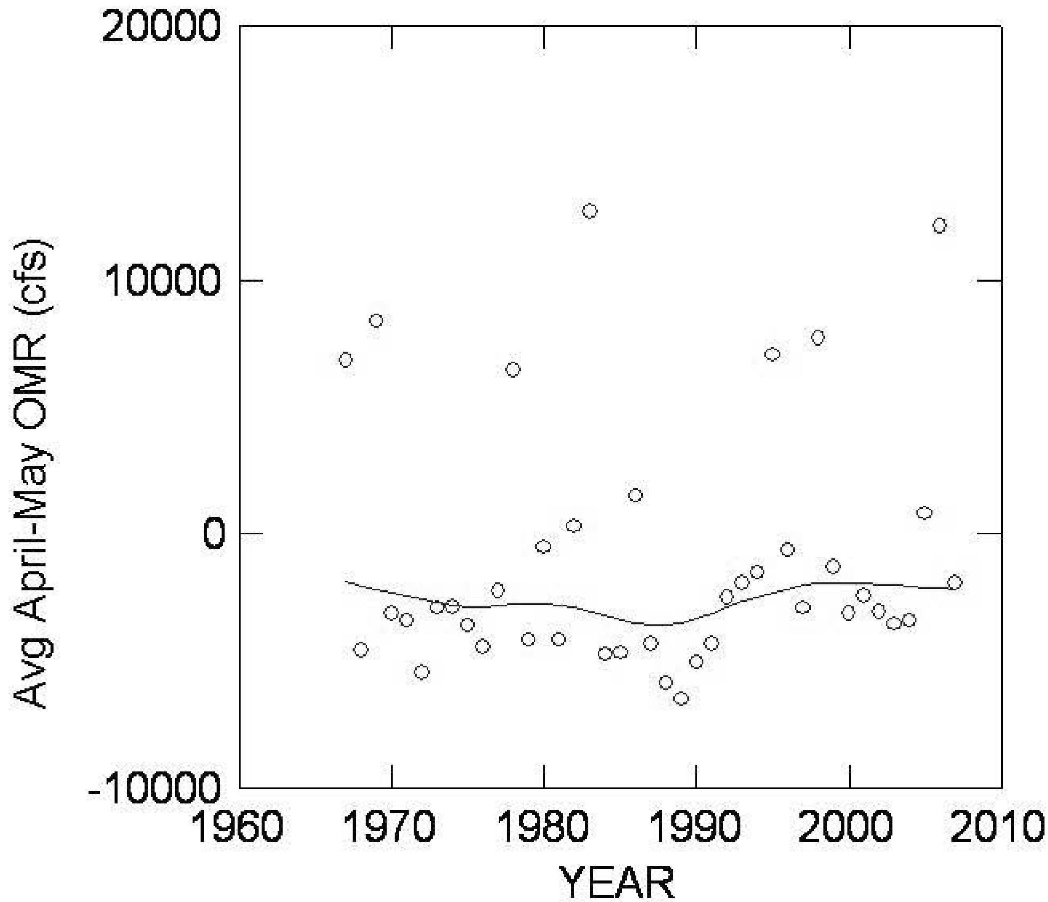


Figure E-10. Time trend in average March – June Delta outflow, 1967-2007. The spline is a LOWESS regression line.

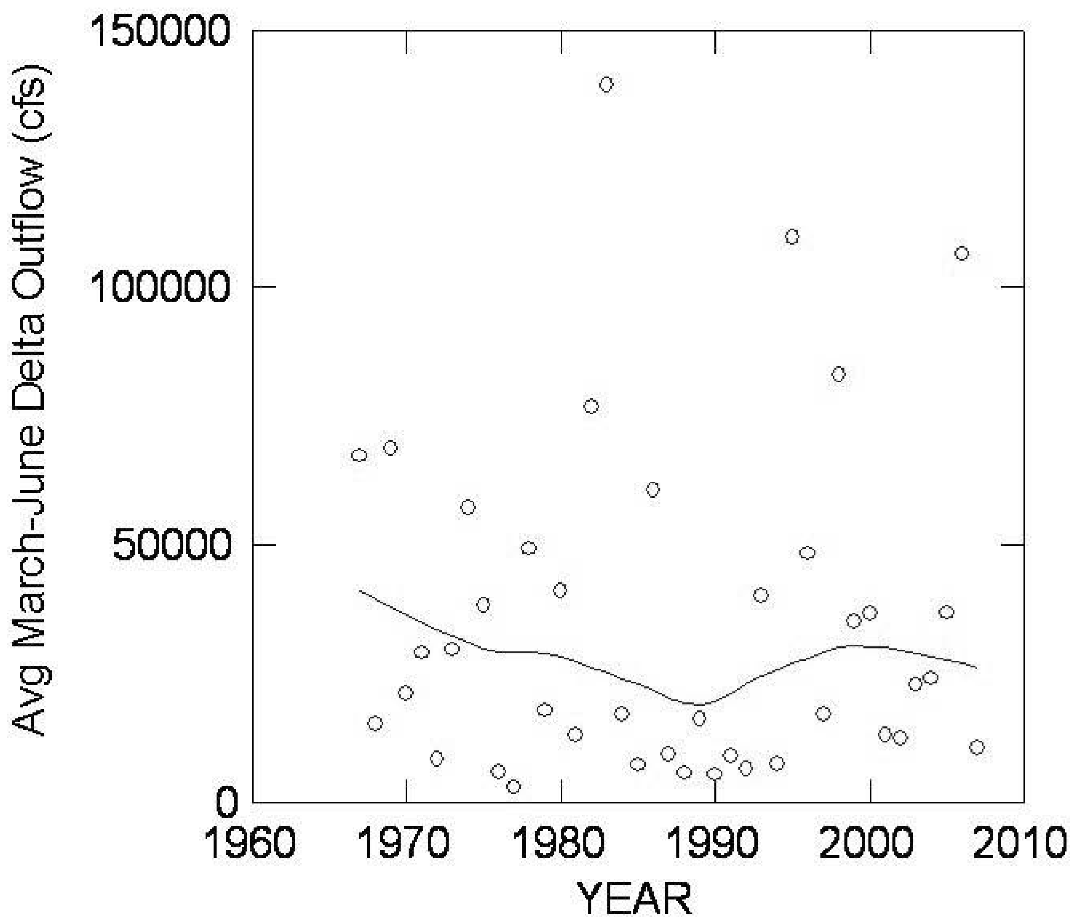


Figure E-11. Time trend in average April - May Delta outflow, 1967-2007. The spline is a LOWESS regression line.

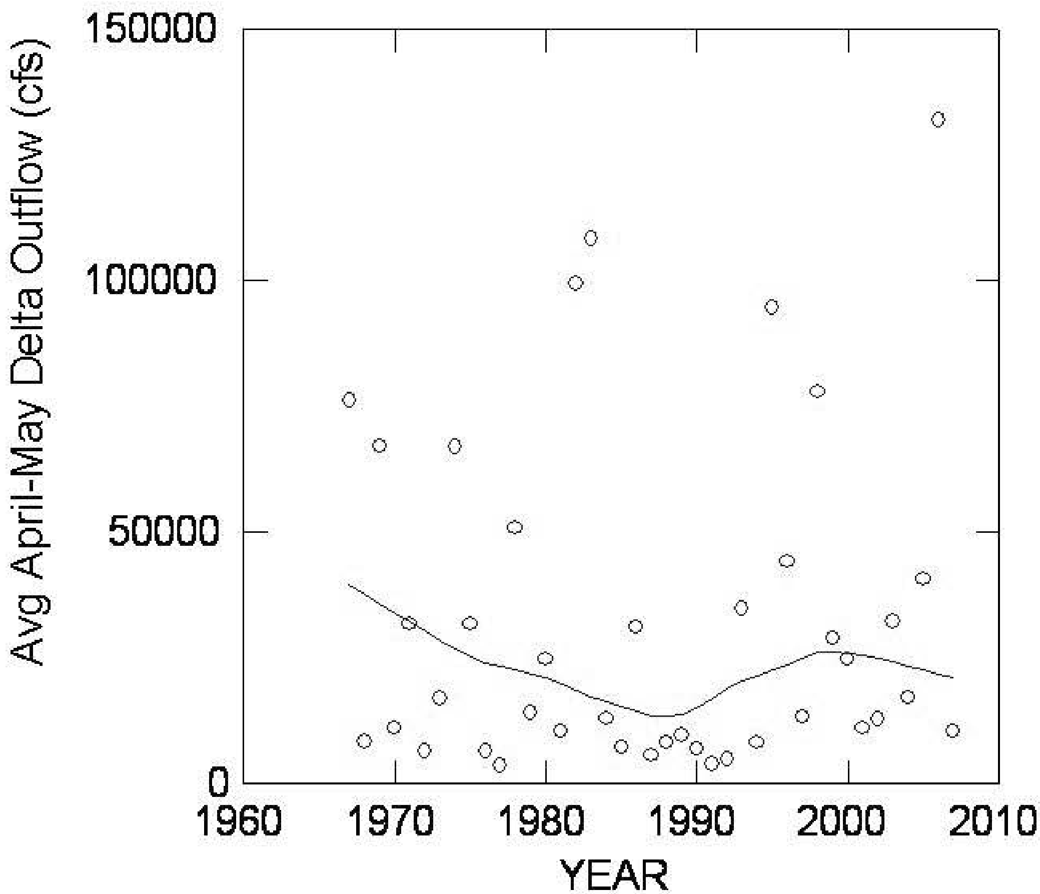


Figure E-12. Boxplot summary of CALSIM II operations study outputs of average March – June flows in Old and Middle rivers for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme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

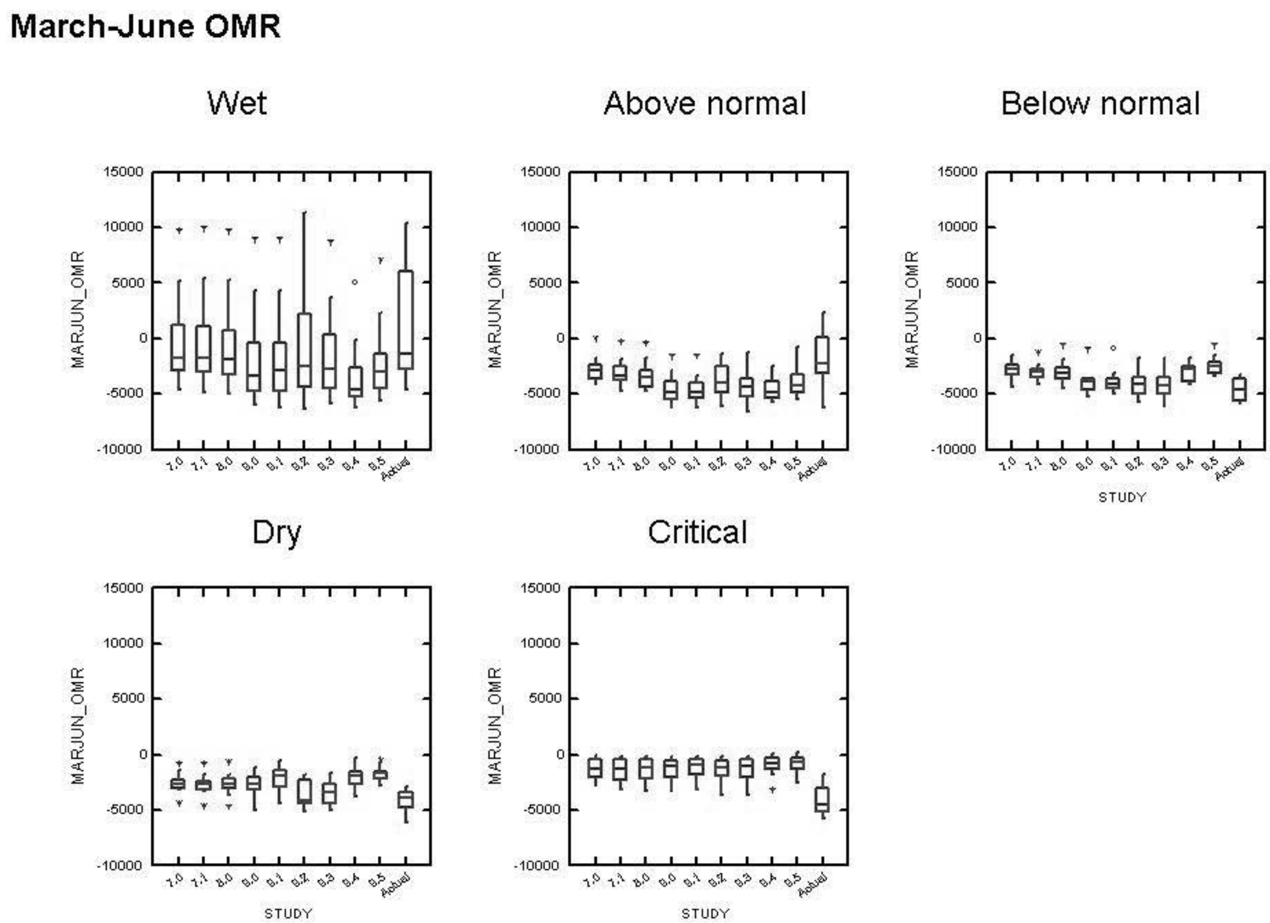


Figure E-13. Boxplot summary of CALSIM II operations study outputs of average April – May flows in Old and Middle rivers for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values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

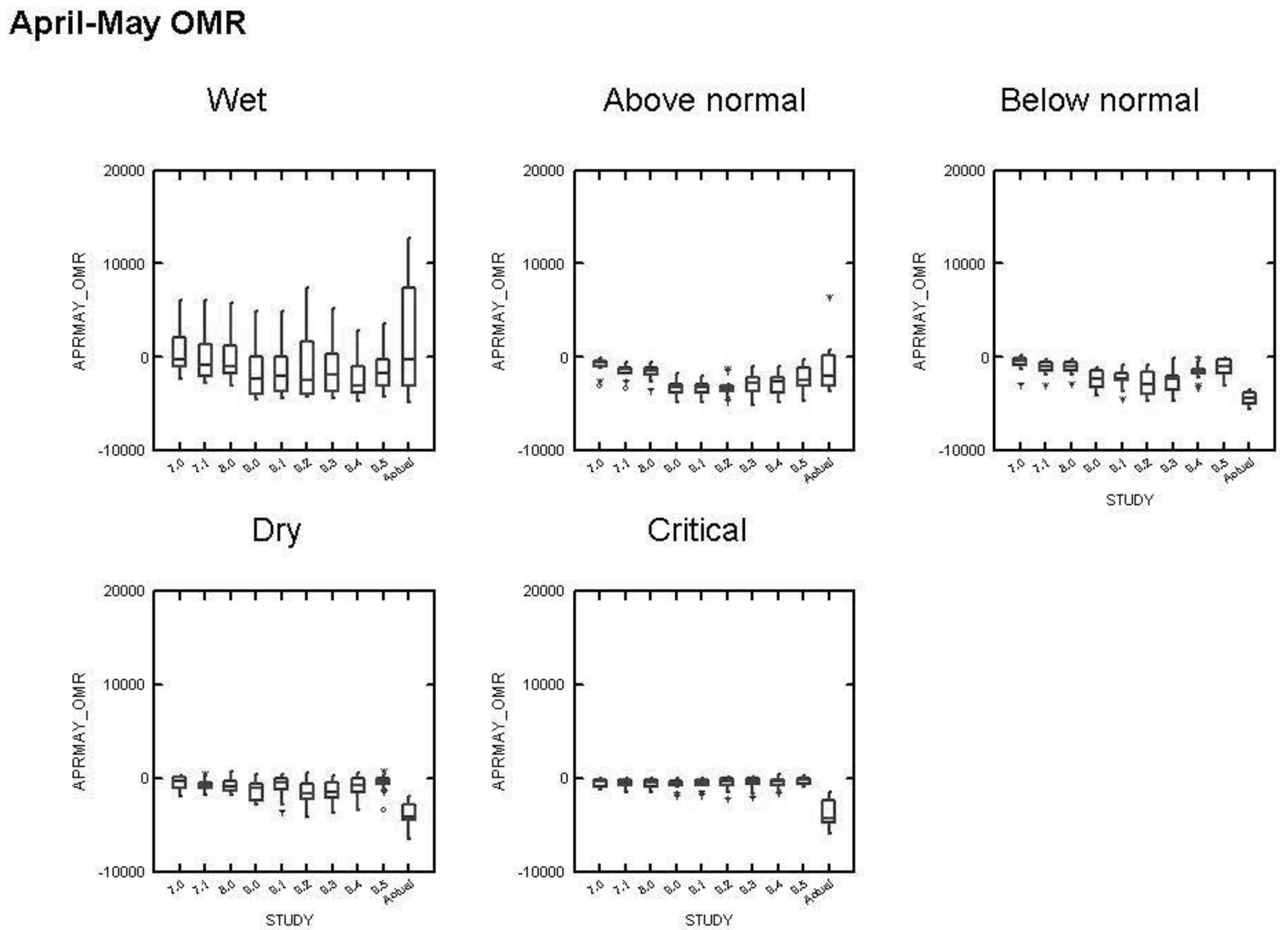


Figure E-14. Boxplot summary of CALSIM II operations study outputs of average March – June X2 positions for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by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

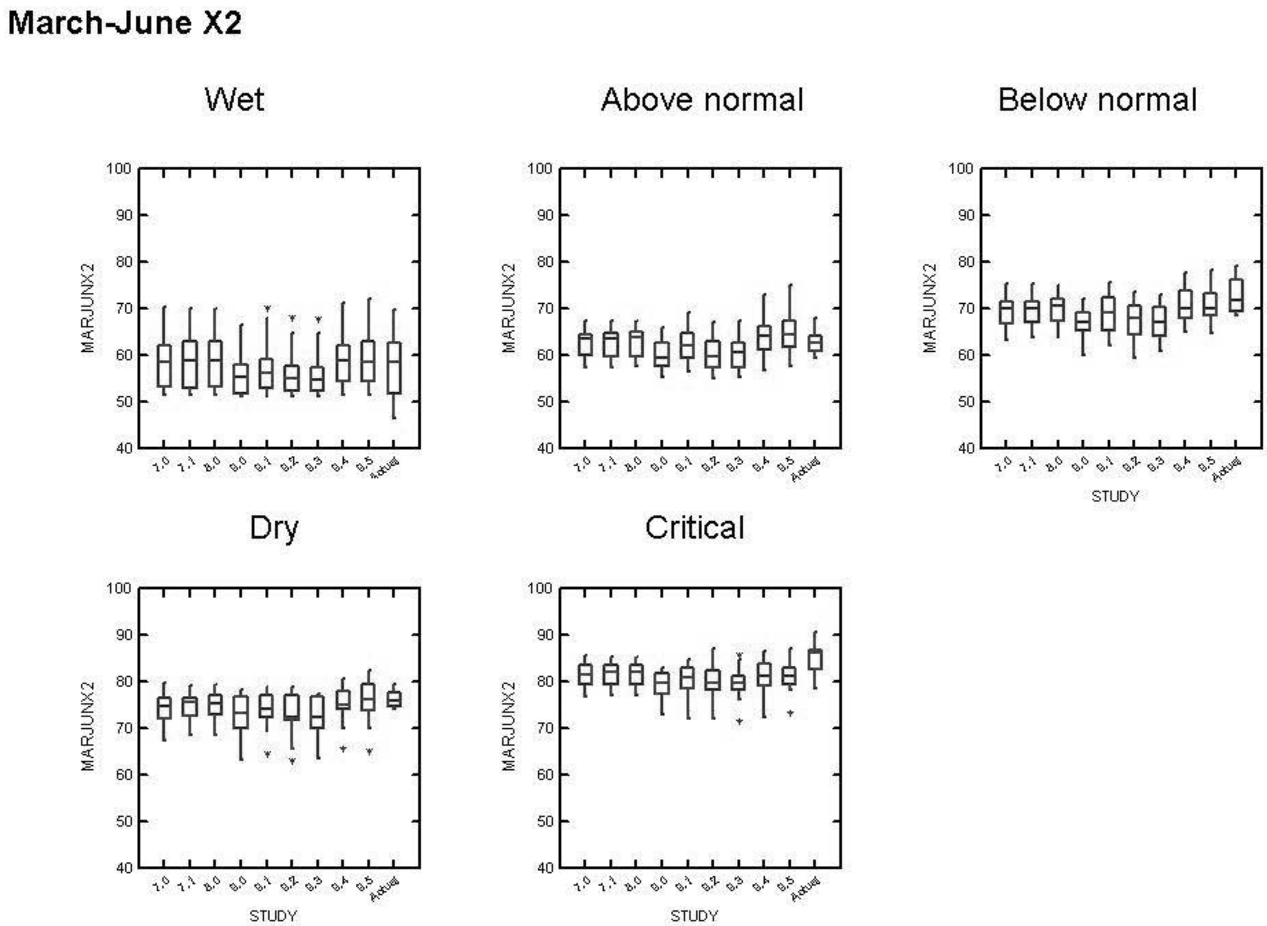


Figure E-15. Boxplot summary of CALSIM II operations study outputs of average April – May X2 positions for five WY types. The boxes depict the interquartile range which is the distance between the 25th and 75th percentiles. The lines within the boxes show the medians, more extreme values are shown by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

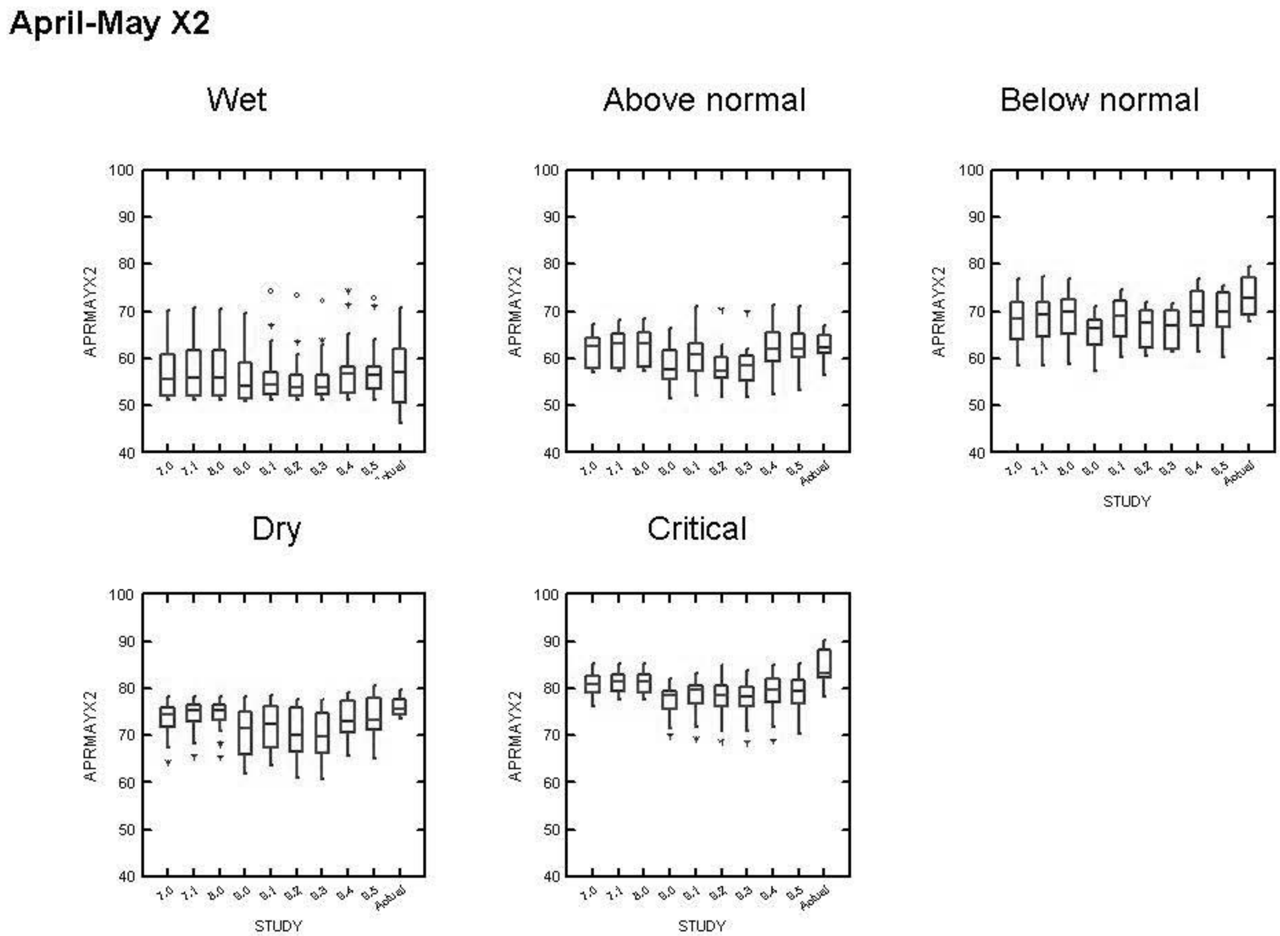


Figure E-16. Time series of estimated percentages of the larval-juvenile delta smelt population entrained in the SWP and CVP South Delta water export diversion facilities. Error bars were estimated by linear regression of Kimmerer's (2008) entrainment estimates versus the upper and lower 95 percent confidence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

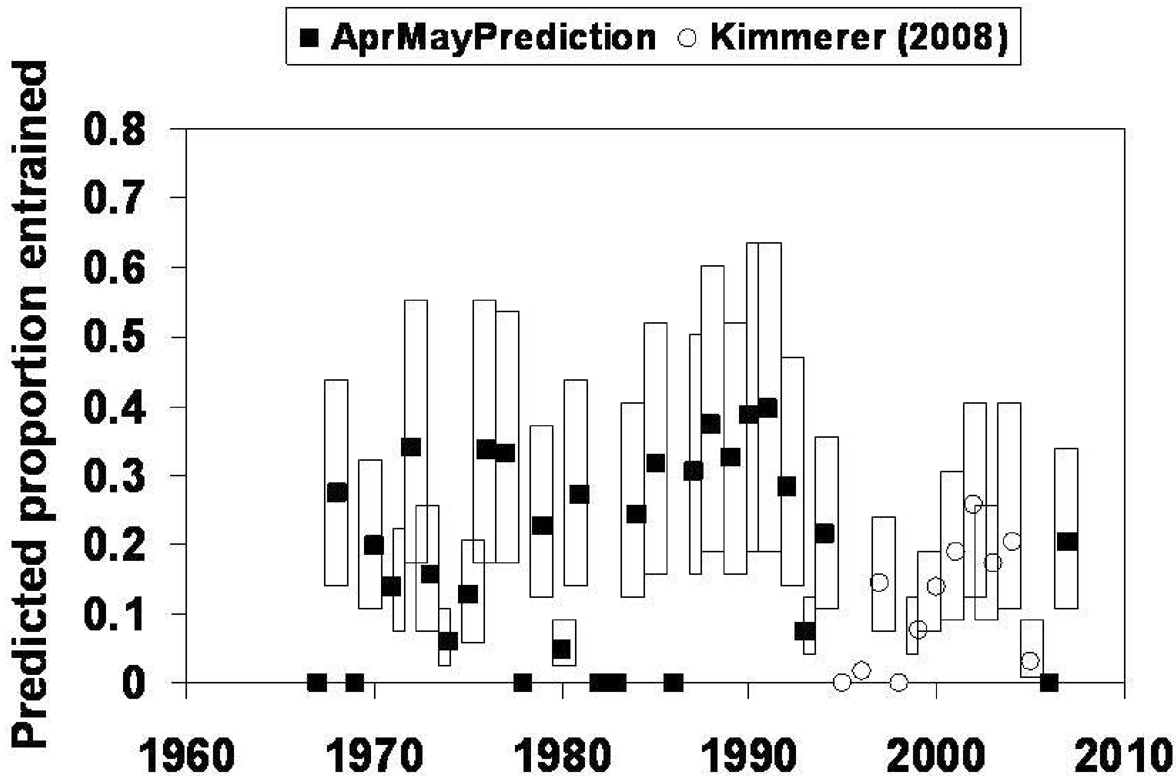


Figure E-17. Frequency distribution of estimated proportions of larval-juvenile delta smelt entrained at Banks and Jones for 1967-1994 and 1995-2007. The data were extrapolated to an 82-year period to make them comparable to the CALSIM II outputs in the biological assessment.

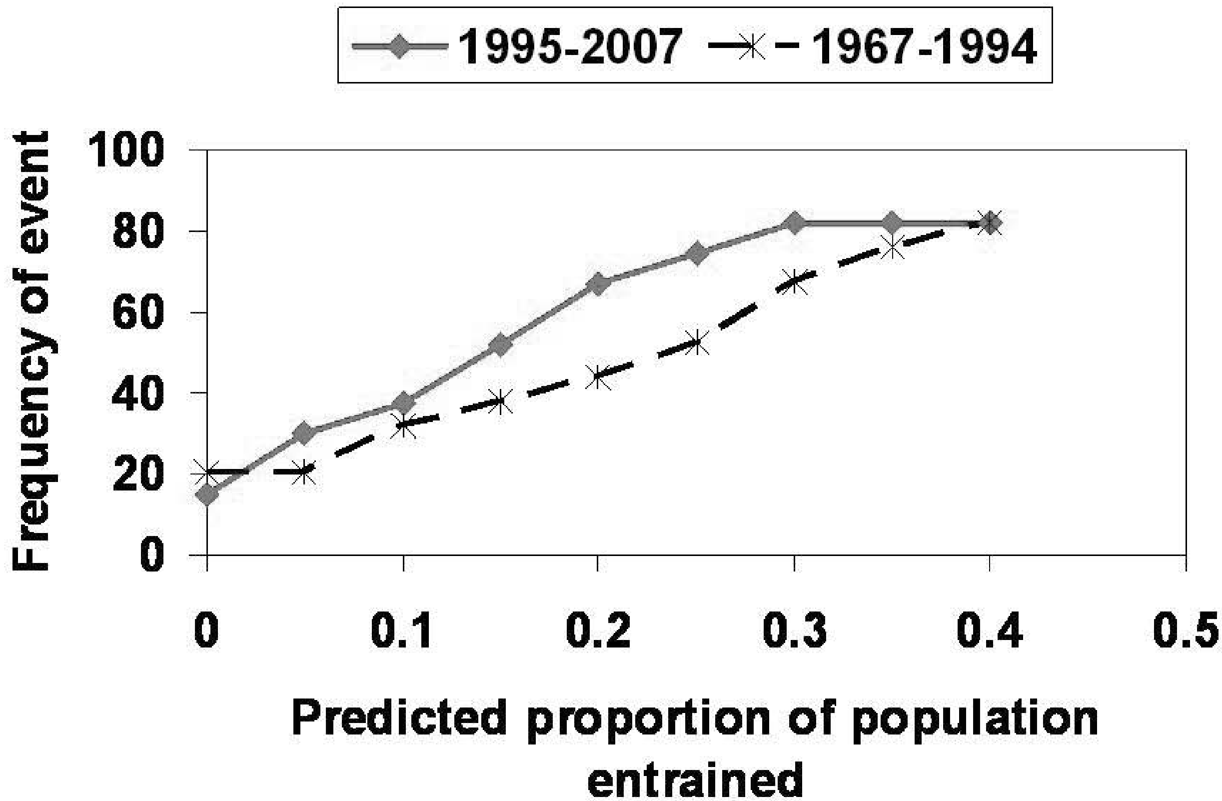


Figure E-18. Same as Figure 17, but including estimates based on X2 and OMR summaries from studies 7.0, 7.1, 8.0, 9.0-9.5 from the biological assessment.

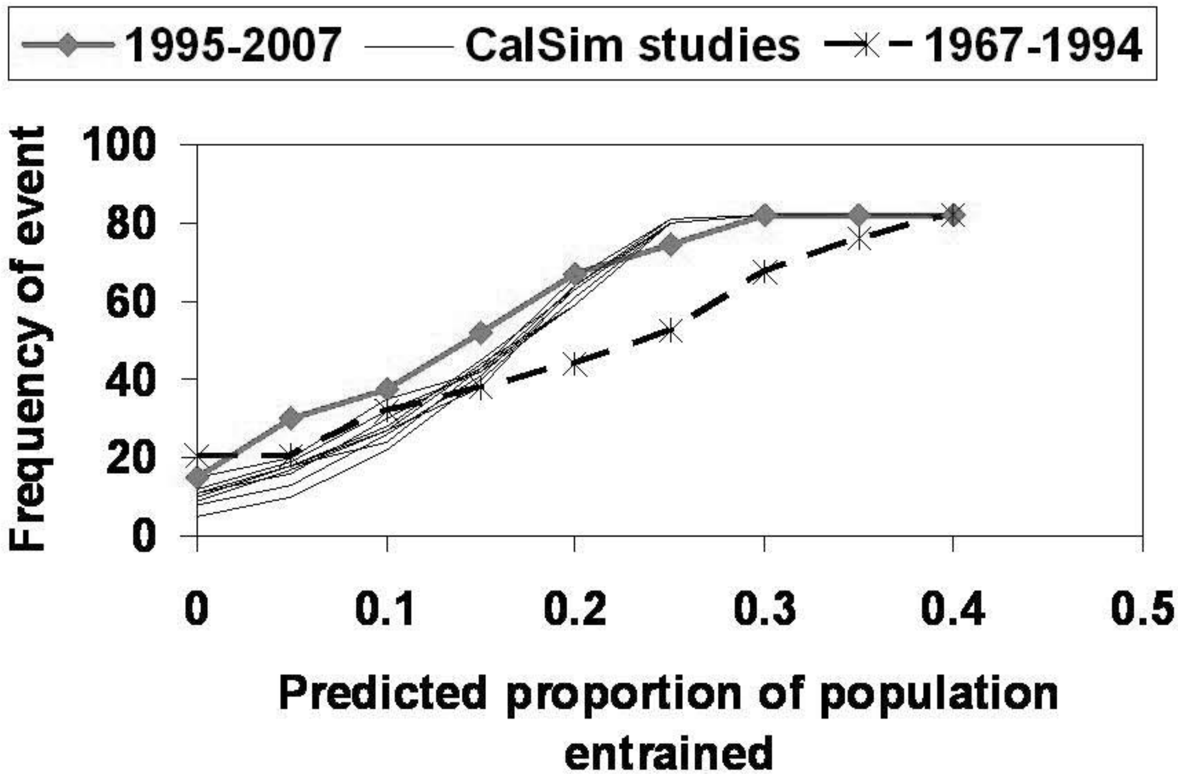


Figure E-19. X2 (km) during September to December based on historic data and CALSIM II model results. The center line in the box is the median and the outer box boundaries are the first and third quartiles.

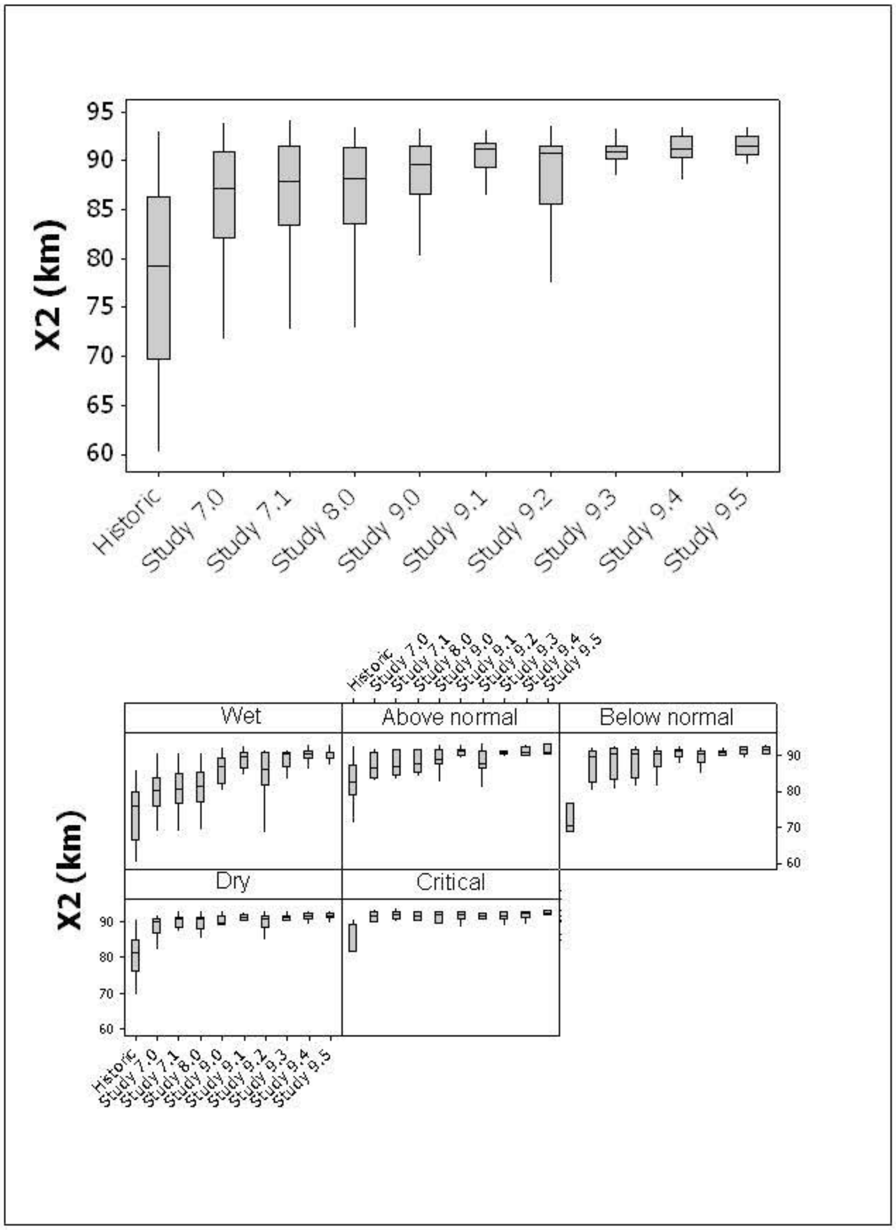
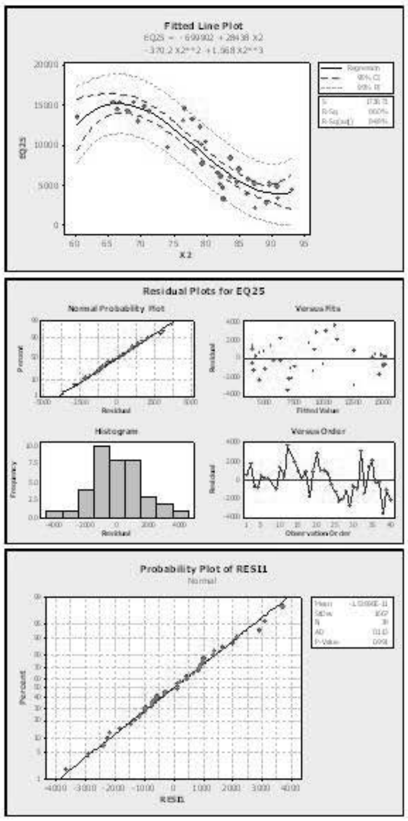


Figure E-20. Summary statistics for the model relating the effect of X2 on the area of suitable abiotic habitat (ha) for delta smelt during September to December.



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

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

Analysis of Variance

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

Sequential Analysis of Variance

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

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

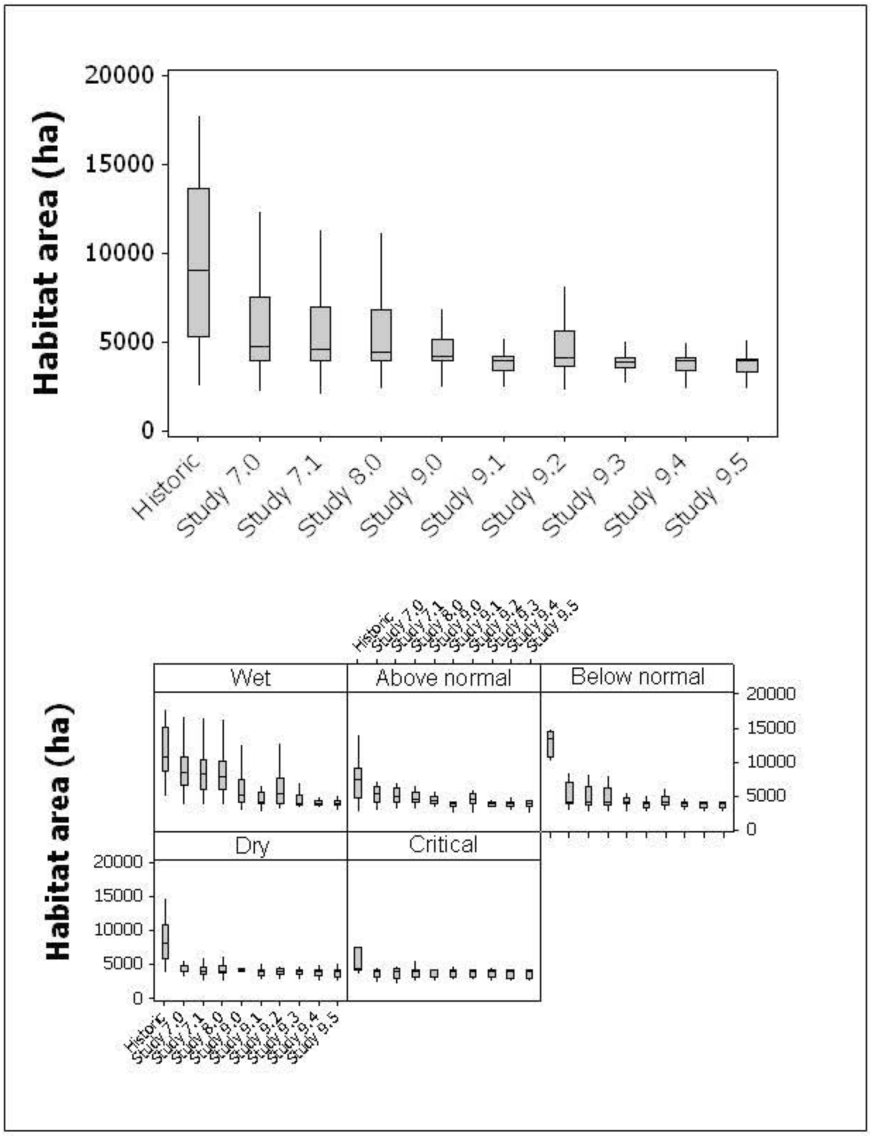
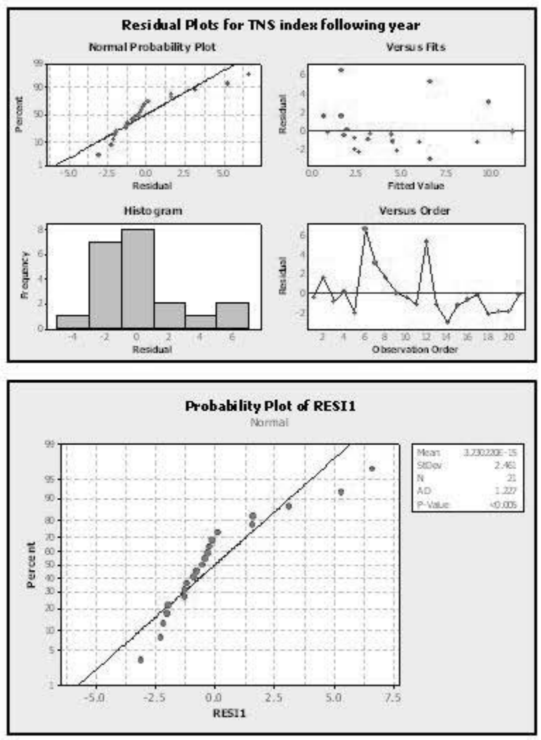


Figure E-22. Summary statistics for the stock-recruit model for delta smelt that incorporates X2 position during September to December as a covariate.



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

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

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

Analysis of Variance

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

Source	DF	Seq SS
FMT index	1	146.751
X2	1	39.383

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

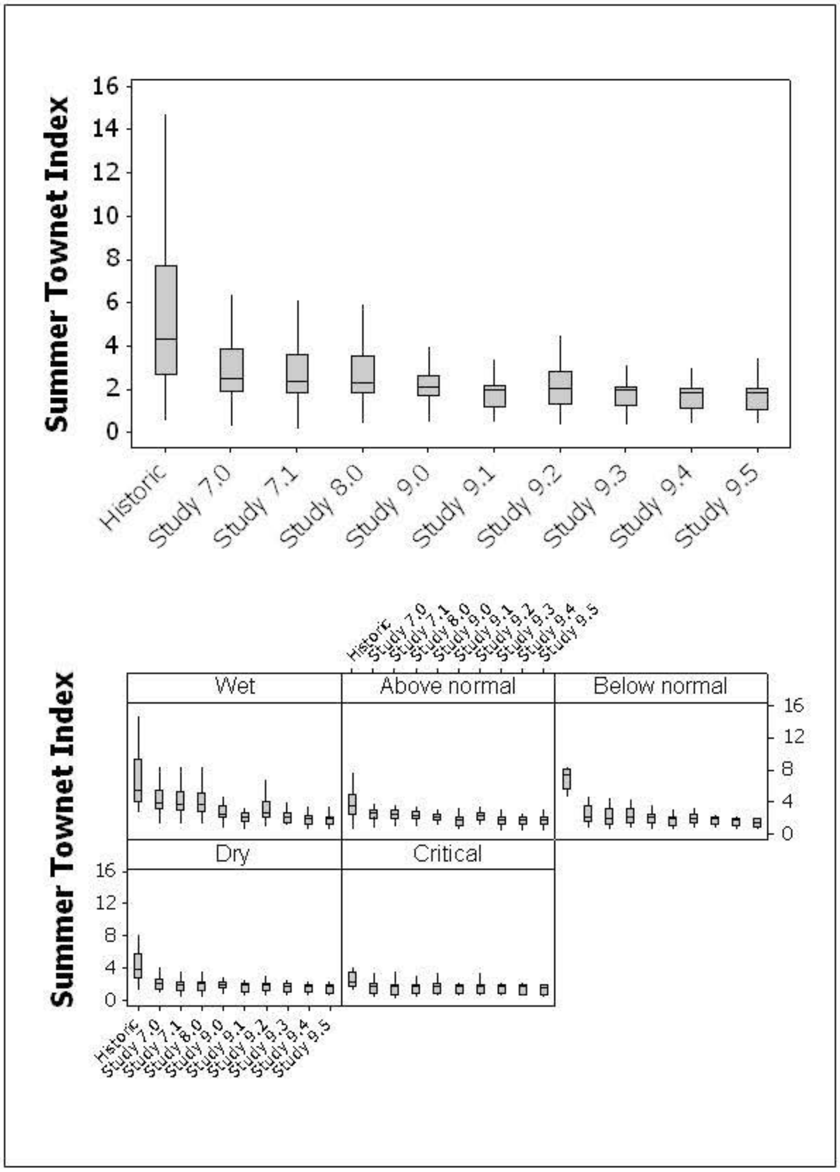


Figure E-24. Time series of historic X2 and E:I ratio for fall (September-December) in the upper panels and their relationship in the lower panel.

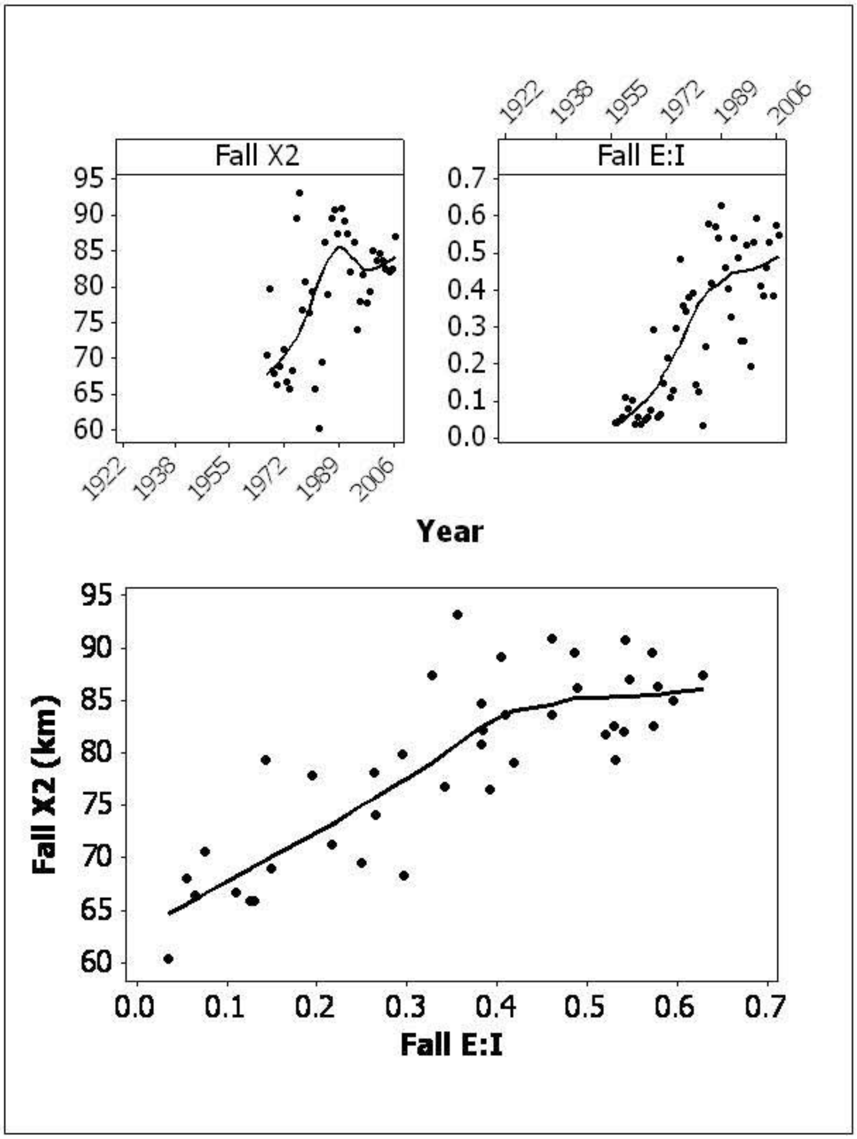


Figure E-25. Smoothed trend lines for the time series of historic and CALSIM II-modeled fall X2.

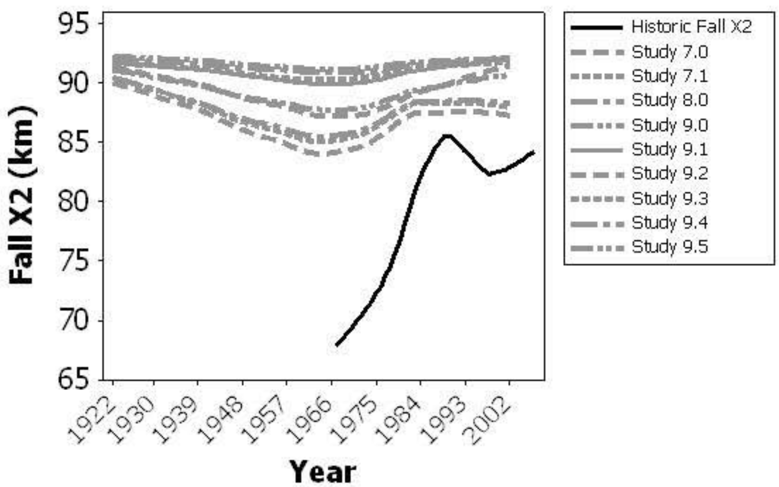


Figure E-26. X2 (km) during individual fall months for historic data and CALSIM II model results. The center line in the box is the median and the outer box boundaries are the first and third quartiles.

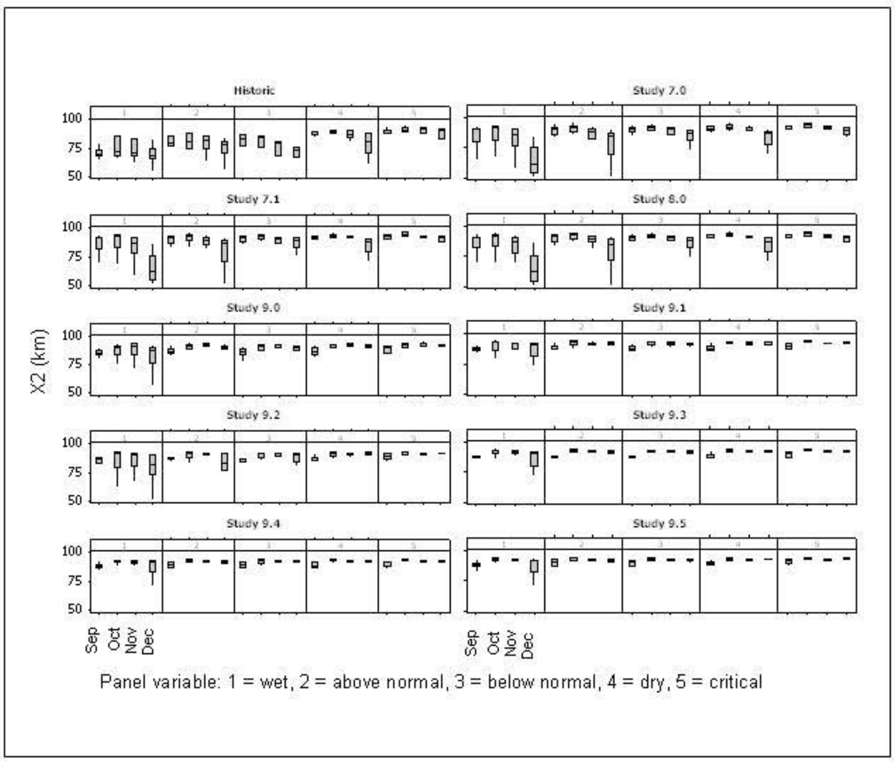


Figure E-27. Time series of fall X2 (September-December) with years noted by WY type for the previous spring.

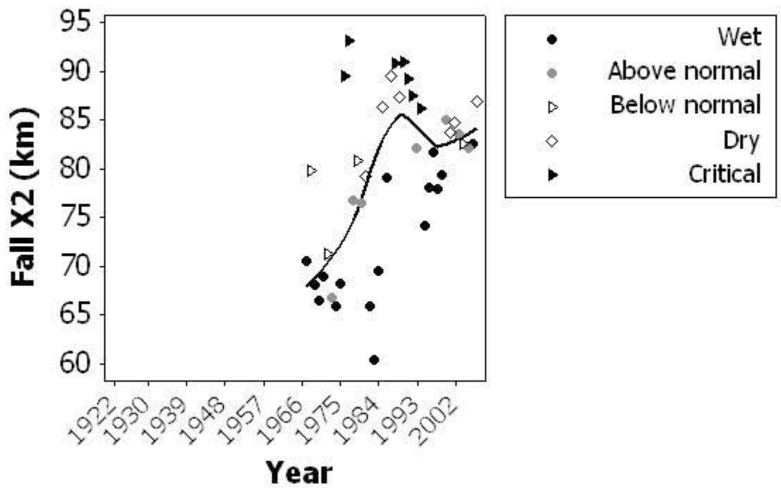


Figure E-28. Top panel: Time series of fall (September-December) and spring (April-July) X2. Lower panel: Smoothed time series of the difference between fall and spring X2 based on historic data and the CALSIM II model results.

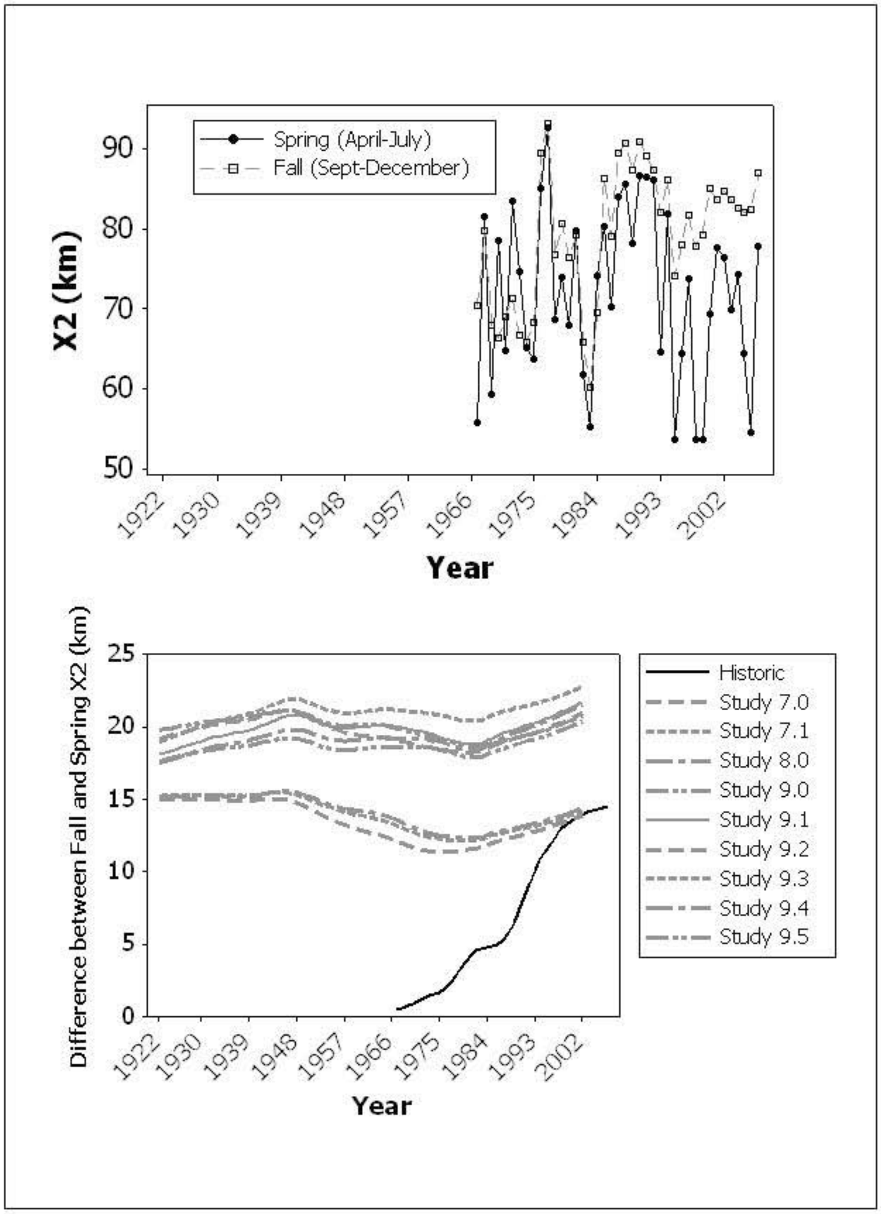
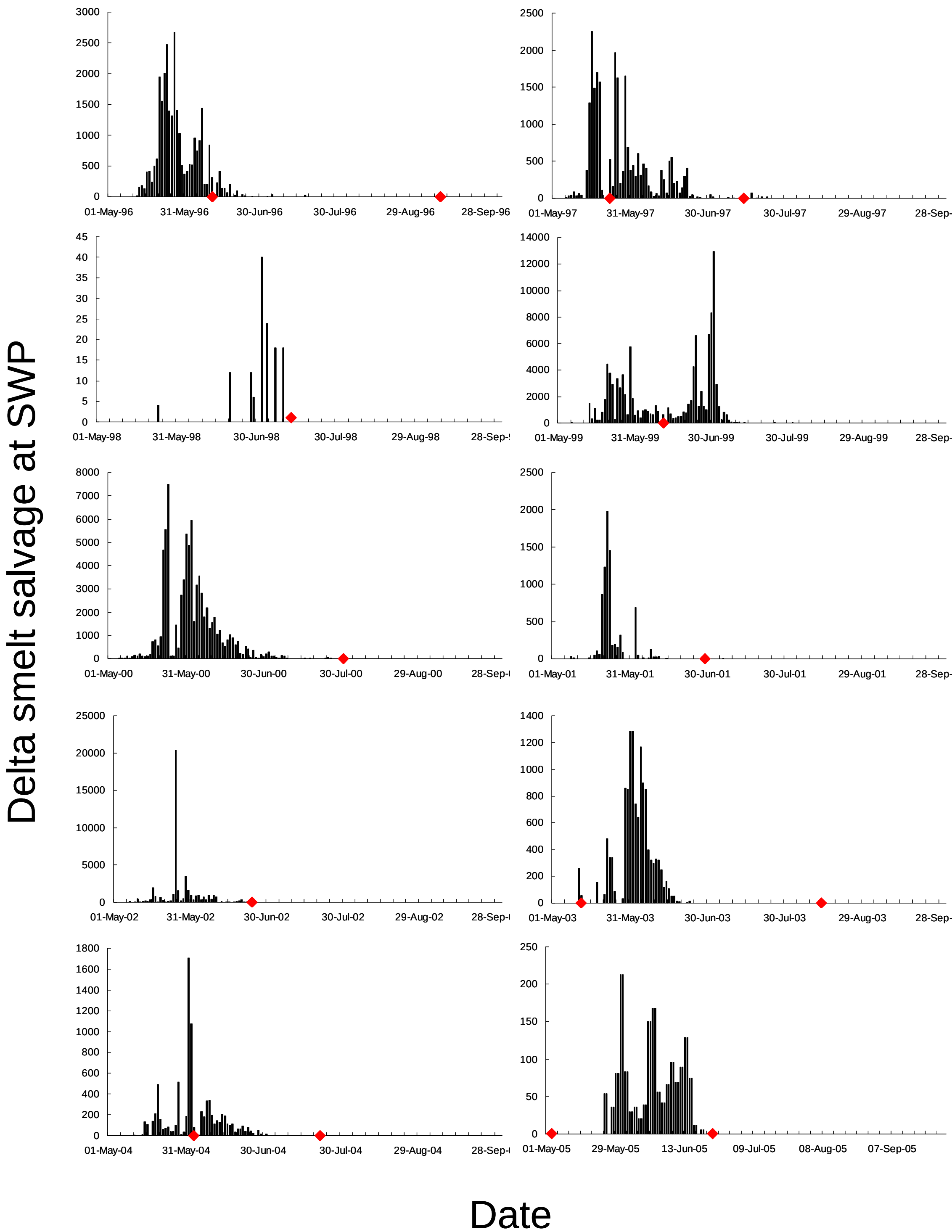


Figure E-29. May-September delta smelt salvage at the SWP Banks Pumping Plant, 1996-2005, with the start and end dates of Komeen or Nautique aquatic weed treatment indicated by the red diamonds.



Conclusion

Delta Smelt

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

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

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

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

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

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

5. To survive and recover, delta smelt need:

(a) a substantially more abundant adult population;

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

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

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

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

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

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

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

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

Delta Smelt Critical Habitat

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

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

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

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

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

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

Reasonable and Prudent Alternative

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

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

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

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

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

Process for Determining Specific Actions within Components 1 and 2

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

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

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

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

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

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

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

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

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

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

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

RPA Component 2: Protection of Larval and Juvenile Delta Smelt

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

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

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

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

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

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

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

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

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

RPA Component 4: Habitat Restoration

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

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

RPA Component 5: Monitoring and Reporting

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

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

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

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

Avoidance of Jeopardy and Adverse Modification

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

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

Incidental Take Statement

Introduction

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

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

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

Form of Take Anticipated

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

Amount or Extent of Take

Take of Delta Smelt at the NBA and CCWD Facilities

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

Take of Adult Delta Smelt

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

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

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

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

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

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

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

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

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

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

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

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

Take of Larval and Juvenile Delta Smelt

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

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

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

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

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

Larval/Juvenile Incidental Take = 1.5 * Concern Level

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

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

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	1	1	102	30	45	502	147	221
4	1	2	104	30	46	504	148	222
6	2	3	106	31	47	506	148	223
8	2	4	108	32	47	510	150	224
10	3	4	110	32	48	520	152	229
12	4	5	120	35	53	530	155	233
14	4	6	130	38	57	540	158	237
16	5	7	140	41	62	550	161	242
18	5	8	150	44	66	560	164	246
20	6	9	160	47	70	570	167	251
22	6	10	170	50	75	580	170	255
24	7	11	180	53	79	590	173	259
26	8	11	190	56	84	600	176	264
28	8	12	200	59	88	620	182	273
30	9	13	220	64	97	640	188	281
34	10	15	240	70	106	660	193	290
38	11	17	260	76	114	680	199	299
42	12	18	280	82	123	700	205	308
48	14	21	300	88	132	720	211	317
54	16	24	320	94	141	740	217	325
60	18	26	340	100	150	760	223	334
66	19	29	360	106	158	780	229	343
72	21	32	380	111	167	800	235	352
78	23	34	400	117	176	840	246	369
84	25	37	420	123	185	880	258	387
90	26	40	460	135	202	920	270	405
96	28	42	480	141	211	960	281	422
100	29	44	500	147	220	1000	293	440

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

FMWT Index	Concern Level	Incidental Take
2	26	39
4	52	78
6	78	117
8	104	156
10	130	196
12	156	235
14	182	274
16	209	313
18	235	352
20	261	391
22	287	430
24	313	469
26	339	508
28	365	547
30	391	587
34	443	665
38	495	743
42	547	821
48	626	938
54	704	1056
60	782	1173
66	860	1290
72	938	1408
78	1017	1525
84	1095	1642
90	1173	1760
96	1251	1877
100	1303	1955

FMWT Index	Concern Level	Incidental Take
102	1329	1994
104	1356	2033
106	1382	2072
108	1408	2112
110	1434	2151
120	1564	2346
130	1694	2542
140	1825	2737
150	1955	2933
160	2085	3128
170	2216	3324
180	2346	3519
190	2476	3715
200	2607	3910
220	2868	4301
240	3128	4692
260	3389	5083
280	3650	5474
300	3910	5865
320	4171	6256
340	4432	6647
360	4692	7038
380	4953	7429
400	5214	7821
420	5474	8212
460	5996	8994
480	6256	9385
500	6517	9776

FMWT Index	Concern Level	Incidental Take
502	6543	9815
504	6569	9854
506	6595	9893
510	6647	9971
520	6778	10167
530	6908	10362
540	7038	10558
550	7169	10753
560	7299	10949
570	7429	11144
580	7560	11340
590	7690	11535
600	7821	11731
620	8081	12122
640	8342	12513
660	8603	12904
680	8863	13295
700	9124	13686
720	9385	14077
740	9645	14468
760	9906	14859
780	10167	15250
800	10427	15641
840	10949	16423
880	11470	17205
920	11991	17987
960	12513	18769
1000	13034	19551

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

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	66	99	102	3369	5053	502	16578	24868
4	132	198	104	3435	5152	504	16644	24967
6	198	297	106	3501	5251	506	16711	25066
8	264	396	108	3567	5350	510	16843	25264
10	330	495	110	3633	5449	520	17173	25759
12	396	594	120	3963	5944	530	17503	26255
14	462	694	130	4293	6440	540	17833	26750
16	528	793	140	4623	6935	550	18164	27245
18	594	892	150	4954	7431	560	18494	27741
20	660	991	160	5284	7926	570	18824	28236
22	727	1090	170	5614	8421	580	19154	28732
24	793	1189	180	5944	8917	590	19485	29227
26	859	1288	190	6275	9412	600	19815	29722
28	925	1387	200	6605	9907	620	20475	30713
30	991	1486	220	7265	10898	640	21136	31704
34	1123	1684	240	7926	11889	660	21796	32695
38	1255	1882	260	8586	12880	680	22457	33685
42	1387	2081	280	9247	13870	700	23117	34676
48	1585	2378	300	9907	14861	720	23778	35667
54	1783	2675	320	10568	15852	740	24438	36657
60	1981	2972	340	11228	16843	760	25099	37648
66	2180	3269	360	11889	17833	780	25759	38639
72	2378	3567	380	12549	18824	800	26420	39630
78	2576	3864	400	13210	19815	840	27741	41611
84	2774	4161	420	13870	20806	880	29062	43593
90	2972	4458	460	15191	22787	920	30383	45574
96	3170	4756	480	15852	23778	960	31704	47556
100	3302	4954	500	16512	24769	1000	33025	49537

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

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

Effect of the Take

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

Reasonable and Prudent Measures

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

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

2. Minimize adverse effects of operations of the NBA.

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

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

Terms and Conditions

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

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

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

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

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

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

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

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

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

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

Monitoring Requirements

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

Reporting Requirements

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

Conservation Recommendations

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

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

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

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

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

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

Reinitiation-Closing Statement

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

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

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

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

Cc: California Department of Water Resources, Sacramento, CA

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

National Marine Fisheries Service, Sacramento, CA

Literature Cited

Arthur, J. F., M. D. Ball, and S. Y. Baughman. 1996. Summary of federal and State water project impacts in the San Francisco Bay-Delta estuary, California. Pages 445-495 in J. T. Hollibaugh (editor) San Francisco Bay: the ecosystem. AAAS, San Francisco, CA.

Adib-Samii 2008. Personal communication via e-mail with Victoria Poage, USFWS, re: water temperature thresholds for collection of delta smelt in routine survey sampling, October 8, 2008

Alpine, A. E., and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnology and Oceanography 37: 946-955.

Amweg, E.L., D.P. Weston, & N.M. Ureda. 2005. Use and toxicity of pyrethroid pesticides in the Central Valley, California, USA. Environmental Toxicology and Chemistry 24:966–972.

Bailey, H. C., C. Alexander, C. DiGiorgio, M. Miller, S. I. Doroshov, and D. E. Hinton. 1994. The effect of agricultural discharge on striped bass (Morone saxatilis) in California's Sacramento-San Joaquin drainage. Ecotoxicology 3: 123-142.

Baskerville-Bridges, B., J.C. Lindberg and S.I. Doroshov. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. Pages 219-228 *in* F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi, eds. Early fife history of fishes in the San Francisco Estuary and watershed. Am. Fish. Soc. Symp. 39, Bethesda, MD, USA

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. 2008. Pelagic organism decline progress report: 2007 synthesis of results. (available at: http://www/science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf)

Bennett, WA, Moyle, PB. 1996. Where have all the fishes gone? Interactive factors producing fish declines. Pages 519-541 in Hollibaugh, JT, editor. San Francisco Bay: the ecosystem. Pacific Division of the American Association for the Advancement of Science. San Francisco, CA.

Bennett, WA, Kimmerer, WJ, Burau, JR. 2002. Plasticity in vertical migration by native and exotic fishes in a dynamic low-salinity zone. Limnology and Oceanography 47:1496-1507.

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [Internet] 3(2) http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1

Bennett, WA, Hobbs, JA, Teh, S. 2008. Interplay of environmental forcing and growth-selective mortality in the poor year-class success of delta smelt in 2005. Final Report to the Interagency Ecological Program.

Brandes, P.L. and J.S. McClain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. *In* R.L. Brown (ed.), Contributions to the biology of Central Valley salmonids. Fish Bulletin 179, pp 39-137

Bouley, P. and W. J. Kimmerer 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series 324: 219-228.

Brown, R., S. Greene, P. Coulston, and S. Barrow. 1996. An evaluation of the effectiveness of fish salvage operations at the intake of the California Aqueduct, 1979-1993. Pages 497-518 in J. T. Hollibaugh (editor) San Francisco Bay: the ecosystem. AAAS, San Francisco, CA.

Brown, L.R. 2003. Will tidal wetland restoration enhance populations of native fishes? San Francisco and Watershed Science 1: http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2.

Brown, L. R., W. Kimmerer, and R. Brown. 2008. Managing water to protect fish: a review of California's Environmental Water Account, 2001-2005. Environmental Management DOI 10.1007/s00267-008-9213-4 http://www.springerlink.com/content/u4022223x2181287/fulltext.pdf

Brown, R.L. and W.J. Kimmerer. 2001. Environmental and institutional background for CALFED's Environmental Water Account. CALFED Bay-Delta Program, Sacramento, California

Brown, R.L. & W. Kimmerer. 2002. Delta smelt and CALFED's Environmental Water Account: A summary of the 2002 delta smelt workshop. Prepared for the CALFED Science Program, October 2002.

Brown, LR, Michniuk, D. 2007. Littoral fish assemblages of the alien-dominated Sacramento-San Joaquin Delta, California, 1980-1983 and 2001-2003. Estuaries and Coasts 30:186-200.

Bryant, ME, Arnold, JD. 2007. Diets of age-0 striped bass in the San Francisco Estuary, 1973-2002. California Fish and Game 93:1-22.

California Department of Fish and Game. 2008a. ttp://www.delta.dfg.ca.gov/data/20mm/

California Department of Fish and Game. 2008b. Spring Kodiak Trawl Survey. http://www.delta.dfg.ca.gov/data/skt/

California Department of Fish and Game. 2008c. Summer Tow Net Survey. http://www.delta.dfg.ca.gov/data/townet/

Castillo, G., Morinaka, J., Baskerville-Bridges, B., Lindberg, J., Fujimura, R., Dubois, J., Tigan, G., Poage, V. 2008. Pilot Mark-Recapture Study to Estimate Delta Smelt Pre-screen Loss and Salvage Efficiency. 2008 CALFED Science Conference Presentation

Cook and Buffaloe 1998. – Determining the effect of earlier entrainment has been limited because previous studies either (1) did not quantify the volumes of water diverted (Hallock and Van Woert 1959, Pickard et al. 1982) or (2) did not sample at times when, or locations where, delta smelt were abundant

Culberson, S.D., C.B. Harrison. C. Enright and M.L. Nobriga. 2004. Sensitivity of larval fish transport to location, timing, and behavior using a particle tracking model in Suisun Marsh, California. Pages 257-267 *in* F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi, eds. Early fife history of fishes in the San Francisco Estuary and watershed. Am. Fish. Soc. Symp. 39, Bethesda, MD, USA

Davis, J.A., D. Yee, J.N. Collins, S.E. Schwarzbach, & S.N. Luoma. 2003. Potential for Increased Mercury Accumulation in the Estuary Food Web. San Francisco Estuary and Watershed Science. Vol. 1.

Dege, M. and L.R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Am. Fish. Soc. Symposium 39: 49-65

Dettinger, MD. 2005. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science 3:http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4.

Dugdale, RC, Wilkerson, FP, Hogue, VE, Marchi, A. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal, and Shelf Science 73:17-29.

Durand J. San Francisco State University, oral presentation at 2006 CALFED Science Conference

DWR Delta Overview. http://baydeltaoffice.water.ca.gov/sdbtbp/deltaoverview/delta_overview.pdf

DWR and Reclamation (California Department of Water Resources and U.S. Bureau of Reclamation). 1994. Biological Assessment — Effects of the Central Valley Project and State Water Project on Delta Smelt and Sacramento Splittail. Prepared for U.S. Fish and Wildlife Service, Sacramento, CA. 230 p.

DWR. 1994. Temporary Barriers Project Fishery, Water Quality, and Vegetation Monitoring, 1993. Submitted to U.S. Army Corps of Engineers for permit requirements. 169 pp. plus appendixes.

DWR. 2000a. Benchmark Studies Assumptions, (Draft), Sacramento, CA, Sept. 2000.

DWR 2007. Morrow Island Distribution System fish entrainment study. Interim data summary report, Division of Environmental Services, Sacramento, CA.

Edmunds, J.L., K.M. Kuivila, B.E. Cole, & J.E. Cloern. 1999. Do herbicides impair phytoplankton primary production in the Sacramento-San Joaquin River Delta? In: USGS Toxic Substances Hydrology Program Technical Meeting Proceedings, Charleston, SC, March 8-12, 1999.

Edwards, G.W., K. Urquhart , & T. Tillman. 1996. Adult salmon migration monitoring during the various operational phases of the Suisun Marsh Salinity Control Gates, September–November 1994. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. Technical Report 50. 27 p.

Enos, C, Sutherland, J, Nobriga, M. 2007. Results of a two year fish entrainment study at Morrow Island Distribution System in Suisun Marsh. Interagency Ecological Program Newsletter 20(1):10-19.

Feyrer, F, Herbold, B, Matern, SA, Moyle, PB. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67:277-288.

Feyrer, F, Nobriga, ML, Sommer, TR. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Feyrer, F, Newman, K, Nobriga, ML, Sommer, TR. 2008. Modeling the effects of water management actions on suitable habitat and abundance of a critically imperiled estuarine fish (delta smelt *Hypomesus transpacificus*). Manuscript in preparation.

Foott, J. S., K. True, & R. Stone. 2006. Histological evaluation and viral survey of juvenile longfin smelt, (*Spirinchus thaleichthys*) and threadfin shad (*Dorosoma petenense*) collected in the Sacramento-San Joaquin River Delta, April-October 2006. California Nevada Fish Health Center

Giddings, J.M., L.W. Hall, Jr, & K.R. Solomon. 2000. Ecological risks of diazinon from agricultural use in the Sacramento - San Joaquin River Basins, California. Risk Analysis 20:545–572.

Grimaldo, LF, Sommer, T, Van Ark, N, Jones, G, Holland, E, Moyle, P, Smith, P, Herbold, B. Factors affecting fish entrainment into massive water diversions in a freshwater tidal estuary: can fish losses be managed? North American Journal of Fisheries Management: accepted manuscript

Grimaldo, L.F., A. R. Stewart, and W. Kimmerer. Dietary segregation of pelagic and littoral fish assemblages in a highly modified tidal freshwater estuary. In review Marine and Coastal Fisheries

Hallock, RJ, Van Woert, W. 1959. A survey of anadromous fish losses in irrigation diversions from the Sacramento and San Joaquin rivers. California Fish and Game 45: 227-521.

Hobbs, JA, Bennett, WA, Burton, J. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco Estuary. Journal of Fish Biology 69: 907-922.

Hobbs, JA, Bennett, WA, Burton, J, Gras, M. 2007. Classification of larval and adult delta smelt to nursery areas by use of trace elemental fingerprinting. Transactions of the American Fisheries Society 136:518-527.

Horppila, *J., A.* Liljendahl-Nurminen and T. Malinen. 2004. Effects of clay turbidity and light on the predator–prey interaction between smelts and chaoborids. Can. J. Fish. Aquat. Sci. 61: 1862-1870

Herren, JR, Kawasaki, SS. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. California Department of Fish and Game Fish Bulletin 179(vol.2):343-355.

Jassby, A. D., J. E. Cloern, and T. M. Powell. 1993. Organic carbon sources and sinks in San Francisco Bay: variability induced by river flow. Mar. Ecol. Prog. Ser. 95: 39-54.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecol. Appl. 5(1): 272-289

Jassby, AD, Cloern, JE, Cole, BE. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712.

Jassby, A.D., A.B. Mueller-Solger and M. Vaysierres. 2005. Subregions of the

Sacramento-San Joaquin Delta: identification and use. Interagency Ecological Program Newsletter 18(2): 46-56

Kawakami, B.T., Denton, R.A., Gartrell, G. 2008. Investigation of the Basis for Increases in Delta Fall Salinity. CALFED Sceince Conference Poster Presentation.

Kimmerer, WJ, Orsi, JJ. 1996. Causes of long-term declines in zooplankton in the San Francisco Bay estuary since 1987. Pages 403-424 in J. T. Hollibaugh (editor) San Francisco Bay: the ecosystem. AAAS, San Francisco, CA.

Kimmerer, W.J. 2002. Physical, biological and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275-1290

Kimmerer, W. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological processes. San Francisco Estuary and Watershed Science [Internet] 2(1) http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1

Kimmerer, W. and M. Nobriga 2005. Development of bootstrapped confidence intervals for the IEP fish abundance indices. Interagency Ecological Program Newsletter 18(2): 68-75.

Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entraiment in water diversioins in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science [online serial] Vol. 6, Issue 2 (June 2008), Article 2 http://repositories.cdlib.org/jmie/sfews/vol6/iss2/art2

Kimmerer, W.J. and M.L. Nobriga. 2008. Investigating particle transport and fate in the Sacramento-San Joaquin Delta using a particle tracking model. San Francisco Estuary and Watershed Science [online serial] Vol. 6, Issue 2 (February 2008), Article 4 http://repositories.cdlib.org/jmie/sfews/vol6/iss1/art4

Kimmerer, W.J. in prep Draft report on Tasl 4: Modeling. Report to the CALFED Ecosystem Restoration Program, Contract ERP-02-P19. Submitted June 12, 2008

Knutson, A.C. Jr and J.J. Orsi. 1983. Factors regulating abundance and distribution of the shrimp *Neomysis mercedis* in the Sacramento-San Joaquin Estuary. T. Am. Fish. Soc. 112: 476-485

Kuivila, K. M., and C. G. Foe 1995. Concentrations, transport, and biological effects of dormant spray pesticides in the San Francisco Estuary, California. Environmental Toxicology and Chemistry 14: 1141-1150.

Kuivila, KM, Moon, GE. 2004. Potential exposure of larval and juvenile delta smelt to dissolved pesticides in the Sacramento-San Joaquin Delta, California. American Fisheries Society Symposium 39:229-242.

Lehman, PW, Boyer, G, Hall, C, Waller, S, Gehrts, K. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99.

Lehman, PW, Boyer, G, Satchwell, M, Waller, S. 2008. The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia 600:187-204.

Lehman, P. W., T. Sommer and L. Rivard, 2008. The influence of floodplain habitat on the quantity of riverine phytoplankton carbon produced during the flood season in San Francisco Estuary. Aquatic Ecology 42: 363-378.

Liermann, M. and R. Hilborn. 2001. Depensation, evidence, models and implications. Fish and Fisheries 2:33-58.

Lindberg, Joan C., B. Baskerville-Bridges, and S.I. Doroshov. 2003. "Two Reproductive Concerns Tested in Captive Delta Smelt, *Hypomesus transpacificus*, 2002: I. Effect of substrate and water velocity on spawning behavior.

Linville, R.G., S.N. Luoma, L. Cutter, & G.A. Cutter. 2002. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology 57: 51-64.

Lopez , C. B., Cloern, J.E., Schraga, T.S., Little, A.J., Lucas, L.V., Thompson, J.K., and Burau, J.R., 2006, Ecological values of shallow-water habitats: implications for restoration of disturbed ecosystems, Ecosystems 9: 422-440.

Lott, J. 1998. Feeding habits of juvenile and adult delta smelt from the Sacramento-San Joaquin River Estuary. Interagency Ecological Program Newsletter 11(1):14-19 (available at http://iep.water.ca.gov/report/newsletter/)

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle. 2007. Envisioning Futures for the Sacramento-San Joaquin Delta. San Francisco, CA: Public Policy Institute of California.

Mager RC. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, *Hypomesus transpacificus.* [Dissertation] Davis: University of California, Davis. 115 pages.

Mager, R.C., S.I. Doroshov, J.P. Van Eenennaam and R.L. Brown. 2004. Early life stages of delta smelt. Pages 169-180 *in* F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi, eds. Early fife history of fishes in the San Francisco Estuary and watershed. Am. Fish. Soc. Symp. 39, Bethesda, MD, USA

Manly, B.F.J. and M. Chotkowski. 2006. Two new methods for regime change analyses.

Arch. Hydrobiol. 167(1-4): 593-607

Monson, N.E., J.E. Cloern and J.R. Burau. 2007. Effects of flow diversion on water and habitat quality: examples from California's highly manipulated Sacramento-San Joaquin

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley and Los Angeles, California

Moyle, PB, Herbold, B, Stevens, DE, Miller LW. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, P. B. 1976. Inland fishes of California. University of California Press. Berkeley, CA.

Moyle, PB, Herbold, B, Stevens, DE, Miller LW. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, PB, Israel, JA. 2005. Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries 30(5):20-28.

Miller, BJ. 2007. Declaration of William J. (B.J.) Miller, Ph.D. Regarding Interim Injunctive Relief, July 23, 2007, Proceedings of Natural Resources Defense Council, et al. v. Kempthorne, et al., Case No. 05 CV-01207 OWW (E.D. Cal.)

Mueller-Solger, A.B., Jassby, A.D., Mueller-Navarra, D.C. 2002. Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento?San Joaquin River Delta), Limnol. Oceanogr. 47(5), 2002, 1468-1476.

Newman KB. 2008. Sample design-based methodology for estimating delta smelt abundance. San Francisco Estuary and Watershed Science 6(3): article 3. Available from: http://repositories.cdlib.org/jmie/sfews/vol6/iss3/art3

Nobriga, M, Hymanson, Z, Oltmann, R. 2000. Environmental factors influencing the distribution and salvage of young delta smelt: a comparison of factors occurring in 1996 and 1999. Interagency Ecological Program Newsletter 13(2):55-65. Available online at http://www.iep.ca.gov/report/newsletter/2000spring/IEPNewsletter_Spring2000.pdf

Nobriga, M. and M. Chotkowski 2000. Recent historical evidence of centrarchid increases and tule perch decrease in the Delta. Interagency Ecological Program Newsletter 13(1):23-27. Available online at http://www.iep.ca.gov/report/newsletter

Nobriga, M. L. and F. Feyrer (in press). Diet composition of San Francisco Estuary striped bass: does trophic adaptability have its limits? Environmental Biology of Fishes. In press.

Nobriga, ML. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. California Fish and Game 88:149-164.

Nobriga, Matthew L, , Z Matica, and Z.P. Hymanson 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. Pages 281-295 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Nobriga, ML, Feyrer, F, Baxter, RD, Chotkowski, M. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies and biomass. Estuaries 28:776-785.

Nobriga, M.L., & F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5:http://repositories.cdlib.org/jmie/sfews/vol5/iss2/art4.

Nobriga, M. and B. Herbold. 2008. Conceptual model for delta smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP)

Nobriga, ML, Sommer, TR, Feyrer, F, Fleming, K. 2008. Long-term trends in summertime habitat suitability for delta smelt, *Hypomesus transpacificus*. San Francisco Estuary and Watershed Science 6: http//repositories.cdlib.org/ jmie/sfews/vol6/iss1/art1.

Odum, W. E. 1988. Comparative ecology of tidal freshwater and salt marshes. Ann. Rev. Ecol. Syst. 19:147-176.

Ostrach, D. 2008. Multiple stressors and their effects on the striped bass population in the San Francisco estuary. Presented at Interagency Ecological Program 2008 Annual Workshop, Pacific Grove, CA, February 26-29, 2008.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon, in Ecological studies of the Sacramento-San Joaquin Delta, Part II. In: S.L. Turner & D.W. Kelley (Eds.), Ecological Studies of the Sacramento–San Joaquin Estuary, pp. 115-129. California Department of Fish and Game Fish Bulletin 136.

Reclamation 2008. OCAP Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.

Rose, KA. 2000. Why are quantitative relationships between environmental quality and fish populations so elusive? Ecological Applications 10:367-385.

Rose, KA., J.H. Cowan, K.O. Winemiller, R.A. Myers, and R. Hilborn. 2001. Compensatory density-dependence in fish populations: importance, controversy, understanding, and prognosis. Fish and Fisheries 2: 293-327.

Ruhl, C.A., P.E. Smith, J.J. Simi and J.R. Burau. 2006. The pelagic organism decline and long-term trends in Sacramento-San Joaquin Delta hydrodynamics. Presentation at the 4th Biennial 2006 CALFED Science Conference, October 23-25, 2006, Sacramento, California

Saiki, MK, Jennings, MR, Wiedmeyer, RH. 1992. Toxicity of agricultural subsurface drainwater from the San Joaquin River, California, to juvenile Chinook salmon and striped bass. Transactions of the American Fisheries Society 121:78-93.

Saiki, M.K. 1998. An ecological assessment of the Grassland Bypass Project on fishes inhabiting the Grassland Water District, California. Final report submitted to U.S. Fish and Wildlife Service, Sacramento, CA. 72 pp.

Slater Steven unpublished data California Department of Fish and Game

Sommer, T. R., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126: 961-976.

Spaar, S. 1994. Delta agricultural diversion evaluation1992 pilot study. California Department of Water Resources, Interagency Ecological Program Technical Report 3, Sacramento, California

Sobczak, W. V., J. E. Cloern, A. D. Jassby, and A. B. Muller-Solger. 2002. Bioavailability of organic matter in a highly disturbed estuary: The role of detrital and algal resources. Proceedings of the National Academy of Sciences 99, no. 12: 8101-8105.

Sommer, T.R., W.C. Harrell, A. Mueller-Solger, B. Tom, and W. Kimmerer. 2004. Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14:247-261.

Sommer, T, Armor, C, Baxter, R, Breuer, R, Brown, L, Chotkowski, M, Culberson, S, Feyrer, F, Gingras, M, Herbold, B, Kimmerer, W, Mueller-Solger, A, Nobriga, M, Souza, K. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32(6):270-277.

Stevens, DE, Miller, LW. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. North American Journal of Fisheries Management 3:425-437.

Sullivan et al., unpublished information

Swanson, C. and J.J. Cech Jr. 1995. Environmental tolerances and requirements of the delta smelt, *Hypomesus transpacificus*. Final Report. California Department of Water Resources Contracts B-59499 and B-58959. Davis, California. July 20, 1995

Swanson, C, Young, PS, Cech, JJ, Jr. 1998. Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations on swimming at submaximal velocities. Journal of Experimental Biology 201:333-345.

Swanson, C., T. Reid, P.S. Young and J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123: 384-390

Sweetnam, DA. 1999. Status of delta smelt in the Sacramento-San Joaquin Estuary. California Fish and Game 85:22-27.

Thetmeyer. H. and U. Kils. 1995. To see and not be seen: the visibility of predator and prey with respect to feeding behaviour. Mar. Ecol. Prog. Ser. 126: 1-8

Tillman, T., G.W. Edwards, K. Urquhart. 1996. Adult salmon migration monitoring during the various operational phases of the Suisun Marsh Salinity Control Gates in Montezuma Slough, August–October 1993. Stockton (CA): California Department of Fish and Game, Bay-Delta and Special Water Projects Division. 35 p.

Trenham, P.C., H.B. Shaffer and P.B. Moyle. 1998. Biochemical identification and assessment of population subdivision in morphometrically similar native and invading smelt species (*Hypomesus*) in the Sacramento-San Joaquin Estuary, California. T. Am. Fish. Soc. 127: 417-424

Turner, J. L. and H. K. Chadwick 1972. Distribution and abundance of young-of-the-year striped bass, Morone saxatilis, in relation to river flow in the Sacramento-San Joaquin estuary. Transactions of the American Fisheries Society 101: 442-452.

Turner, JL, Kelley, DW (editors). 1966. Ecological studies of the Sacramento-San Joaquin Delta, part II, fishes of the Delta. California Department of Fish and Game Fish Bulletin 136.

Utne-Palm, A.C. and J.E. Stiansen. Effect of larval ontogeny, turbulence and light on prey attack rate and swimming activity in herring larvae. J. Exper. Mar. Biol. Ecol. 268(2): 147-170

U.S. Fish and Wildlife Service. 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online]1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1/

Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and adjacent waters, California: a guide to the early life stages. Interagency Ecological Studies Program Technical Report 9. Sacramento

Wang, J.C.S. 1991. Early life stages and early life history of the delta smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary, with comparison of early life stages of the longfin smelt, *Spirinchus thaleichthys*. Interagency Ecological Studies Program Technical Report 28, August 1991

Wang, JCS. 2007. Spawning, early life stages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. Tracy Fish Facilities Studies California Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region.

Werner, I., L.A. Deanovic, V. Conner, V. de Vlaming, H.C. Bailey and D.E. Hinton. 2000. Insecticide-caused toxicity to *Ceriodaphnia dubia* (Cladocera) in the Sacramento-San Joaquin River Delta, California, USA. Environ. Tox. Chem. 19(1): 215-227

Werner, I, Deanovic, L, Markiewicz, D, Stillway, M, Offer, N, Connon, R, Brander, S. 2008. Pelagic organism decline (POD): Acute and chronic invertebrate and fish toxicity testing in the Sacramento-San Joaquin Delta, 2006-2007. Final report to the Interagency Ecological Program, April 30, 2008.

Weston, D.P, R.W. Holmes, J. You, & M.J. Lydy. 2005. Aquatic toxicity due to residential use of pyrethroid insecticides. Environmental Science and Technology 39: 9778-9784.

Weston, D.P., J. You, & M.J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. Environmental Science and Technology 38: 2752-2759.

Whitehead, A., K.M. Kuivila, J.L. Orlando, S. Kotelevtsev, & S.L. Anderson. 2004. Genotoxicity in native fish associated with agricultural runoff events. Environmental Toxicology and Chemistry: 23:2868–2877

Wilkerson, FP, Dugdale, RC, Hogue, VE, Marchi, A. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29:401-416.

Winemiller, KO, Rose, KA. 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences 49:2196-2218.

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Attachment A-Delta Smelt Risk Assessment Matrix

Triggers	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**
Life Stage	Adults	Adults	Adults	Adults and larvae	Adults and larvae	Larvae and juveniles	Larvae and juveniles	Juveniles
Previous Year's Fall Midwater Trawl Recovery Index (1)	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74
Risk of Entrainment (2)				X2 upstream of Chipps Island and temps are ≥ 12°	X2 upstream of Chipps Island and temps are between 12° and 18°C	X2 upstream of Chipps Island and mean delta-wide temps <18°C and south delta temps below 28°C	X2 upstream of Chipps Island and temps are below 28°C	X2 upstream of Chipps Island and temps are below 28°C
Duration of Spawning period (number of days temperatures are between 12 and 18°C) (3)					39 days or less by April 15	50 days or less by May 1		
Spawning Stage as determined by spring Kodiak trawl and/or salvage (4)			Presence of Adults at spawning stage ≥ 4	Adult spawning stage ≥ 4	Adult spawning stage ≥ 4			
smelt distribution (5)	See footnote #5	See footnote #5	See footnote #5	See footnote #5 or negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm/summer townet centroid or low juvenile abundance	Negative 20mm/summer townet centroid or low juvenile abundance
Salvage Trigger (6)	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation		If salvage is above zero	If salvage is above zero	

Delta Smelt Risk Assessment Matrix (DSRAM) **May 2008**

Tools for Change (7)	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**
Export reduction at one or both facilities	X	X	X	X	X	X	X	X
Change in barrier operations						X	X	X
Change in San Joaquin River flows				X	X	X	X	X
Change position of cross channel gates						X	X	

Delta Smelt Risk Assessment Matrix Footnotes

1 The Recovery index is calculated from a subset of the September and October Fall Midwater Trawl sampling (http://www.delta.dfg.ca.gov/). The number in the matrix, 74, is the median value for the 1980-2002 Recovery Index (Figure 1)

2 The temperature range of 12 to 18 °C is the range in which most successful delta smelt spawning occurs. This has been analyzed by using observed cohorts entering the 20-mm Survey length frequency graphs (1996-02). Cohorts were defined by having a noticeable peak or signal and occurring over three or more surveys during the rearing season. Temperature data from DWR's CDEC web site was compiled using three stations representing the South Delta (Mossdale), confluence (Antioch), and North Delta (Rio Vista). Spawning dates for each cohort was back-calculated by applying an average daily growth rate (wild fish) of 0.45 mm/day (Bennett, DFG pers. comm.) and egg incubation period of 8-14 days (Baskerville-Bridges, Lindberg pers. comm.)(Mager et al. 2004) from the median value of the analyzed cohort. Each spawning event was then plotted against temperature over time (Figure 2). While spawning does occur outside of the 12-18 °C range, larval survival is most likely reduced when temperatures are either below (DFG pers. comm.) or above this range (Baskerville-Bridges & DFG pers. comm.).

Critical thermal maxima for delta smelt was reached at 25.4 °C in the laboratory (Swanson et al., 2000); however, in 2007 delta smelt were observed in the delta and in salvage at temperatures up to about 28 °C.

Websites for the temperature data: http://cdec.water.ca.gov/cgi-progs/queryF?MSD
http://cdec.water.ca.gov/cgi-progs/queryF?ANH
http://cdec.water.ca.gov/cgi-progs/queryF?RIV

Mager RC, Doroshov SI, Van Eenennaam JP, and Brown RL. 2004. Early Life Stages of Delta Smelt. American Fisheries Society Symposium 39:169-180.

Swanson C, Reid T, Young PS, and Cech JJ. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced Wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123:384-390.

3 Figure 3: The working hypothesis for delta smelt is that spawning only occurs when temperatures are suitable during the winter and spring. In years with few days having suitable spawning temperatures, the spawning "window" is limited, so the species produces fewer cohorts of young smelt. Few cohorts increase the risk that mortality sources such as entrainment may have population level effects.

The figures below were used to help define years when there were relatively days with suitable temperatures. For April 15 and May 1, the figures show the cumulative spawning days for each year during 1984-2002. The cumulative spawning days for each year were calculated based on the number of days that the mean water temperature for three Delta stations (Antioch; Mossdale and Rio Vista) was in the 12 - 18 °C range starting on February 1. The results are plotted in terms of the ranks to identify the lower quartile. In other words, years in the lower quartile represent examples of years with relatively few spawning days.

4 The adult spawning stage is determined by the Spring Kodiak Trawl and/or fish salvaged at the pumping facilities (http://www.delta.dfg.ca.gov/). A stage greater than or equal to 4 indicates female delta smelt are ripe and ready to spawn or have already spawned (Mager 1996).

Mager RC. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, *Hypomesus transpacificus.* [Dissertation] Davis: University of California, Davis. 115 pages. Published.

5 The spring kodiak trawl will be used to help generally determine the distribution of adult smelt. However, since the spring kodiak trawl is not intended to be a survey for abundance or distributions, no definitive trigger for concern can be determined at this time.

Juveniles (March-July) – distribution of juvenile delta smelt where the centroid is located upstream (negative) or downstream (positive) of the Sacramento-San Joaquin River confluence (Figure 4). The 20-mm Survey (or Summer Townet Survey) centroid is calculated by multiplying the observed delta smelt station CPUE (fish/10,000 m3) by a distance parameter in km from the confluence. The summed result (summed over a survey) is divided by the survey CPUE which gives the survey centroid position (Figure 5)

Low juvenile abundance will also be a trigger. Abundance (total cumulative count) will be monitored throughout the sampling season with low values based upon median values of historic cumulative 20-mm Survey catch (1995-2003). Each survey within a season has a median value associated with it and when catch is equal to or below that value, concern is high (Table 1).

6 Salvage trigger: the salvage trigger for December through March is determined by calculating the ratio of adult salvage to the fall MWT index. This ratio will increase as fish are salvaged during the winter months. If the ratio exceeds the median of what was observed during December-March 1980-2002, then the trigger was met (see Figure 6 for more explanation of the calculation)

During May and June, if delta smelt salvage at the salvage facilities is greater than zero, then the working group will meet. This is because May and June are the peak of smelt salvage and salvage densities cannot be predicted. Therefore, during these two months, the SWG will meet proactively to protect these fish by looking at relevant information such as salvage, Delta temperatures, Delta hydrology and smelt distributions.

7 The tools for change are actions that the working group can recommend to the DAT and WOMT group to help protect delta smelt. Exports may be reduced at one or both of the South Delta export facilities and a proposed duration of the reduction would be recommended by the working group. Export reductions and changes in San Joaquin River flows may be covered by (b)(2) or EWA assets. Details of past fish actions can be found at the CALFED Ops website: http://wwwoco.water.ca.gov/calfedops/index.html; >Operations [year]

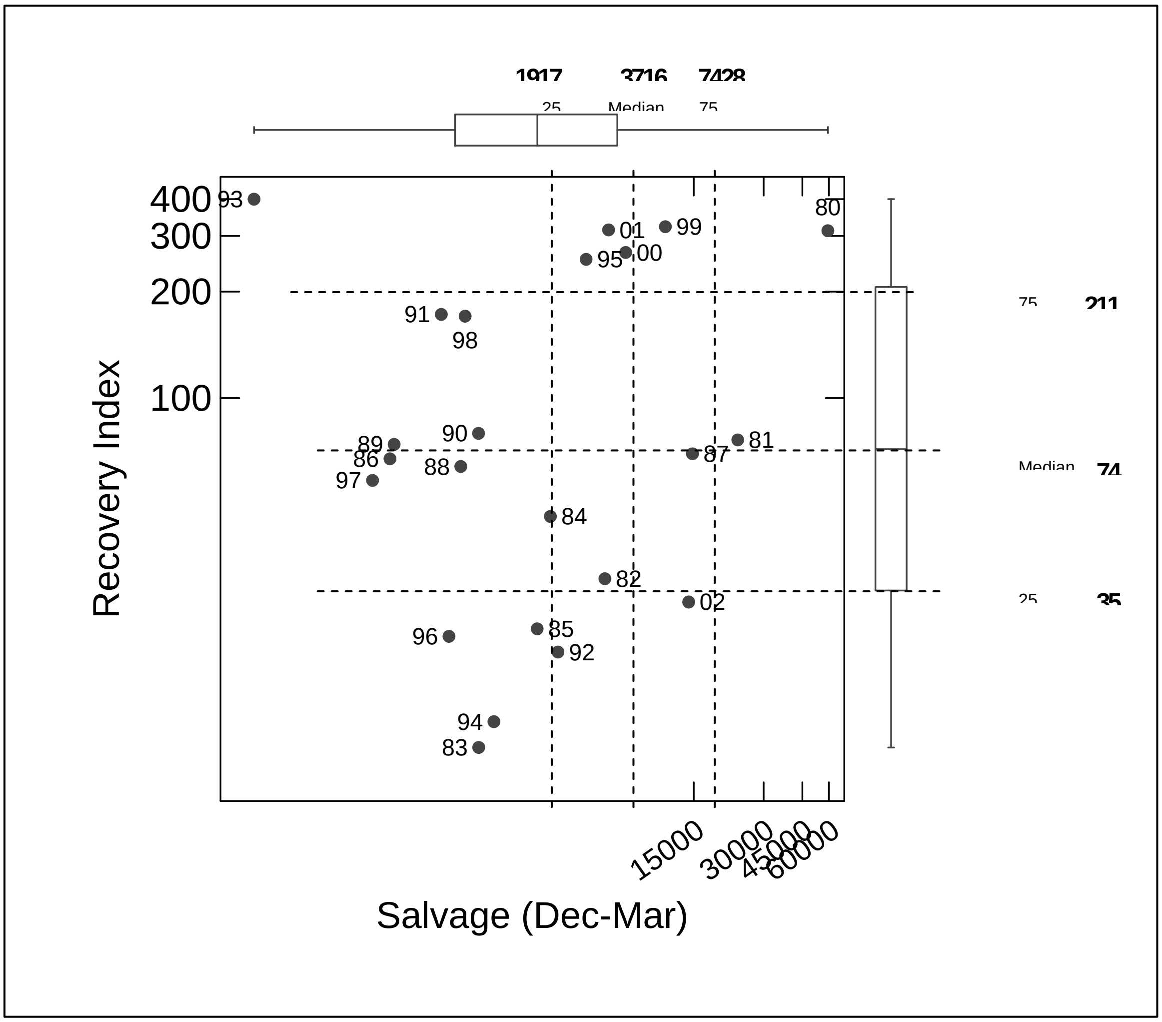


Figure 1 1980-2002 Recovery Index

Figure 1 points are labeled with the year representing the recovery index.
The winter salvage is for this analysis starts in December of the recovery index year and carries through March of the following year.

Figure 2 shows the successful delta smelt spawning periods (black bars) and start and end of spawning season (yellow bars) determined by the 20-mm Survey catch results (1996-2002). Temperature data (^{o}C) was compiled from CDEC using mean daily temperatures from the South Delta (Mossdale), North Delta (Rio Vista), and confluence (Antioch).

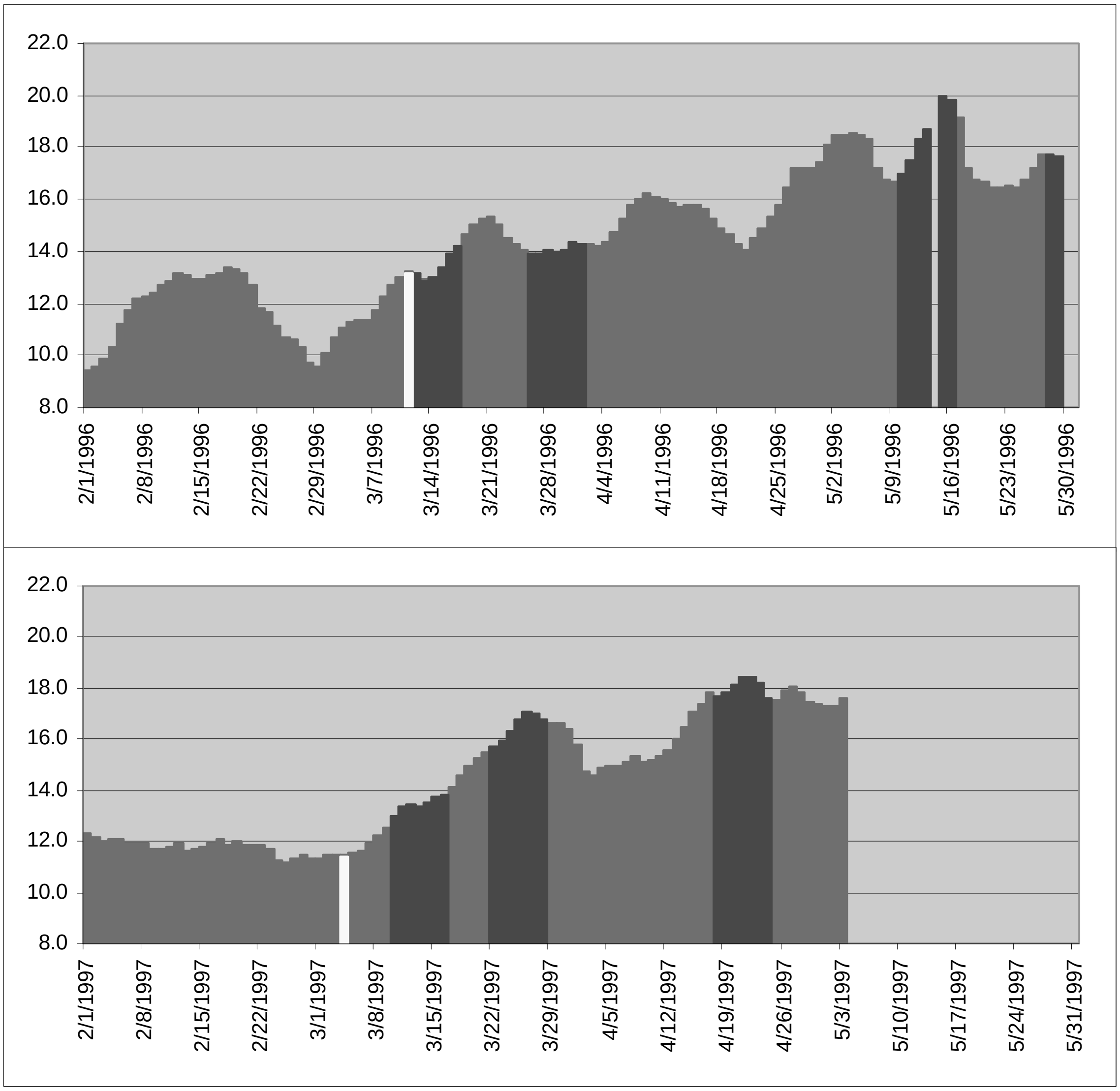
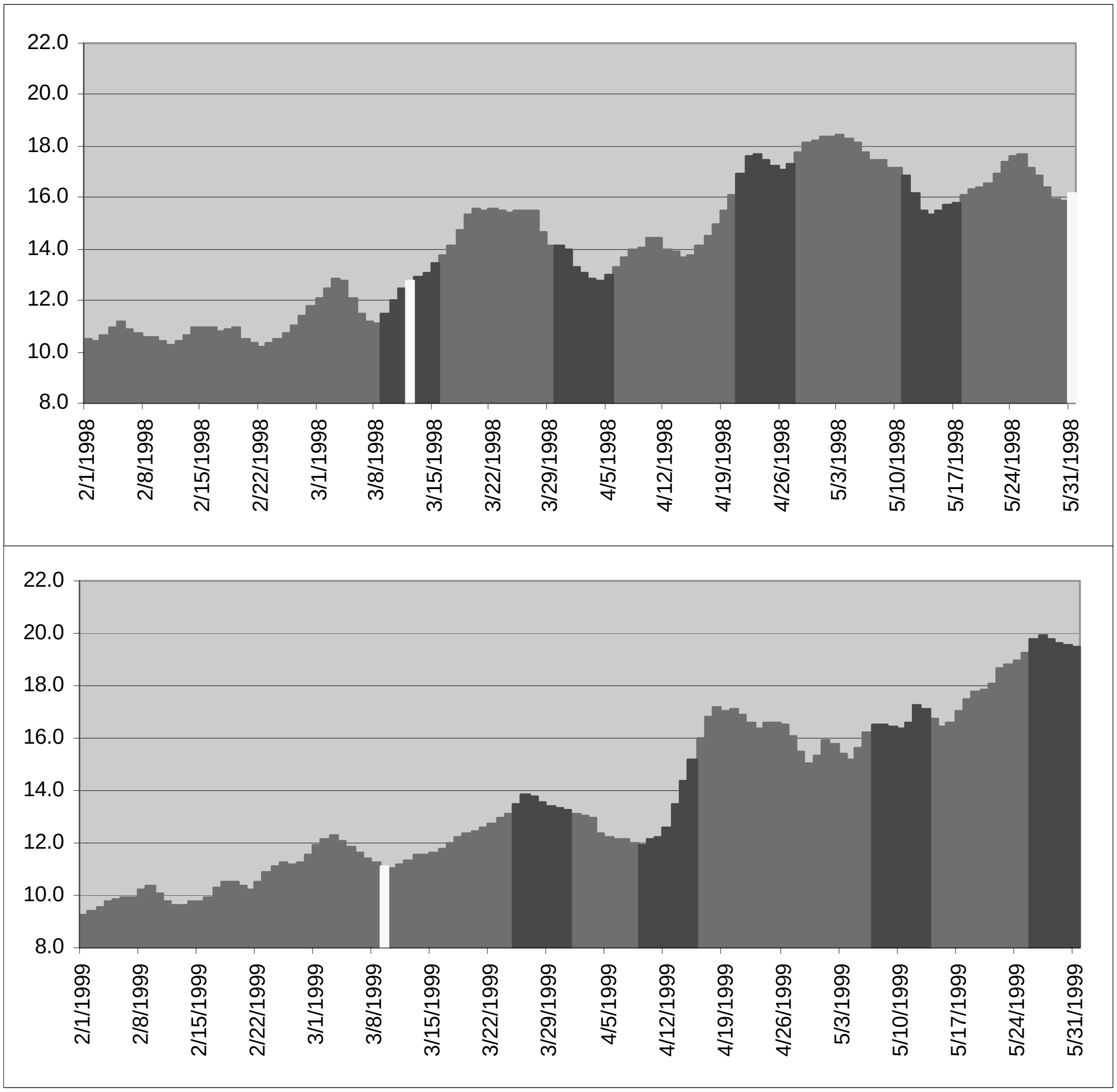


Figure 2 Successful delta smelt spawning periods


22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
2/1/1998
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2/15/1998
2/22/1998
3/1/1998
3/8/1998
3/15/1998
3/22/1998
3/29/1998
4/5/1998
4/12/1998
4/19/1998
4/26/1998
5/3/1998
5/10/1998
5/17/1998
5/24/1998
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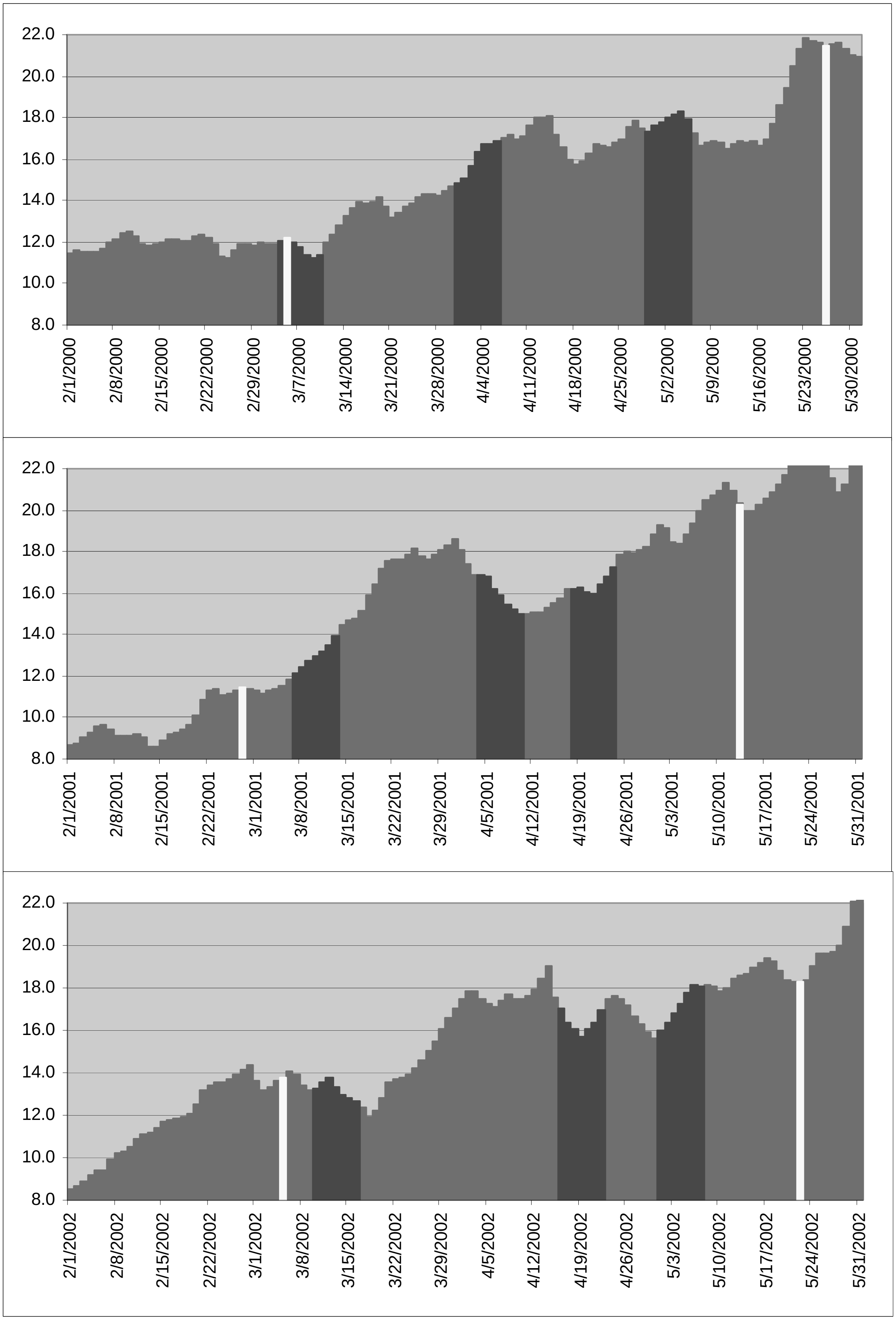
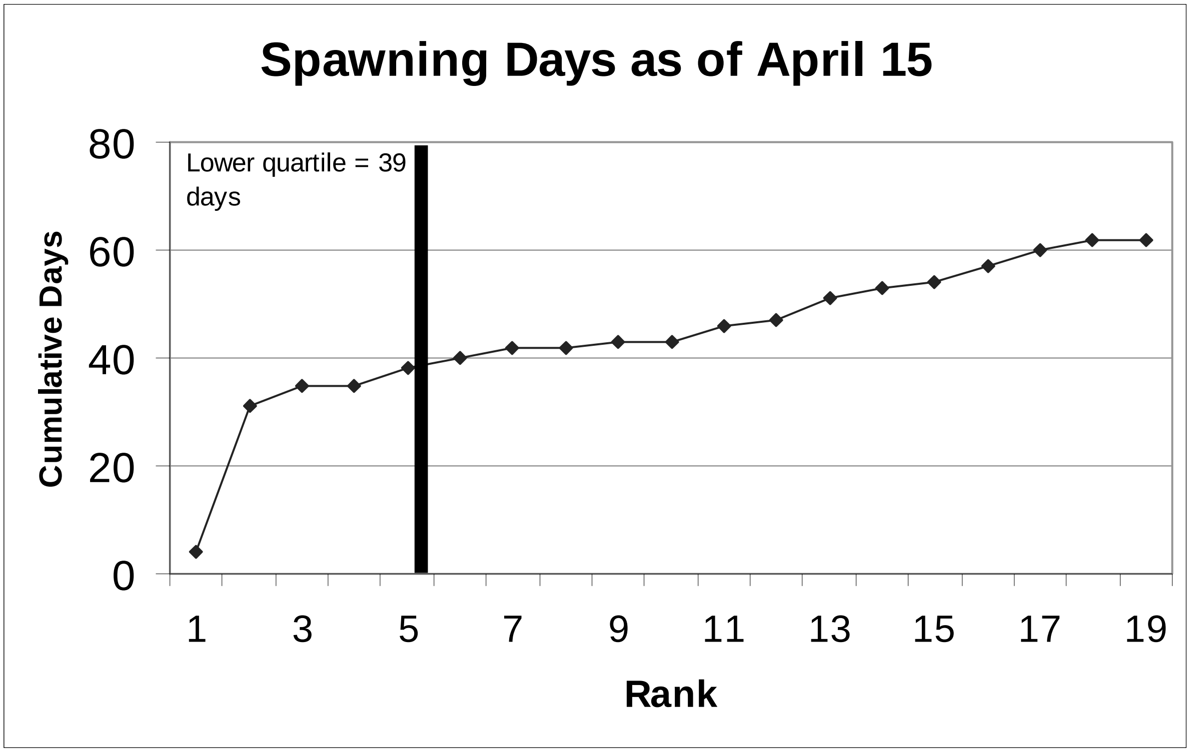


Figure 2 cont.



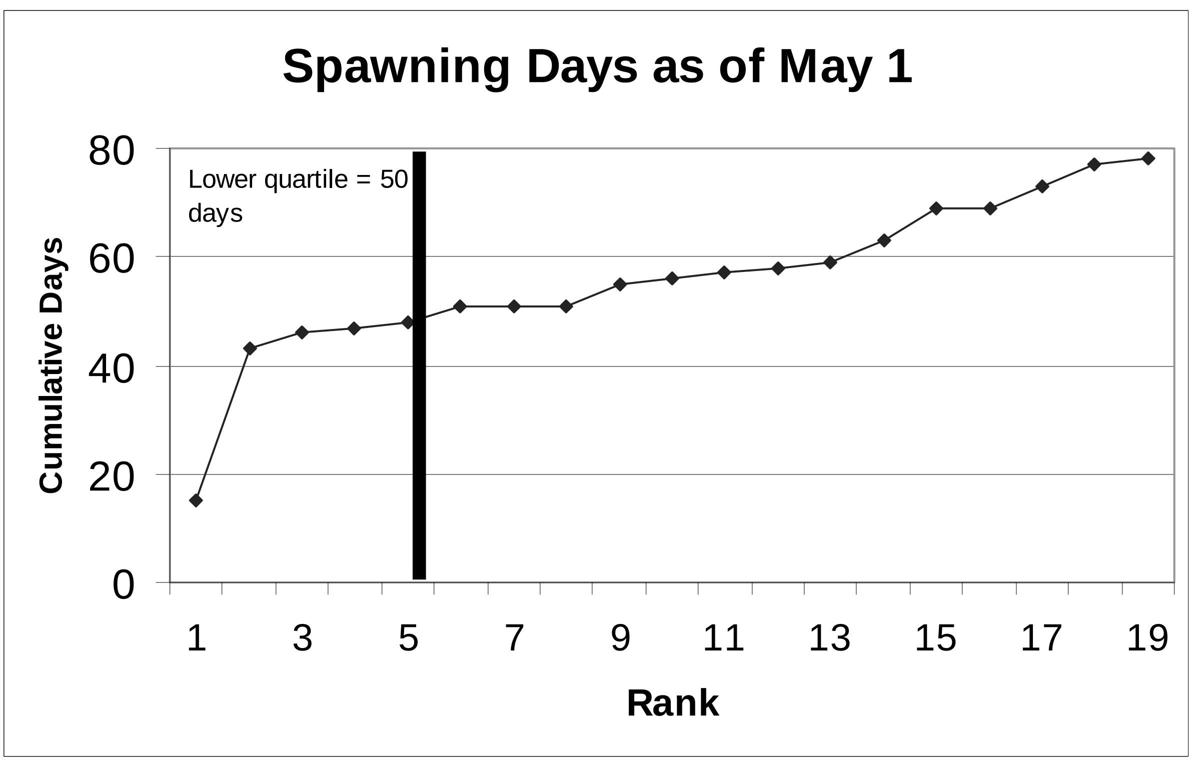


Figure 3 Delta smelt spawning days

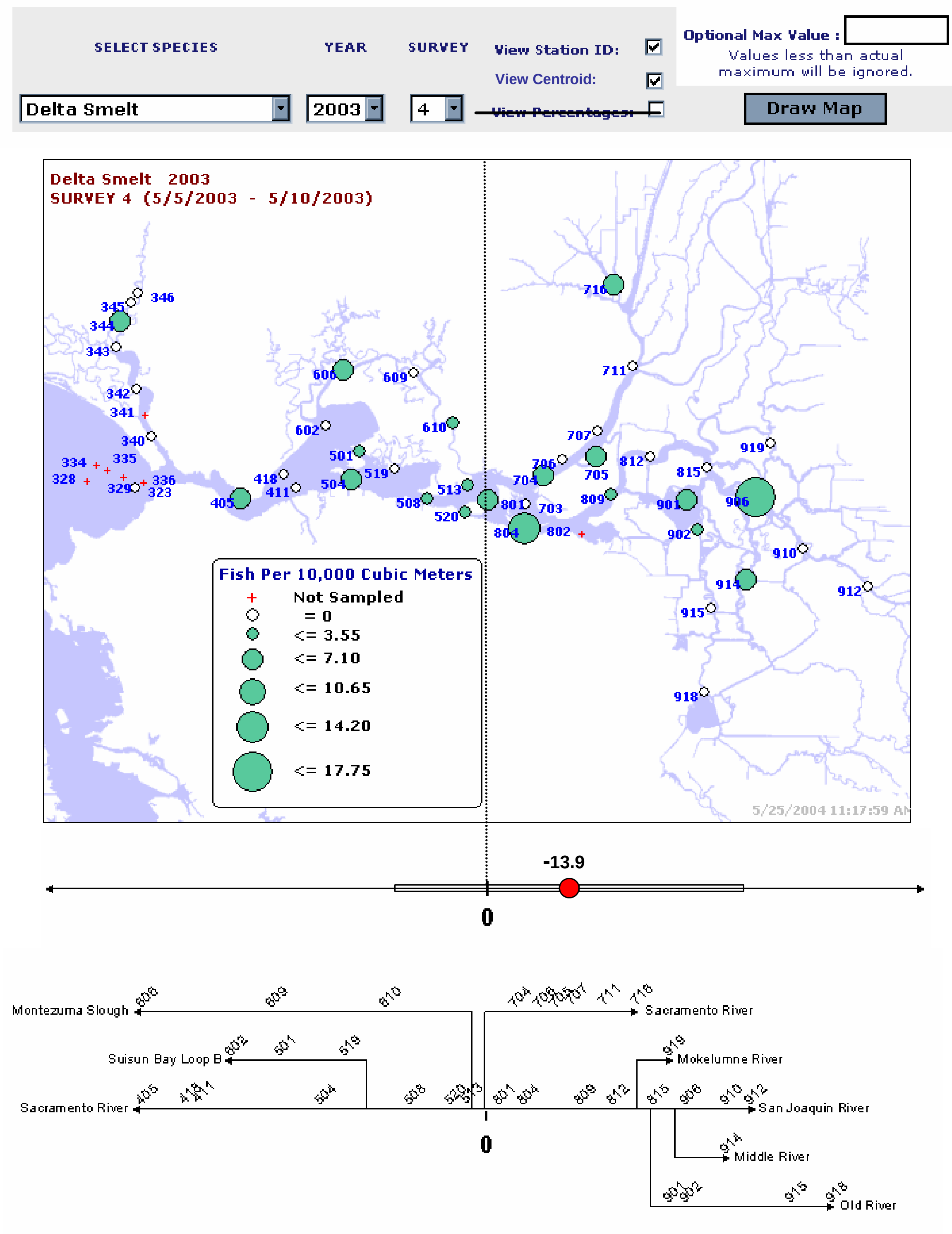


Figure 4 A 20-mm Survey delta smelt bubble plot map with calculated centroid position from the confluence of Sacramento-San Joaquin Rivers with one standard deviation.

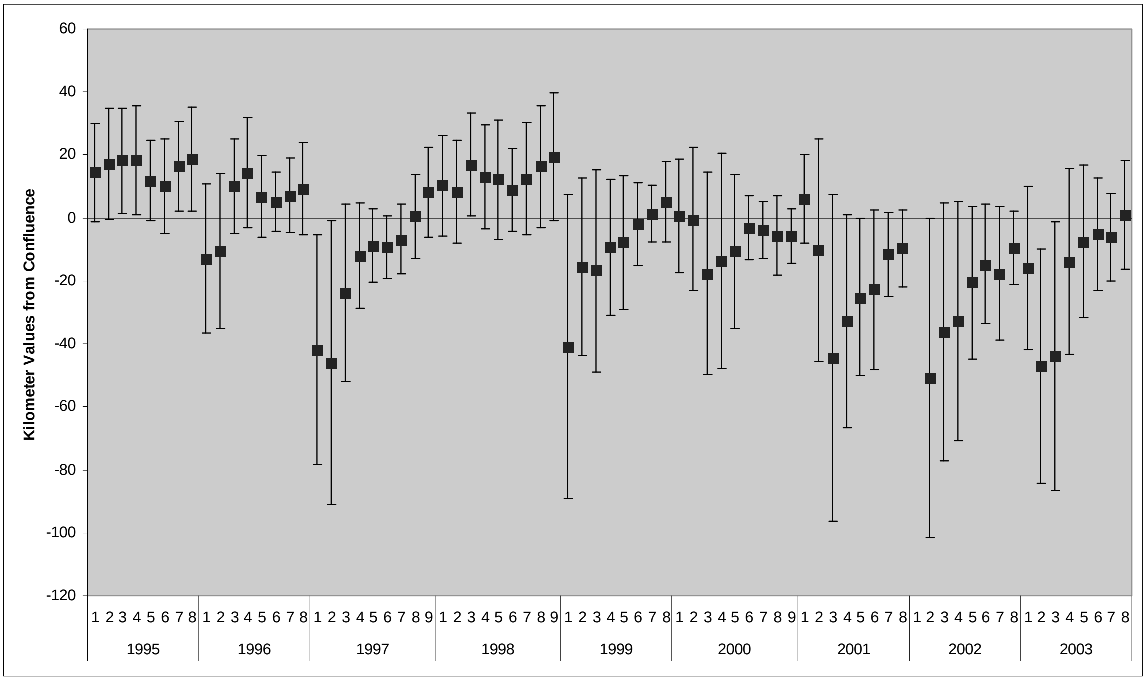


Figure 5 Historic juvenile centroid position (20-mm Survey) with one standard deviation.

Table 6 Lower quartile values of cumulative catch from the 20-mm Survey. When cumulative catch per survey during a season is at or below the calculated value, concern is high.

	survey 1	survey 2	survey 3	survey 4	survey 5	survey 6	survey 7	survey 8
lower quartile	12	40	144	188	346	500	924	1019

In Figure 7**,** the objective is to quantify a level of concern for adult delta smelt during the winter, that is based upon not only the number of fish salvaged but also accounts for the overall abundance of smelt. Whatever quantifier we select should reflect that when the abundance is low and salvage is high concern is high and conversely, when abundance is high and salvage is low that concern is low.

Below is a Quantile plot of the ratio of winter salvage to MWT index (ln (winter salvage/MWT index)). Winter salvage is defined as the total salvage from December through March. In the figure below, the size of the bubbles is proportional to the log of the fall midwater trawl just to give some indication of relative abundance. The resulting quartiles of the ratio are as follows:

25^{th} percentile =: 2.950; 50^{th} percentile = 3.575; 75^{th} percentile = 5.029.

If we were to use this approach to calculate winter concern levels and use the median value, then all years above the 1999 point in the graph would have been years of concern. In other words, these are the years in which we may have recommended some protection. Comparing it to the protection afforded adult delta smelt in the winter by the 1995 biological opinion ("red light" was, or would have been reached in the following winters of 1980, 1981, 1982, 1984 and 1999) .

If the median was selected as the measure of concern it would be calculated by:

concern level = anti ln(3.575)* MWT recovery index

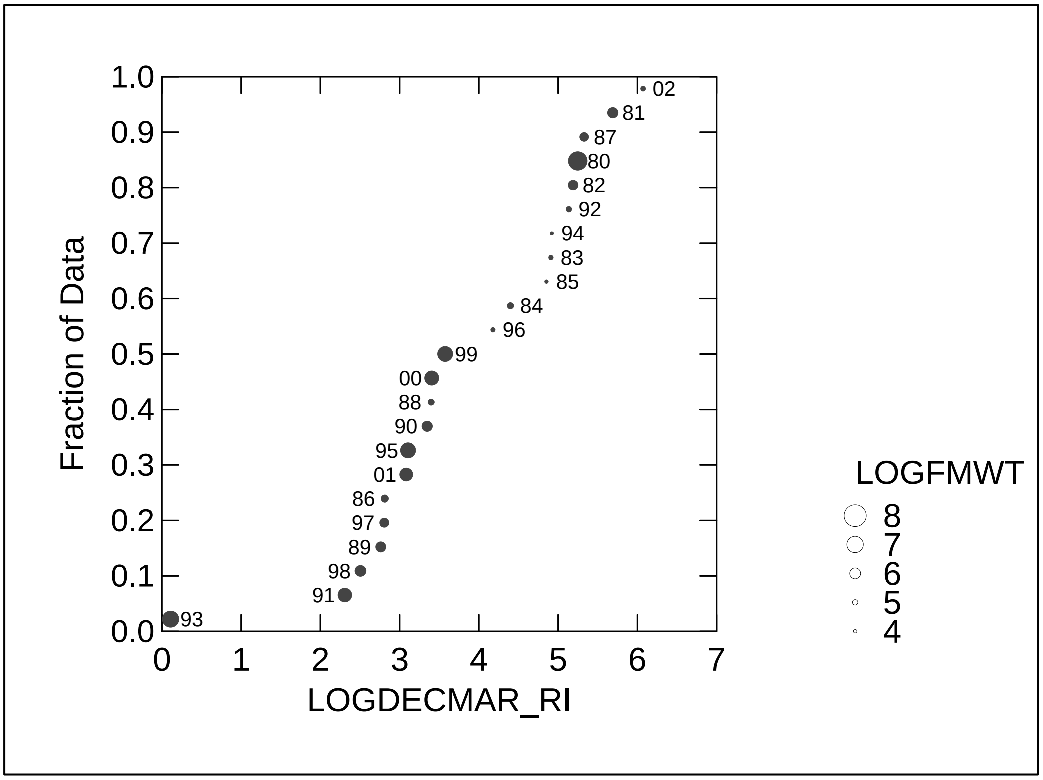


Figure 7 Quantile plot of the ratio of winter salvage to MWT recovery index

The goal for the DSRAM is to avoid the upper quartile of the above graph, in general, to avoid high salvage events when the MWT recovery index is low. Actions would be taken prior to salvage events and ideally, high salvage events would not occur.

Attachment B, Supplemental Information related to the Reasonable and Prudent Alternative

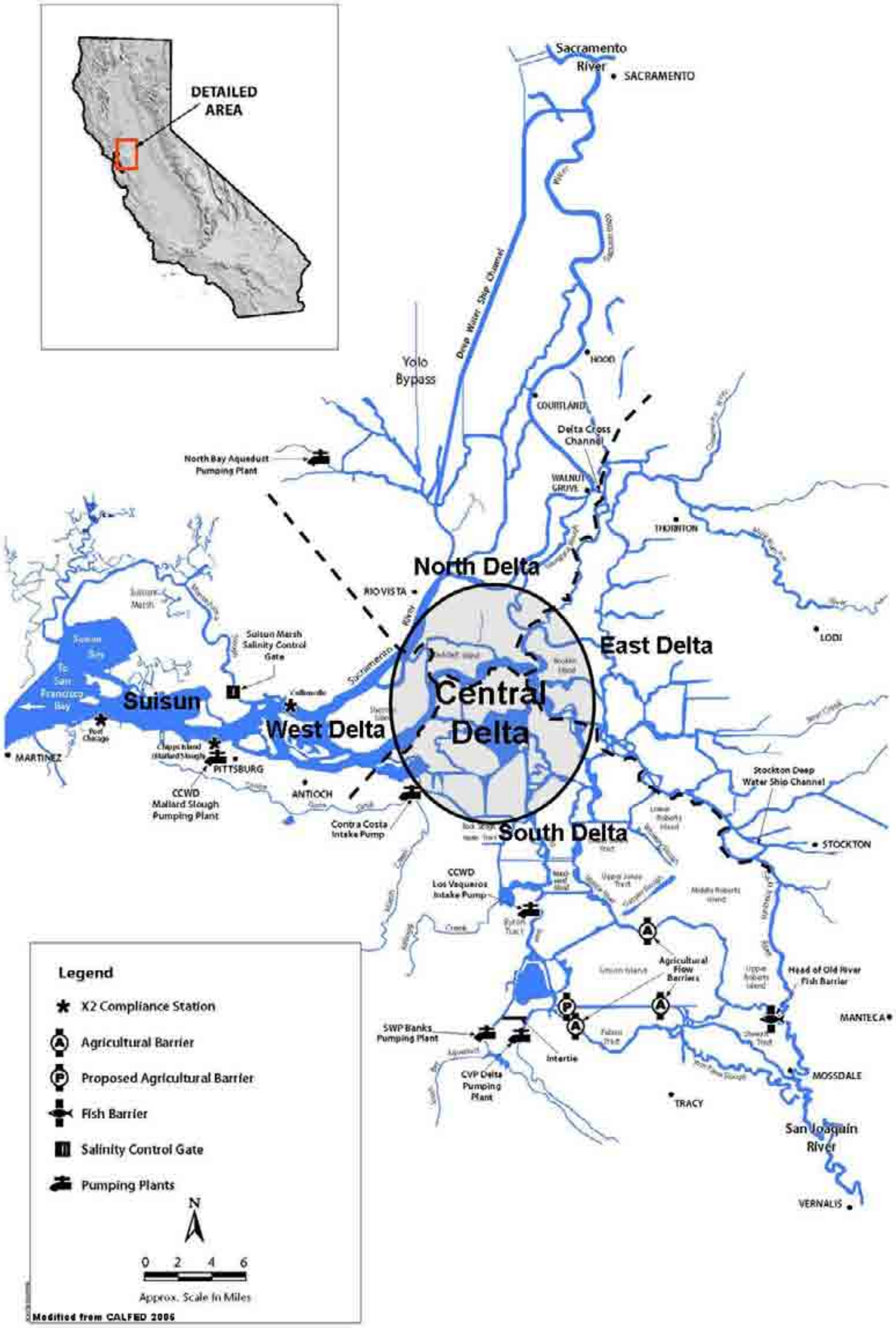
There are three major factors related to operations of the CVP/SWP affecting delta smelt population resilience and long-term viability. It is also recognized that the hydrologic changes from the CVP/SWP result in ecological conditions that influence delta smelt interactions with other stressors within the Delta. The following actions were developed to counter these adverse effects based upon the Baseline and Effects section of the biological opinion.

These three factors are: 1) direct mortality associated with entrainment of pre-spawning adult delta smelt by CVP/SWP operations; 2) direct mortality of larval and early juvenile delta smelt associated with entrainment by CVP/SWP operations; and, 3) indirect mortality and reduced fitness through reductions to and degradation of Delta habitats by CVP/SWP operations, with the fall as a particular concern. The actions below address these factors and will ameliorate the adverse effects that are brought about from the hydrologic modifications that influence delta smelt interactions with other stressors in the Delta.

The metric for monitoring direct mortality of delta smelt is salvage at Banks and Jones during pumping operations. However, this metric alone cannot be used to trigger operational changes in CVP/SWP to prevent entrainment. This is because the combination of tidal cycles, hydrologic and meteorological events, and CVP/SWP operations can draw delta smelt into the South and Central Delta (see Map 1) where they are more susceptible to entrainment by the facilities prior to any observed delta smelt salvage. This necessitates an anticipatory strategy in order to sufficiently protect delta smelt from entrainment.

As discussed in the Baseline and Effects Sections of the biological opinion, there are other impacts to delta smelt through reduction and degradation of habitat. These effects are functional year-round, through mechanisms defined and discussed in those sections. Indirect mortality and reduced fitness of juvenile delta smelt due to degraded environmental quality (habitat suitability) in the fall impacts delta smelt. The mechanism of this impact is habitat constriction, entrainment of primary and secondary productivity leading to food-web deprivation for prey species, decreased dilution flows resulting in increased exposure to lethal and sublethal concentrations of contaminants. Additionally it results in reduced habitat variability that is expected to help control invasive species such as *Corbula* or *Microcystis* that either compete with, or directly impact survival of delta smelt. The operational criteria to restore habitat quality for rearing juveniles in the estuary are related to increasing delta outflows during fall months (September through November) of above-normal and wet WYs to improve habitat variability.

Actions 1 and 2 will reduce the direct mortality of pre-spawning adult delta smelt (Adult Entrainment). Action 3 will reduce the direct mortality of larval and juvenile delta smelt (Larval/Early Juvenile Entrainment). Action 4 will restore habitat quality for rearing juveniles in the estuary that are directly related to increasing Delta outflows during fall months (September through November) of above-normal and wet WYs to restore habitat



Map 1: Delta Regions

suitability. Action 5 describes the installation and operations of the spring temporary Head of Old River Barrier (HORB) and the temporary agricultural barriers to reduce juvenile entrainment. The detailed elements of these prescriptions, including rationale and justification, appear in subsequent sections of this document, by Action.

Delta Smelt Evaluation Team

To develop the initial actions, the Service re-evaluated the Interim Remedies for delta smelt protection as proposed in the Service's declarations of July 3, 2007 and August 3, 2007 (Cay Collette Goude 2007), and implemented in the Federal District Court's Interim Remedies Order. The Service used the CALLite operations model to evaluate different operational scenarios. Different operational parameters were run to evaluate their influence upon predicted entrainment. These parameters included export-inflow (EI) ratios, QWest, X2, and OMR flows, among others.

During these sessions, two clear patterns became evident. First, shifting operations to reduce exports during any one given month resulted in a shift in operations to increase exports in other months. Second, holding one particular parameter steady did not prevent other parameters from adapting to meet similar water supply objectives. For example, modeling Qwest to some static number still allowed considerable variability in negative OMR flows, due to the contribution of other intervening variables to Qwest, including operation of the DCC and Sacramento and San Joaquin River flows. For these reasons, the most logical operational criterion for protecting delta smelt from entrainment is controlling the magnitude of flows in the South and Central Delta towards the export facilities. This is reflected quantitatively as net negative OMR flows during the time periods when delta smelt are present and subject to entrainment.

In July 2008, the Service convened a team of experts comprising members of the Adaptive Management Planning Team (AMPT) of the ERP, technical staff from the Department of Fish and Game and the Service, and an expert hydrodynamicist to conduct evaluations of Interim Remedy actions using the evaluation process and conceptual models developed for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) in light of the current project description.

To the extent practicable, the DRERIP evaluation tools were used in formulating potential actions to ameliorate the anticipated effects of the proposed action. The DRERIP tools include peer reviewed ecosystem and species conceptual models for the Delta drafted by teams of experts. These models represent a compilation of the current state of scientific knowledge regarding specific ecosystems and fish species, including delta smelt.

The full DRERIP evaluation process was not applied to the potential actions for delta smelt, but elements of the process were considered and followed during the initial phases of actions development and evaluation. The nature of the task before the evaluation team finally necessitated direct involvement of technical experts in providing up-to-date quantitative analysis and detailed evaluation exceeding the level of detail inherent in the current DRERIP conceptual models.

Role of Adaptive Process and Monitoring

As discussed in the Baseline and Effects Sections of this biological opinion, we recognize that there are multiple factors affecting delta smelt population dynamics and that not all are directly influenced by operations of the CVP/SWP. With respect to direct mortality from entrainment, the prescriptions and triggers presented in actions 1, 2, and 3 are based on historical data. Net daily OMR flows serve as a key indicator of overall Delta hydrodynamics and changing OMR flows will change a key underlying driver of future salvage. Based on the low numbers of delta smelt and therefore the difficulties in delta smelt monitoring and the uncertainty in relying on historical data, the use of an adaptive process with regulatory sideboards is essential.

It is very important that the control mechanisms used to implement the actions be functionally protective when delta smelt densities are low. Delta smelt densities are likely to remain low for the foreseeable future. When delta smelt occur at low densities, it becomes difficult to reliably infer distribution and flux towards Banks and Jones based on IEP monitoring data. In circumstances where it is difficult to reliably infer these parameters, automated control mechanisms that assume reliable distribution information are likely to fail.

The real-time monitoring of final flow prescriptions within these actions are necessary parts of the final actions. Such a strategy utilizes weekly review of the sampling data and real-time salvage data at the CVP/SWP. It utilizes the most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity, and thereby adapts to current conditions. This would provide protection to delta smelt and reduce operational constraints when the risk of delta smelt entrainment is low based on distribution and data analysis. Such a strategy would provide necessary protections while utilizing the minimum possible regulatory constraints on the project.

ACTION 1: ADULT MIGRATION AND ENTRAINMENT (FIRST FLUSH)

Objective: A fixed duration action to protect pre-spawning adult delta smelt from entrainment during the first flush, and to provide advantageous hydrodynamic conditions early in the migration period.

Action: Limit exports so that the average daily OMR flow[6] is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).

Timing:

Part A: December 1 to December 20 – Based upon an examination of turbidity data from Prisoner's Point, Holland Cut, and Victoria Canal and salvage data from CVP/SWP (see below), and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, FMWT, and river flows; the SWG may recommend a start date to the Service. The Service will make the final determination.

Part B: After December 20 – The action will begin if the 3 day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 NTU. However the SWG can recommend a delayed start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment.

Triggers (Part B):

Turbidity: 3-day average of 12 NTU or greater @ *all three* stations (Prisoner's Point, Holland Cut, Victoria Canal)

OR

Salvage: Three days of delta smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value ≥0.5 (daily delta smelt salvage > one-half prior year FMWT index value).

The window for triggering Action 1 concludes when either offramp condition described below is met. These offramp conditions may occur without Action 1 ever being

[6] OMR Flows for this and all relevant actions will be measured at the Old River at Bacon Island and Middle River at Middle River stations, as has been established already by the Interim Order.

triggered. If this occurs, then Action 3 is triggered[7], unless the Service concludes on the basis of the totality of available information that Action 2 should be implemented instead.

Off-ramps:

Temperature: Water temperature reaches 12^{o}C based on a three station daily mean at Mossdale, Antioch, and Rio Vista

OR

Biological: Onset of spawning (presence of spent females in SKT or at Banks or Jones).

[7] The offramp criteria for Actions 1 and 2 to protect adults from entrainment are identical to the initiation triggers for Action 3 to protect larval/juveniles from entrainment

Background

Adult delta smelt entrainment is characterized by a pulse of pre-spawning migrants entering the Central and South Delta following a “first flush” flow event in winter. This event generally involves a coincident increase in turbidity; which, along with the flows, is a cue for delta smelt migration. The interaction of these migratory cues: flow, turbidity, temperature, and season, leads to migration patterns that are difficult to predict yearly. However, historical salvage of delta smelt at Banks and Jones provides an index of entrainment that can be compared against key general predictors like flow and turbidity. Figures B-1 and B-2 below graphically depict the relationship of these variables against daily smelt salvage at Banks and Jones during two example WYs. Once the initial pulse of pre-spawning migration passes, it is believed that spawning adults moderate their movements to maintain their geographical range to a smaller area (when conditions stay favorable) and to the extent that delta smelt can control their location based on extant flow variables.

Entrainment effects upon delta smelt populations can be substantial (Kimmerer 2008). In one historically common scenario, a tight coincidence between calendar timing, sudden influx of turbid (>12 NTU) fresh water into the Delta, and high Delta exports may lead to very high salvage spikes. These events are seen within the data as high amplitude peaks in the daily adult delta smelt salvage histogram. Such events occurred in WY’s 1993 and 2003, as displayed in Figures B-3 and B-4, which plot turbidity and negative OMR on visually convenient scales against total salvage. If this scenario plays out in years where there are few delta smelt, it may be difficult to detect salvage spikes even if they represent substantial proportional entrainment events.

In a second scenario there are no large salvage spikes, but chronic entrainment over a sufficient duration adds up to a relatively large cumulative salvage. Alternatively, there may be multiple entrainment spikes in years where the timing of migratory cues is diffuse or occurs in episodes. This would appear graphically as a histogram with generally low-amplitude over the duration of the entrainment period. Examples of such entrainment years would include WY 2004 and 2005, as displayed in Figures B-5, and B-6.

Total entrainment depends on precipitation patterns, ambient air temperature, controlled and uncontrolled releases from waterways feeding the Delta, specific operation of facilities such as the DCC, and condition of that year’s pre-spawning cohort based on current year habitat quality. All of these factors may affect the distribution of delta smelt adults as and after they migrate into the Delta—and it is the migration into the entrainment risk zone and the area of that zone based on operational conditions at the time that determines ultimate mortality. However, the list of variables known or believed to influence delta smelt distribution during this period is not complete, and there is substantial apparently stochastic variation in adult delta smelt habitat use.

Figure B-1: 1995 WY OMR, Turbidity, Salvage

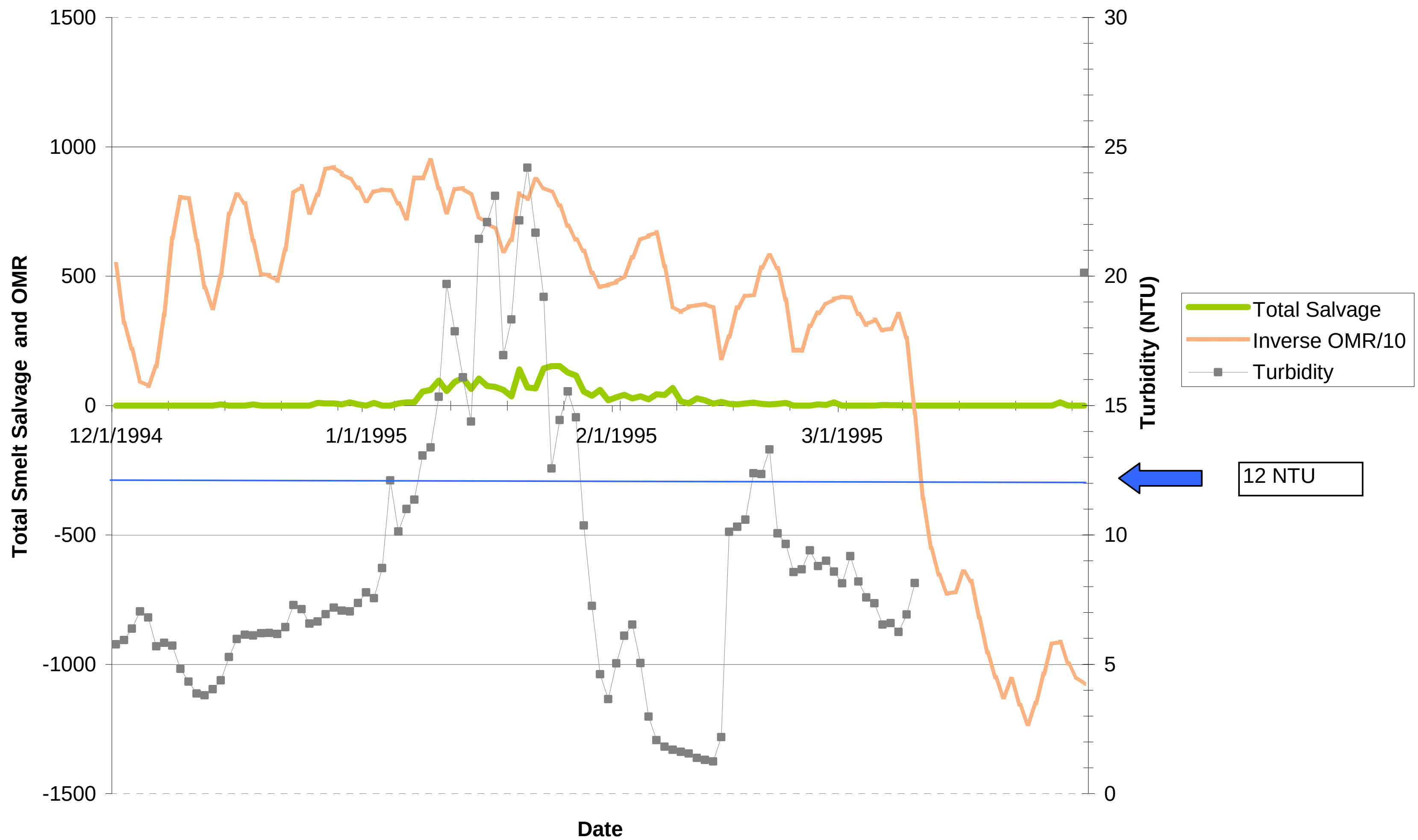


Figure B-2: 2002 WY OMR, Turbidity, Salvage

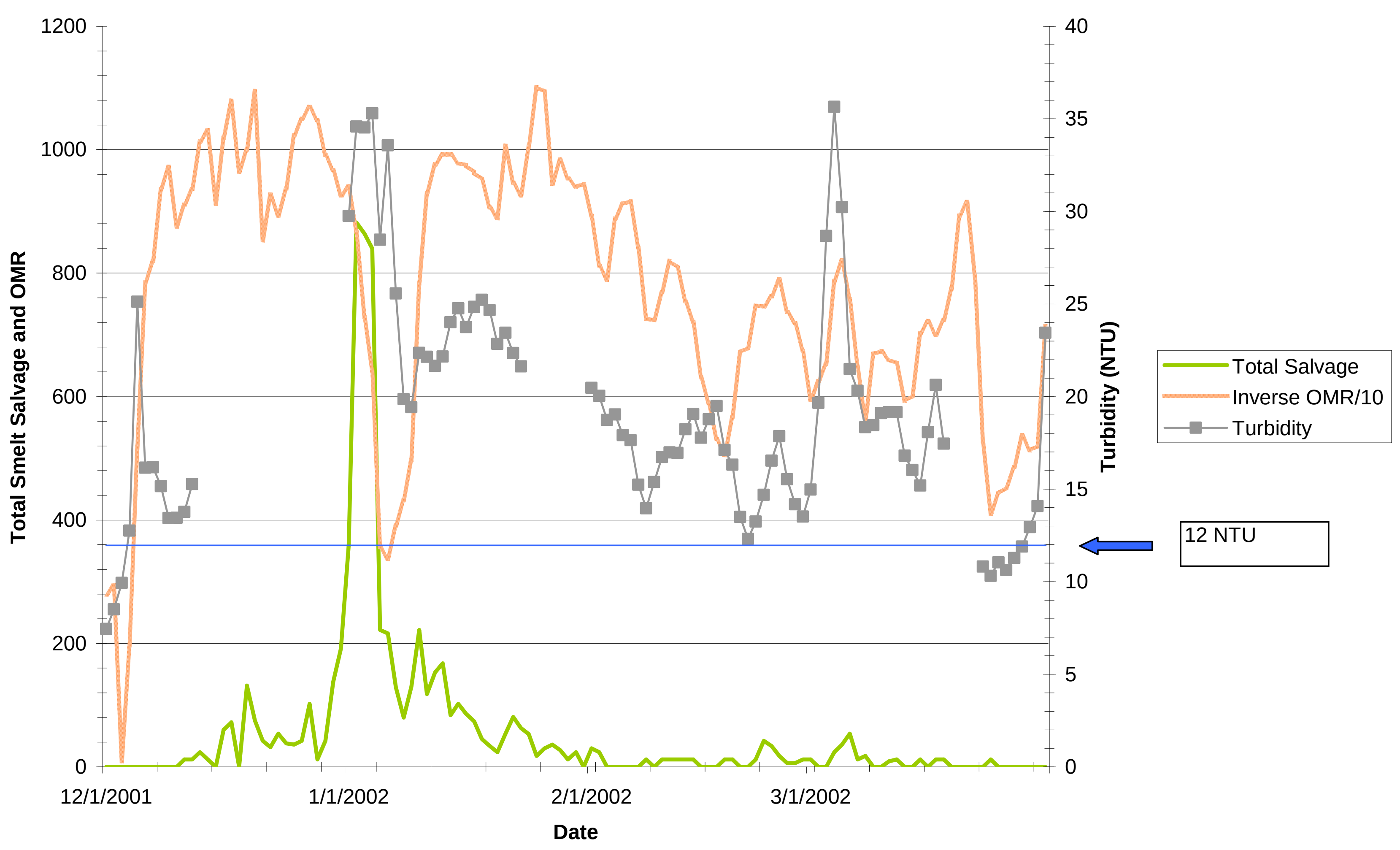


Figure B-3: 1993 WY OMR, Turbidity, Salvage

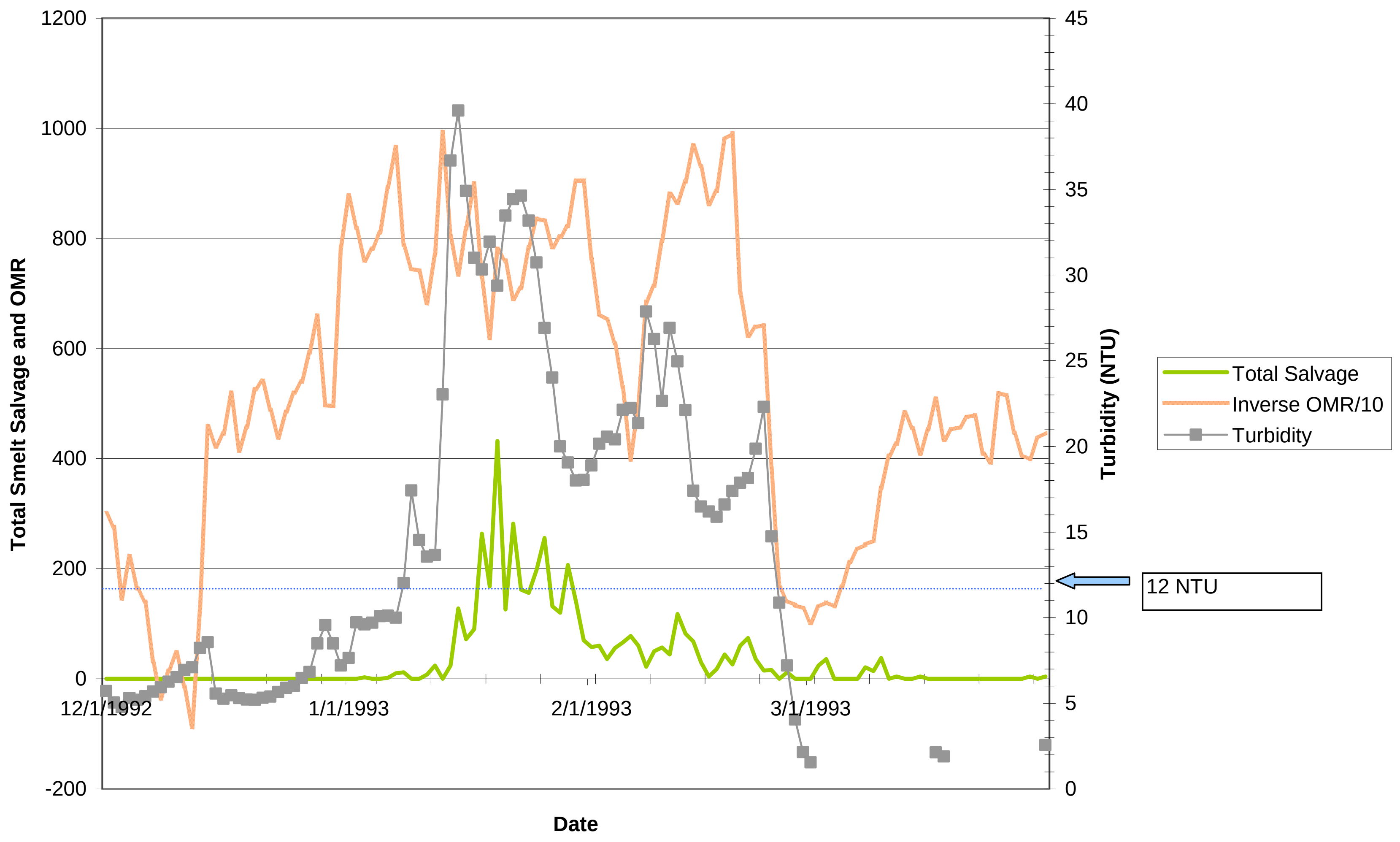


Figure B-4: 2003 WY OMR, Turbidity, Salvage

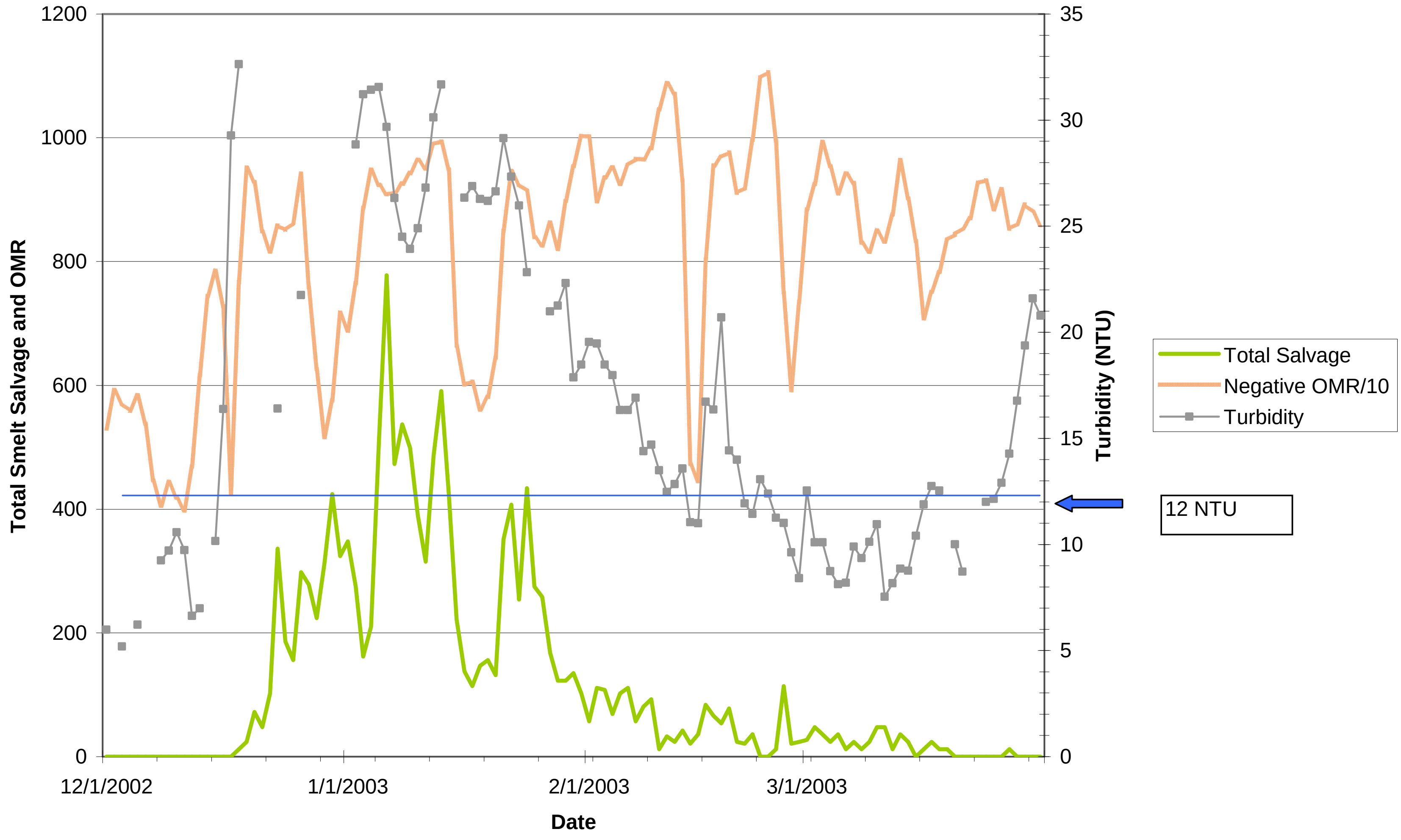


Figure B-5: 2004 WY OMR, Turbidity, Salvage

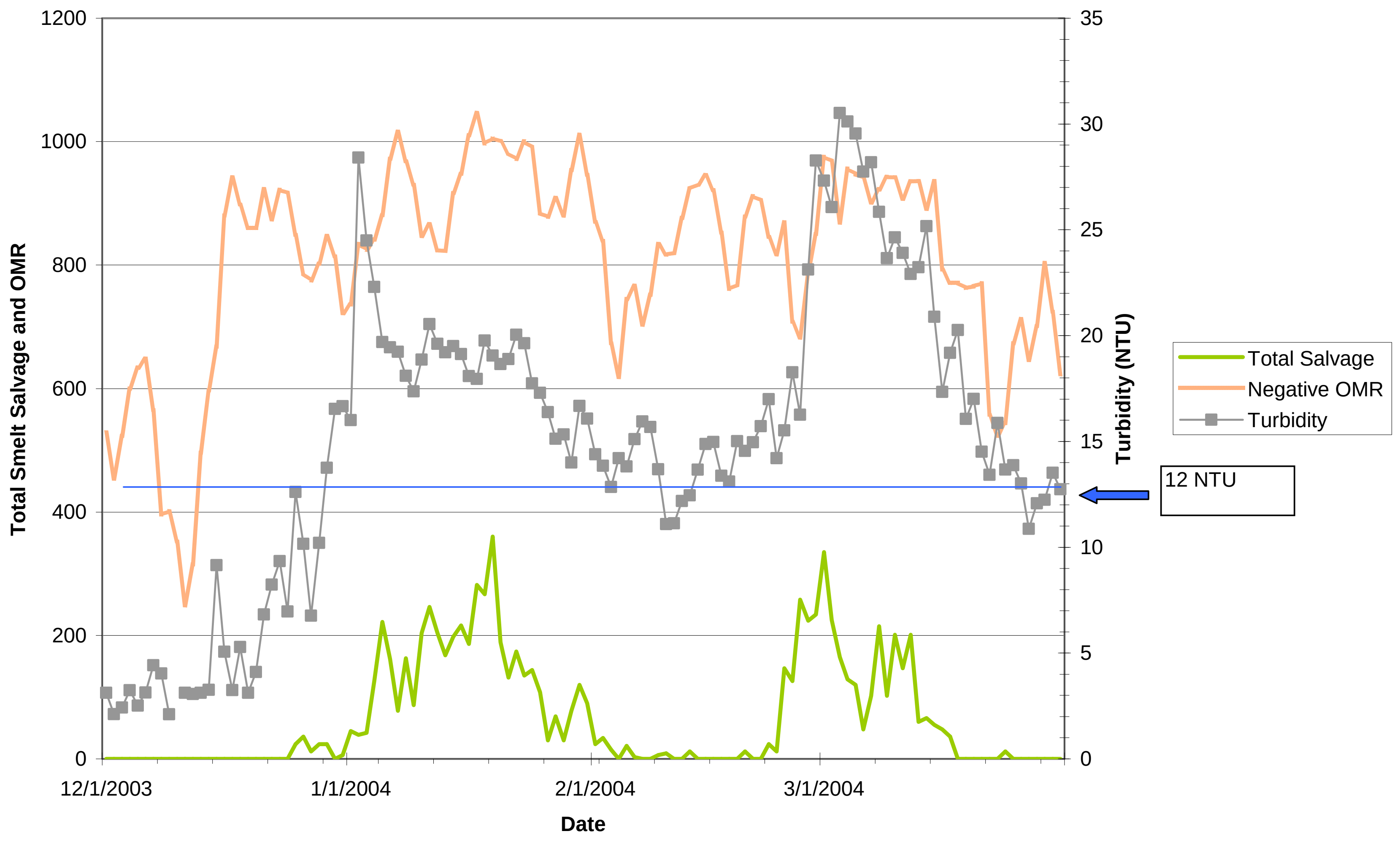
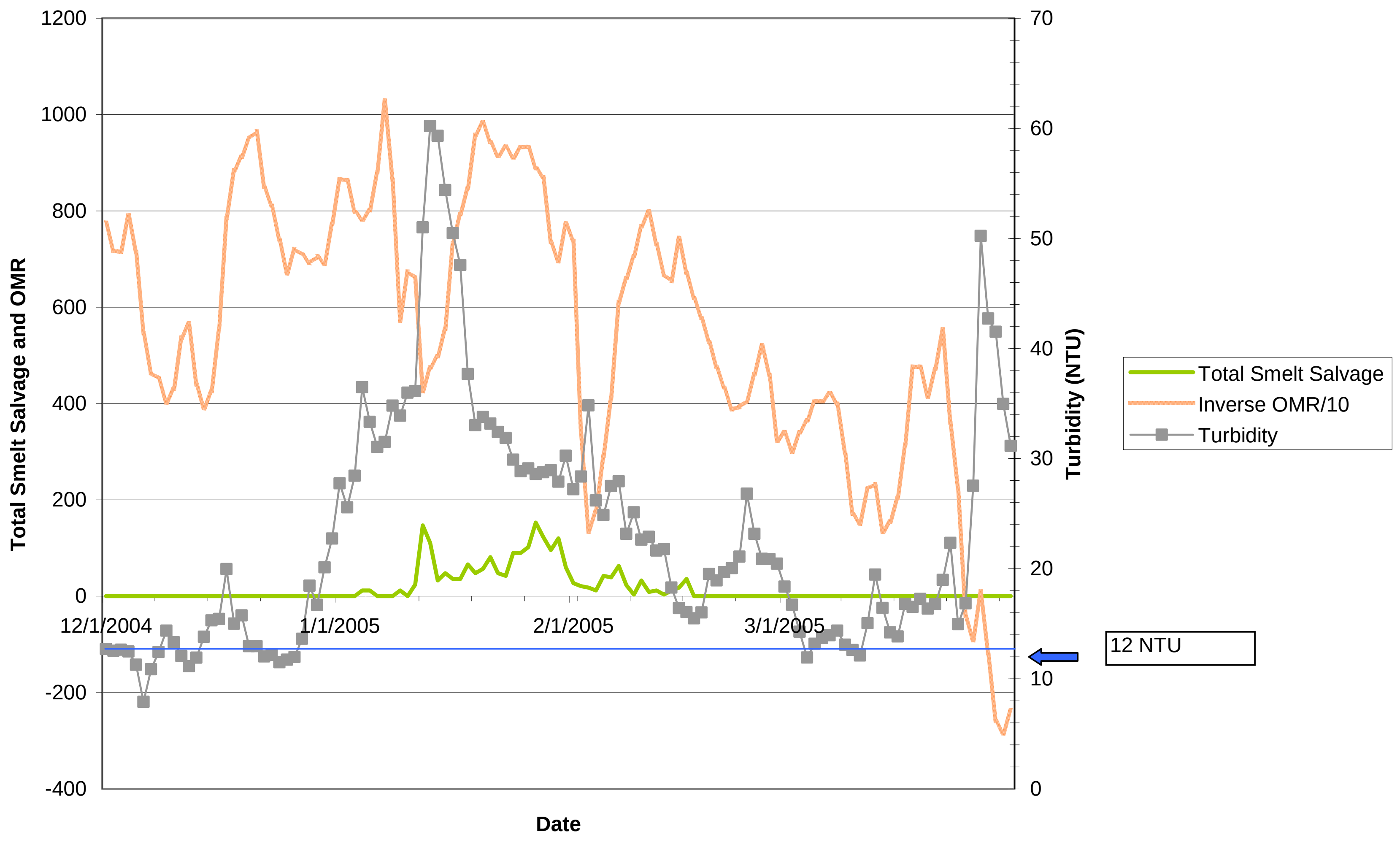


Figure B-6: 2005 WY OMR, Turbidity, Salvage



Up to fifty percent of the pre-spawning adult population has been entrained at the export facilities in recent years, depending on circumstances (Kimmerer 2008). Entrainment risk depends most importantly upon the distribution of delta smelt relative to the entrainment footprint of the CVP/SWP export facilities. Monitoring programs such as the FMWT and SKT provide a useful basis for estimating the abundance and distribution of delta smelt, despite having drawbacks (Newman 2008). The margin of error associated with abundance and distribution inferences increases at low abundances that have characterized the last several years. Abundances near the detection threshold of the sampling techniques makes it very difficult to draw reliable inferences about how many delta smelt there are, and where they are located.

To provide context to determine the magnitude of effect of pre-spawning adult direct mortality through entrainment within any given season (as measured by salvage), it is necessary to consider two important factors. First, although salvage is an index of entrainment, it is not a direct quantitative equivalent. The number of delta smelt that are actually counted at the salvage facilities represents a small percentage of the actual number entrained (See baseline section). Efficiency of sampling methodology is another consideration given the delicate tissues of the delta smelt, and this decreases inversely with fish size (adults are most accurately counted, while juvenile salvage efficiency is much lower, while <20mm smelt are mostly undetectable at the salvage facilities). Finally, although surviving individuals are held and released to the Delta, it is generally thought that they do not survive. Therefore salvage at the Banks and Jones facilities is not a good estimate of actual adult delta smelt mortality through entrainment (See baseline section).

The second factor to consider when relating salvage data to population-level significance is that the total number salvaged at the facilities does not necessarily indicate a negative impact upon the overall delta smelt population. The Salvage Index normalizes salvage to the population size based upon the previous FMWT Index:

Salvage Index = Number of Delta Smelt Salvaged ÷ Prior Year FMWT Index

Summaries of delta smelt salvage are presented by WY in Table B-2. Figures B-7 through B-11 display salvage data normalized to prior-year FMWT for the POD years (WY2002-WY2006). These plots have consistent units on the y-axis, reflecting the Salvage Index. The area under the salvage histogram reflects the total number of smelt salvaged, and this is a metric that can be related to total demographic impacts through entrainment. Review of salvage histograms within Figures B-7 through B-11 gives a sense of the magnitude of entrainment effects for all detectable lifestages of smelt through the water year.

Table B-2: Total Adult Delta Smelt Salvage by Year, including summary statistics

Year	Total Salvage	Prior Year FMWT	Cumulative Salvage Index	Peak Daily Salvage "Amplitude"	Salvage distribution	12 NTU "Trigger Date"	NTU trigger to peak salvage (days)	Total # salvaged before trigger	propn of total season salvage prior to trigger date
1993	4425	156	28.4	2.77	unimodal	10-Jan	12	27	0.0061
1994	398	1078	0.37	0.08	unimodal	4-Jan	52	100	0.25
1995	2600	102	25.5	1.49	unimodal	9-Jan	16	150	0.058
1996*	5634	899	6.27	0.52	unimodal	14-Feb	36	0	0.00
1997	1816	127	14.3	1.12	unimodal	20-Dec	80	12	0.007
1998	1027	303	3.39	0.38	bimodal	20-Dec	10 & 94	75	0.073
1999	2074	420	4.94	0.40	unimodal	14-Jan	36	20	0.0096
2000	11493	864	13.34	0.72	unimodal	23-Jan	28	482	0.042
2001	7991	756	10.6	0.49	unimodal	13-Jan	29	255	0.032
2002	6865	603	11.4	1.46	unimodal	20-Dec	14	324	0.047
2003	14323	139	103	5.60	unimodal	20-Dec	17	108	0.0075
2004	8148	210	38.8	1.71	bimodal	31-Dec	19	126	0.015
2005	2018	74	27.3	2.07	unimodal	20-Dec	39	0	0.00

* 3 NTU sensor malfunctions most of year; date evaluated as Dec 20 using total inflow > 25,000 cfs

Review of salvage data across years for which monitoring data are available indicate some patterns which led to the development of Interim Remedies Action 1; the same logic has been used to develop the present Action 1. First, salvage data during winter generally follows a unimodal distribution, with a defined salvage peak, and short duration. Occasionally, climatic conditions and operational criteria interact to produce bimodal or diffuse salvage distributions, however these year types are the exception, as summarized in Table B-2. Peak salvage usually occurs during the month of January, however this pattern does not hold during all year types, and some years even exhibit low overall adult salvage (wet WY of 1997 and 1998, or dry years with no winter first flush as in WY 1994).

Historic delta smelt salvage data and the current population status suggest a protective strategy for this period that focuses upon prevention of the attraction and subsequent entrainment of pre-spawning adults during the onset of upstream migration. While salvage itself is a useful indicator of distribution after the fact, it has serious drawbacks as a management tool when used on its own, because a large entrainment event may be inevitable by the time an increase in salvage is detected.

Figure B-7: 2002 WY Salvage Index

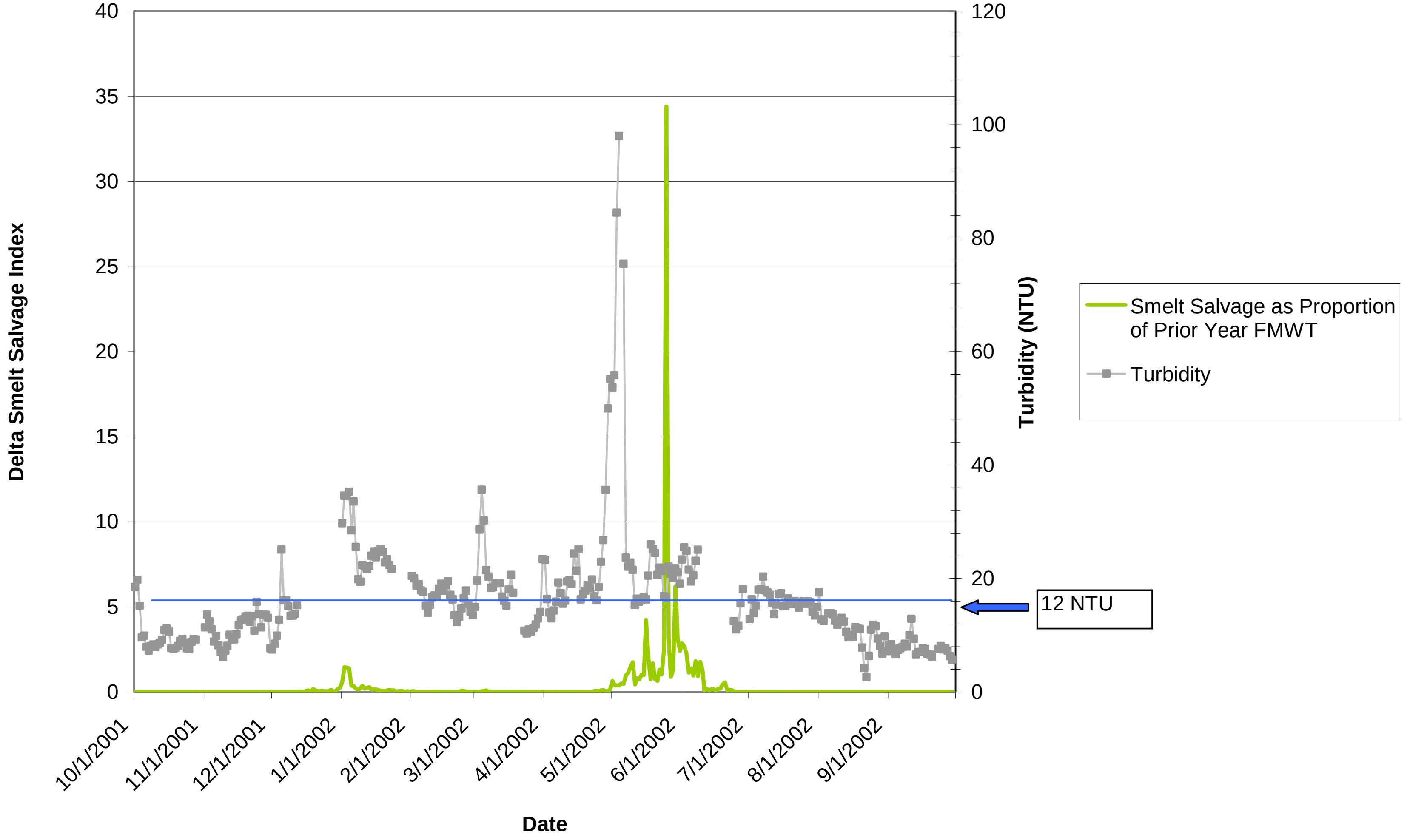


Figure B-8: 2003 WY Salvage Index

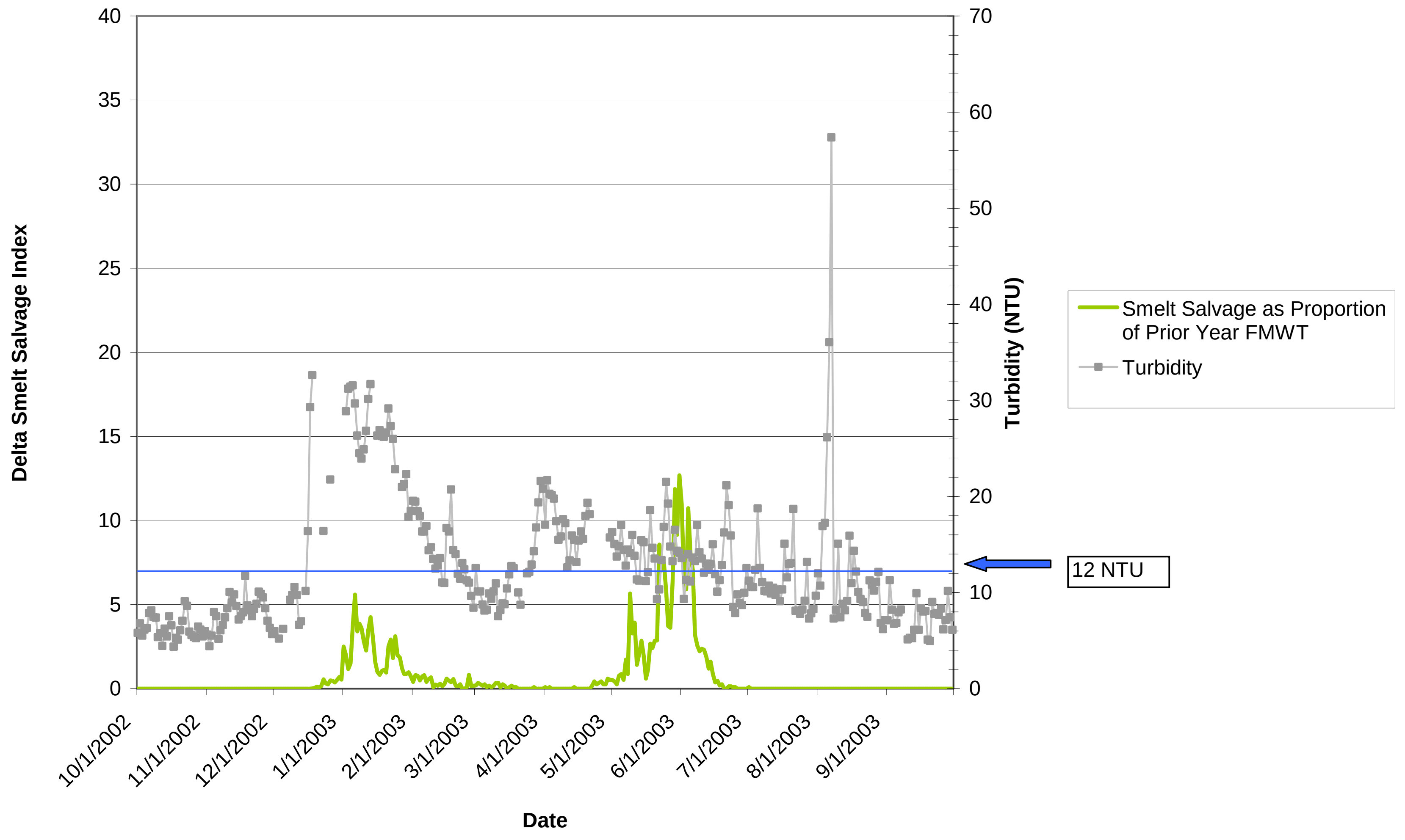


Figure B-9: 2004 WY Salvage Index

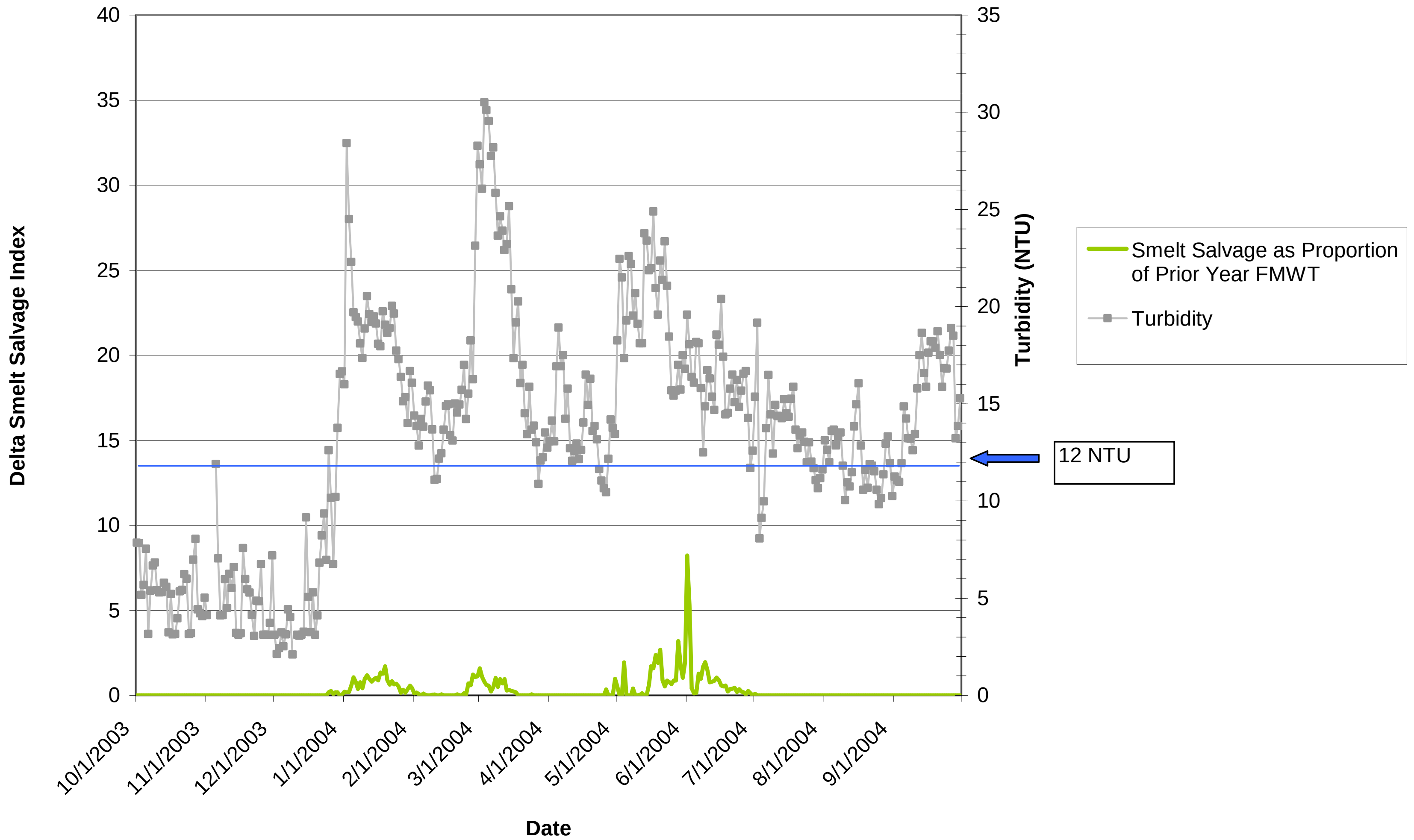


Figure B-10: 2005 WY Salvage Index

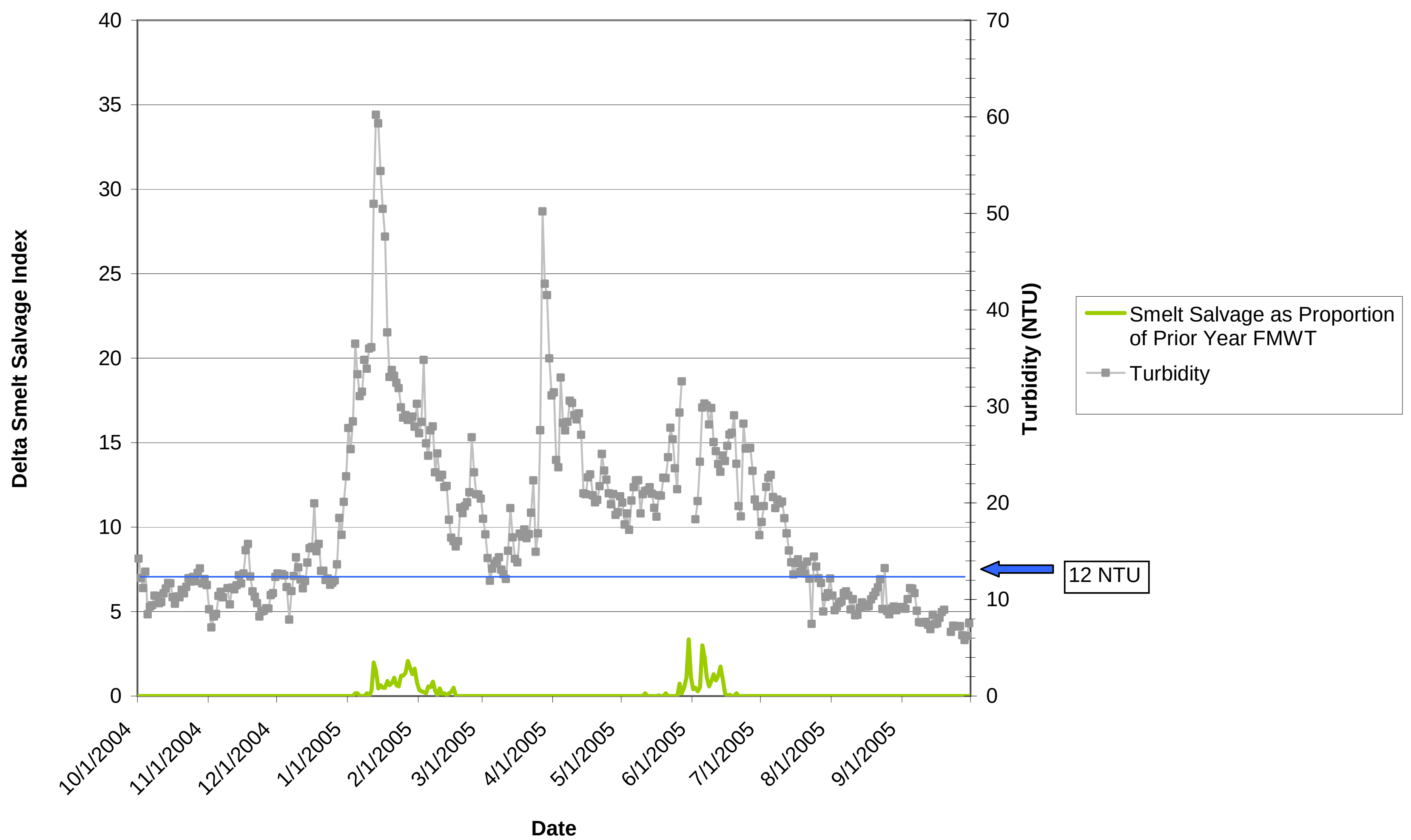
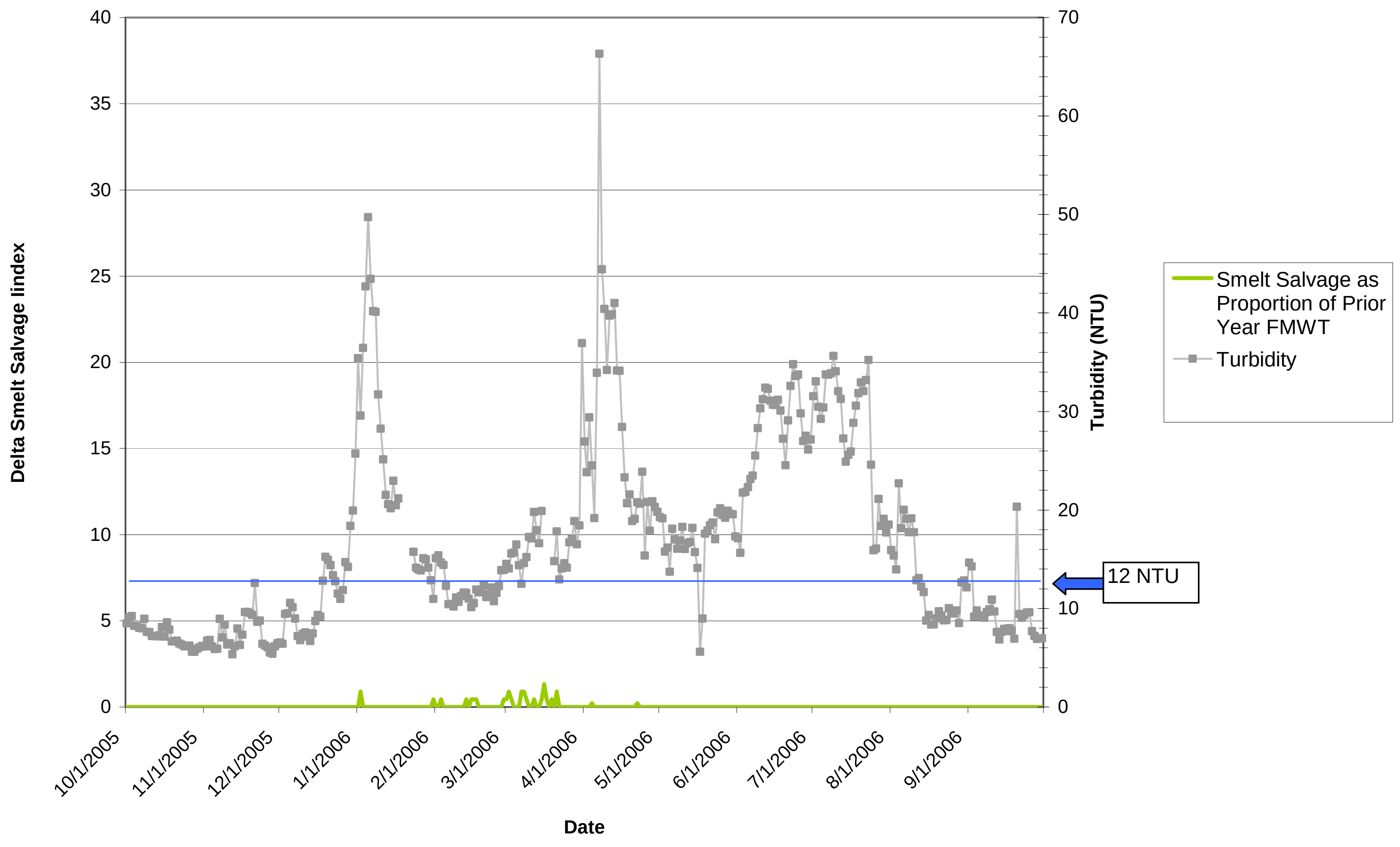


Figure B-11: 2006 WY Salvage Index



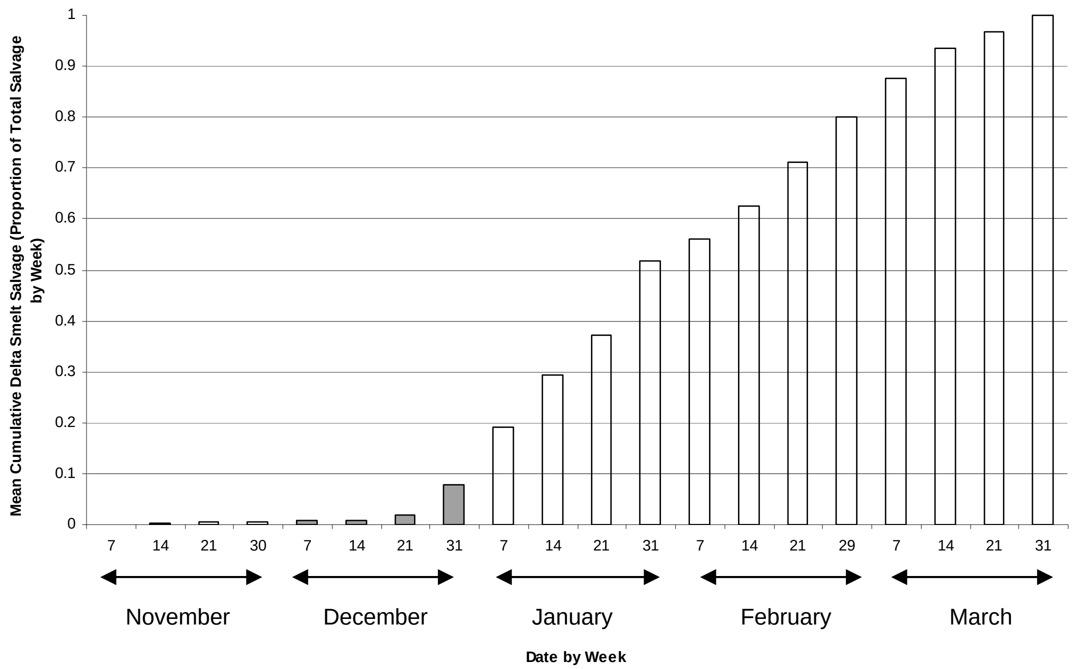
Justification for Timing of Action 1

Action 1, Part A covers the period (December 1 to December 20) when first flush salvage events were historically uncommon (Figure B-12). During this period the SWG will review conditions from week to week and may recommend to the Service that Action 1 be triggered. Part B of Action 1 (December 20 to March) covers a period when first flush salvage events have been historically more common. Part B will be triggered when turbidity increases above 12 NTU. The Service can bypass implementation of the trigger if the SWG concludes that the trigger was met by conditions (i.e., wind-induced turbidity) not likely to initiate smelt migration.

The timing of first flush salvage events is variable in any given WY. Thus, initiation of Action 1 is based on conditions (i.e., turbidity) rather than a specific month. Action 1 is therefore designed to provide flexibility and maximum protection for delta smelt. On average, about 1 percent of cumulative adult delta smelt entrainment occurs by December 21 (Figure B-12). By December 31, cumulative salvage has historically reached 3.2 percent.

Action 1 will be shifted from December 25 (as described in the Interim Remedies) to December 20 because it better reflects the period when protection will be needed. As previously mentioned, the Service will decide to initiate Action 1 before December 20 if the conditions warrant evidence smelt are migrating upstream (i.e., salvage, trawl data). Beginning in December, the SWG will review physical and biological parameters historically associated with smelt migration (i.e., precipitation, operations, turbidity, and salvage data) to make ongoing recommendations to the Service about the need to implement Action 1 at any time.

Figure B-12: Cumulative Proportional Salvage for WY 1993 to 2006 by Week



Duration of Action 1

The Interim Remedies Action 1 has been revised from ten to 14 days to incorporate coverage between spring and neap tidal cycles that may influence migration rate into the interior Delta.

Justification for the Salvage Guideline Action 1

In many years, delta smelt have been salvaged prior to when turbidity elevates above 12 NTU (Table B-2). In the case that salvage begins prior to the trigger, the decision to implement Action 1 will be based on the following: 1) magnitude of salvage scaled to the population size (Table B-2), and 2) the amplitude which represents daily salvage divided by the prior year FMWT.

The 4th column in Table B-2 lists the cumulative seasonal salvage of adult delta smelt divided by the prior year FMWT Index (the Cumulative Salvage Index). This value ranged from a minimum of 0.37 in WY 1994 to a maximum of 103 during WY 2003. The combination of peak (amplitude in the histogram or maximum daily salvage), and Cumulative Salvage Index is a general index of the magnitude of adult entrainment in a given WY.

The median value for the Cumulative Salvage Index for the years presented would be 13.3. The mean value for all years within the range presented in Table B-2 is 22.1. For peak daily salvage, the Salvage Index mean for the WY 1993 through 2005 is 1.45. The median amplitude value is 1.1. Taking these data into account, a Cumulative (seasonal) Salvage Index exceeding 7.25 appears to be indicative of an unacceptable risk threshold based on the current low numbers of delta smelt. A peak Daily Salvage Index of 1.0 is suggested as an index of daily smelt salvage at levels or maintained at existing levels that ongoing or anticipated salvage could rapidly reach unacceptable losses if exports are to increase. These values are carried forward into the prescriptions as pre-emptive triggers, and as releases from Action prescriptions to carry forward through Actions 1 and 2.

Justification for the Turbidity Criterion as a Trigger in Action 1 (Part B)

Onset of Action 1 during Part B

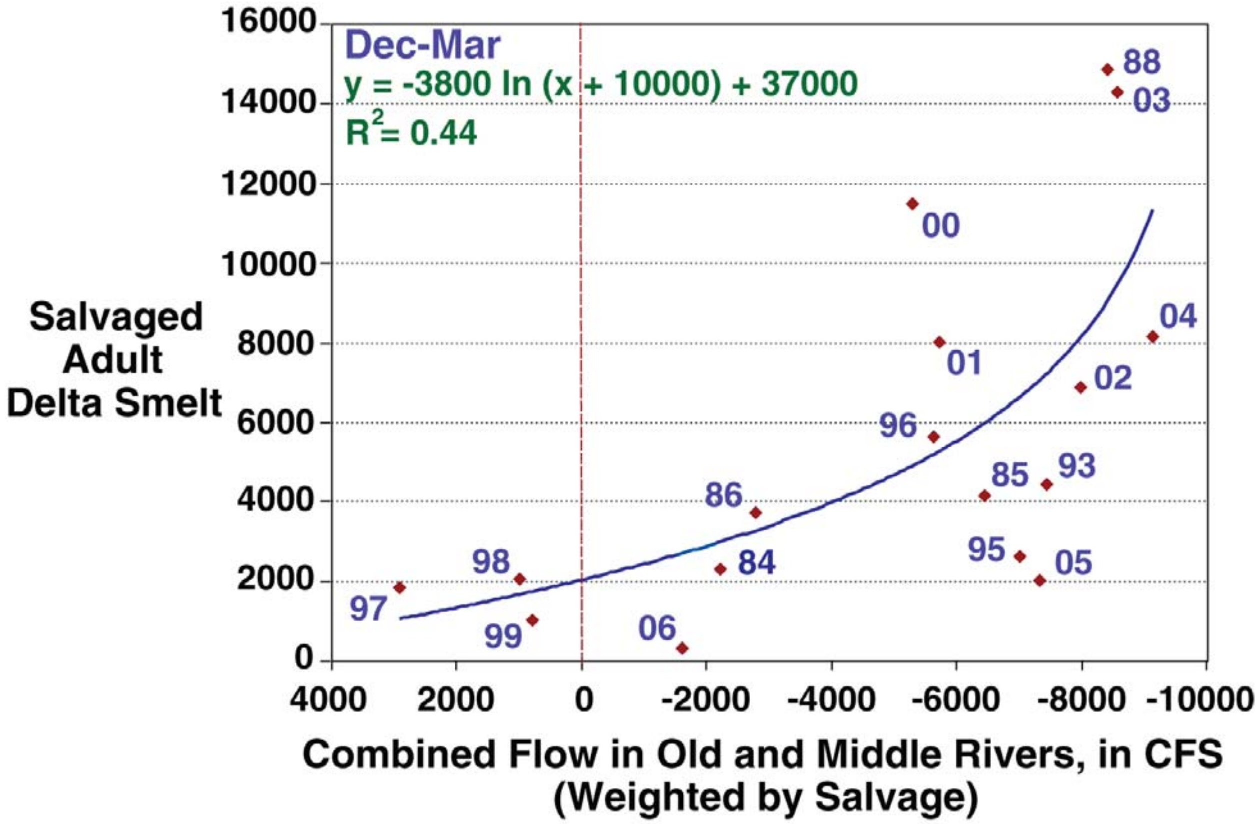
Turbidity associated with freshets of water is a reasonable indicator of when smelt begin to migrate upstream and become vulnerable to salvage. Though this historical trend is based on the turbidity sensor located outside the Clifton Court Forebay, there is no expectation that the relationship between increased flow and turbidity would differ from recently installed sensors identified in the Interim Remedies: Prisoners Point, Holland Cut, and Victoria Canal. It appears that the Holland Cut sensor is sensitive to localized wind conditions at times. On December 25-27, 2007, a three-day rise in turbidity at the Holland Cut monitoring station triggered Action 1. It was unlikely that a wind-associated turbidity event initiated smelt migration. Rather than rely on one of these stations to trigger Action 1 (Interim Remedies), Action 1 will be triggered when turbidities elevate over 12 NTU at all three stations. The use of three stations would better reflect a Delta-wide change in turbidity than one station which may be prone to localized conditions.

Timing and the Protectiveness of the 12 NTU criterion

If the 12 NTU threshold had been used in previous years, Action 1 would have likely provided early protection (i.e., less salvage) during most years. The degree to which it would have minimized the number of smelt entering the South Delta is unknown.

Justification for Flow Prescriptions in Action 1

Understanding the relationship between OMR flows and delta smelt salvage allows a determination of what flows will result in salvage. The OMR-Salvage analysis herein was initiated using the relationship between December to March OMR flow and salvage provided by P. Smith and provided as Figure B-13, below. Visual review of the relationship expressed in Figure B-13 indicates what appears to be a “break” in the dataset at approximately -5,000 OMR; however, the curvilinear fit to the data suggest that the break is not real and that the slope of the curve had already begun to increase by the time that OMR flows reached -5,000 cfs.



Note: Data shown are for the period 1984-2007, excluding years 1987, 1989-92, 1994, and 2007 that had low (<12ntu) average water turbidity during Jan-Feb at Clifton Court Forebay.

Figure B-13. OMR-Salvage relationship for adult delta smelt. (source, P. Smith). Data from this figure were the raw data used in the piecewise polynomial regression analysis.

Further, a nonlinear regression was performed on the dataset, and the resulting pseudo-R^2 value was 0.44—suggesting that although the curvilinear fit is a reasonable description of the data, other functional relationships also may be appropriate for describing the data. Fitting a different function to the data could also determine the location where salvage increased, i.e. identify the “break point” in the relationship between salvage and OMR flows. Consequently, an analysis was performed to determine if the apparent break at -5,000 cfs OMR was real. A piecewise polynomial regression, sometimes referred to as a multiphase model, was used to establish the change (break) point in the dataset.

A piecewise polynomial regression analysis with a linear-linear fit was performed using data from 1985 to 2006. The linear-linear fit was selected because it was the analysis that required the fewest parameters to be estimated relative to the amount of variation in the salvage data. Piecewise polynomial regressions were performed using Number Cruncher Statistical Systems (© Hintz, J., NCSS and PASS, Number Cruncher Statistical Systems, Kaysville UT).

The piecewise polynomial regression analysis resulted in a change point of -1162, i.e. at -1162 cfs OMR, the slope changed from 0 to positive (Figure B-14). These results indicate that there is a relatively constant amount of salvage at all flows more positive than -1162 cfs but that at flows more negative than -1162, salvage increases. The pseudo-R^2 value was 0.42, a value similar to that obtained by P. Smith in the original analysis.

To verify that there was no natural break at any other point, the analysis was performed using a linear-linear-linear fit (fitting two change points). The linear-linear-linear fit resulted in two change points, -1,500 cfs OMR and -2,930 cfs OMR. The -1,500 cfs value is again the location in the dataset at which the slope changes from 0 to positive. The pseudo-R^2 value is 0.42 indicating that this relationship is not a better description of the data. Because of the additional parameters estimated for the model, it was determined that the linear-linear-linear fit was not the best function to fit the data, and it was rejected. No formal AIC analysis was performed because of the obvious outcome.

A major assumption of this analysis is that as the population of Delta smelt declined, the number of fish at risk of entrainment remained constant. If the number of fish in the vicinity of the pumps declined, fewer fish would be entrained and more negative OMR flows would result in lower salvage. This situation would result in an overestimate, i.e. the change point would be more positive. In fact, if the residuals are examined for the relationship in Figure B-13 above, the salvage for the POD years 2002, 2004, 2005, and 2006 are all below the line. 2003 is above the line although the line is not extended to the points at the top of the figure, and these data points occur when the curve becomes almost vertical. The negative residuals could be a result of a smaller population size available for entrainment and salvage. This could be verified by normalizing the salvage data by the estimated population size based on the FMWT data.

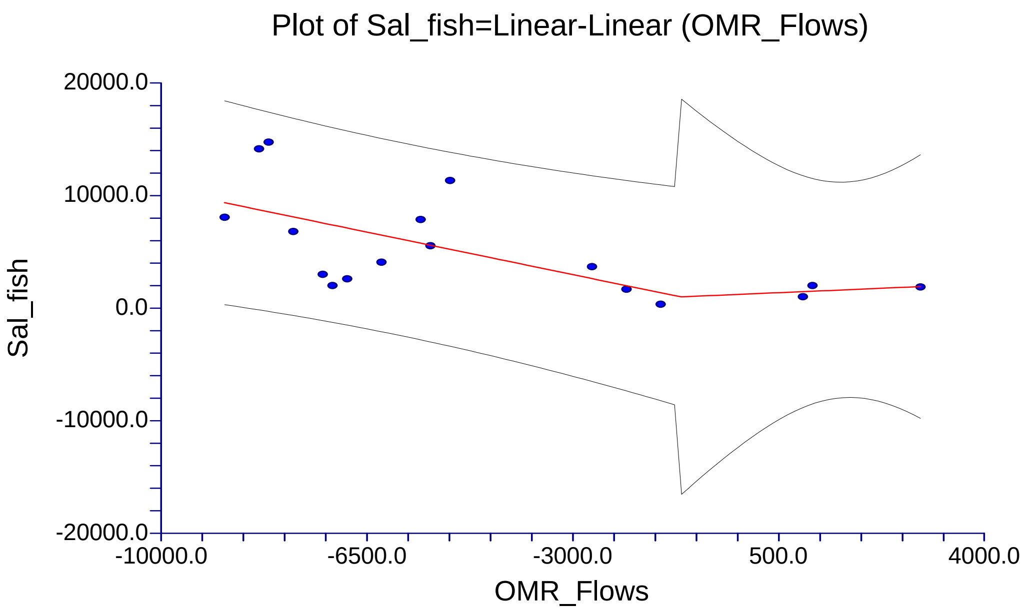


Figure B-14. Piecewise polynomial regression of OMR flows and salvage. The change point is the location at which the two regression lines meet; -1,162 cfs OMR.

The original values of OMR and salvage could have been measured with error due to a number of causes, consequently the values used in the original piecewise polynomial analysis could be slightly different than the "true" values of salvage and OMR flow. Consequently, a second analysis was undertaken to examine the effect of adding stochastic variation to the OMR and salvage values in the piecewise polynomial regression analysis. The correlation between OMR and salvage in the original dataset was -0.61 indicating that the more negative the OMR, the greater the salvage. Consequently, it was necessary to maintain the original covariance structure of the data when adding the error terms and performing the regressions. The original covariance structure of the OMR–salvage data was maintained by adding a random error term to both parameters. The random error term was added to OMR and a correlated error term was added to salvage. The expected value of the correlated errors was -0.61.

The error terms were selected from a normal distribution with a mean of 1.0 and a standard deviation of 0.25 which provided reasonable variability in the original data. Operationally this process generated a normal distribution of OMR and salvage values in which the mean of the distributions were the original data points. Additional analyses were performed with standard deviations of 0.075, 0.025, and 0.125. Smaller standard deviations in the error term resulted in estimates of the change point nearer to the original estimate of -1,162 cfs. This is to be expected as the narrower the distribution of error terms, the more likely the randomly selected values would be close to the mean of the distribution. The process was repeated one hundred times, each time a new dataset was generated and a new piecewise polynomial regression was performed. The software package @Risk (© Palisade Decision Tools) was used to perform the Monte Carlo simulations. Latin hypercube sampling was used to insure that the distributions of OMR and salvage values were sampled from across their full distributions. The parameter of interest in the simulations was the change point, the value of the OMR flow at which the amount of salvage began to increase. Incorporating uncertainty into the analysis moved the change point to -1,800 cfs OMR, indicating that at flows above -1683, the baseline level of salvage occurred but with flows more negative than -1683, salvage increased.

Justification for Release from Prescriptions of Action 1

Temperature

The Interim Remedies prescribed regulatory release from Action 1 once mean water temperatures at Rio Vista, Antioch, and Mossdale Stations reaches 12^{O}C. This metric is used as a surrogate to indicate time when spawning is likely to have begun based on physiological preferences.

Biological Conditions

The Interim Remedies prescribed regulatory release from Action 1 once spent females are detected in the SKT or at the salvage facilities.

Changing the Timing of the Action

If the SWG recommends a delayed start or interruption to Action 1 based on variations in conditions which may affect vulnerability to entrainment (e.g., no observed salvage and a rapid reduction in turbidity after the first week of Action 1), the Service will weigh such information and make a final determination on protective OMR flow requirements.

ACTION 2: ADULT MIGRATION AND ENTRAINMENT

Objective: An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions.

Action: The range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions (and the general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 2 through its termination (see Adaptive Process in Introduction). The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.

Timing: Beginning immediately after Action 1. Before this date (in time for operators to implement the flow requirement) the SWG will recommend specific requirement OMR flows based on salvage and on physical and biological data on an ongoing basis. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt.

Suspension of Action:

Flow: OMR flow requirements do not apply whenever a three day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of the Action are again in place.

Off-ramps:

Temperature: Water temperature reaches 12^{o}C based on a three station daily average (Rio Vista, Antioch, Mossdale)

OR

Biological: Onset of spawning (presence of spent females in SKT or at either facility)

Adaptive Process Required Parameters:

Two scenarios span the range of circumstances likely to exist during Action 2. First, the low-entrainment risk scenario. There may be a low risk of adult entrainment because (a) there has been no discernable migration of adults into the South and Central Delta (b) the upstream migration has already occurred but turbidity is low and there is no or little evidence of ongoing adult entrainment. In this scenario, higher negative OMR flow rates as high as -5,000 cfs may be ventured as long as entrainment risk factors and salvage permit.

The second scenario, the high-entrainment risk scenario, is one in which either (a) there is evidence that upstream adult migration is currently occurring, or (b) upstream migration has already occurred and there are adult fish in the South and Central Delta and turbidity is high, increasing the risk of entrainment, or (c) there is evidence of ongoing entrainment, regardless of other risk factors. In this case, OMR flow will be set to reduce entrainment and/or the risk of entrainment as the totality of circumstances warrant.

Generally, if the available distributional information suggests that most of the delta smelt are in the North or North/Central Delta, then OMR flow can be chosen to minimize Central Delta entrainment. However, if the distributional information suggests there are delta smelt in the Central or South Delta, then OMR flow will have to be set lower to reduce entrainment of delta smelt.

The following two paragraphs describe how these action guidelines would be implemented at the start of Action 2 and at other times during Action 2.

1. OMR flow setting at initiation of Action 2

a) If salvage is zero during the final 7 days of Action 1, and three-station mean turbidity is below 15 NTU, then increase negative OMR flow to no more negative than -5,000 cfs on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable required OMR flow[8]; *UNLESS*

b) If salvage is less in the most recent three days than in the preceding three days of Action 1, and the maximum Daily Salvage Index is ≤1 during the prior 7 days, then limit exports to achieve OMR flows no

[8] Both the 14-day and the 5-day running averages will be computed using the "tidally filtered" daily average OMR flows reported by USGS.

more negative than -3,500 cfs on a 14-day running average for 7 days (or until 4 consecutive days of zero salvage or any 5 of 7 days with zero salvage), with a 5-day running average within 25 percent of the applicable required OMR flow; *OR*

c) If salvage is greater or equal in the last three days than in the preceding three days of Action 1, and maximum Daily Salvage Index ≥1 during any of those days, then continue OMR flow at no more negative than -2,000 cfs on a 14-day running average for an additional 7 days (or until 4 succeeding days of zero salvage or any 5 of 7 days zero salvage), with a simultaneous 5-day running average within 25 percent of the applicable requirement OMR; *OR*

d) If circumstances existing at the initiation of Action 2 are, in the judgment of the Service, markedly different from those anticipated in (a) through (c) above, then the OMR flow requirement in (c) will be applied and the SWG will review available data and recommend an initial flow rate to the Service.

2. OMR flow setting after initiation of Action 2

a) The SWG will review all available information and request updated entrainment simulations and/or other information, as needed, on a weekly basis to decide whether the current OMR flow requirement is appropriate or should be changed.

b) Unless OMR flow is grossly positive regardless of water project operations, due to high Delta inflows, then important variables that affect the risk of adult entrainment during Action 2 include (1) salvage or other actual entrainment indicators, (2) turbidity, (3) available monitoring results, hydrologic variables other than export pumping rates that affect OMR flow, (4) apparent population size from the preceding FMWT survey, and (5) particle tracking or other model-based entrainment risk information.

c) As described above, the risk of entrainment is generally higher when there is evidence of ongoing entrainment or turbidity is high, and these two variables are the most likely triggers of decisions to raise or lower OMR flow requirements.

d) Based on historical experience, OMR flow requirements between the limits of -2,000 cfs and -5,000 cfs are likely to be adequate in most years. The exception is years in which there appears, for whatever reasons, to be a substantial fraction of the adult spawning migrant population in the Central and/or South Delta. When this occurs, more stringent OMR limitation (possibly to no more negative than -1,250 cfs) may be required.

Background

Action 2 reflects the period when OMR prescriptions for pre-spawning adult delta smelt are still required to protect parental stock prior to reproduction, however such controls may generally be relaxed because the main pulse of fish migration has occurred and adults are holding more tightly to their selected spawning areas. Action 2 may also be needed to extend protections consistent with Action 1 in years of longer spawning migration periods or changing environmental conditions. Conditions are highly variable in any given year. Rather than provide a prescription that is protective under all circumstances, an adaptive process based on the guidelines outlined herein is warranted. This process can most efficiently and effectively provide protections utilizing analysis of all available data and seasonal conditions.

The OMR flow prescriptions set forth during Action 2 will be based upon analysis of population status in any given year, available monitoring data from the SKT, seasonal variables such as WY type, CVP and SWP reservoir storage levels, temperature, and observed salvage during Action 1. Of these, population status and real-time salvage data are expected to be the primary driving criterion.

Justification for Guidelines in Setting Prescriptions of Action 2

The SWG will apply the following criteria to set the flow prescriptions during Action 2, to be operational until the onset of Action 3.

Zero Salvage or Extended Salvage Index of Low Amplitude

a) If salvage is zero during the final 7 days of Action 1, then increase negative OMR to no more negative than -5,000 cfs on a 14-day running average, with a simultaneous 5-day running average within 25 percent of the applicable requirement OMR; *OR*

Decreasing Salvage or Salvage Index with Low Amplitude

b) If salvage is less in the last three days than in the preceding three days and the maximum daily salvage index is ≤1 during the prior 7 days, then limit exports to achieve OMR flows no more negative than -4,000 cfs on a 14-day running average for 7 more days with average OMR for the period within 25 percent of the requirement (or until 4 succeeding days of zero salvage or any 5 of 7 days zero salvage); *OR*

Rising Salvage or Salvage Index with High Amplitude

c) If salvage is greater or equal in the last three days than in the preceding three days, and maximum daily salvage index ≥1 during any of those days, then continue OMR flow at no more negative than -2000 cfs on a 14-day running average for an additional 7 days (or until 4 succeeding days of zero salvage or any

5 of 7 days zero salvage), with a simultaneous 5-day running average within 25 percent of the applicable OMR requirement.

Flow requirements will be monitored in real-time utilizing salvage data as a check on performance of the Service-recommended requirements, consistent with the objectives and numerical requirements established in the take statement (Attachment C).

Flow requirements defined within Action 2 follow the same protectiveness criterion established during Action 1, as adjusted to reflect real-time conditions and predicted entrainment risk relative to the anticipated distribution and abundance of year-class delta smelt; and reflecting their behavioral propensity to hold in their chosen spawning habitat. These are allowed to vary based upon assessment of available data as described in the adaptive process described in the Introductions to Actions section above.

Justification for Release from Prescriptions of Action 2

Flow

The Interim Remedies provided release from the prescription of Action 2 when the three day average Sacramento River flow at Freeport is greater than 80,000 cfs.
During WY 1982 and 1995, salvage was observed during periods when Sacramento River flows exceeded this criterion. During 1995, Sacramento River flows at Freeport exceeded 90,000 cfs while San Joaquin River flows approximated 5,000 cfs—salvage still occurred. This data suggests that adult delta smelt can still navigate the channels upstream at these flows. During 1997 and 1998, low salvage was observed while flows within both the Sacramento and San Joaquin rivers were high. For these reasons, it was determined that the offramp for prescriptions in Actions 1 and 2 should be Sacramento River flows at *Rio Vista* exceeding a three-day average of *90,000* cfs *and* San Joaquin River flows at Vernalis exceeding 10,000 cfs. Based on historic observations, it is predicted that salvage under these flow conditions will be minimal.

Temperature

The Interim Remedies prescribed regulatory release from Action 1 once mean water temperatures at Rio Vista, Antioch, and Mossdale Stations reaches 12^{O}C. This metric is used as a surrogate to indicate time when spawning is likely to have begun based on physiological preferences.

Biological Conditions

The Interim Remedies prescribed regulatory release from Action 1 once spent females are detected in the SKT or at the salvage facilities.

ACTION 3: ENTRAINMENT PROTECTION OF LARVAL SMELT

Objective: Minimize the number of larval delta smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval delta smelt, e.g., by using a VAMP-like action. Because protective OMR flow requirements vary over time (especially between years), the action is adaptive and flexible within appropriate constraints.

Action: Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR.[9] Depending on extant conditions (and the general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination (see adaptive process in Introduction).[10] The SWG would provide these recommendations based upon weekly review of sampling data, from real-time salvage data at the CVP/SWP, and expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.

Timing: Initiate the action after reaching the triggers below, which are indicative of spawning activity and the probable presence of larval delta smelt in the South and Central Delta. Based upon daily salvage data, the SWG may recommend an earlier start to Action 3. The Service will make the final determination.

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[9] Both the 14-day and the 5-day running averages will be computed using the "tidally filtered" daily average OMR flows reported by USGS.

[10] During most conditions, it is expected that maximum negative OMR flows will range between -2000 and -3500. During certain years of higher or lower predicted entrainment risk, requirements as low as -1,250 or -5,000 will be recommended to the Service by the SWG.

Triggers:

Temperature: When temperature reaches 12°C based on a three station average at Mossdale, Antioch, and Rio Vista.

OR

Biological: Onset of spawning (presence of spent females in SKT or at either facility).

Offramps:

Temporal: June 30;

OR

Temperature: Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay.

Adaptive Process Required Parameters:

During the larval/juvenile entrainment risk period, the SWG will meet weekly to review available physical and biological data and develop a recommendation to the Service. The Service will determine the specific OMR requirement based upon the SWG recommendation and the strength of the accompanying scientific justification.

Two scenarios span the range of circumstances likely to exist during Action 3. First, the low-entrainment risk scenario. There may be a low risk of larval/juvenile entrainment because there has been no evidence of delta smelt in the South and Central Delta or larval delta smelt are not yet susceptible to entrainment. In this scenario, negative OMR flow rates as high as -5,000 cfs may occur as long as entrainment risk factors permit.

The second scenario, the high-entrainment risk scenario, is one in which either (a) there is evidence of delta smelt in the South and Central Delta from the SKT and/or 20mm survey, or (b) there is evidence of ongoing entrainment, regardless of other risk factors. In this case, OMR should be set to reduce entrainment and/or the risk of entrainment as the totality of circumstances warrant.

Usually, if the available distributional information suggests that most delta smelt are in the North or North/Central Delta, then OMR flow can be chosen to minimize Central Delta entrainment. However, if the distributional information suggests there are delta smelt in the Central or South Delta, then OMR flows will have to be set lower to reduce entrainment of these fish. If delta smelt abundance is low, distribution cannot be reliably inferred. Therefore, the adaptive process is extremely important. The SWG may recommend any specific OMR flow within the specified range above.

Action 3 is initiated when temperature reaches 12^{o}C based on a three station average at Mossdale, Antioch, and Rio Vista, or when spent females or larva are detected;

a) Once larvae are likely to become vulnerable to entrainment, set OMR flows to no more negative than -2,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR;[11]

b) The SWG will use available physical and biological real-time monitoring data to decide whether a large fraction of the delta smelt population is in the Central Delta and therefore at risk of entrainment. If a large portion of the delta smelt population appears to be in the Central Delta, OMR flows would likely be set to no more negative than -1,250 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR; [6]

c) The SWG will use available physical and biological real-time monitoring data to decide whether the delta smelt population is at a lesser entrainment risk. In this circumstance, OMR flows would likely be set to no more negative than -3,500 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR;[6]

d) The SWG will use available physical and biological real-time monitoring data to decide whether the delta smelt population is at a low entrainment risk. In this circumstance, OMR flows to no more negative than -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR;[6]

e) If circumstances existing at the initiation of Action 3 are, in the judgment of the Service, markedly different from those anticipated in (a) through (d) above, then the OMR flow prescription will be set to entrain no more than 1 percent of the particle entrainment at Station 815 (approximately no more than 10 percent of the cumulative population).

[11] Both the 14-day and the 5-day running averages will be computed using the “tidally filtered” daily average OMR flows reported by USGS.

Background

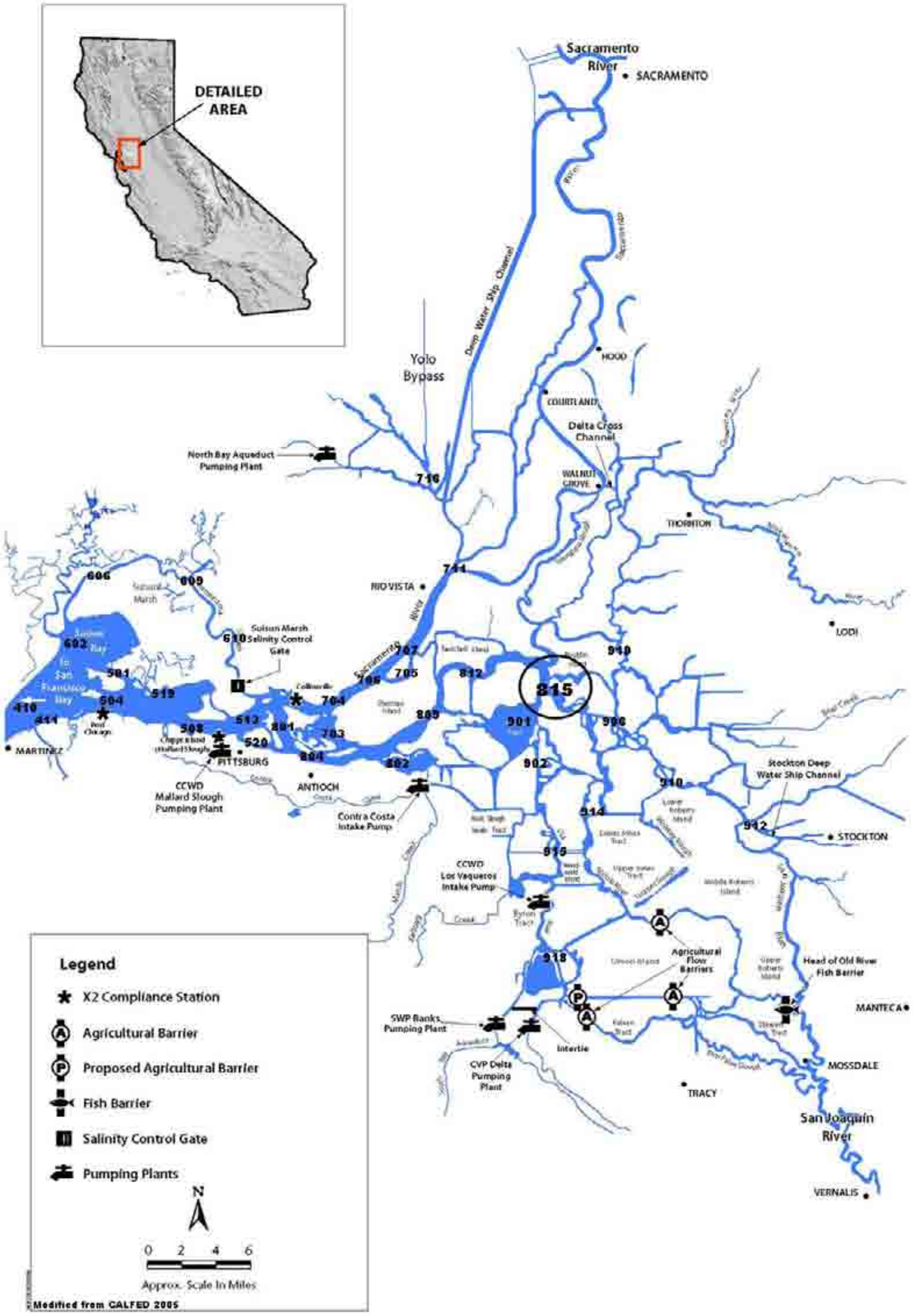
Action 3 is intended to minimize the entrainment of larval/juvenile delta smelt in the Central and South Delta. When the distribution of delta smelt is in the North or North/Central Delta, this will generally be accomplished by holding entrainment to ~1 percent of the individuals utilizing the Central and South Delta (south and east [upstream] of Station 815, see Map 2) across a 14-day particle modeling interval. Preserving larvae and juveniles that are in the Central Delta, or might be in the Central Delta in circumstances where it is difficult to ascertain the distribution of the fish, is critical to ensuring year-to-year stock-recruitment of the population and minimize the risk of localized disturbances that might adversely affect the North Delta.

In circumstances where it is known or suspected that the Central Delta or South Delta is a principal source of emerging larvae, as occurred in WY 2003, OMR restrictions might be calculated using reduction of 14-day Station 815 entrainment below 1 percent, or other methods as needed to ensure protection of the larval population in conditions of such severe vulnerability. The Action utilizes OMR restrictions to achieve the desired end, as OMR flow is a strong predictor of geographical variation in entrainment risk in the Central and North Delta. The OMR flows associated with the protectiveness criteria defined above have been derived from particle tracking modeling with the input assumptions defined below.

These protections are directly tied to presence of vulnerable larval and juvenile delta smelt within the zone of entrainment of Banks and Jones. Therefore, Action 3 must commence no later than the time when larvae are likely to become vulnerable to entrainment.

Data presented in the Effects section of this biological opinion support the conclusion that flow conditions during the VAMP (during the years in which they have been in effect) have been instrumental in protecting delta smelt progeny. Examination of the OMR flow records shows that the combination of increased San Joaquin River flows and reduced pumping during the VAMP generally resulted in OMR flows of approximately -2,000 cfs (Figure B-15).

Protection from entrainment for larval and juvenile delta smelt will be achieved using OMR prescriptions generally ranging between -2,000 to -3,500 cfs on a 14-day running average with a simultaneous 5-day average not more negative by more than 25 percent of the current OMR flow requirement. However, during certain years of unusual smelt distribution (while predicted or measured larval/juvenile delta smelt distribution are in close proximity to the zone of entrainment), maximum negative OMR flows may for a time be set as low as -1,250 cfs. Overall, the OMR flow may be set anywhere between -1,250 to -5,000 cfs on a 14-day running average with a simultaneous 5-day average (from actual daily OMR values) not more negative than the required OMR by more than 25 percent.



Map 2 Biological Monitoring Stations in the Delta

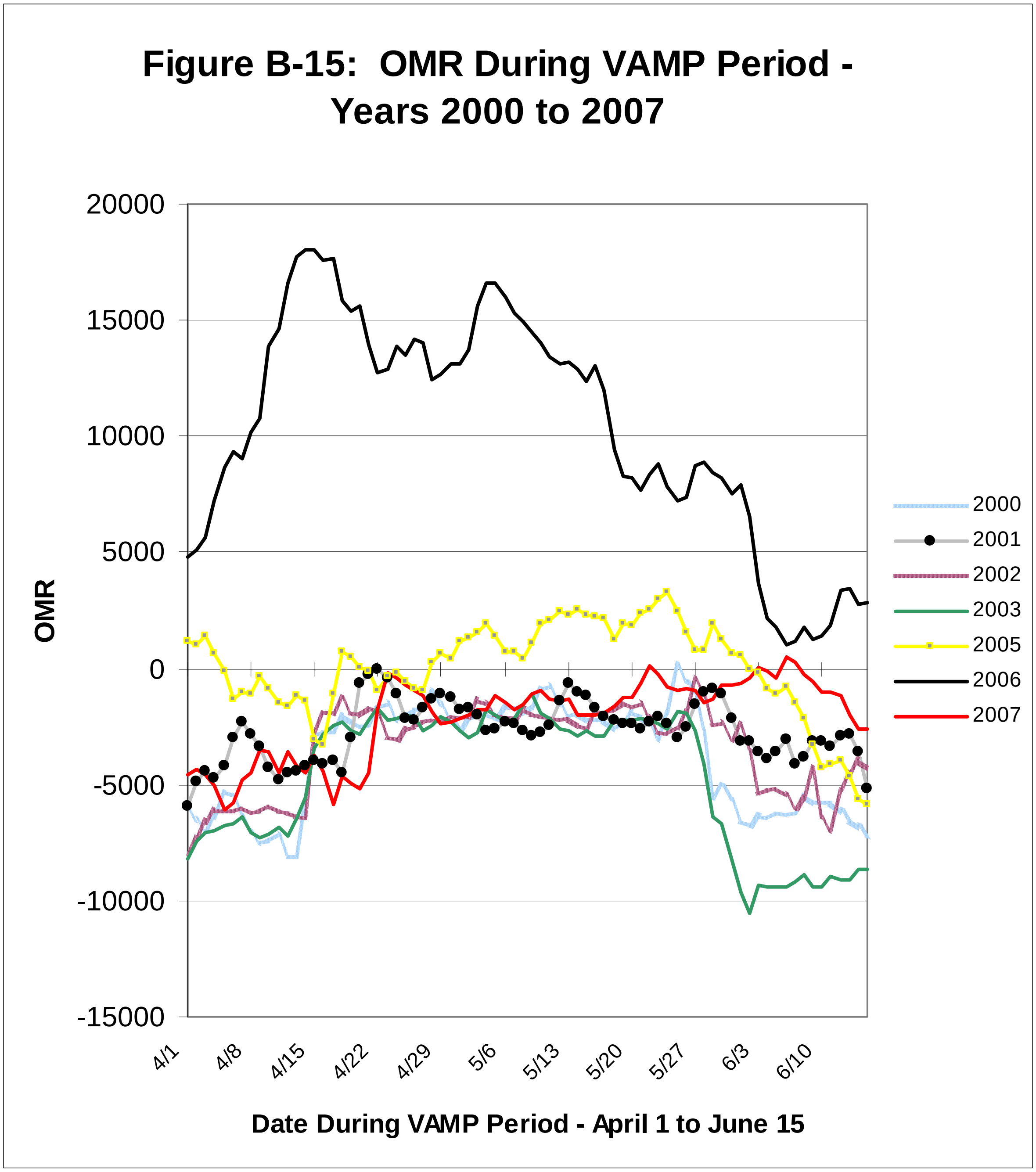


Figure B-15. OMR flows across VAMP period (usually April 15-May 15). Note that although exact VAMP conditions vary across years, the period is easily identified by OMR flows no more negative than -2000 cfs.

The following examples provide the insight on when exceptions to the ranges of OMR flows above would be used. In high risk years, when delta smelt are in the South Delta, suggesting that delta smelt are particularly sensitive to entrainment (as for example in 2003), a stricter limit on OMR flow of -1,250 cfs would be necessary to meet the defined protectiveness criterion. Alternatively, in years when sampling indicates that it appears that most adults have spawned in the Cache Slough complex and larvae may be at reduced risk of entrainment, an OMR flow of about -3,500 cfs may be possible while still meeting the protectiveness criterion. Later in the season, as more juvenile delta smelt are found seaward and while physical conditions in the Delta become less conducive to smelt larvae, OMR flow requirements could relax further. Once conditions in the Delta are inconsistent with smelt survival (i.e. South Delta waters are too warm), the larval protections of Action 3 cease.

Justification for Timing of Action 3

The window for delta smelt spawning generally begins during February, but is variable based on seasonal conditions of flow, temperature, and physiological condition of the current year spawning cohort. Further, low adult abundances make it very difficult to discern adult spawning distribution using current monitoring methods. Lastly, protective and successful flow restrictions during the winter may reduce the discriminatory power of salvage itself as an indicator of the distribution of spawning smelt and timing to initiate Action 3.

For these reasons, it is believed that an adaptive approach using recommendations from the SWG in real-time is preferred to protective prescriptions that are applied regardless of variation or nuance in actual conditions. By monitoring a combination of these factors, along with tracking of important parameters in real time that are indicative of smelt presence and the timing of smelt spawning activity, the SWG is best situated to judge when OMR actions should be initiated or adjusted in Action 3.

During Action 3 (generally March through June 30), the SWG will recommend OMR flows to the Service. These will be based upon the best-available predictive capacity of the experts within the group given available data in real-time, and will be protective of larval/juvenile delta smelt to the criteria defined above.

Justification for Different OMR Requirements of Action 3

Analysis of the birth dates of delta smelt collected from the Summer Townet Survey (Bennett 2008) indicates that in 2005 the delta smelt found in the summer were almost entirely born during the VAMP period. Collection of spawned adults suggests that larvae were produced throughout much of the February-May period, but only the late produced young survived. Thus, we have determined that managing the hydrodynamics of the Central Delta, e.g., by providing VAMP-like conditions throughout Action 3 will be beneficial to larval and juvenile delta smelt. During most year types, these OMR requirements will range between -2,000 to -3,500 cfs.

If sampling, salvage, or any applicable and available information suggests that delta smelt are at high risk in the Central or South Delta, then the OMR will need to be as low as a 14-day running average of -1,250 cfs. If for example, based on the sampling, minimal to no salvage at the export facilities, increase in temperature, decreases in turbidity or higher

San Joaquin River inflows suggest that delta smelt larvae are at lower risk in the South and Central Delta then flows may be held to no more negative than -3,500 cfs. As temperatures rise, trawl data continue to show no fish in the Central and South Delta, and salvage does not occur, OMR flows will be allowed to become as negative as -5,000 cfs. When temperature rises and turbidity drops to levels likely to be inimical to delta smelt (> 25^{o}C, turbidity <12 NTU), no further restrictions are needed as long as salvage remains at or close to zero.

The Influence-Exposure-Intensity-Response (IEIR) Analysis

On December 13, 2007, the Service requested the SWG to formulate a process to determine protective OMR flow recommendations for delta smelt larvae during the spring. The SWG agreed that a strict decision-tree approach was imprudent because it would be inflexible to real-time conditions. In such circumstances, where dynamic and interacting parameters determine delta smelt risk, static prescriptions tend to be imperfect moderators of such risk.

The process that has been developed is called “influence-exposure-intensity-response analysis” (IEIR Analysis). It involves four steps:

1) Particle tracking modeling of current and/or projected Delta conditions describes Banks and Jones’ relevant hydrological influence at different flow rates.

2) Risk exposure of smelt larvae is determined by comparing Banks and Jones’ relevant hydrological influence from the PTM results with current knowledge of smelt distribution using real-time data from surveys and salvage.

3) PTM runs are used to predict the probability of delta smelt entrainment at several OMR flow limits using “particle injection” points corresponding to 20mm survey sampling stations.

4) OMR flow recommendations are developed to reduce the projected entrainment risk to the extant delta smelt population, as estimated by the prior-year FMWT Index.

The levels of concern expressed through this analytical real-time adaptive approach have been classified into three categories: High Concern, Medium Concern and Less Concern. These correspond generally to the following realized values of key physical, operational, and biological parameters, and were applied in 2008 such as:

Factor	***State***
• Prior Year FMWT	<40 = High Concern; >300 = Less Concern
• Salvage	high numbers = high concern; low numbers = less concern
• Distribution	south = high concern; north/northwest = less concern
• X2 Location	>80 km = high concern; <75 km = less concern

- Temperature 	$12^{o}C$ to $25^{o}C$ = high concern; $>25^{o}C$ = less concern

These five factors were chosen based on the following:

1. Size of spawning population: A low FMWT index indicates low abundance of potential spawners which makes population growth rate more sensitive to loss of individuals.

2. Salvage: Salvage of delta smelt indicates that larvae and juveniles are located in the Central and South Delta and are vulnerable to entrainment. Future entrainment becomes more demographically significant as cumulative entrainment numbers increase.

3. Fish Distribution: The hydrodynamic influence of Banks and Jones increases when larvae are closer to the intakes. Thus, smelt located in the Central and South Delta are exposed to greater intensity of entrainment risk than those located in the North or West Delta.

4. X2 Location: Estimating the distribution of larval smelt and their exposure to pumping effects from existing survey data includes high inherent uncertainty, with increasing magnitude at low population abundances. However, the majority of smelt larvae and juveniles are often located just inland of X2, and so an easterly X2 would indicate that the smelt are at greater risk of entrainment at Banks and Jones

5. Water Temperature: Laboratory studies of delta smelt temperature tolerance has shown increased mortality at temperatures exceeding $25^{o}C$. An average south Delta water temperature of $25^{o}C$ corresponds in most years to a distribution of delta smelt juveniles towards Suisun Bay, and out of the zone of entrainment risk. Most delta smelt remaining in the San Joaquin River portion of the Delta are not expected to survive as water temperatures increase above $25^{o}C$, so their loss at salvage will not affect recruitment success.

The balance of conditions relative to level of concern within the IEIR analysis determines the foundation upon which a final flow recommendation may be based.

Application of IEIR Analysis: Further Guidelines for the Adaptive Process

In light of the experience in 2008, the IEIR is adjusted to make the following amendments.

As before, the SWG will evaluate data from the 20-mm survey and other parameters and make recommendations for specific timing of the more protective levels of OMR flows based upon real-time assessment of entrainment risk of larval smelt based upon their proximity to Banks and Jones, forecast operations, and particle tracking modeling run results based on a control-point method using a protectiveness criterion of 1 percent per 14-day time interval salvage threshold at Station 815.

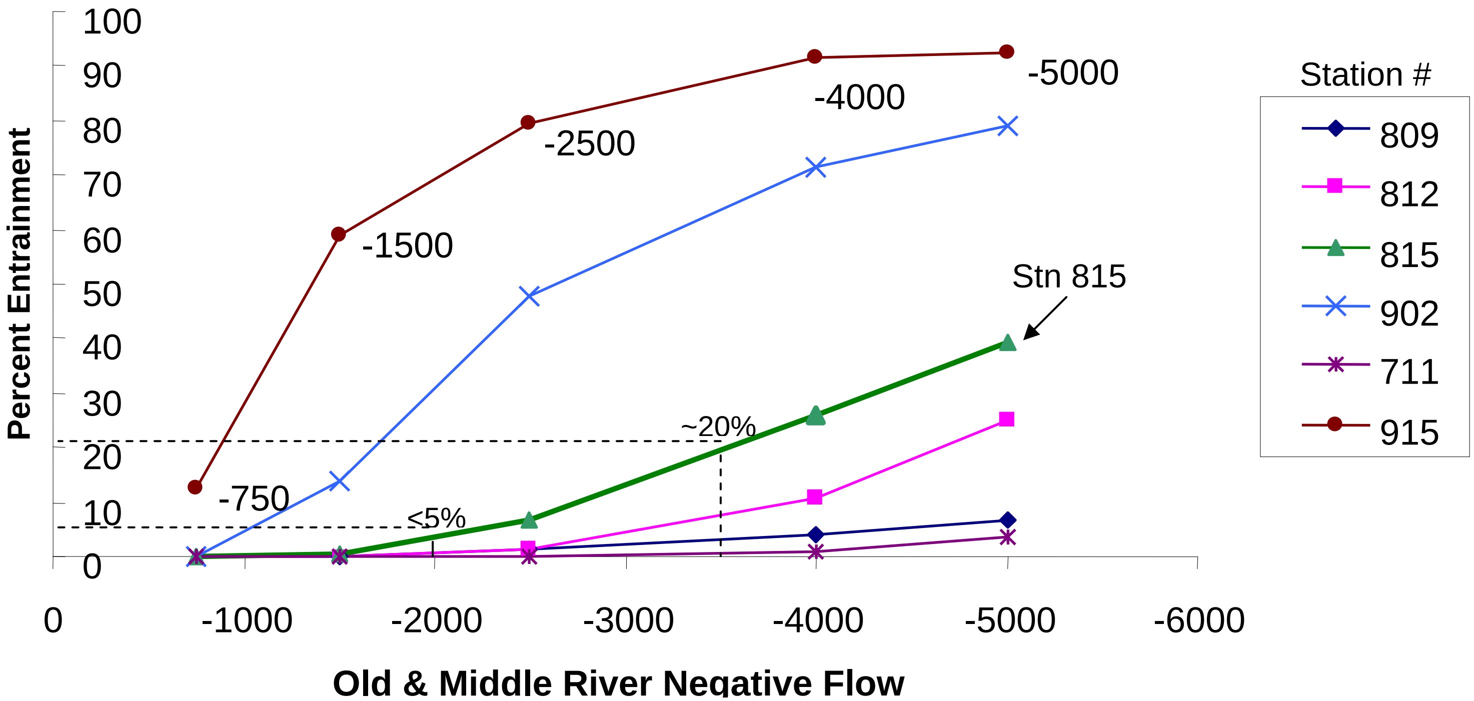
The SWG may recommend using the less stringent level of OMR restriction based on an average Recovery Index (RI) from the preceding two years exceeding 84 (the minimum for a recovery period in the Delta Native Fishes Recovery Plan, Service 1995); however, low San Joaquin River inflows, high cross-Delta flows or other conditions that degrade larval habitat in the Central Delta could preclude such relaxations. During periods of intermediate concern (recovery indices from the preceding year in excess of 239), a reduction to a shorter period of restriction to the -2000 cfs level in the larval period may be supported, if the SWG determines that a large part of the larval population would not be put at risk.

The most efficient protective measure for protecting the resilience and not precluding the recovery of the delta smelt population specific to the larval/juvenile lifestage is to prevent entrainment of fish in as large a portion of the Central Delta as is practical. Results of PTM modeling focusing on protections at station 815 (Prisoner's Point) indicates that precluding entrainment of larval/juvenile delta smelt at this station would also protect fish at station 812 (Fisherman's Cut) and other stations north and west (downstream) of station 815. While the target entrainment at station 815 would ideally also be zero, there appears to be little additional entrainment protection (less than 5 percent) at OMR flows at -750 cfs (the strictest level addressed by Interim Remedies). However, entrainment risk grows exponentially at OMR flows increasingly more negative than -2000 cfs.

Figure B-16 displays injection points for modeled particle tracking runs that were conducted in February 2008 with injection points at Stations 711, 809, 812, 815, 902, 915. This figure plots projected relationships for OMR flows by injection point, including entrainment probabilities for station 815 (over 30 days).

The results from these runs indicate an approximate <5 percent entrainment risk at OMR flow not more negative than -2000 cfs. At a requirement of -3,500 cfs OMR flow, entrainment risk at station 815 is roughly 20 percent over each 30 day interval. Assuming cumulative entrainment is additive, over a roughly four month (~120 days) interval in which Action 3 would be under effect, consistently operating at -3,500 OMR would yield a net entrainment probability placing at risk approximately 80 percent of the larval/juvenile subpopulation utilizing the South Delta at and below Station 815. If immigration of larval smelt from the Central or North Delta into the zone of entrainment during spring

Figure B-16: Pump Entrainment at Various Levels of Negative Flow at Old and Middle River Monitoring



were to occur, the population-level risk would be even greater. Such entrainment levels are potentially a significant adverse risk to delta smelt population.

Justification for Release from Prescriptions of Action 3

Calendar Date

The Interim Remedies specified the duration of Action 3 to extend to *around* June 20, or until the temperature metric below. Based upon salvage data observed during WY 2008 (see Figure B-17, above), this temporal window should be amended (extended) to June 30 in order to provide sufficient protections to late-spawned delta smelt larvae.

Temperature

When South Delta temperatures reach a daily average of 25^{o}C for three consecutive days at Clifton Court Forebay, it is expected that conditions are no longer suitable for smelt survival. This metric is a functionally adequate predictor that viable smelt will not be present within the entrainment zone of Banks and Jones.

ACTION 4: ESTUARINE HABITAT DURING FALL

Objective: Improve fall habitat for delta smelt by managing of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal. This will help return ecological conditions of the estuary to that which occurred in the late 1990s when smelt populations were much larger. Flows provided by this action are expected to provide direct and indirect benefits to delta smelt. Both the direct and indirect benefits to delta smelt are considered equally important to minimize adverse effects.

Action: Subject to adaptive management as described below, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall target. The action will be evaluated and may be modified or terminated as determined by the Service.

Timing:

September 1 to November 30.

Triggers:

Wet and above normal WY type classification from the 1995 Water Quality Control Plan that is used to implement D-1641.

Adaptive Management of Habitat Action:

To address uncertainties about the efficiency of the Action, it will be adaptively managed under the supervision of the Service. Adaptive management is a mode of operation that provides for learning and feedback to adjust an action undertaken in the face of uncertainty. To improve the efficiency of the Action and align its management more closely with the general plan articulated in Walters (1997) and endorsed by the independent peer review of this BO, the Service will supervise the implementation of a formal adaptive management process.

According to Walters (1997), an adaptive management plan should include a clearly stated conceptual model, predictions of outcomes, a study design to determine the results of actions, a formal process for assessment and action adjustment, and a program of periodic peer review. A conceptual model that is based on the best available scientific information underlying the present Action is described in the Effects section. Expected outcomes are described in general terms below, though there is a high degree of uncertainty about the quantitative relationship between the size of the Action described above and the expected increment in delta smelt recruitment or production.

The adaptive management plan will include the following new elements to ensure that performance measures and plans to evaluate the outcome of the Action are in place by the time it is implemented and that refinements to the Action can be developed as quickly as possible. These are listed in chronological order of implementation, but steps (2) through (6) are viewed as steps in an adaptive feedback loop that may cycle multiple times. The loop is closed when new information developed in (3) – (5) and/or Service decisions to alter the Action in (6) provide a basis for altering the conceptual model and/or study design in (2) or create a need to alter the performance measures in (3). The process will then continue from the re-entry step.

(1) Delta smelt habitat study group (HSG)

A panel of scientists will be convened by the Service to review and improve the habitat conceptual model, design performance measures for the Action, and prepare a study plan to improve scientific understanding of delta smelt habitat. Products produced by the HSG will be made publicly available by the Service.

(2) Conceptual model review and preparation of study design

In this instance, the conceptual model (summarized below and in the effects section) describes multiple mechanisms potentially contributing to the observed habitat/flow relationship that motivates the Action. Consequently, the study group will develop an improved conceptual model more clearly sorting out component mechanisms as an important goal. With the conceptual model in hand, two lines of investigation will be developed: one line will be designed to evaluate the performance of the specific Action described in Part A above, while the other will address the scientific uncertainties underlying the relationship between summer/fall habitat quality and delta smelt adult recruitment. The second line of investigation will provide new scientific information that is likely to aid in refinement of the Action in Part A.

(3) Performance evaluation of the Action

The study group will develop performance measures for the Action, and these measures will be subject to independent peer review. The study to evaluate the present Action will be implemented in accordance with its design prior to the first September following adoption of the biological opinion.

(4) Studies to elucidate the operative mechanism(s) controlling the relationship between delta smelt habitat features and quality and delta smelt production.

The HSG will develop a habitat investigation, and the plan will be subject to independent peer review. There are several potentially fruitful lines of investigation to pursue, including studies to elucidate the precise mechanisms by which habitat affects delta smelt and studies intended to develop management tools to improve habitat. The peer review panel provided several useful suggestions in its review of the proposed actions.

(5) Peer review

Studies conducted under the guidance of the study group will be subject to independent peer review both at the design stage (when possible) and after results are obtained. Conclusions regarding the efficiency of the Action and potential alternatives will also be independently peer reviewed prior to receipt for official consideration by the Service.

(6) Service review and Action adjustment

The Service will direct all stages of the adaptive management plan, and will adjust the Action if/when circumstances and improved scientific understanding warrant. The HSG will provide technical assistance in the interpretation of results, but the Service will have ultimate responsibility for drawing conclusions regarding the advisability of any changes to the Action.

The Service will conduct a comprehensive review of the outcomes of the Action and the effectiveness of the adaptive management program ten years from the adoption of the BO, or sooner if circumstances warrant. This review will entail an independent peer review of the full history of the Action. The purposes of the review will be (1) to evaluate the overall benefits of the Action and (2) to evaluate the effectiveness of the adaptive management program.

The adaptive management program will have specific implementation deadlines. The creation of the HSG, initial habitat conceptual model review, and formulation of performance measures, implementation of performance evaluation, and peer review of the performance measures and evaluation that are described in steps (1) through (3) will be completed before the first September following adoption of the BO. This will ensure that measures required to evaluate the effectiveness of the action are in place during the first autumn after adoption. Additional studies addressing elements of the habitat conceptual model will be formulated as soon as possible, promptly implemented, and reported as soon as complete. As described above, there will also be a ten year review of the Action and its consequences.

Background

Delta outflows of as much as 20,000 cfs formerly occurred in fall months of all but drought WYs. Currently, however, fall outflows are similar to historic droughts regardless of WY type. Fall Delta outflows in wet and above normal WYs (i.e., from 1993-98) average 8,000-10,000 cfs; whereas after 1998, monthly averages have been 5,600 cfs across all WY types and monthly outflow variation has been very small. High among-month variability in Delta outflows may be important for restoring estuarine habitat conditions favoring many native species (Lund et. al. 2007).

Habitat parameters for delta smelt have been well described for both the summer and fall seasons as combinations of salinity, temperature, and turbidity. In winter and spring, temperature seems to be a dominant driver of habitat suitability both for adult spawning and for larval occurrence (Bennett 2005). Summer habitat is controlled largely by changes in turbidity due to changes in sediment supply and in the distribution of the sediment-trapping aquatic weed, *Egeria densa*. (Nobriga et al. 2008) Fall habitat (and smelt) shifts in abundance and distribution largely due to fluctuations in salinity (Feyrer et al. 2007). X2, which reflects salinity distribution in the estuary (Jassby et al. 1995), fluctuates mostly in response to fluctuations in outflow, although atmospheric conditions and barrier operations can also affect it.

X2 is strongly influenced by tidal cycles, moving twice daily up and downstream 6-10 km from its average daily location. For example, when the average daily X2 is near Sherman Island, delta smelt habitat can range from Chipps Island to Franks Tract. When the daily average X2 is centered on Browns Island, delta smelt habitat can range from Honker Bay to Big Break. The daily fluctuation in X2 around an upstream point such as Brown's Island confines the population to narrow channels, where delta smelt may be exposed to more stressors (e.g., agricultural diversions, predation) relative to a downstream X2. Adverse effects on adult delta smelt during fall may be a part of the reason that Feyrer et al. (2007) found a statistical association between fall X2 and the production of young delta smelt during the following year.

Other factors can degrade the quality of smelt habitat, principally water quality degradation. In September 2007 all collected delta smelt were found at salinities much higher than ever before. This observation was coincident with a period when their usual salinity range was heavily infested with the cyanobacterium *Microcystis aeruginosa*. *Microcystis* produces toxins in its normal life, but the concentrations of these toxins in water sharply increase when the population dies, usually in September and October (Lehman pers. comm.). In September 2008, delta smelt were in their normal salinity range and *Microcystis* were less abundant than in September 2007 (pers. comm. Randy Baxter DFG and Peggy Lehman DWR). Low flow conditions are among the factors associated with *Microcystis* blooms (Lehman et al. 2008).

Protection and restoration of habitat is an essential element in any conservation strategy where habitat has been lost or degraded. However, identifying the exact role habitat quality and volume play in the growth and survival of a species comes with some uncertainty. In the case of fall delta smelt, habitat area is a significant covariate in its stock-recruit relationship, indicating evidence of an effect on the population. Westward and variable locations of fall habitat provide increased habitat area and moves the delta smelt population away from the risks of possible future entrainment in the Delta, and distributes it more broadly throughout the estuary.

This action is designed to increase baseline monthly outflows in the fall period of wet and above normal WYs to increase areas of habitat and move the habitat away from Delta impacts and into broader open waters west of Sherman Island; and to increase variability of monthly habitat extent by having 2-3 months above the baseline. This would be expected to distribute smelt into more diverse geographic areas, helping to reduce the risk of localized losses from future entrainment, contaminants, and predation. Finally, it may reduce the proliferation of other factors that reduce habitat suitability such as *Microcystis* and *Egeria* growth.

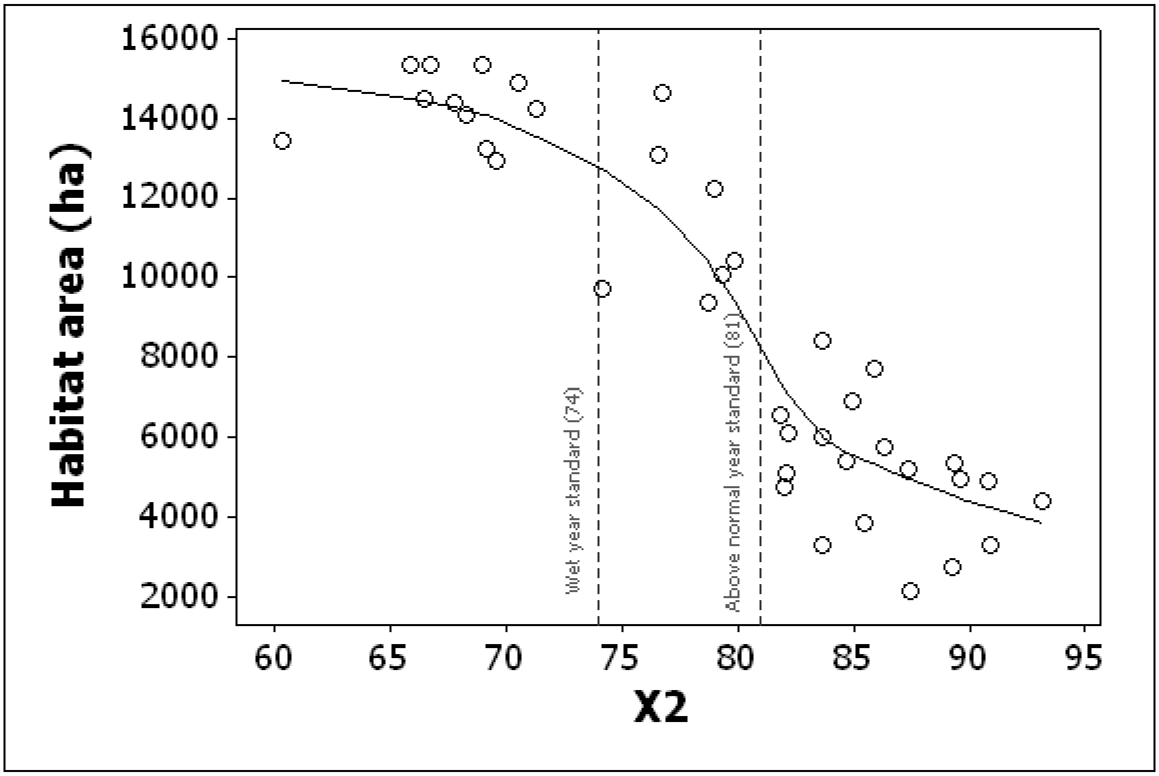
Justification:

The Effects section clearly indicates that there will be significant adverse impacts on X2, which is a surrogate indicator of habitat suitability and availability for delta smelt in all years (Figures E-19 and E-25 in Effects section). Moreover, the results of Feyrer et al. (2007) suggest that adverse effects on adult delta smelt during fall may be part of the reason that there is a statistical association between fall X2 and the production of young delta smelt during the following year. The action is focused on wet and above normal years because these are the years in which project operations have most significantly adversely affected fall (Figure E-27 in Effects section) and therefore, actions in these years are more likely to benefit delta smelt.

The action is designed to be governed by hydrologic conditions and therefore will be ecologically-based. For the purposes of implementation of this action, water year type is defined as the water year that ends in the September of the calendar year in which the action will be implemented. The standards of 74km in wet years and 81km in above normal years are designed to mitigate the effects of X2 encroachment upstream in current and proposed action operations, and provide suitable habitat area for delta smelt (Figure B-17).

The long-term trend in which all falls have Delta outflows indicative of dry or critical years matches long-term upward trends in the E:I ratio and X2 (Figure E-28 in effects

Figure B-17. Relationship between X2 and habitat area for delta smelt during fall, with standard shown for wet and above normal years.



section). The overall effect is readily observed as a substantial divergence in the difference between fall X2 and X2 the preceding spring (April-July). Given that these conditions will persist under the proposed CVP/SWP operations, the modeling also shows they may be exacerbated under various climate change scenarios (Figure E-28 in effects section).

The persistence of this significant hydrologic change to the estuary threatens the recovery and persistence of delta smelt. Outflow during fall determines the location of X2, which determines the amount of suitable abiotic habitat available to delta smelt (Feyrer et al. 2007, 2008). The long-term upstream shift in X2 during fall has caused a long-term decrease in habitat area availability for delta smelt (Feyrer et al. 2007, 2008), and the condition will persist and possibly worsen in the future. This alone is a significant adverse effect on delta smelt.

However, the problem is further complicated because there are several lines of published peer reviewed scientific research that link habitat alteration to the decline of delta smelt (Bennett 2005; Feyrer et al. 2007; Nobriga et al. 2008). An important point regarding this action is that because of the current, extremely low abundance of delta smelt, it is unlikely that habitat space is currently a limiting factor. However, it is clear that delta smelt have become increasingly habitat limited over time and that this has contributed to the population attaining record-low abundance levels (Bennett 2005; Baxter et al. 2008;

Feyrer et al. 2007, 2008; Nobriga et al. 2008). Further, as detailed in the Effects section, persistent degraded or worsened habitat conditions are likely to contribute to depensatory density-dependent effects on the delta smelt population while it is at historical low levels, and would at some point in the proposed term of this project, limit delta smelt recovery.

Therefore, the continued loss and constriction of habitat into areas of low habitat quality under the proposed action significantly threatens the ability of the delta smelt population to recover and persist in the estuary at self-sustaining levels higher than the current record-lows. While it is not yet proven why habitat quality under this constant dry-year fall X2 scenario has been degraded for rearing delta smelt, the coincidence of this pattern with sustained and significant population level losses for this lifestage (as measured in survival rates and smelt physiological condition), along with the increasing body of support ascribing the aforementioned hypothesized mechanisms of action to habitat degradation and smelt condition, and finally the current critically low level of the current population, make the implementation of a fall action essential to the maintenance of the population resilience for delta smelt. In short, the historically high variability in summer/fall survival rates does not negate the need for protection from direct mortality losses due to adult and larval/juvenile entrainment, it actually highlights the need for restoring flow variability to the Delta environment so that smelt populations can recover through allowing these essential periods of population rebound.

Monitoring Component to Assess Performance of Action 4

The Service will require that Action 4 be implemented with an adaptive management program to provide for learning and improvement of the action over time. The adaptive management program will include commissioning studies to clarify the mechanisms underlying the effects of fall habitat on the delta smelt population and should, at the least, focus on the following general study questions:

i. What is the effect of habitat area and distribution on delta smelt distribution?

ii. How does fish condition/health vary across a gradient of habitat quality?

iii. Does fish condition/health in fall affect over-winter survival?

iv. Does fish condition/health affect fecundity and egg viability?

v. Does spatio-temporal salinity variation resulting from this fall action affect *Microcystis*?

vi. Does spatio-temporal salinity variation resulting from this fall action affect *Corbula* and the benthic invertebrate community?

Given the low numbers of delta smelt currently in the estuary, a suite of surrogate species is probably required to address questions ii-iv, although question iv could be examined directly with experiments on fish from the Tracy Fish Culture Facility. It is recommended that studies designed address these research questions be coordinated and implemented through the IEP and POD Management Teams. The research and monitoring plan will include reporting criteria, data sharing and dissemination requirements, oversight and contractual compliance elements for purposes of quality assurance and ensure the transparency and timely completion of necessary monitoring, research and assessment.

ACTION 5: TEMPORARY SPRING HEAD OF OLD RIVER BARRIER (HORB) AND THE TEMPORARY BARRIER PROJECT (TBP)

Objective: To minimize entrainment of larval and juvenile delta smelt at Banks and Jones or from being transported into the South and Central Delta, where they could later become entrained.

Action: Do not install the HORB if delta smelt entrainment is a concern. If installation of the HORB is not allowed, the agricultural barriers would be installed as described in the Project Description. If installation of the HORB is allowed, the TBP flap gates would be tied in the open position until May 15.

Timing: The timing of the action would vary depending on the conditions. The normal installation of the spring temporary HORB and the TBP is in April.

Triggers: For delta smelt, installation of the HORB will only occur when PTM results show that entrainment levels of delta smelt will not increase beyond 1 percent at Station 815 as a result of installing the HORB.

Offramps: If Action 3 ends or May 15, whichever comes first.

Justification for Action 5

The TBP change the hydraulics of the Delta, which can affect delta smelt. The HORB blocks San Joaquin River flow from entering Old River. This increases the flow toward Banks and Jones from Turner and Columbia cuts, which can increase the predicted entrainment risk of particles in the East and Central Delta by up to about 10 percent (Kimmerer and Nobriga 2008). In most instances, net flow is directed towards Banks and Jones and local agricultural diversions. Computer simulations have shown that placement of the barriers changes South Delta hydrodynamics, increasing Central Delta flows toward the export facilities (DWR 2000). In years with substantial numbers of adult delta smelt in the Central Delta, increases in negative OMR flow caused by installation of the TBP can increase entrainment. The directional flow towards Banks and Jones increases the vulnerability of fish to entrainment. Larval and juvenile delta smelt are especially susceptible to these flows.

The varying operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables limit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. In 1996, the installation of the HORB caused a sharp reversal of net flow in the South Delta to the upstream direction. Coincident with this change was a strong peak in delta smelt salvage (Nobriga et al. 2000). This observation indicates that short-term salvage can significantly increase when the HORB is installed in such a manner that it causes a sharp change or reversal of positive net daily flow in the South and Central Delta.

Many of these potential effects to delta smelt would be reduced by the OMR flows provided in Action 3. In order to determine if there will be adverse effects to delta smelt from the installation of the HORB, PTM will be completed during Action 3. The Service may use the control point method of maintaining an entrainment level at Banks and Jones below 1 percent at Station 815. If the PTM results show that entrainment would be higher than 1 percent during the period when the HORB would be installed, and would result in increased risk to juvenile delta smelt, then it would not be installed.

Additionally, the OMR flows provided in Action 3 or high San Joaquin River flows may provide beneficial conditions in the Delta for out-migrating salmonids and sturgeon, which would preclude the need for the HORB installation. This analysis, combined with the PTM results will provide data to help determine if listed fish would be adversely affected by the HORB. If the spring temporary HORB is not installed, the TBP would be operated as described in the Project Description.

Justification for Release from Prescriptions of Action 5

If Action 3 has ended, the entrainment concern has likely abated, and delta smelt larvae and juveniles are not likely to be present in the Central and South Delta. High flows on the San Joaquin River may also preclude the spring temporary HORB from being installed since it is not physically possible during these flows to install the HORB. The concerns for entrainment are reduced during high San Joaquin River flows.

ACTION 6: HABITAT RESTORATION

Objective: To improve habitat conditions for delta smelt by enhancing food production and availability.

Action: A program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh shall be implemented. A monitoring program shall be developed to focus on the effectiveness of the restoration program.

Timing: The restoration efforts shall begin within 12 months of signature of this biological opinion and be completed within a 10 year period.

Background

The historic Delta was a tidal wetland-floodplain system including about 350,000 acres of tidal wetland. Almost all of the historic wetlands in the Delta have been lost due to conversion to agriculture and urban development. The Delta currently supports less than 10,000 acres of tidal wetland, all of which is small and fragmented. This conversion of the Delta's wetlands beginning in the mid-nineteenth century has resulted in a landscape dominated by agricultural lands intersected by deep and comparatively uniform tidal channels.

Delta smelt feed mainly on zooplankton throughout their life cycle (Nobriga and Herbold 2008) with the copepod Pseudodiaptomus forbesi being the dominant prey item for juvenile delta smelt in the summer (Lott 1998; Nobriga 2002; Hobbs et al. 2006). Diatoms form the base of the pelagic foodweb and primary consumers (e.g. copepods) appear to be food-limited in the Delta and Suisun (Muller-Solger et al. 2002; Sobczak et al. 2002). Pelagic productivity in the Delta and Suisun Bay has been declining for several decades with a steep decline following the introduction of the overbite clam in 1986 (Kimmerer and Orsi 1996). Histopathological evaluations have provided evidence that delta smelt have been food-limited during the summer months (Bennett 2005). This finding has been corroborated by recent work on juvenile delta smelt as part of ongoing studies on the POD. Moreover, recent studies suggest a statistical association between delta smelt survival and the biomass of copepods in the estuary (Kimmerer 2008).

Overall research in other estuaries has indicated that tidal wetlands are highly productive. Although definitive studies have not been done on the type and amount of productivity in freshwater tidal wetlands of the Delta, brackish tidal wetlands of Suisun Marsh are one of the most productive habitats in northern San Francisco Bay-Delta estuary (Sobczak et al. 2002). It is likely that restored freshwater tidal wetlands in the Delta would have higher productivity than the brackish wetlands of Suisun (Odum 1988). A large portion of the production in Suisun Marsh consists of high quality phytoplankton-derived carbon (Sobczak et al. 2002) that is an important food source for zooplankton and therefore can contribute to the base of the pelagic foodweb. Modeling suggests that the tidal wetlands of Suisun currently provide about 6 percent of the organic carbon to the pelagic habitats of Suisun Bay (Jassby et al. 1993). In addition, sampling in Liberty Island shows that these freshwater tidal habitats can be a source of high-quality phytoplankton that contribute to the pelagic food web downstream (Lehman et al. 2008). Thus, restoration of large amounts of intertidal habitat in the Delta and Suisun could enhance the ecosystem's pelagic productivity.

Justification:

Since it was introduced into the estuary in 1988, the zooplankton Pseudodiaptomus forbesi has been the dominant summertime prey for delta smelt (Lott 1998; Nobriga 2002; Hobbs et al. 2006). There is evidence suggesting that the co-occurrence of delta smelt and Pseudodiaptomus forbesi has a strong influence on the survival of young delta smelt from summer to fall (Miller 2007). The Effects Section indicates that

Pseudodiaptomus distribution may be vulnerable to effects of export facilities operations and therefore, the projects have a likely effect on the food supply available to delta smelt.

The near complete loss of tidal wetlands from the Delta threatens the persistence of delta smelt by reducing productivity at the base of the pelagic foodweb. Primary production in tidal wetlands of the Northern San Francisco estuary has been shown to support high zooplankton growth (Muller-Solger et al. 2002). This action should therefore enhance the foodweb on which delta smelt depend. This action is designed to increase high quality primary and secondary production in the Delta and Suisun Marsh through an increase in tidal wetlands. Exchange of water between the tidal wetlands and surrounding channels should distribute primary and secondary production from the wetlands to adjacent pelagic habitats where delta smelt occur. This exchange should be optimized through intertidal habitat restoration designed to incorporate extensive tidal channels supported an appropriately sized vegetated marsh plain which will provide the necessary tidal prism to maintain large tidal exchange.

New evidence indicates how tidal marsh may benefit delta smelt even if they do not occur extensively within the marsh itself. Specifically, monitoring suggests this species is taking advantage of recently-created tidal marsh and open water habitat in Liberty Island. The fact that delta smelt make heavy use of habitat in the Cache Slough complex has been evident in sampling by the DFG's Spring Kodiak trawl and 20 mm surveys (www.delta.dfg.ca.gov). The Spring Kodiak trawls show that delta smelt are present in channels of the Cache Slough complex during winter and spring; the collection of larval delta smelt in subsequent 20-mm surveys indicates that these adult delta smelt eventually spawn in the vicinity. In addition, the use of Cache Slough complex by delta smelt includes habitat on Liberty Island. The island flooded in 1998 and has evolved rapidly into a system of open-water and tidal marsh habitat. Recent sampling of Liberty Island by USFWS biologists (http://www.delta.dfg.ca.gov/jfmp/libertyisland.asp) revealed that delta smelt both spawn and rear in Liberty Island. Light traps collected relatively high numbers of larval delta smelt in several locations of Liberty Island during the 2003 spawning period for this species. Moreover, subsequent beach seine sampling showed that older delta smelt were present at all ten of their sampling stations during 2002-2004 and in all seasons of the year (USFWS, unpublished data). These results are particularly striking because they were from a period when delta smelt was at record low abundance. Collection of delta smelt from shallow inshore areas using seines indicates that the fish do not occupy deeper pelagic habitat exclusively. These results seem reasonable in light of the area's consistently high turbidity (Nobriga et al. 2005; DWR, unpublished data) and zooplankton abundance (e.g. Sommer et al. 2004), both of which are important habitat characteristics for delta smelt (Bennett 2005; Feyrer et al. 2007). In any case, these data suggest that freshwater tidal wetlands can be an important habitat type to delta smelt with proper design and location.

A monitoring program shall be developed to focus on the effectiveness of the restoration program. This program shall be reviewed and modified as new information becomes available.

Attachment C: Methods Used in Developing the Incidental Take Statement

Methods Used in Developing the Incidental Take Statement

The objective adopted by the Service to minimize take of adult delta smelt through entrainment is two-fold. First, adult entrainment shall be minimized during all year types through the RPA. More critically, demographic losses from periodic episodes of high entrainment will be eliminated through implementation of the RPA. These outcomes shall be accomplished through the application of measures as defined in RPA Components 1 and 2.

Adoption of the RPA included in this biological opinion is expected to appreciably reduce the number of delta smelt salvaged during certain years. Implementation of the RPA should avoid significant mortality during those years of high entrainment. The Service believes these high salvage year events (such as in WY 2003 for adult delta smelt) resulted in mortality at levels that were demographically significant to the delta smelt population. Further, at low abundances observed in the last few years, high entrainment events (observed more frequently, for adult delta smelt in 2003, 2004, and 2005, successively) further reduces the resilience of the current delta smelt population.

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

This approach was adopted because it reflects the most reasonable strategy to allow continued CVP/SWP operations while providing necessary protection to the delta smelt population under real-time conditions. It accounts for uncertainty of adult smelt entrainment risk resulting from variable environmental, demographic, and operational conditions; and adapts operations in response to real-time data.

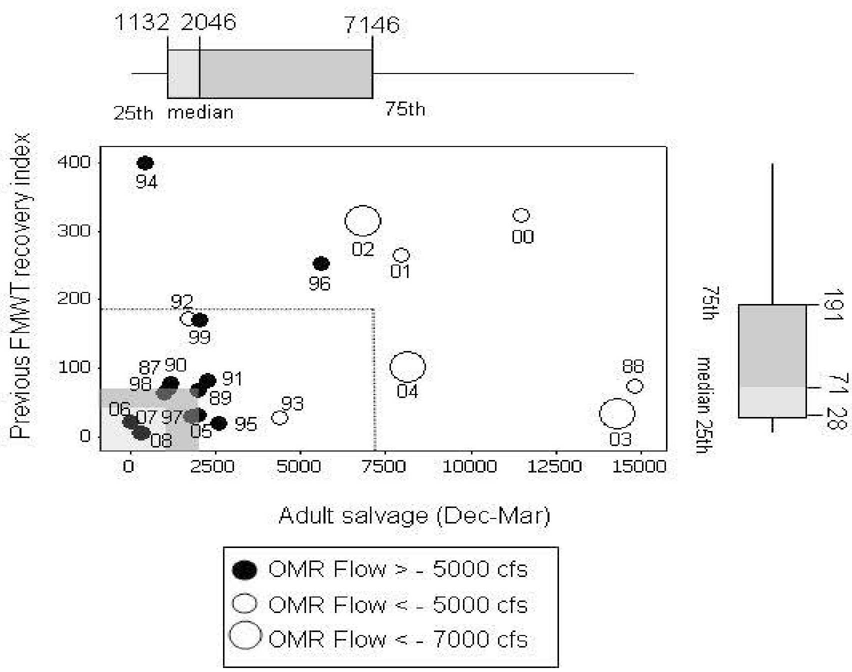
The specific level of take of adult delta smelt at the CVP/SWP pumping facilities is difficult to definitively project, due to inherent uncertainties. First, the only data available from which to derive population estimates come from monitoring that is not specifically designed to assess the abundance of delta smelt. Distribution of adult smelt is highly variable between years, and is driven by factors that are both inherently difficult to predict and also not completely understood. These factors are, at best, imperfectly controlled. Additionally, salvage data (our most definitive measurement endpoint) reflects only a portion of the total mortality associated with entrainment. Losses to predation and inefficient screening are significant, but unknown. Finally, salvage itself is clearly at least partially a function of abundance. In other words, the more delta smelt there are out there, the higher the salvage numbers will be, given the same operational conditions and delta smelt distribution. In short, entrainment and the population-level effect from direct mortality attributed to pumping is a multivariate and complex process, and this complexity defies ready predictive modeling.

The Service in past take statements has relied upon historic salvage as the most reasonable predictor of future salvage. Adult delta smelt salvage data (grouped by sorting entrainment years into quartiles by the total number salvaged between December and March) can be plotted by year and related to delta smelt population abundance and flows as shown in Figure C-1. The historic (1987-2007) median salvage levels with 25th and 75th percentiles are plotted versus the preceding FMWT Recovery Index (RI). The RI provides an indication of the status of the delta smelt population based on distributional and abundance criteria from a subset of September and October FWMT sampling data (Service 1995). A low RI indicates the delta smelt population is at a low level, whereas a high RI value (~400) indicates a larger population. Figure 1 uses 1987 to 2007 as the historic baseline dataset for this analysis because these years represent the period after which delta smelt experienced coincident declines in abundance and habitat quality (Feyrer et al. 2007), and because these are years for which salvage data are considered most reliable.

One benchmark for determining the severity of salvage is the 25th percentile (first quartile) of recent historic winter salvage of delta smelt at the CVP/SWP export facilities. For reference, the first quartile historic salvage count for 1987 through 2007 is 1,132 adult delta smelt, while the median value during this same interval is 2,046 individuals. Salvage above these levels is likely to lead to large losses of spawning delta smelt relative to the mean population size. For example, in 2003 and 2004, the projects salvaged 14,323 and 8,148 adult delta smelt respectively. These losses are disproportionately high (i.e., greater than the 75th percentile of historical salvage) for their given RI values, 33 (2003) and 101 (2004), respectively. According to Kimmerer (2008), 2003 and 2004 were years when entrainment accounted for 50 percent and 19 percent losses, respectively, of adults from the population. These are very high loss rates even by commercial fishery standards and for delta smelt, with such low population numbers, it is an even greater concern.

As presented in Figure C-1, using a rough estimate of expected future flows based on implementation of the RPA (i.e., >-5,000 cfs OMR) and when abundance indices are low (based on RI), adult salvage levels during WY's 2006, 2007, and 2008 best approximates adult salvage numbers expected in the future.

Figure C-1. Adult delta smelt salvage levels in relation to OMR flows and the FMWT RI for the period 1987-2007.



To estimate take with implementation of the RPA, the Service scaled projected salvage to abundance using the estimates provided by the prior year's FMWT Index (note that this differs somewhat from Figure C-1, which used the RI, reflecting a subset of FMWT Index data). The segregation of year types is based upon descriptive statistics comprising quartiles, as expressed above in Figure C-1, and quantified following the approach described below.

A *Cumulative Salvage Index*

The Cumulative Salvage Index (CSI) is calculated as the total year's adult salvage (the aggregate number for expanded salvage at both the Banks and Jones export facilities for the period December through March) divided by the previous year's FMWT Index. Taking all water year types together (regardless of abundance or OMR flows in a given year), the median CSI value for the period 1993 to 2008 is 12.0. The first and third quartile CSI values for this period are 6 and 26, respectively. These data are summarized below in Table C-1.

Incidental Take for Adult Entrainment (Salvage)

Water years 2006 to 2008 were years in which salvage, negative OMR flows, and delta smelt abundance were all relatively lower relative to the historic values. These are the only three years of lower negative OMR flows which coincided with salvage values below the first quartile within the historic range and low overall adult delta smelt abundances (below first quartile FMWT Index). The corresponding CSI values are: 8.3 (2006), 0.88 (2007), and 12.6 (2008). The Service therefore believes these years within the historic dataset best approximate expected salvage under the RPA Component 1.

The mean value for adult salvage during WYs 2006 to 2008 is 247 adult delta smelt. The average CSI value for WYs 2006 to 2008 was 7.25. Projecting this average rate of salvage to the years in which CVP/SWP operations will be conducted within the sideboards established by the RPA would yield estimates of salvage at 7.25 times the prior year's FMWT Index. The Service use this estimator to predict incidental take levels of adult delta smelt during each year that the RPA's will be in effect. This value, which can be calculated upon release of the final FMWT Index within the current water year, is regarded as the incidental take for adult delta smelt under the RPA.

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

As indicated in Table C-1, for the entire span of WY's since 1993, this numerical salvage threshold would have been exceeded in WY's 1993, 1995, and 2003-2005.

Table C-1: Adult Salvage Summary Statistics 1993-2008

Year	FMWT Index	Adult Salvage	Cumulative Salvage Index	Take Threshold
1993	156	4425	28.4	X
1994	1078	359	0.33	
1995	102	2608	25.6	X
1996	899	5628	6.3	
1997	127	1828	14.4	
1998	303	1027	3.4	
1999	420	2074	4.9	
2000	864	11505	13.3	
2001	756	8015	10.6	
2002	603	6865	11.4	
2003	139	14338	103	X
2004	210	8058	38.4	X
2005	74	2018	27.3	X
2006	26	216	8.3	
2007	41	36	0.88	
2008	28	352	12.6	
min	26	36	0.33	
max	1078	14338	103	
mean	364	4335	19.3	
25th	95.0	860.0	5.9	
median	183	2341	12.0	
75th	641.3	7152.5	26.0	

High Concern Level for Adult Entrainment (Salvage)

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

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

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

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

The rationale for a value approaching 75 percent (as opposed to 50 percent, for example), is that the window for adult entrainment, once begun, is generally short (~1 month), and it is not expected that aggressive pumping restrictions would continue for long durations once salvage is occurring and data are available. The SWG will take timing into account during interpretation of salvage within a given season, and recommend OMR restrictions to the Service accordingly.

For reference purposes, the population level losses reported in Kimmerer (2008) appear in Table 2 compared to our CSI metric. Caution is necessary when comparing field data to take estimates from population models due to; (1) their high inherent predictive uncertainty based on broad underlying assumptions and limited monitoring methodology, (2) the crude discriminative capacity of the inherent methodology utilized within the CSI-derived risk thresholds, and (3) the paucity of available data. However, regressing the Kimmerer (2008) estimates against the CSI approach in order to make this comparison ($y = 0.4539x + 1.8905$; $r^2 = 0.9105$) yields an expected take under implementation of the RPA defined herein approximating delta smelt population level losses during the adult lifestage to around 5 percent. The concern level would roughly approximate salvage of 4 percent of the adult pre-spawning population.

Table C-2. Cumulative Salvage Index in comparison to adult take estimates in Kimmerer (2008).

Year	Estimate	Lower 95% Confidence Boundary	Upper 95% Confidence Boundary	FMWT Recovery Index	Total Salvage	CSI
2002	15	5	24	603	6865	11.4
2003	50	19	69	139	14338	103
2004	19	6	31	210	8058	38.4
2005	7	2	12	74	2018	27.3
2006	4	1	6	26	216	8.3

Table C-3 lists threshold levels of high concern and incidental take for a range of potential FMWT indices. This table is intended to be used as a reference to discern levels of salvage reflecting the range of expected adult delta smelt mortality with implementation of the RPA, and an indicator of adult delta smelt salvage levels that constitutes an increasing and adverse effect to the delta smelt population due to CVP/SWP operations.

Table C-3: Incidental Take Expanded Salvage Numbers by FMWT Index Lookup Table

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

Take of Larval and Juvenile Delta Smelt

In contrast to adult delta smelt, there is no well established index of larval and juvenile abundance to reliably scale the take of this lifestage to abundance. Indices of abundance are constructed from fishery surveys performed by DFG (Figure C-2). The DFG has monitored the distribution and relative abundance of larval and post-larval delta smelt throughout their spring range since 1995. This survey is named the 20-mm survey for the size at which delta smelt are retained and readily identified by the fish salvage facilities, and provides near-real time information on larval abundance and distribution for individuals that have reached this size class. There is no established way to measure and document take of larval smelt below this size. Protection of this age class is afforded through the RPA, when setting OMR restrictions, but there is no reliable means to assess performance until later in the season when >20mm larvae are present. This should be kept in mind in light of salvage numbers, pre-emptive OMR prescriptions based on salvage predictions, and the take statement for the earlier part of the spring season (i.e., April).

Historically, as with adults, larval and juvenile delta smelt salvage has varied widely, as a function of overall abundance, distribution and Delta hydrology (Figures C-3 and C-4). This variability makes prediction of salvage of larvae and juvenile delta smelt difficult. In order for a survey to have significant predictive value, it must precede the period of entrainment with as few confounding variables (intervening factors) between the estimate and the event as possible. Larval and juvenile take cannot be scaled to either the 20-mm Survey Index or the TNS Index because both surveys overlap the period during which the salvage occurs. Further, as migration, spawning distribution and success, adult delta smelt entrainment and mortality (due to quantifiable and unquantified variables) occur between the FMWT (the parental generation) and salvage of their progeny (the following April through July); it is difficult to infer actual larval abundance reliably through the next spring. This dilutes the statistical reliability of the calculation of a larval/juvenile salvage index, corresponding to the CSI for adult delta smelt. However, review of the salvage data relative to actual OMR values within a given year does reveal that a relationship of fall parental abundance to salvage of progeny exists—enough so such that predictability does increase through scaling to current water year FMWT.

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

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

The mean values from 2005-2008 were used as an initial estimate of take under the RPA. The reason for selecting this span of years is that the apparent abundance of delta smelt since 2005 as indexed by the 20-mm Survey and the TNS is the lowest on record (Table

C-4). It was necessary to separate out this abundance variable, but also to account for other poorly understood factors relating salvage to OMR, distribution, and the extant conditions. In other words, the most recent conditions are our best available reflection of predicted salvage under the RPA. On a monthly basis (cumulative salvage across the spring), this estimate represents a concern level where entrainment has reached high enough numbers to indicate the need for more protective OMR restrictions. The average JSI for the last four spring seasons by month (April through July), equals: 0.29, 13.03, 33.02, and 37.47, respectively.

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

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

Larval/Juvenile Incidental Take = 1.5 * Concern Level

Lookup tables relating (current WY) FMWT to concern level and incidental take for cumulative salvage by month appears in Table C-5 through C-8, below.

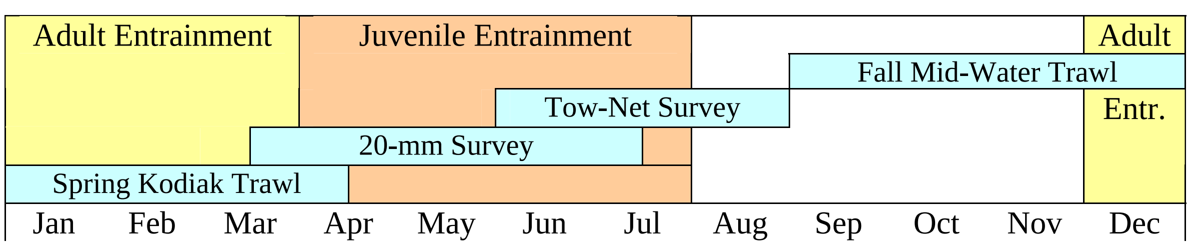


Figure C-2. Fishery surveys conducted by the California Department of Fish and Game that routinely collect delta smelt, and may be used to infer relative abundance.

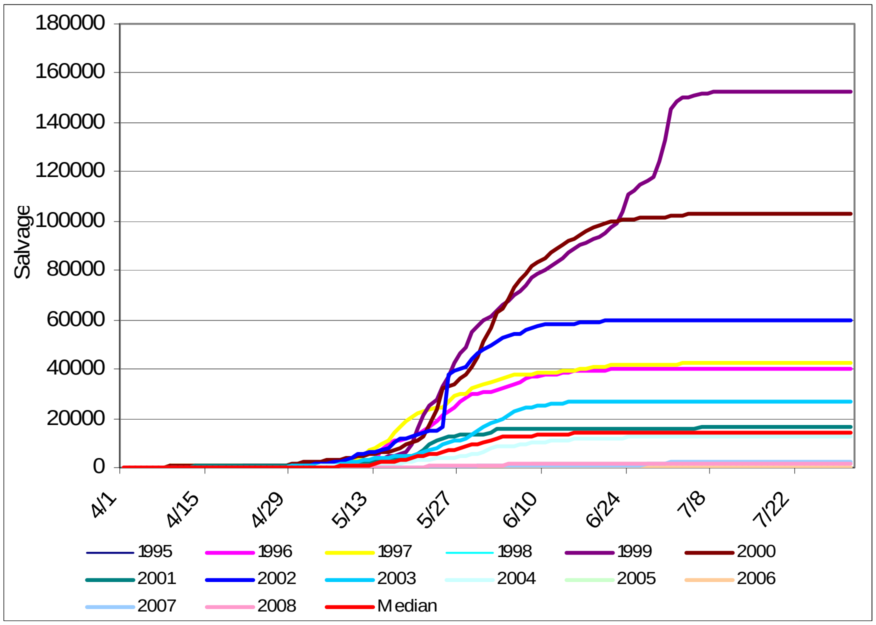


Figure C-3. Cumulative salvage of larval and juvenile delta smelt, 1995 through 2008.

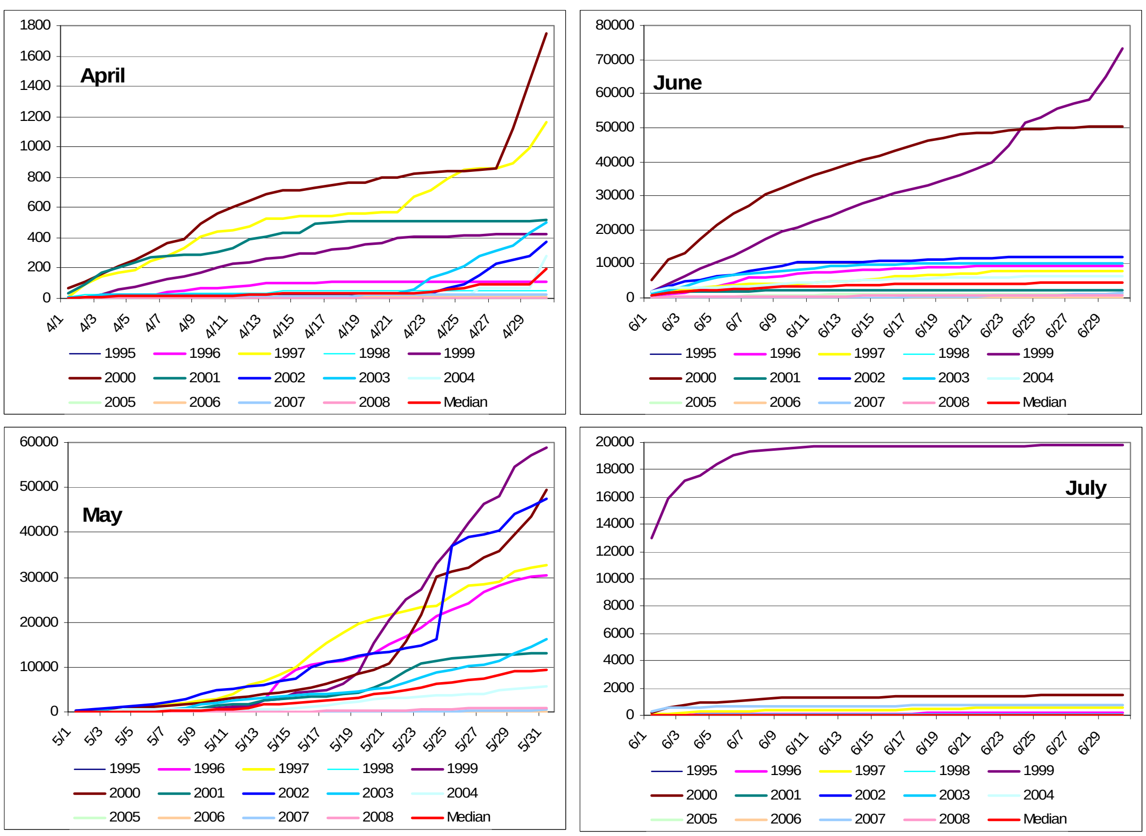


Figure C-4. Cumulative salvage of larval and juvenile delta smelt, 1995-2008, by month.

Table C-4. Larval/juvenile ≥ 20 mm delta smelt abundance and salvage statistics.

Water Year	Prior Year FMWT Index	20-mm Index	STNS	Salvage	Juvenile Salvage Index
1995	102	4.4	3.2	24	0.2
1996	899	33.9	11.1	40099	44.6
1997	127	19.3	4.0	42091	331.4
1998	303	7.7	3.3	242	0.8
1999	420	39.7	11.9	152526	363.2
2000	864	23.8	8.0	101783	117.8
2001	756	11.3	3.5	15984	21.1
2002	603	8	4.7	59652	98.9
2003	139	13.1	1.6	26220	188.6
2004	210	8.2	2.9	12441	59.2
2005	74	15.4	0.3	1734	23.4
2006	27	9.9	0.4	12	0.4
2007	41	1	0.4	2669	65.1
2008	28	2.9	0.6	1705	60.9
min	27	1	0.3	12	0.2
max	899	39.7	11.9	14213	363
mean	328	15.0	4.3	32656	98
25th	81	6.05	0.5	152526	22
median	175	10.6	3.25	1712	60
75th	557	17.3	4.3	41593	363
ITS	**April**	**May**	**June**	**July**	**Total**
Concern Level	0.29*FMWT	13.03*FMWT	33.02*FMWT	37.47*FMWT	37.47*FMWT
Incidental Take	0.44*FMWT	19.6*FMWT	49.5*FMWT	56.2*FMWT	56.2*FMWT

Table C-5: April Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	1	1	102	30	45	502	147	221
4	1	2	104	30	46	504	148	222
6	2	3	106	31	47	506	148	223
8	2	4	108	32	47	510	150	224
10	3	4	110	32	48	520	152	229
12	4	5	120	35	53	530	155	233
14	4	6	130	38	57	540	158	237
16	5	7	140	41	62	550	161	242
18	5	8	150	44	66	560	164	246
20	6	9	160	47	70	570	167	251
22	6	10	170	50	75	580	170	255
24	7	11	180	53	79	590	173	259
26	8	11	190	56	84	600	176	264
28	8	12	200	59	88	620	182	273
30	9	13	220	64	97	640	188	281
34	10	15	240	70	106	660	193	290
38	11	17	260	76	114	680	199	299
42	12	18	280	82	123	700	205	308
48	14	21	300	88	132	720	211	317
54	16	24	320	94	141	740	217	325
60	18	26	340	100	150	760	223	334
66	19	29	360	106	158	780	229	343
72	21	32	380	111	167	800	235	352
78	23	34	400	117	176	840	246	369
84	25	37	420	123	185	880	258	387
90	26	40	460	135	202	920	270	405
96	28	42	480	141	211	960	281	422
100	29	44	500	147	220	1000	293	440

Table C-6: May Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

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

Table C-7: June Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take	FMWT Index	Concern Level	Incidental Take
2	66	99	102	3369	5053	502	16578	24868
4	132	198	104	3435	5152	504	16644	24967
6	198	297	106	3501	5251	506	16711	25066
8	264	396	108	3567	5350	510	16843	25264
10	330	495	110	3633	5449	520	17173	25759
12	396	594	120	3963	5944	530	17503	26255
14	462	694	130	4293	6440	540	17833	26750
16	528	793	140	4623	6935	550	18164	27245
18	594	892	150	4954	7431	560	18494	27741
20	660	991	160	5284	7926	570	18824	28236
22	727	1090	170	5614	8421	580	19154	28732
24	793	1189	180	5944	8917	590	19485	29227
26	859	1288	190	6275	9412	600	19815	29722
28	925	1387	200	6605	9907	620	20475	30713
30	991	1486	220	7265	10898	640	21136	31704
34	1123	1684	240	7926	11889	660	21796	32695
38	1255	1882	260	8586	12880	680	22457	33685
42	1387	2081	280	9247	13870	700	23117	34676
48	1585	2378	300	9907	14861	720	23778	35667
54	1783	2675	320	10568	15852	740	24438	36657
60	1981	2972	340	11228	16843	760	25099	37648
66	2180	3269	360	11889	17833	780	25759	38639
72	2378	3567	380	12549	18824	800	26420	39630
78	2576	3864	400	13210	19815	840	27741	41611
84	2774	4161	420	13870	20806	880	29062	43593
90	2972	4458	460	15191	22787	920	30383	45574
96	3170	4756	480	15852	23778	960	31704	47556
100	3302	4954	500	16512	24769	1000	33025	49537

Table C-8: July Cumulative ≥ 20 mm Juvenile Incidental Take by FMWT Index Lookup Table

FMWT Index	Concern Level	Incidental Take
2	75	112
4	150	225
6	225	337
8	300	450
10	375	562
12	450	674
14	525	787
16	599	899
18	674	1012
20	749	1124
22	824	1236
24	899	1349
26	974	1461
28	1049	1574
30	1124	1686
34	1274	1911
38	1424	2136
42	1574	2360
48	1798	2698
54	2023	3035
60	2248	3372
66	2473	3709
72	2698	4046
78	2922	4384
84	3147	4721
90	3372	5058
96	3597	5395
100	3747	5620

FMWT Index	Concern Level	Incidental Take
102	3822	5732
104	3897	5845
106	3971	5957
108	4046	6070
110	4121	6182
120	4496	6744
130	4871	7306
140	5245	7868
150	5620	8430
160	5995	8992
170	6369	9554
180	6744	10116
190	7119	10678
200	7493	11240
220	8243	12364
240	8992	13488
260	9741	14612
280	10491	15736
300	11240	16860
320	11989	17984
340	12739	19108
360	13488	20232
380	14237	21356
400	14987	22480
420	15736	23604
460	17235	25852
480	17984	26976
500	18733	28100

FMWT Index	Concern Level	Incidental Take
502	18808	28213
504	18883	28325
506	18958	28437
510	19108	28662
520	19483	29224
530	19857	29786
540	20232	30348
550	20607	30910
560	20981	31472
570	21356	32034
580	21731	32596
590	22105	33158
600	22480	33720
620	23229	34844
640	23979	35968
660	24728	37092
680	25477	38216
700	26227	39340
720	26976	40464
740	27725	41588
760	28475	42712
780	29224	43836
800	29973	44960
840	31472	47208
880	32971	49456
920	34469	51704
960	35968	53952
1000	37467	56200