Appendix E

Biological Modeling Methods and Selected Results

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ACRONYMS AND OTHER ABBREVIATIONS

AIC	Akaike's Information Criterion
AUC	area under the curve
AUCo	area under the curve overlapping portions
AUCt	total area under the curve
Banks pumping plant	Harvey O. Banks Pumping Plant
CAMT	Collaborative Adaptive Management Team
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
COS	Continued Operations Scenario
CVP	Central Valley Project
CWT	coded wire tag
DCC	Delta Cross Channel
DFG	California Department of Fish and Game
DLO	driver-linkage-outcome
ESU	Evolutionarily Significant Unit
EXG	existing condition
FL	fork length
FMWT	Fall Mid-water Trawl
HOR	head of Old River
I-E	inflow-export ratio
ITP	Incidental Take Permit
km	kilometers
km/day	kilometers per day
LFS	Longfin Smelt
m^3/sec	cubic meters per second
mm	millimeter
MRV	Middle River
NAA	No Action Alternative
NBA	North Bay Aqueduct
OMR	Old and Middle River flows
ORV	Old River
PA	Proposed Action
PCA	principal components analysis
POD	Pelagic Organism Decline
PP	Proposed Project
PTM	particle tracking model

Skinner fish facility	John E. Skinner Delta Fish Protective Facility
SL	standard length
SLS	Smelt Larva Survey
SST	Salmonid Scoping Team
STARS	Survival, Travel Time, and Routing Analysis
SWP	State Water Project
taf	thousand acre feet
TL	total length
USFWS	U.S. Fish and Wildlife Service
WOA	Without Operations Scenario

BIOLOGICAL MODELING METHODS AND SELECTED RESULTS

E.1 INTRODUCTION

This appendix provides biological modeling methods and selected results for fish species for which quantitative modeling approaches are used. The appendix is divided into Section 2 *Delta Smelt*, Section 3 *Longfin Smelt*, and Section 4 *Salmonids*, and Section 5 *References*. This appendix includes updates since the DEIR to include Refined Alternative 2b, which has been identified as the preferred alternative. This appendix refers to Alternative 2b and Refined Alternative 2b interchangeably.

E.2 DELTA SMELT

E.2.1 PARTICLE TRACKING MODELING (LARVAL ENTRAINMENT)

For the present effects analysis, the most recent version of DSM2 particle tracking model (PTM) was used in the effects analysis to estimate the proportional entrainment of Delta Smelt larvae by various water diversions (i.e., the south Delta export facilities and the North Bay Aqueduct (NBA) Barker Slough Pumping Plant). This approach assumed that the susceptibility of Delta Smelt larvae can be represented by entrainment of passive particles, based on existing literature (Kimmerer 2008, 2011). Results of the PTM simulations do not represent the actual entrainment of larval Delta Smelt that may have occurred in the past or would occur in the future, but rather should be viewed as a comparative indicator of the relative risk of larval entrainment under Existing, ~~and~~ Proposed Project (PP), and Refined Alternative 2b scenarios. For purposes of this effects analysis, those particles that were estimated to have entered the various water diversion locations included in the PTM outputs (e.g., south Delta export facilities and NBA) are characterized as having been entrained. The latest version of DSM2-PTM allows agricultural diversions to be excluded as sources of entrainment (while still being included as water diversion sources): for this effects analysis, these agricultural diversions were excluded, given the relative coarseness of the assumptions related to specific locations of the agricultural diversions, the timing of water withdrawals by individual irrigators, and field observations that the density of young Delta Smelt entrained by these diversions is relatively low (Nobriga et al. 2004, Kimmerer 2008).

Delta smelt starting distributions used in the PTM larval entrainment analysis were based on the California Department of Fish and Wildlife (CDFW) 20 millimeter (mm) larval survey and were developed in association with M. Nobriga (USFWS Bay-Delta Office). This method paired observed Delta Smelt larval distributions from survey data with modeled hydraulic conditions from DSM2 PTM. Each pair was made by matching the observed Delta outflows of the first 20 mm survey that captured larval smelt (16 years of 20 mm surveys, 1995–2011) with the closest modeled mean monthly Delta outflow for the months of March to June in the 82 years of PTM simulations.

The 20 mm survey samples multiple stations throughout the Delta fortnightly. The average length of Delta Smelt caught during each survey was averaged across all stations (8–10 surveys per year) (Table E.2-1). The survey with mean fish length closest to 13 mm was chosen to represent the starting distribution of larval smelt in the Delta for that particular year (Table E.2-1). A length of 13 mm was chosen in order to represent a consistent period each year with respect to size/age of Delta Smelt larvae, while accounting for the mean size by survey across all years and the general pattern of more efficient capture with greater size. Catch efficiency changes rapidly for Delta Smelt larvae as they grow (see Figure 8 of Kimmerer 2008); the choice of 13 mm represents a compromise between larger larvae/early juveniles (e.g., ≥ 20 mm) that are captured more efficiently but which may have moved too far to accurately represent starting distribution and likely would be behaving less like passive particles, and smaller larvae (e.g., < 10 mm) that are not sampled efficiently enough to provide a reliable depiction of starting distribution. During the period included in the analysis (1995–2011), the fourth survey was selected most frequently (range between the first and fifth surveys).

Once a survey date was chosen for a given year, the actual Delta Smelt catch during this survey was examined by station number. Stations downstream of the confluence of the Sacramento and San Joaquin River confluence (in Suisun Bay and Suisun Marsh) were eliminated, as particles originating in these areas would not be subject to entrainment in the Delta and the PTM is better suited for the channels of the Delta than for the open-estuary environment of Suisun Bay. Several stations in the Cache Slough area also were not included as they were introduced in 2008 and did not have data for the entire period from which starting distributions are calculated. A list of stations and counts of Delta Smelt are provided in, along with the fish count not used to calculate the starting distribution, as a percentage of total fish caught during a given survey. Note that the percentage of larvae collected downstream of the Sacramento–San Joaquin confluence varies from zero to almost 100%, depending on water year. For example, in 2002 (survey 4), with relatively low outflow of approximately 13,500 cubic feet per second (cfs), only 2.5% of larvae were downstream of the confluence. In contrast, over 70% of larvae were downstream in 1998 (survey 4), with outflow of nearly 70,000 cfs (Figure E.2-1). These percentages were used to adjust the percentage of particles (particles representing larvae) that would be considered susceptible to entrainment.

Delta smelt counts per station were then divided by the contributing area of a given station in acres (Table E.2-2), to remove spatial disparities, and percentages of the total number of Delta Smelt caught were calculated for each of the main areas included in the analysis. The final annual starting distributions then were established by evenly distributing assigned percentages to each DSM2 PTM node (i.e., model particle insertion points) in a given area.

Table E.2-1. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) – Table E.2-1 a – E.2-1 h

Table E.2-1 a. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at West Delta/Lower Sacramento River Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)~~2(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
Station No. 508	–	51	–	1	3	1	–	–	1	–	2	–	–	–	–	–	–
Station No. 513	–	110	3	–	1	18	1	–	1	7	7	–	–	–	–	2	–
Station No. 520	4	65	26	1	–	9	–	–	1	–	2	–	–	–	–	1	1
Station No. 801	–	41	2	–	8	18	–	–	2	13	1	–	–	1	–	1	–

Table E.2-1 b. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at West Delta/ Sacramento–San Joaquin Confluence Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)~~2(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
704	–	11	8	–	4	–	3	–	–	1	–	–	–	1	–	–	–
705	–	4	12	–	–	1	14	5	1	8	–	1	–	–	1	–	–
706	–	4	14	2	–	1	5	1	–	3	1	–	1	–	–	1	–
707	–	–	–	–	–	–	11	–	–	2	–	–	–	–	–	–	–

Table E.2-1 c. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at Cache Slough and North Delta Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)~~2(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
711	–	–	7	–	–	1	1	1	–	–	–	1	1	–	–	–	–
716	–	–	6	–	–	3	5	1	2	2	1	3	–	–	1	2	1
719	–	–	–	–	–	–	–	–	–	–	–	–	–	2	12	38	39

Table E.2-1 d. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at West Delta/Lower San Joaquin River Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)2~~(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
804	–	8	32	12	15	8	–	4	4	5	–	1	–	1	–	1	–
809	–	20	13	–	–	–	28	1	1	87	–	–	–	–	–	–	–
812	–	8	6	–	–	1	49	3	–	6	–	–	–	1	–	–	–
815	–	3	5	–	18	1	13	5	–	26	1	1	–	2	1	1	–
901	–	5	5	–	7	–	13	2	1	4	–	–	–	–	–	–	–

Table E.2-1 e. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at South Delta Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)2~~(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
902–915	–	0	4	–	45	18	11	14	8	3	2	–	–	3	2	1	–
918	–	1	–	–	–	21	1	1	–	2	1	–	–	–	–	–	–

Table E.2-1 f. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at East Delta Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)2~~(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
919	–	1	5	–	–	1	10	1	–	–	–	–	–	–	–	–	–

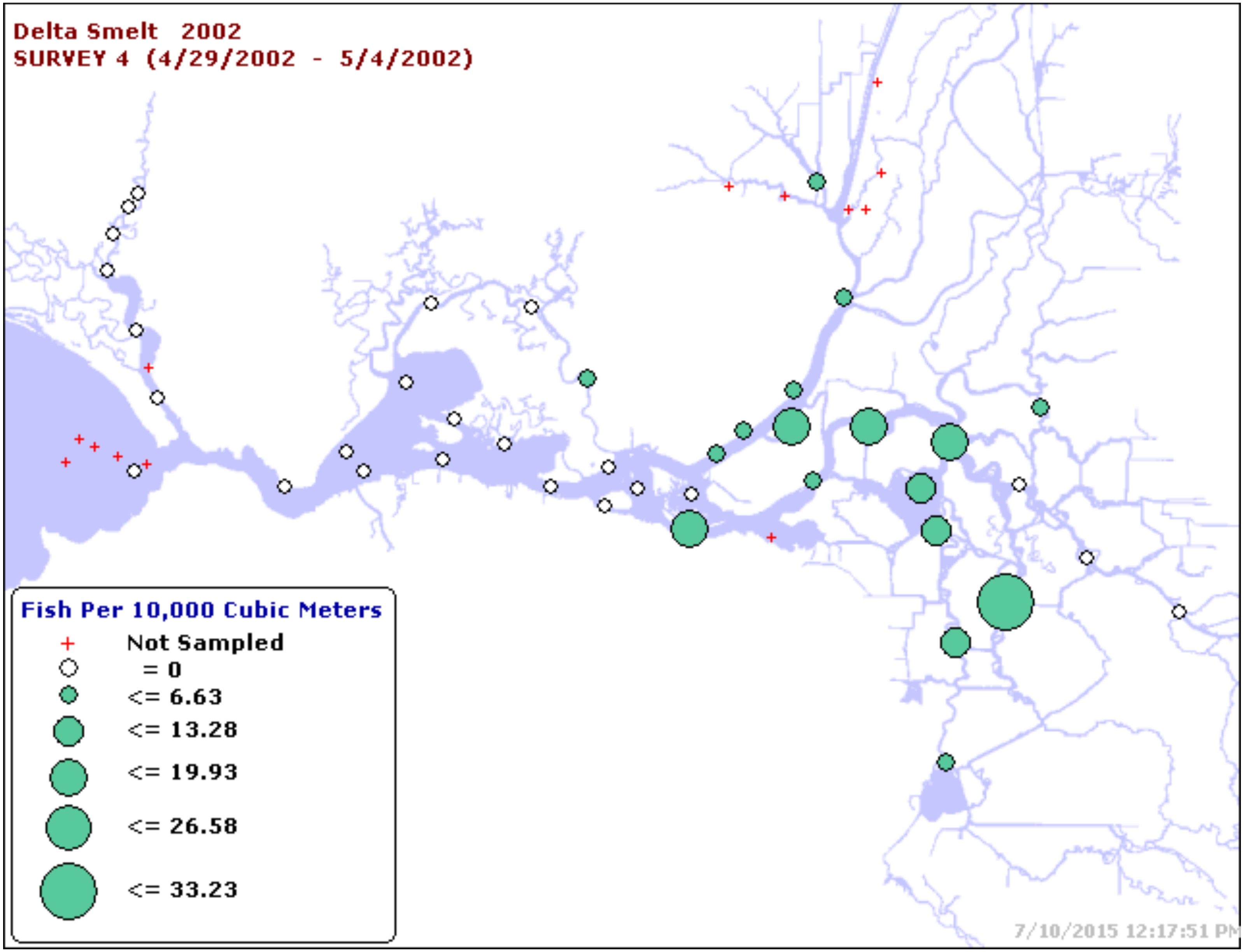
Table E.2-1 g. Distribution of Larval Delta Smelt (Number of Smelt) in Selected Survey Period (Survey Number) at Other Sampling Stations

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)2~~(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
Cache Slough Stations	0	0	0	0	0	0	0	0	0	0	0	0	0	10	4	16	4
Downstream of Confluence	7	567	66	43	127	46	8	1	7	20	50	242	1	0	1	4	120

Table E.2-1 h. Percentage of Total Larval Delta Smelt Count in Selected Survey Period (Survey Number) Not Considered for Starting Distribution

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey Number	1	3	4	4	2	4	5	4	4	4	4	5	4	4	4	4	4
Average Monthly Outflow ~~(cfs)2~~(cfs	90,837	46,021	12,257	67,612	35,509	22,057	9,612	13,483	41,877	12,354	29,876	82,004	11,235	9,482	11,944	25,102	84,981
Cache Slough Stations	0	0	0	0	0	0	0	0	0	0	0	0	0	47.6	18.2	23.5	2.4
Downstream of Confluence	63.6	63.1	30.8	72.9	55.7	31.1	4.6	2.5	24.1	10.6	73.5	97.2	33.3	0	4.5	5.9	72.7

Note:
"–" indicates the cell is blank.



Source: http://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp. Accessed: July 10, 2015.

Figure E.2-1. Density of Delta Smelt from 20 mm Survey 4, 2002

Table E.2-2. Area of Water Represented by Each 20 mm Survey Station

Station	Area (acres)
508	2,296
513	1,703
520	438
801	2,226
704	605
705	277
706	931
707	1,859
711	1,994
716	3,110*
719	3,110*
804	1,195
809	1,392
812	1,767
815	4,023
901	3,822
902	1,744
906	1,780
910	1,925
912	1,225
914	1,554
915	1,146
918	1,601
919	2,043

Source: Saha 2008.
*Acreage for Station 716 was split between Stations 716 and 719

Each of the 328 months included in the PTM (i.e., March-June in 82 years) was matched to the closest starting distribution based on the average monthly Delta outflow. Average monthly Delta outflow for the months modeled by PTM hydro periods were based on CALSIM (Existing scenario). Average monthly Delta outflow during the selected 20 mm survey period was calculated from DAYFLOW. If the selected survey period spanned two months (usually April–May), the applied outflow was for the month when most of the sampling occurred. The correspondence between the modeled Delta outflow and the applied starting distribution outflow from the 20 mm survey was reasonable: the mean difference was 4% (median = 1%), with a range from -221% (modeled Delta outflow of over 290,000 cfs in March 1983 matched with historical outflow of 90,837 cfs during survey 1 of 1995) to +58% (modeled Delta outflow of 4,000 cfs in several months matched with historical outflow of 9,482 cfs during survey 4 of 2008). Analysis of the PTM outputs was then done by multiplying the percentage of particles entrained from each release location by the applicable starting distribution percentage summarized in Table E.2-3. ~~Results were summarized for 30-day particle tracking periods as the percentage of particles being entrained at the south Delta exports (Clifton Court Forebay, with CVP~~

~~considered separately for cumulative effects), or NBA. The total number of particles released at each location was 4,000. Note that a 30-day particle tracking period may result in relatively low fate resolution at low flows (Kimmerer and Nobriga 2008), but the relative differences between scenarios would be expected to be consistent, based on previous model comparisons of 30-day and 60-day fates.~~

Table E.2-3. Percentage of Particles at PTM Insertion Location Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis - Table E.2-3 a - E.2-3 f

Table E.2-3 a. Percentage of Particles at PTM Insertion Locations in Sacramento–San Joaquin Confluence Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
Sacramento River at Sherman Lake	16.52	7.72	1.65	0	8.21	0	0.11	2.65	0	6.55	2.65	19.9	3.65	0	2.92	25.00
Sacramento River at Port Chicago	16.52	7.72	1.65	0	8.21	0	0.11	2.65	0	6.55	2.65	19.9	3.65	0	2.92	25.00
San Joaquin River downstream of Dutch Slough	16.52	7.72	1.65	0	8.21	0	0.11	2.65	0	6.55	2.65	19.9	3.65	0	2.92	25.00
Sacramento River at Pittsburg	16.52	7.72	1.65	0	8.21	0	0.11	2.65	0	6.55	2.65	19.9	3.65	0	2.92	25.00

Table E.2-3 b. Percentage of Particles at PTM Insertion Locations in Lower Sacramento River Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
Threemile Slough	1.30	0.67	4.24	8.76	6.96	10.64	9.10	2.35	6.00	4.13	2.35	2.13	2.12	8.76	0	0
Sacramento River at Rio Vista	1.30	0.67	4.24	8.76	6.96	10.64	9.10	2.35	6.00	4.13	2.35	2.13	2.12	8.76	0	0
Sacramento River downstream of Decker Island	1.30	0.67	4.24	8.76	6.96	10.64	9.10	2.35	6.00	4.13	2.35	2.13	2.12	8.76	0	0

Table E.2-3 c. Percentage of Particles at PTM Insertion Locations in Cache Slough and North Delta Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
Miner Slough	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Sacramento Deep Water Ship Channel	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Cache Slough at Shag Slough	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Cache Slough at Liberty Island	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Lindsey Slough at Barker Slough	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Sacramento River at Sacramento	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Sacramento River at Sutter Slough	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Sacramento River at Ryde	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0
Sacramento River near Cache Slough confluence	0.32	0.35	0.06	5.86	1.26	1.05	0.40	0	9.11	0.60	0	0	0	5.86	9.82	0

Table E.2-3 d. Percentage of Particles at PTM Insertion Locations in West Delta/San Joaquin River Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
San Joaquin River at Potato Slough	0.80	2.86	25.12	7.00	10.87	11.13	19.73	17.80	0	13.16	17.80	4.24	26.34	7.00	0	0
San Joaquin River at Twitchell Island	0.80	2.86	25.12	7.00	10.87	11.13	19.73	17.80	0	13.16	17.80	4.24	26.34	7.00	0	0
San Joaquin River near Jersey Point	0.80	2.86	25.12	7.00	10.87	11.13	19.73	17.80	0	13.16	17.80	4.24	26.34	7.00	0	0

Table E.2-3 e. Percentage of Particles at PTM Insertion Locations in Central/South Delta Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
San Joaquin River downstream of Rough and Ready Island	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
San Joaquin River at Buckley Cove	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
San Joaquin River near Medford Island	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Old River near Victoria Canal	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Old River at Railroad Cut	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Old River near Quimby Island	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Middle River at Victoria Canal	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Middle River u/s of Mildred Island	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Grant Line Canal	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0
Frank's Tract East	2.47	5.50	0.47	0	0.07	2.34	0.50	2.89	0	1.66	2.89	0.10	0	0	0	0

Table E.2-3 f. Percentage of Particles at PTM Insertion Locations in East Delta Area Used as Starting Distributions in the Delta Smelt Particle Tracking Analysis

Average Monthly Outflow in cfs:	9,482	9,612	11,235	11,944	12,257	12,354	13,483	22,057	25,102	29,876	35,509	46,021	67,612	82,004	84,891	90,837
Little Potato Slough	0	0.08	0	0	0.26	0.30	0.74	0.00	0	0	0	0.03	0	0	0	0
Mokelumne River downstream of Cosumnes confluence	0	0.08	0	0	0.26	0.30	0.74	0.00	0	0	0	0.03	0	0	0	0
South Fork Mokelumne	0	0.08	0	0	0.26	0.30	0.74	0.00	0	0	0	0.03	0	0	0	0
Mokelumne River downstream of Georgiana confluence	0	0.08	0	0	0.26	0.30	0.74	0.00	0	0	0	0.03	0	0	0	0
North Fork Mokelumne	0	0.08	0	0	0.26	0.30	0.74	0	0	0	0	0.03	0	0	0	0
Georgiana Slough	0	0.08	0	0	0.26	0.30	0.74	0	0	0	0	0.03	0	0	0	0

Results were summarized for 30-day particle tracking periods as the percentage of particles being entrained at the south Delta exports (Clifton Court Forebay, with CVP considered separately for cumulative effects), or NBA. The total number of particles released at each location was 4,000. Note that a 30-day particle tracking period may result in relatively low fate resolution at low flows (Kimmerer and Nobriga 2008), but the relative differences between scenarios would be expected to be consistent, based on previous model comparisons of 30-day and 60-day fates.

Results of the PTM analysis for entrainment into the SWP's Clifton Court Forebay and Barker Slough Pumping Plant are presented in Section 4.4 of the DEIR. Table E.2-4 provides results for the CVP Jones Pumping Plant for consideration of cumulative impacts in the DEIR Section 4.6.

Table E.2-4. Percentage of Particles Entrained Over 30 Days into the Central Valley Project Jones Pumping Plant.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	2.20	1.83	-0.37 (-17%)
March	Above Normal	3.57	3.01	-0.55 (-16%)
March	Below Normal	7.56	6.45	-1.11 (-15%)
March	Dry	11.94	10.01	-1.93 (-16%)
March	Critical	9.43	10.54	1.11 (12%)
April	Wet	0.79	1.63	0.84 (107%)
April	Above Normal	1.85	2.87	1.03 (56%)
April	Below Normal	4.21	5.41	1.20 (28%)
April	Dry	5.49	5.23	-0.26 (-5%)
April	Critical	4.84	4.31	-0.53 (-11%)
May	Wet	1.82	3.69	1.87 (103%)
May	Above Normal	3.19	7.96	4.77 (150%)
May	Below Normal	3.15	8.37	5.22 (166%)
May	Dry	5.82	8.30	2.48 (43%)
May	Critical	8.99	7.70	-1.29 (-14%)
June	Wet	9.56	9.67	0.11 (1%)
June	Above Normal	13.20	13.00	-0.20 (-2%)
June	Below Normal	16.01	16.07	0.06 (0%)
June	Dry	17.49	17.15	-0.35 (-2%)
June	Critical	12.12	11.04	-1.07 (-9%)

E.2.2 *Eurytemora affinis*-X2 Analysis

This analysis followed Kimmerer's (2002) methods to conduct an analysis of the relationship between *Eurytemora affinis* and spring (March–May) X2 for the period from 1980 to 2017, as described by Greenwood (2018). The main steps in preparing the data for analysis were as follows:

1. Historical zooplankton data were obtained from ftp://ftp.dfg.ca.gov/IEP_Zooplankton/1972-2017CBMatrix.xlsx
    a. Data were subsetted to only include surveys 3, 4, and 5 (March-May).
    b. Specific conductance was converted to salinity by applying Schemel's (2001) method, then only samples within the low salinity zone (salinity = 0.5-6) were selected.

c. A constant of 10 was added to *E. affinis* adult catch per unit effort (number per cubic meter) in each sample, then the resulting value was $\log_{10}$-transformed.

d. The $\log_{10}$-transformed values were averaged first by month, and then by year.

2. Historical X2 data were obtained from DAYFLOW (https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data)

   a. For years prior to water year 1997 (which is the year DAYFLOW X2 values began to be provided), the DAYFLOW daily predictive equation for X2 was used, based on a starting value from Anke Mueller-Solger (see Greenwood 2018 for details).

   b. The mean March-May X2 was calculated for each year.

Similar to Kimmerer (2002), a general linear model was used to regress mean annual $\log_{10}$-transformed *E. affinis* catch per unit effort against mean March-May X2, including a step change between 1987 and 1988 to reflect the *Potamocorbula amurensis* clam invasion and a step change between 2002 and 2003 to reflect the onset of the Pelagic Organism Decline (POD; Thomson et al. 2010). The interaction of X2 and the step change was included in a full model, but the interaction was not statistically significant, so the model was re-run with only X2 and the step changes included. These analyses were conducted in SAS 9.4 software. The statistical outputs indicate that there is little difference in the coefficients for the post-*Potamocorbula* and POD step changes, whereas both coefficients were significantly less than the coefficient for the pre-*Potamocorbula* period. Regression coefficients from the model were stored for prediction of *E. affinis* relative abundance for the Existing, ~~and~~ PP, and Refined Alternative 2b scenarios.

The stored regression coefficients from the regression of historical *E. affinis* catch per unit effort vs. X2 and step changes were then applied to the Existing, ~~and~~ PP, and Refined Alternative 2b X2 inputs using PROC PLM in SAS 9.4 software. The basic regression model being applied was:

$$\log_{10}(\textit{E. affinis}\text{ catch per unit effort}) = 3.9404 - 0.0152\ (\text{mean March-May X2}) - 0.7863$$

where 3.9404 is the intercept and -0.7863 is the coefficient for the POD step change. Predictions were back-transformed to the original measurement scale (catch per unit effort, number per cubic meter) for summary of results.

E.3 LONGFIN SMELT

E.3.1 Particle Tracking Modeling (Larval Entrainment)

E.3.1.1 Derivation of Larval Longfin Smelt Hatching Locations

The potential effect of the PP and Refined Alternative 2b on larval Longfin Smelt entrainment in the Delta and Suisun Marsh was evaluated through a PTM of neutrally buoyant particles representing newly hatched larvae inserted at various locations in the Delta. The first step in the analysis involved determining appropriate weights for particle insertion points to reflect the hatching locations of larval Longfin Smelt. Injection points for comparisons of Existing to PP and Existing to Refined Alternative 2b effects were determined through examination of the spatial distributions of larvae observed in the Smelt Larva Survey (SLS) from 2009 to 2014. This methodology is consistent with the approach used by California Department of Fish and Game (DFG) in its effects and Incidental Take Permit (ITP) analysis for State Water Project (SWP) and Central Valley Project (CVP) Data (California Department of Fish and Game 2009a). Data were obtained from the CDFW website (ftp://ftp.delta.dfg.ca.gov/Delta%20Smelt/SLS.mdb). For most of this time period, the SLS generally included 5-6 surveys at 35 stations in the Delta and Suisun Marsh and Bay during January-March; stations 323 to 343 in the Napa River were added in 2014, but are not considered in the present analysis because there is only one year of data. Data were filtered to include Longfin Smelt larvae ≤ 6-mm total length (TL), which represents mostly newly hatched larvae, but includes some larvae up to 8 days old, assuming conservative hatch lengths as low of 4-mm standard length (SL) and growth rate of 0.25 mm d^{-1} (California Department of Fish and Game 2009b). Inspection of size distribution and presence of yolk-sacs of the larval Longfin Smelt catch from the SLS data suggest that most newly hatched larvae are around 6-mm TL (Figure E.3-1), which is consistent with the presumed range of 4- to 8-mm SL (Wang 2007; California Department of Fish and Game 2009b).

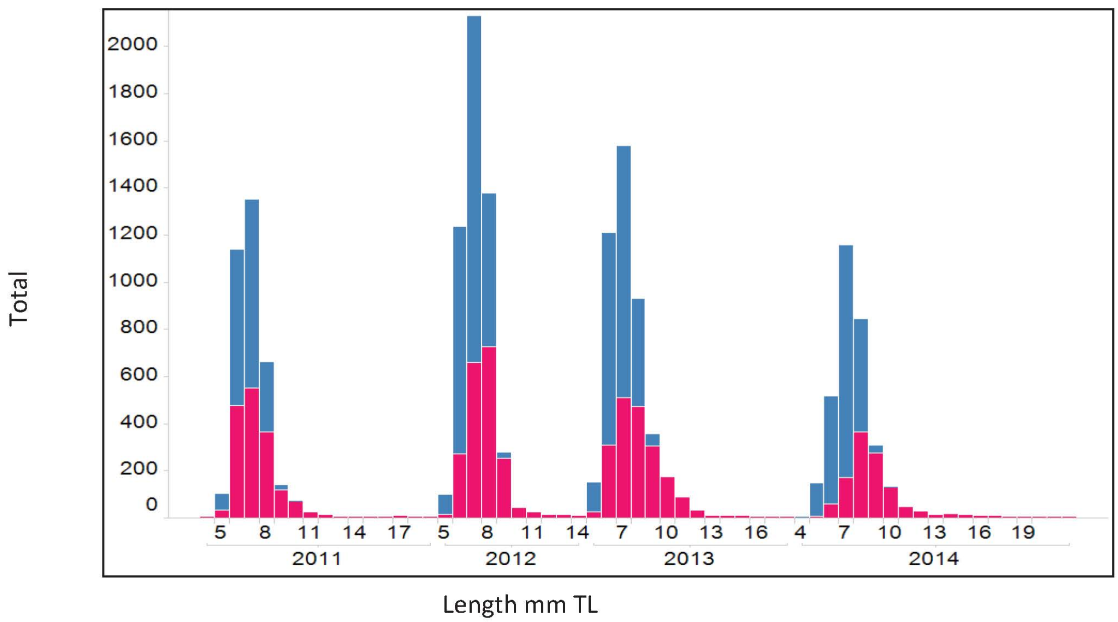


Figure E.3-1. Length-frequency histogram of Longfin Smelt larvae collected in the SLS. Larvae with yolk-sacs are represented by blue bars. DFG did not distinguish yolk sac larvae in 2009 and 2010

The density of larvae (≤ 6 mm TL) per cubic meter sampled at each station was calculated as:

Density = Number of larvae/(0.37*(26873+99999)*Net meter reading),

where the conversion factor derives from calibration of the net flow meter used during SLS sampling.[1]

The SLS includes a subset of the stations that are used for the March-June 20-mm survey for larval/juvenile delta smelt. Saha (2008) estimated the areas and volumes that each of the 20-mm stations represents within the Delta and Suisun Marsh and Bay using a Voronoi diagram (Figure E.3-2). There is a station (723) that was not part of the 20-mm Survey when Saha (2008) made the area and volume calculations; this station is close to station 716, so the area and volume represented by station 716 were halved for the present analysis, with the other half being considered to be the area and volume represented by station 723 (Table E.3-1).

The total number of Longfin Smelt larvae ≤ 6 mm in the volume of water represented by each station (Table E.3-1) was calculated by multiplying the density of larvae by the volume of each station.[2] The proportion of larvae in the volume of water represented by each SLS station was calculated for each survey as the number of larvae per station divided by the total sum of larvae across all stations (Table E.3-2).

There was little evidence that the general distribution of Longfin Smelt larvae from the SLS varied by year in relation to hydrological conditions, at least for the groups of stations examined herein[3] (Table E.3-3). Therefore an overall mean distribution was used to weigh the results of the DSM2-PTM analysis, based on the mean proportion by station from all surveys during 2009–2014.

E.3.1.2 DSM2-PTM Runs

Sixty-day-long DSM2-PTM[4] runs were undertaken for the Existing, PP, and Refined Alternative 2b scenarios at 39 particle injection locations in the Delta and Suisun Marsh and Bay (Table E.3-4) during January, February, and March in 1922–2003. The particle injection locations were chosen to provide a representative variety of locations generally associated with SLS stations, with particular emphasis on the Delta. For each run, 4,000 neutrally buoyant passive particles were injected evenly every hour (i.e.,

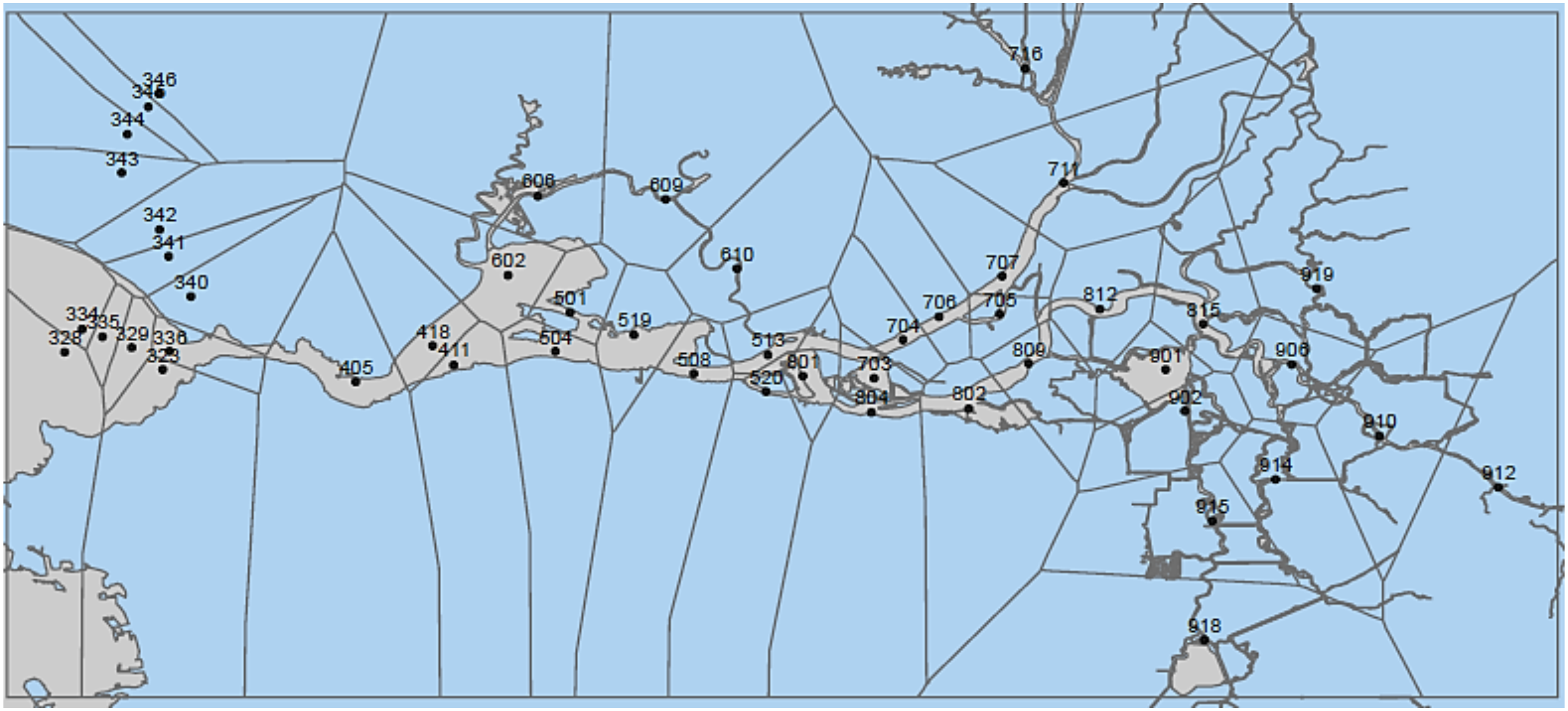
[1] See Eijkelkamp Agrisearch Equipment (no date) for further details.

[2] For reference, the overall estimated number of larvae across all stations ranged from around 600,000 (survey 6 in 2014) to around 160,000,000 (survey 4 in 2009). Dividing these estimates by fecundity of 7,500 (California Department of Fish and Game 2009b: Figure 3) for a 2-year-old female and multiplying by 2 (under the assumption of a 1:1 sex ratio) gives an estimate of adult Longfin Smelt abundance, assuming 100% survival from eggs to larvae . Applying 10%, 50%, and 90% survival from eggs to larvae gives estimates of adult population size of around 500-2,300 (survey 6 in 2014) to 130,000-650,000 (survey 4 in 2009). These estimates bracket the "tens of thousands" of adults suggested by Newman (pers. comm. to California Department of Fish and Game 2009b), perhaps providing some indication that the numbers are of a reasonable order of magnitude for the purposes of the present analysis. Note, however, that the analysis is not dependent on absolute numbers of larvae to be accurately represented, as gear efficiency for smaller stages would need to be refined.

[3] This does not preclude the possibility of a considerable proportion of the population occurring downstream of the SLS sampling area during wet years, for example.

[4] DSM2 modeling methods and results for the NAA and PP are presented in ICF International (2016: Appendix 5.B *DSM2 Modeling and Results*).

about 160 particles per hour) over a 24.75-hour period at the beginning of the month. The fate of the particles was output at forty-five days, which was assumed to represent the duration that newly hatched larvae could be considered to act as neutrally buoyant particles with relatively poor swimming ability, and would therefore be susceptible to movement by prevailing channel currents, including entrainment. By the time larvae develop air bladders at around 12-mm TL, they are able to manipulate their position in the water column (Bennett et al. 2002), although they are still susceptible to entrainment, which is not represented by the tracking of particles for 45 days in the present analysis. For consistency with the analysis conducted by DFG (2009a), runs were also undertaken with surface (top 10% of water column) orientation of particles.



Source: Saha (2008).

Figure E.3-2. Division of the Delta and Suisun Marsh and Bay Around 20-mm Survey Stations With a Voronoi Diagram

Table E.3-1. Area and Volume Represented by Smelt Larval Survey Stations

Station	Area (ac)	Volume (ac-ft)	Area (m2)	Volume (m3)
405	3,547	139,804	14,354,198	172,445,718
411	2,119	37,344	8,575,288	46,063,152
418	2,756	63,186	11,153,135	77,938,794
501	3,692	36,856	14,940,992	45,461,213
504	2,403	44,046	9,724,595	54,329,948
508	2,296	53,344	9,291,581	65,798,864
513	1,703	41,921	6,891,796	51,708,799
519	4,101	67,942	16,596,156	83,805,234
520	438	12,130	1,772,523	14,962,137
602	7,361	72,852	29,788,907	89,861,631
606	1,332	17,685	5,390,412	21,814,129
609	727	8,114	2,942,064	10,008,473
610	259	3,156	1,048,136	3,892,869
703	2,091	25,853	8,461,976	31,889,210
704	605	15,952	2,448,348	19,676,505
705	277	3,741	1,120,979	4,614,456
706	931	24,539	3,767,623	30,268,415
707	1,859	37,076	7,523,105	45,732,579
711	1,994	39,391	8,069,431	48,588,089
716*	3,110	51,796	12,583,699	63,889,434
723*	3,110	51,796	12,583,699	63,889,434
801	2,226	45,662	9,008,301	56,323,255
802	3,546	45,094	14,350,151	55,622,637
804	1,195	32,119	4,835,993	39,618,208
809	1,392	33,562	5,633,224	41,398,123
812	1,767	43,810	7,150,795	54,038,846
815	4023	72053	16,280,502	88,876,079
901	3,822	33,855	15,467,084	41,759,533
902	1,744	22,095	7,057,717	27,253,785
906	1,780	32,694	7,203,404	40,327,461
910	1,925	25,760	7,790,198	31,774,496
912	1,225	13,747	4,957,399	16,956,677
914	1,554	23,552	6,288,814	29,050,968
915	1,146	13,302	4,637,697	16,407,778
918	1601	14,685	6,479,016	18,113,683
919	2,043	20,702	8,267,727	25,535,544

Source: Saha (2008)

*See text for discussion of values for stations 716 and 723.

The total number of Longfin Smelt larvae ≤ 6 mm in the volume of water represented by each station (Table E.3-1) was calculated by multiplying the density of larvae by the volume of each station.[5] The proportion of larvae in the volume of water represented by each SLS station was calculated for each survey as the number of larvae per station divided by the total sum of larvae across all stations (Table E.3-2).

There was little evidence that the general distribution of Longfin Smelt larvae from the SLS varied by year in relation to hydrological conditions, at least for the groups of stations examined herein[6] (Table E.3-3). Therefore an overall mean distribution was used to weigh the results of the DSM2-PTM analysis, based on the mean proportion by station from all surveys during 2009–2014.

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[5] For reference, the overall estimated number of larvae across all stations ranged from around 600,000 (survey 6 in 2014) to around 160,000,000 (survey 4 in 2009). Dividing these estimates by fecundity of 7,500 (California Department of Fish and Game 2009b: Figure 3) for a 2-year-old female and multiplying by 2 (under the assumption of a 1:1 sex ratio) gives an estimate of adult Longfin Smelt abundance, assuming 100% survival from eggs to larvae . Applying 10%, 50%, and 90% survival from eggs to larvae gives estimates of adult population size of around 500-2,300 (survey 6 in 2014) to 130,000-650,000 (survey 4 in 2009). These estimates bracket the “tens of thousands” of adults suggested by Newman (pers. comm. to California Department of Fish and Game 2009b), perhaps providing some indication that the numbers are of a reasonable order of magnitude for the purposes of the present analysis. Note, however, that the analysis is not dependent on absolute numbers of larvae to be accurately represented, as gear efficiency for smaller stages would need to be refined.

[6] This does not preclude the possibility of a considerable proportion of the population occurring downstream of the SLS sampling area during wet years, for example.

[7] DSM2 modeling methods and results for the NAA and PP are presented in ICF International (2016: Appendix 5.B *DSM2 Modeling and Results*).

Table E.3-2. Volume-Weighted Proportion of Longfin Smelt Larvae ≤ 6 mm By Station, 2009-2014

Year	Survey	405	411	418	501	504	508	513	519	520	602	606	609	610	703	704	705	706	707	711	716	723	801	804	809	812	815	901	902	906	910	912	914	915	918	919
2009	1	0.0466	0.0000	0.0000	0.0118	0.0000	0.0151	0.2600	0.0217	0.0079	0.0000	0.0164	0.0000	0.0000	0.0164	0.0173	0.0104	0.2071	0.0365	0.0504	0.0161	0.0470	0.1693	0.0089	0.0193	0.0000	0.0000	0.0110	0.0000	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	2	0.0000	0.0000	0.0000	0.0034	0.0000	0.1338	0.0993	0.0057	0.0227	0.0142	0.0015	0.0014	0.0033	0.0144	0.0771	0.0221	0.0779	0.2020	0.0296	0.0254	0.0045	0.0437	0.0848	0.0651	0.0150	0.0179	0.0324	0.0000	0.0000	0.0000	0.0000	0.0000	0.0027	0.0000	0.0000
2009	3	0.0000	0.0000	0.0000	0.0035	0.0021	0.0479	0.0019	0.0099	0.0099	0.0029	0.0083	0.0037	0.0009	0.0774	0.0369	0.0125	0.1055	0.1392	0.0355	0.1416	0.1250	0.0784	0.0316	0.0437	0.0632	0.0124	0.0056	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000
2009	4	0.1055	0.0222	0.0320	0.0052	0.0016	0.0773	0.2536	0.0267	0.0164	0.0827	0.0007	0.0013	0.0005	0.0126	0.0231	0.0027	0.0101	0.0309	0.0000	0.0305	0.0302	0.1554	0.0467	0.0209	0.0016	0.0028	0.0050	0.0008	0.0000	0.0000	0.0000	0.0008	0.0005	0.0000	0.0000
2009	5	0.0152	0.0190	0.0447	0.1238	0.0582	0.2174	0.1067	0.0734	0.0199	0.0931	0.0095	0.0012	0.0002	0.0129	0.0052	0.0015	0.0062	0.0139	0.0000	0.0178	0.0185	0.0587	0.0543	0.0047	0.0084	0.0064	0.0090	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	1	0.0130	0.0118	0.0218	0.0429	0.0161	0.1210	0.0807	0.0456	0.0451	0.0300	0.0000	0.0014	0.0006	0.0048	0.0105	0.0078	0.0526	0.1396	0.0035	0.0639	0.0745	0.0257	0.0383	0.0734	0.0421	0.0000	0.0272	0.0038	0.0000	0.0000	0.0000	0.0021	0.0000	0.0000	0.0000
2010	4	0.0506	0.0167	0.0480	0.0663	0.1274	0.0574	0.0304	0.0226	0.0283	0.0371	0.0000	0.0019	0.0033	0.0086	0.0753	0.0031	0.0841	0.1396	0.0038	0.0225	0.0094	0.0457	0.0631	0.0208	0.0095	0.0133	0.0097	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	5	0.0670	0.1457	0.0848	0.1239	0.0744	0.0428	0.0147	0.0515	0.0162	0.0436	0.0000	0.0011	0.0000	0.0280	0.0164	0.0038	0.0361	0.0436	0.0106	0.0197	0.0534	0.0400	0.0274	0.0283	0.0175	0.0000	0.0071	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0000
2010	6	0.0171	0.0000	0.0000	0.0000	0.0106	0.1488	0.3585	0.0163	0.0095	0.0103	0.0095	0.0000	0.0005	0.0143	0.0479	0.0000	0.1063	0.0431	0.0167	0.0220	0.1016	0.0112	0.0161	0.0120	0.0138	0.0000	0.0088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0022	0.0000	0.0029
2011	1	0.0130	0.0110	0.0187	0.0146	0.0212	0.1665	0.0837	0.2172	0.0349	0.0542	0.0204	0.0008	0.0006	0.0159	0.0576	0.0030	0.0682	0.1289	0.0000	0.0096	0.0102	0.0034	0.0278	0.0186	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	2	0.0336	0.0024	0.0307	0.0287	0.0181	0.0758	0.0363	0.0819	0.0251	0.0191	0.0053	0.0005	0.0044	0.0029	0.0314	0.0042	0.0487	0.0846	0.0193	0.0785	0.1454	0.0624	0.0531	0.0296	0.0137	0.0134	0.0490	0.0013	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000
2011	3	0.0000	0.0079	0.0062	0.0150	0.0301	0.0522	0.0043	0.0143	0.0067	0.0000	0.0000	0.0009	0.0010	0.0725	0.0207	0.0069	0.0611	0.1476	0.0775	0.2083	0.1842	0.0000	0.0228	0.0259	0.0190	0.0075	0.0075	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	4	0.0000	0.0038	0.0000	0.0916	0.1170	0.2984	0.0612	0.0802	0.0198	0.0184	0.0000	0.0000	0.0005	0.0113	0.0252	0.0030	0.0097	0.1250	0.0144	0.0057	0.0846	0.0128	0.0044	0.0000	0.0050	0.0000	0.0049	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	5	0.2285	0.0972	0.0192	0.0641	0.1032	0.0171	0.0000	0.0814	0.0078	0.2402	0.0000	0.0000	0.0009	0.0236	0.0183	0.0012	0.0000	0.0000	0.0124	0.0000	0.0289	0.0000	0.0100	0.0096	0.0259	0.0000	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	1	0.0000	0.0000	0.0127	0.0206	0.0000	0.1460	0.1212	0.0000	0.0075	0.0282	0.0017	0.0022	0.0000	0.0224	0.0130	0.0028	0.0766	0.1361	0.0000	0.1099	0.1076	0.0275	0.0437	0.0819	0.0196	0.0189	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	2	0.2521	0.0066	0.0415	0.0310	0.0193	0.0884	0.0153	0.0077	0.0072	0.0519	0.0029	0.0010	0.0009	0.0301	0.0301	0.0011	0.0460	0.0765	0.0000	0.0543	0.0935	0.0384	0.0047	0.0355	0.0373	0.0000	0.0203	0.0035	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012
2012	3	0.0000	0.0000	0.0143	0.0081	0.0000	0.1628	0.0815	0.0082	0.0225	0.0258	0.0000	0.0009	0.0024	0.0026	0.0182	0.0024	0.0551	0.1591	0.0164	0.1159	0.1445	0.0047	0.0522	0.0050	0.0373	0.0508	0.0095	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	4	0.0593	0.0053	0.0236	0.0390	0.0248	0.0813	0.0322	0.1418	0.0230	0.0000	0.0000	0.0011	0.0000	0.0099	0.0250	0.0015	0.0829	0.1637	0.0168	0.0388	0.1124	0.0754	0.0192	0.0043	0.0000	0.0000	0.0102	0.0063	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0000
2012	6	0.0894	0.0469	0.0522	0.0211	0.2308	0.1499	0.0583	0.0204	0.0683	0.1683	0.0000	0.0000	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0151	0.0000	0.0392	0.0082	0.0000	0.0274	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	1	0.1422	0.0980	0.0000	0.0635	0.1968	0.0000	0.2731	0.0000	0.0000	0.1031	0.0000	0.0000	0.0000	0.0000	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0208	0.0000	0.0141	0.0192	0.0000	0.0614	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	2	0.0124	0.0147	0.1148	0.0597	0.0858	0.0918	0.0308	0.1344	0.0087	0.1266	0.0000	0.0000	0.0000	0.0330	0.0013	0.0009	0.0704	0.0787	0.0034	0.0423	0.0280	0.0224	0.0202	0.0117	0.0000	0.0000	0.0079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	3	0.0440	0.0000	0.0713	0.0527	0.0554	0.0301	0.0232	0.0568	0.0187	0.0499	0.0000	0.0000	0.0000	0.0514	0.0289	0.0037	0.0223	0.0807	0.0462	0.0927	0.1084	0.0435	0.0099	0.0472	0.0098	0.0164	0.0348	0.0000	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	4	0.0000	0.0548	0.0103	0.0188	0.0253	0.0369	0.0194	0.0912	0.0116	0.0510	0.0000	0.0000	0.0000	0.0045	0.0296	0.0035	0.0585	0.1107	0.0934	0.1044	0.1985	0.0276	0.0201	0.0110	0.0036	0.0000	0.0134	0.0017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	5	0.0689	0.0000	0.0506	0.0253	0.0280	0.1278	0.0172	0.0957	0.0245	0.0084	0.0000	0.0000	0.0000	0.0083	0.0134	0.0029	0.0422	0.1206	0.0498	0.0531	0.1243	0.0666	0.0384	0.0192	0.0115	0.0000	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	6	0.0000	0.0680	0.0000	0.0000	0.0000	0.0000	0.1270	0.0000	0.0550	0.0000	0.0000	0.0000	0.0000	0.0411	0.0000	0.0000	0.3130	0.0000	0.0000	0.0000	0.0000	0.0000	0.3286	0.0000	0.0000	0.0000	0.0673	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	1	0.0000	0.0000	0.0190	0.0094	0.0000	0.2113	0.2272	0.0000	0.0332	0.0382	0.0053	0.0022	0.0100	0.0320	0.0287	0.0008	0.0131	0.0197	0.0276	0.0126	0.0259	0.0814	0.0425	0.0773	0.0467	0.0175	0.0183	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0494	0.0598	0.0291	0.0171	0.0373	0.0020	0.0009	0.0007	0.0137	0.0079	0.0021	0.0095	0.0501	0.0446	0.2024	0.2176	0.0570	0.0096	0.0156	0.1374	0.0143	0.0162	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	3	0.0000	0.0168	0.0415	0.0223	0.0137	0.0434	0.0381	0.0462	0.0159	0.0413	0.0000	0.0042	0.0000	0.0148	0.0024	0.0046	0.0042	0.0230	0.0367	0.2676	0.1165	0.1119	0.0160	0.0664	0.0324	0.0000	0.0201	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	4	0.0000	0.0000	0.0000	0.0000	0.0098	0.0124	0.0606	0.1058	0.0194	0.0000	0.0000	0.0018	0.0014	0.0208	0.0358	0.0000	0.0762	0.1184	0.0000	0.0980	0.2803	0.1038	0.0000	0.0280	0.0207	0.0000	0.0070	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	5	0.0000	0.0000	0.2679	0.0000	0.1638	0.0460	0.0423	0.0652	0.0338	0.0000	0.0000	0.0000	0.0105	0.0000	0.0000	0.0000	0.0221	0.0000	0.0000	0.0000	0.0000	0.0900	0.1203	0.0316	0.0391	0.0000	0.0673	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	6	0.0000	0.0000	0.0000	0.0000	0.3797	0.0000	0.0000	0.0000	0.1078	0.0000	0.0000	0.0000	0.0338	0.0000	0.0000	0.0000	0.4788	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: Surveys 2 and 3 in 2010 and 5 in 2012 had missing data and were excluded from the analysis.

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Table E.3-3. Mean Proportion of Longfin Smelt Larvae In Each Group of SLS Stations

Year	Mean Dec.-Mar. Delta Outflow (cfs)	400s	500s	600s	700s	800s	900s
2009	13,808	0.06	0.33	0.05	0.35	0.20	0.02
2010	19,863	0.12	0.39	0.03	0.32	0.12	0.02
2011	55,663	0.09	0.37	0.07	0.37	0.07	0.02
2012	11,946	0.12	0.33	0.06	0.36	0.13	0.01
2013	23,600	0.13	0.31	0.06	0.35	0.13	0.03
2014	8,331	0.06	0.31	0.03	0.38	0.19	0.02
Mean	–	0.09	0.34	0.05	0.36	0.14	0.02

Note:
"–" indicates the cell is blank.

Each particle injection location was assigned to one or more SLS stations, and some SLS stations had multiple particle injection locations assigned to them, reflecting the relative distribution of the nearest SLS station to particle injection locations (e.g., station 919 had five injection locations assigned to it, whereas station 901 had one injection location assigned to it; Table E.3-4). The weight assigned to the particles injected at each PTM injection location reflected the mean proportion of larvae captured at the associated SLS station (Table E.3-2) divided by the number of injection locations at a given station. As an example, station 707 was assigned two particle injection locations: Threemile Slough (location no. 15) and Sacramento River at Rio Vista (location no. 31) (Table E.3-4). The overall mean proportion of larval Longfin Smelt at station 707 across all surveys in 2009–2014 was 0.078 (mean of values in the 707 column of Table E.3-2 This 0.078 (i.e., 7.8% of larvae) was then divided equally among the two particle injection locations assigned to SLS station 707, giving a weight of 0.039 (i.e., 3.9% of larvae) for the particles injected at both locations (Table E.3-4). Professional judgement was used to assign representative weights in situations where a broader area needed to be represented by relatively few stations (e.g., Cache Slough Complex stations 22–26 represented by SLS stations 716 and 713).

Table E.3-4. Particle Injection Locations, Associated SLS Stations, and Location Weight for the DSM2-PTM Analysis of Potential Larval Longfin Smelt Entrainment

PTM Injection Location Number	PTM Injection Location Name	SLS Station	Weight
1	San Joaquin River at Vernalis	912	0.000014
2	San Joaquin River at Mossdale	912	0.000014
3	San Joaquin River D/S of Rough and Ready Island	910	0.000000
4	San Joaquin River at Buckley Cove	910	0.000000
5	San Joaquin River near Medford Island	906	0.000463
6	San Joaquin River at Potato Slough	815	0.003088
7	San Joaquin River at Twitchell Island	812	0.021832
8	Old River near Victoria Canal	918	0.000032
9	Old River at Railroad Cut	915	0.000191
10	Old River near Quimby Island	902	0.000957
11	Middle River at Victoria Canal	918	0.000032
12	Middle River u/s of Mildred Island	914	0.000094
13	Grant Line Canal	918	0.000032
14	Frank's Tract East	901	0.017578

PTM Injection Location Number	PTM Injection Location Name	SLS Station	Weight
15	Threemile Slough	707	0.038899
16	Little Potato Slough	919	0.000026
17	Mokelumne River d/s of Cosumnes confluence	919	0.000026
18	South Fork Mokelumne	919	0.000026
19	Mokelumne River d/s of Georgiana confluence	815	0.003088
20	North Fork Mokelumne	919	0.000026
21	Georgiana Slough	919	0.000026
22	Miner Slough	716+723	0.028025
23	Sacramento Deep Water Ship Channel	716+723	0.028025
24	Cache Slough at Shag Slough	716+723	0.028025
25	Cache Slough at Liberty Island	716+723	0.028025
26	Cache Slough near Lindsey Slough	716+723	0.028025
27	Sacramento River at Sacramento	upstream	0.000000
28	Sacramento River at Sutter Slough	upstream	0.000000
29	Sacramento River at Ryde	711	0.009815
30	Sacramento River near Cache Slough confluence	711	0.009815
31	Sacramento River at Rio Vista	707	0.038899
32	Sacramento River d/s of Decker Island	705+706	0.075899
33	Sacramento River at Sherman Lake	704	0.022743
34	Sacramento River at Port Chicago	downstream	0.000000
35	Montezuma Slough near National Steel	downstream	0.000000
36	Montezuma Slough at Suisun Slough	downstream	0.000000
37	San Joaquin River d/s of Dutch Slough	703+804	0.058814
38	Sacramento River at Pittsburg	801	0.048938
39	San Joaquin River near Jersey Point	809	0.026464

SLS stations downstream of the Sacramento-San Joaquin river confluence (i.e., stations numbered 400s to 600s) were considered to be downstream of the influence of the SWP/CVP export facilities, and so were not included in the PTM analysis (but were used in the calculation of proportions; see Table E.3-2). Similarly, PTM injection locations downstream of the confluence were assigned zero weight[8], because these particles would not be susceptible to entrainment at the locations of interest. In addition, particles injected in the Sacramento River at Sacramento and Sutter Slough were assigned zero weight because they are upstream of the range of the SLS (suggesting that this portion of the river is of minor concern for Longfin Smelt management). The summed weight of all the PTM injection locations in the analysis was 0.52, reflecting that 0.48 of the larval population was assumed to be downstream of the confluence and therefore not susceptible to entrainment in the Delta (see sum of the 400s, 500s, and 600s stations in Table E.3-3). As discussed further in Section E.3.1.3 *Note on Proportion of Larval Population Outside the Delta and Suisun Marsh and Bay*, the spatial extent of the SLS data used in the present analysis includes only the Delta and Suisun Marsh and Bay, but the full extent of the distribution of larval Longfin Smelt may be considerably greater.

[8] PTM results for injection locations assigned zero weight are available upon request.

For each simulated month in the DSM2-PTM analysis, the percentage of particles from each particle injection location was output for several fates: entrainment (the SWP's Clifton Court Forebay, the CVP's Jones Pumping Plant, and the NBA Barker Slough Pumping Plant), and passing Chipps Island. These percentages were multiplied by the weight for each particle injection location (Table E.3-4), and then summed across all injection locations to give a relative comparison of the overall percentage of larvae that would have been entrained or entered the south Delta under the Existing, and PP, and Refined Alternative 2b scenarios. Note that these percentages are not intended to represent an absolute estimate of the actual percentage of larvae that would be entrained, and should be interpreted only as a comparisons of two pairs of operational scenarios (Existing and vs. PP and Existing vs. Refined Alternative 2b). The latest version of DSM2-PTM allows the user to not allow particles to be entrained into small agricultural diversions; this option was used for the present analysis in order to represent the hypothesis that such losses may not be substantial for Longfin Smelt (based on observations for delta smelt; Nobriga et al. 2004) and because losses at agricultural diversions were not the focus of the present analysis. In addition to reporting of the above fates, the percentage of particles remaining in the DSM2-PTM modeling domain after 45 -days (i.e., neither entrained nor having left the domain) was also calculated.

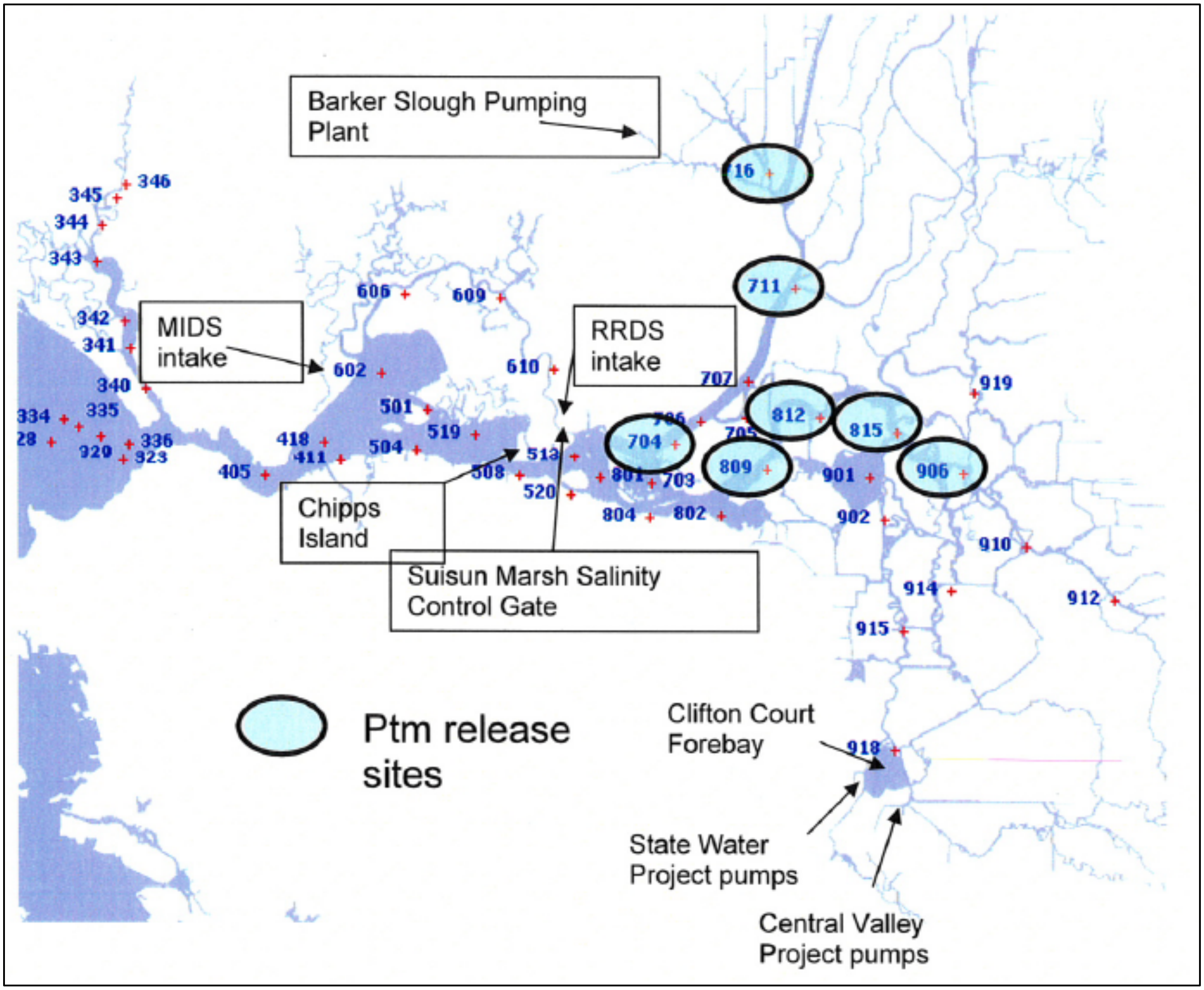
E.3.1.3 NOTE ON PROPORTION OF LARVAL POPULATION OUTSIDE THE DELTA AND SUISUN MARSH AND BAY

The spatial distribution of newly hatched larvae determined from the SLS is likely much broader than observed, especially during wet years. Grimaldo et al. (2014) recently showed that larval Longfin Smelt are hatching in shallow water and tidal marsh habitats in salinities up to 8 parts per thousand (ppt). Previously thought to concentrate spawning in freshwater (Rosenfield and Baxter 2007; California Department of Fish and Game 2009a,b; Kimmerer et al. 2009), the analysis presented here and work by Grimaldo et al. (2014) shows that Longfin Smelt hatching is broadly distributed throughout Suisun Bay in most years (Table E.3-2). The proportion of newly hatched larvae from Delta stations was consistently lower than densities observed in Suisun Bay. Further, because overall larval Longfin Smelt abundance in the SLS is lowest during wet years, it is likely that spawning and hatching is occurring in San Pablo Bay and adjacent tributaries (e.g., Napa River, Petaluma River) when the area becomes suitable for spawning. Ultimately, this does not affect interpretation of results presented here because relative comparisons of Existing, and PP, and Refined Alternative 2b were made using data for observations of larvae. The potential effects of survey bias would be more relevant for real-time operations where interpretation of proportional losses are likely to be affected by the observed versus actual distribution of larvae in the SLS survey.

E.3.1.4 DETAILED RESULTS FOR DFG (2009A) STATIONS OF INTEREST

To supplement the above analysis and provide some comparability with the DFG (2009a) effects analysis, PTM results were summarized for the seven particle injection stations analyzed by DFG (2009; Figure E.3--3). The results are presented below for Existing vs. PP in Tables E.3--5, E.3--6, E.3--7, E.3--8, E.3--9, E.3--10, E.3--11, E.3--12, E.3--13, E.3--14, E.3--15, E.3--16, E.3--17, and E.3--18; and for Existing vs. Refined Alternative 2b in Tables XE.3--5, XE.3--6, XE.3--7, XE.3--8, XE.3--9, XE.3--10, XE.3--11,

XE.3-‑12, XE.3-‑13, XE.3-‑14, XE.3-‑15, XE.3-‑16, XE.3-‑17, and XE.3-‑18. Note that these are 'raw' results, with no weighting as undertaken by DFG (2009a).



Source: DFG (2009a).

Figure E.3-3. Particle Tracking Injection (Release) Locations Used by DFG (2009a)

RESULTS FOR PROPOSED PROJECT

Table E.3-5. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-5 a - E.3-5 d

Table E.3-5 ba. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.33	0.35	0.02 (6%)
January	Above Normal	0.86	0.85	-0.01 (-2%)
January	Below Normal	1.90	1.84	-0.06 (-3%)
January	Dry	3.01	3.59	0.58 (19%)
January	Critical	3.32	3.55	0.23 (7%)
February	Wet	0.06	0.09	0.02 (36%)
February	Above Normal	0.29	0.24	-0.05 (-18%)
February	Below Normal	0.68	0.69	0.01 (2%)
February	Dry	1.39	1.58	0.19 (14%)
February	Critical	2.21	2.25	0.04 (2%)
March	Wet	0.09	0.06	-0.03 (-31%)
March	Above Normal	0.10	0.08	-0.03 (-26%)
March	Below Normal	0.51	0.38	-0.13 (-25%)
March	Dry	0.72	0.61	-0.11 (-15%)
March	Critical	0.97	1.19	0.23 (23%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-5 b. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.27	0.21	-0.06 (-24%)
January	Above Normal	0.75	0.84	0.09 (12%)
January	Below Normal	1.53	1.56	0.03 (2%)
January	Dry	2.92	3.23	0.31 (10%)
January	Critical	3.56	3.79	0.23 (7%)
February	Wet	0.06	0.05	-0.01 (-16%)
February	Above Normal	0.26	0.22	-0.04 (-15%)
February	Below Normal	0.56	0.57	0.01 (2%)
February	Dry	1.29	1.37	0.08 (6%)
February	Critical	2.38	2.54	0.16 (7%)
March	Wet	0.05	0.04	-0.01 (-25%)
March	Above Normal	0.06	0.06	-0.01 (-10%)
March	Below Normal	0.42	0.27	-0.15 (-36%)
March	Dry	0.75	0.49	-0.26 (-35%)
March	Critical	0.93	1.12	0.19 (20%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-5 c. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	1.54	1.53	-0.01 (-1%)
January	Above Normal	1.61	1.54	-0.07 (-5%)
January	Below Normal	1.91	1.78	-0.13 (-7%)
January	Dry	2.09	2.15	0.07 (3%)
January	Critical	1.74	1.69	-0.05 (-3%)
February	Wet	1.54	1.55	0.01 (1%)
February	Above Normal	1.58	1.50	-0.08 (-5%)
February	Below Normal	1.78	1.67	-0.11 (-6%)
February	Dry	1.44	1.44	0.00 (0%)
February	Critical	1.30	1.33	0.03 (3%)
March	Wet	1.47	1.46	-0.01 (-1%)
March	Above Normal	1.68	1.61	-0.07 (-4%)
March	Below Normal	2.08	2.07	-0.01 (0%)
March	Dry	1.52	1.45	-0.06 (-4%)
March	Critical	0.79	0.84	0.04 (6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-5 d. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	92.34	92.55	0.21 (0%)
January	Above Normal	86.53	87.23	0.70 (1%)
January	Below Normal	80.40	81.17	0.77 (1%)
January	Dry	68.70	66.79	-1.91 (-3%)
January	Critical	62.09	60.02	-2.08 (-3%)
February	Wet	93.90	93.89	-0.01 (0%)
February	Above Normal	91.41	91.86	0.46 (0%)
February	Below Normal	86.16	86.56	0.40 (0%)
February	Dry	79.71	79.43	-0.28 (0%)
February	Critical	67.77	67.99	0.22 (0%)
March	Wet	96.16	96.24	0.08 (0%)
March	Above Normal	95.87	95.88	0.00 (0%)
March	Below Normal	91.56	92.10	0.54 (1%)
March	Dry	86.49	87.15	0.66 (1%)
March	Critical	75.64	73.82	-1.82 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-6. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-6 ~~c~~ a - E.3-6 d

Table E.3-6 ~~d~~a. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	1.02	1.01	-0.01 (-1%)
January	Above Normal	0.98	1.03	0.05 (5%)
January	Below Normal	0.99	1.08	0.08 (8%)
January	Dry	0.37	0.38	0.01 (3%)
January	Critical	0.31	0.35	0.04 (12%)
February	Wet	0.76	0.56	-0.20 (-26%)
February	Above Normal	1.33	1.15	-0.17 (-13%)
February	Below Normal	1.20	1.10	-0.10 (-8%)
February	Dry	0.50	0.40	-0.10 (-20%)
February	Critical	0.24	0.21	-0.03 (-12%)
March	Wet	0.38	0.43	0.05 (12%)
March	Above Normal	0.48	0.48	0.00 (0%)
March	Below Normal	0.22	0.24	0.02 (7%)
March	Dry	0.24	0.23	-0.01 (-5%)
March	Critical	0.09	0.07	-0.01 (-15%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-6 b. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.87	0.78	-0.09 (-10%)
January	Above Normal	0.90	1.00	0.10 (11%)
January	Below Normal	0.85	1.10	0.24 (28%)
January	Dry	0.49	0.48	-0.01 (-3%)
January	Critical	0.45	0.44	-0.02 (-4%)
February	Wet	0.42	0.39	-0.03 (-7%)
February	Above Normal	1.10	1.15	0.04 (4%)
February	Below Normal	1.16	0.86	-0.30 (-26%)
February	Dry	0.79	0.73	-0.06 (-8%)
February	Critical	0.37	0.36	-0.01 (-4%)
March	Wet	0.21	0.27	0.06 (28%)
March	Above Normal	0.35	0.30	-0.05 (-13%)
March	Below Normal	0.22	0.19	-0.03 (-14%)
March	Dry	0.23	0.20	-0.03 (-12%)
March	Critical	0.09	0.16	0.08 (88%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-6 c. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	1.96	1.92	-0.04 (-2%)
January	Above Normal	2.77	2.59	-0.18 (-6%)
January	Below Normal	3.54	3.33	-0.21 (-6%)
January	Dry	2.90	2.90	0.00 (0%)
January	Critical	1.72	1.79	0.08 (4%)
February	Wet	1.77	1.72	-0.06 (-3%)
February	Above Normal	2.50	2.51	0.02 (1%)
February	Below Normal	3.01	2.92	-0.10 (-3%)
February	Dry	0.79	0.84	0.05 (6%)
February	Critical	0.35	0.54	0.19 (55%)
March	Wet	2.54	2.41	-0.13 (-5%)
March	Above Normal	3.28	3.08	-0.20 (-6%)
March	Below Normal	4.94	5.00	0.06 (1%)
March	Dry	1.25	1.26	0.01 (1%)
March	Critical	0.28	0.22	-0.06 (-20%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-6 d. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	73.50	74.51	1.02 (1%)
January	Above Normal	49.84	50.25	0.41 (1%)
January	Below Normal	11.72	13.57	1.86 (16%)
January	Dry	5.31	5.36	0.05 (1%)
January	Critical	0.10	0.14	0.04 (40%)
February	Wet	75.05	75.92	0.87 (1%)
February	Above Normal	57.91	59.16	1.25 (2%)
February	Below Normal	25.76	29.46	3.70 (14%)
February	Dry	8.62	8.95	0.33 (4%)
February	Critical	0.94	0.82	-0.11 (-12%)
March	Wet	61.93	62.46	0.53 (1%)
March	Above Normal	45.26	46.46	1.20 (3%)
March	Below Normal	4.23	4.21	-0.02 (-1%)
March	Dry	4.45	5.02	0.57 (13%)
March	Critical	0.80	0.64	-0.17 (-21%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-7. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-7 ~~e~~ a - E.3-7 d

Table E.3-7 ~~f~~a. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.42	0.39	-0.03 (-7%)
January	Above Normal	0.93	1.01	0.08 (8%)
January	Below Normal	2.39	2.46	0.07 (3%)
January	Dry	3.61	4.44	0.83 (23%)
January	Critical	4.02	4.46	0.44 (11%)
February	Wet	0.06	0.06	0.00 (8%)
February	Above Normal	0.35	0.28	-0.07 (-19%)
February	Below Normal	0.90	0.95	0.05 (6%)
February	Dry	1.81	1.94	0.13 (7%)
February	Critical	2.89	2.92	0.03 (1%)
March	Wet	0.10	0.06	-0.04 (-41%)
March	Above Normal	0.12	0.09	-0.03 (-27%)
March	Below Normal	0.67	0.40	-0.27 (-41%)
March	Dry	0.99	0.83	-0.16 (-16%)
March	Critical	1.20	1.78	0.57 (48%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-7 b. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.35	0.27	-0.08 (-23%)
January	Above Normal	0.89	0.93	0.04 (5%)
January	Below Normal	1.97	2.12	0.16 (8%)
January	Dry	3.51	3.71	0.19 (5%)
January	Critical	4.28	4.51	0.23 (5%)
February	Wet	0.06	0.04	-0.02 (-36%)
February	Above Normal	0.28	0.22	-0.06 (-22%)
February	Below Normal	0.81	0.79	-0.01 (-2%)
February	Dry	1.66	1.83	0.17 (10%)
February	Critical	3.16	3.24	0.08 (2%)
March	Wet	0.06	0.04	-0.03 (-43%)
March	Above Normal	0.09	0.06	-0.03 (-34%)
March	Below Normal	0.51	0.27	-0.24 (-47%)
March	Dry	0.96	0.67	-0.29 (-31%)
March	Critical	1.45	1.55	0.10 (7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-7 c. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.11	0.10	-0.02 (-14%)
January	Above Normal	0.26	0.24	-0.02 (-7%)
January	Below Normal	0.35	0.34	-0.01 (-2%)
January	Dry	0.40	0.45	0.05 (12%)
January	Critical	0.39	0.40	0.01 (2%)
February	Wet	0.05	0.05	0.00 (-2%)
February	Above Normal	0.12	0.12	0.00 (-2%)
February	Below Normal	0.27	0.25	-0.02 (-8%)
February	Dry	0.29	0.29	0.00 (1%)
February	Critical	0.24	0.29	0.05 (23%)
March	Wet	0.08	0.09	0.01 (11%)
March	Above Normal	0.11	0.11	0.00 (-2%)
March	Below Normal	0.36	0.36	0.00 (0%)
March	Dry	0.28	0.28	0.00 (0%)
March	Critical	0.17	0.18	0.02 (10%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-7 d. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	93.51	93.83	0.32 (0%)
January	Above Normal	88.03	88.57	0.54 (1%)
January	Below Normal	81.30	81.42	0.11 (0%)
January	Dry	70.49	68.92	-1.56 (-2%)
January	Critical	64.71	62.78	-1.93 (-3%)
February	Wet	95.62	95.68	0.06 (0%)
February	Above Normal	93.12	93.61	0.49 (1%)
February	Below Normal	88.05	88.19	0.14 (0%)
February	Dry	81.42	81.21	-0.21 (0%)
February	Critical	70.65	70.81	0.16 (0%)
March	Wet	98.38	98.39	0.02 (0%)
March	Above Normal	98.14	98.28	0.14 (0%)
March	Below Normal	95.73	96.58	0.85 (1%)
March	Dry	92.33	92.97	0.64 (1%)
March	Critical	84.48	82.83	-1.65 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-8. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing – Table E.3-8 a - d

Table E.3-8 ~~g~~a. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	4.44	4.46	0.02 (0%)
January	Above Normal	9.64	8.96	-0.69 (-7%)
January	Below Normal	14.73	15.18	0.45 (3%)
January	Dry	12.66	12.43	-0.24 (-2%)
January	Critical	10.36	9.99	-0.37 (-4%)
February	Wet	2.88	2.59	-0.29 (-10%)
February	Above Normal	6.62	6.15	-0.47 (-7%)
February	Below Normal	10.29	9.52	-0.77 (-7%)
February	Dry	12.98	12.61	-0.37 (-3%)
February	Critical	11.22	11.64	0.41 (4%)
March	Wet	3.04	3.42	0.38 (13%)
March	Above Normal	3.90	3.84	-0.06 (-2%)
March	Below Normal	9.38	10.26	0.88 (9%)
March	Dry	8.92	9.71	0.80 (9%)
March	Critical	5.55	7.37	1.81 (33%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-8 b. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.76	3.71	-0.05 (-1%)
January	Above Normal	9.21	8.97	-0.24 (-3%)
January	Below Normal	13.56	13.18	-0.38 (-3%)
January	Dry	14.75	14.29	-0.46 (-3%)
January	Critical	14.62	12.24	-2.39 (-16%)
February	Wet	2.09	1.79	-0.30 (-14%)
February	Above Normal	6.14	5.59	-0.54 (-9%)
February	Below Normal	8.65	8.32	-0.33 (-4%)
February	Dry	13.83	13.59	-0.25 (-2%)
February	Critical	14.04	15.00	0.96 (7%)
March	Wet	2.03	2.00	-0.04 (-2%)
March	Above Normal	3.12	2.70	-0.42 (-13%)
March	Below Normal	8.03	6.97	-1.06 (-13%)
March	Dry	10.85	9.40	-1.45 (-13%)
March	Critical	7.06	7.18	0.12 (2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-8 c. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.36	0.33	-0.03 (-8%)
January	Above Normal	0.94	0.77	-0.17 (-19%)
January	Below Normal	1.20	0.99	-0.21 (-18%)
January	Dry	1.38	1.40	0.02 (2%)
January	Critical	1.06	1.05	-0.01 (-1%)
February	Wet	0.08	0.09	0.00 (6%)
February	Above Normal	0.35	0.25	-0.10 (-29%)
February	Below Normal	0.72	0.63	-0.10 (-14%)
February	Dry	0.26	0.26	0.00 (1%)
February	Critical	0.12	0.20	0.07 (62%)
March	Wet	0.28	0.24	-0.04 (-15%)
March	Above Normal	0.34	0.38	0.04 (11%)
March	Below Normal	1.58	1.44	-0.14 (-9%)
March	Dry	0.48	0.39	-0.08 (-18%)
March	Critical	0.11	0.09	-0.02 (-16%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-8 d. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Passed Chipps Island

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	77.16	78.06	0.90 (1%)
January	Above Normal	51.37	52.42	1.05 (2%)
January	Below Normal	17.27	19.44	2.17 (13%)
January	Dry	6.41	6.26	-0.15 (-2%)
January	Critical	0.43	0.60	0.18 (41%)
February	Wet	83.65	84.15	0.51 (1%)
February	Above Normal	64.73	65.66	0.94 (1%)
February	Below Normal	40.83	43.19	2.36 (6%)
February	Dry	14.97	15.18	0.20 (1%)
February	Critical	2.63	2.68	0.05 (2%)
March	Wet	78.34	79.33	1.00 (1%)
March	Above Normal	69.90	72.93	3.03 (4%)
March	Below Normal	23.04	25.63	2.59 (11%)
March	Dry	11.47	12.57	1.10 (10%)
March	Critical	3.72	3.54	-0.18 (-5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-9. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing – Table E.3-9 a - E.3-9 d

Table E.3-9 ~~b~~a. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.01	0.01	0.00 (8%)
January	Above Normal	0.04	0.05	0.01 (41%)
January	Below Normal	0.12	0.15	0.02 (17%)
January	Dry	0.16	0.22	0.06 (38%)
January	Critical	0.21	0.22	0.01 (4%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.01	0.00 (50%)
February	Below Normal	0.02	0.02	0.00 (-10%)
February	Dry	0.04	0.06	0.02 (43%)
February	Critical	0.10	0.10	0.00 (-4%)
March	Wet	0.00	0.00	0.00 (-100%)
March	Above Normal	0.00	0.00	0.00 (-100%)
March	Below Normal	0.01	0.01	0.00 (-40%)
March	Dry	0.02	0.02	0.00 (-20%)
March	Critical	0.03	0.05	0.02 (63%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-9 b. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.02	0.01	-0.01 (-35%)
January	Above Normal	0.03	0.05	0.03 (108%)
January	Below Normal	0.10	0.12	0.02 (24%)
January	Dry	0.17	0.24	0.07 (39%)
January	Critical	0.24	0.32	0.08 (32%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.01	0.02	0.01 (71%)
February	Dry	0.04	0.06	0.02 (56%)
February	Critical	0.15	0.12	-0.03 (-22%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.00	-0.01 (-80%)
March	Dry	0.02	0.01	-0.01 (-64%)
March	Critical	0.03	0.04	0.01 (19%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-9 c. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
anuary	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-9 d. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	94.87	95.04	0.17 (0%)
January	Above Normal	91.45	91.68	0.23 (0%)
January	Below Normal	86.50	86.74	0.24 (0%)
January	Dry	81.15	80.47	-0.68 (-1%)
January	Critical	78.49	76.51	-1.98 (-3%)
February	Wet	96.63	96.65	0.02 (0%)
February	Above Normal	94.68	95.07	0.39 (0%)
February	Below Normal	91.55	91.73	0.18 (0%)
February	Dry	87.77	87.71	-0.06 (0%)
February	Critical	81.69	81.90	0.21 (0%)
March	Wet	98.61	98.61	0.00 (0%)
March	Above Normal	98.65	98.60	-0.04 (0%)
March	Below Normal	99.17	99.17	0.01 (0%)
March	Dry	99.07	98.95	-0.13 (0%)
March	Critical	98.09	97.88	-0.21 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-10. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing – Table E.3-10 a - E.3-10 d

Table E.3-10 ia. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.16	2.70	-0.47 (-15%)
January	Above Normal	8.10	7.54	-0.56 (-7%)
January	Below Normal	15.90	16.41	0.51 (3%)
January	Dry	21.30	22.92	1.62 (8%)
January	Critical	21.36	21.80	0.44 (2%)
February	Wet	0.89	0.81	-0.08 (-9%)
February	Above Normal	3.93	3.10	-0.83 (-21%)
February	Below Normal	9.23	7.53	-1.70 (-18%)
February	Dry	14.24	13.41	-0.83 (-6%)
February	Critical	15.00	15.22	0.22 (1%)
March	Wet	0.77	1.20	0.43 (56%)
March	Above Normal	0.80	0.89	0.09 (11%)
March	Below Normal	4.93	7.86	2.92 (59%)
March	Dry	7.64	10.07	2.43 (32%)
March	Critical	9.31	12.14	2.82 (30%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-10 b. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	2.55	2.19	-0.37 (-14%)
January	Above Normal	7.48	7.57	0.09 (1%)
January	Below Normal	14.41	14.17	-0.24 (-2%)
January	Dry	24.50	25.08	0.58 (2%)
January	Critical	28.37	27.17	-1.20 (-4%)
February	Wet	0.84	0.54	-0.30 (-35%)
February	Above Normal	3.59	2.84	-0.75 (-21%)
February	Below Normal	6.82	6.60	-0.22 (-3%)
February	Dry	14.80	13.71	-1.09 (-7%)
February	Critical	19.48	20.42	0.94 (5%)
March	Wet	0.66	0.75	0.09 (13%)
March	Above Normal	0.87	0.78	-0.09 (-11%)
March	Below Normal	5.06	4.97	-0.10 (-2%)
March	Dry	10.03	7.95	-2.08 (-21%)
March	Critical	11.88	12.32	0.44 (4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-10 c. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (-100%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (-100%)
January	Dry	0.00	0.01	0.01 (600%)
January	Critical	0.01	0.00	-0.01 (-100%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.00	0.00 (-67%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-10 d. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	82.10	82.92	0.82 (1%)
January	Above Normal	56.95	59.00	2.06 (4%)
January	Below Normal	22.70	24.98	2.29 (10%)
January	Dry	6.46	6.41	-0.05 (-1%)
January	Critical	0.83	1.19	0.35 (43%)
February	Wet	88.98	89.12	0.15 (0%)
February	Above Normal	73.33	74.77	1.45 (2%)
February	Below Normal	49.97	51.99	2.02 (4%)
February	Dry	20.67	20.91	0.23 (1%)
February	Critical	3.80	4.10	0.29 (8%)
March	Wet	86.52	87.19	0.67 (1%)
March	Above Normal	84.57	86.75	2.18 (3%)
March	Below Normal	37.35	41.07	3.72 (10%)
March	Dry	17.83	20.73	2.90 (16%)
March	Critical	6.53	6.36	-0.17 (-3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-11. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-11 j a - E.3-11 d

Table E.3-11 ka. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.96	0.89	-0.06 (-7%)
January	Above Normal	1.99	2.15	0.16 (8%)
January	Below Normal	4.35	4.57	0.22 (5%)
January	Dry	6.86	7.98	1.12 (16%)
January	Critical	6.85	7.22	0.37 (5%)
February	Wet	0.22	0.22	0.01 (3%)
February	Above Normal	0.97	0.86	-0.11 (-12%)
February	Below Normal	2.01	2.06	0.06 (3%)
February	Dry	4.00	4.22	0.22 (5%)
February	Critical	5.68	5.84	0.16 (3%)
March	Wet	0.26	0.17	-0.09 (-34%)
March	Above Normal	0.37	0.24	-0.12 (-34%)
March	Below Normal	1.53	1.01	-0.52 (-34%)
March	Dry	2.11	1.61	-0.50 (-24%)
March	Critical	2.43	3.19	0.76 (31%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-11 b. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.77	0.70	-0.08 (-10%)
January	Above Normal	1.81	2.17	0.35 (20%)
January	Below Normal	3.85	4.08	0.23 (6%)
January	Dry	6.51	6.95	0.44 (7%)
January	Critical	7.34	7.34	0.00 (0%)
February	Wet	0.15	0.14	-0.02 (-11%)
February	Above Normal	0.81	0.78	-0.03 (-4%)
February	Below Normal	1.71	1.87	0.15 (9%)
February	Dry	3.51	3.85	0.34 (10%)
February	Critical	5.87	6.25	0.38 (6%)
March	Wet	0.17	0.10	-0.07 (-39%)
March	Above Normal	0.26	0.13	-0.13 (-50%)
March	Below Normal	1.16	0.72	-0.43 (-37%)
March	Dry	2.04	1.38	-0.67 (-33%)
March	Critical	2.56	2.92	0.36 (14%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-11 c. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-11 d. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	93.10	93.42	0.32 (0%)
January	Above Normal	86.18	86.39	0.21 (0%)
January	Below Normal	77.81	78.24	0.43 (1%)
January	Dry	64.65	62.47	-2.18 (-3%)
January	Critical	59.64	57.83	-1.81 (-3%)
February	Wet	95.87	96.01	0.14 (0%)
February	Above Normal	91.84	92.50	0.67 (1%)
February	Below Normal	86.08	86.16	0.08 (0%)
February	Dry	77.42	76.98	-0.44 (-1%)
February	Critical	64.72	64.28	-0.44 (-1%)
March	Wet	98.38	98.58	0.20 (0%)
March	Above Normal	97.95	98.28	0.33 (0%)
March	Below Normal	94.37	95.99	1.62 (2%)
March	Dry	89.18	91.17	1.98 (2%)
March	Critical	81.11	78.27	-2.84 (-4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-12. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-12 l a - E.3-12 hd

Table E.3-12 ma. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	13.49	13.39	-0.10 (-1%)
January	Above Normal	23.36	23.49	0.13 (1%)
January	Below Normal	37.59	38.78	1.18 (3%)
January	Dry	37.53	39.73	2.21 (6%)
January	Critical	34.41	36.73	2.32 (7%)
February	Wet	8.50	7.62	-0.88 (-10%)
February	Above Normal	18.99	17.61	-1.38 (-7%)
February	Below Normal	28.53	26.42	-2.12 (-7%)
February	Dry	34.66	34.40	-0.27 (-1%)
February	Critical	33.24	33.50	0.26 (1%)
March	Wet	9.05	9.78	0.73 (8%)
March	Above Normal	12.68	12.21	-0.47 (-4%)
March	Below Normal	26.79	30.06	3.27 (12%)
March	Dry	29.40	30.84	1.44 (5%)
March	Critical	22.12	26.04	3.92 (18%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-12 b. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	11.54	10.74	-0.80 (-7%)
January	Above Normal	23.63	23.60	-0.03 (0%)
January	Below Normal	36.47	35.45	-1.01 (-3%)
January	Dry	43.67	42.91	-0.76 (-2%)
January	Critical	47.84	44.31	-3.53 (-7%)
February	Wet	6.05	5.14	-0.91 (-15%)
February	Above Normal	16.51	15.15	-1.36 (-8%)
February	Below Normal	25.05	23.41	-1.64 (-7%)
February	Dry	38.72	38.03	-0.69 (-2%)
February	Critical	42.67	43.76	1.09 (3%)
March	Wet	5.79	5.75	-0.04 (-1%)
March	Above Normal	10.08	7.82	-2.26 (-22%)
March	Below Normal	22.04	19.37	-2.67 (-12%)
March	Dry	33.57	29.03	-4.54 (-14%)
March	Critical	31.73	32.54	0.81 (3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-12 c. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (-100%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.01	0.00 (50%)
January	Dry	0.01	0.01	0.00 (0%)
January	Critical	0.00	0.00	0.00 (-100%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (-100%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.01	-0.01 (-38%)
March	Dry	0.00	0.00	0.00 (50%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-12 d. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	63.60	64.38	0.78 (1%)
January	Above Normal	35.21	35.65	0.44 (1%)
January	Below Normal	5.17	5.42	0.24 (5%)
January	Dry	1.15	1.12	-0.03 (-3%)
January	Critical	0.08	0.10	0.02 (24%)
February	Wet	74.93	76.17	1.23 (2%)
February	Above Normal	46.38	46.88	0.50 (1%)
February	Below Normal	23.16	25.54	2.38 (10%)
February	Dry	4.13	3.57	-0.56 (-13%)
February	Critical	0.44	0.50	0.06 (15%)
March	Wet	64.99	66.54	1.54 (2%)
March	Above Normal	48.39	54.24	5.85 (12%)
March	Below Normal	9.62	11.94	2.32 (24%)
March	Dry	2.08	3.03	0.95 (46%)
March	Critical	0.70	0.59	-0.11 (-16%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-13. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-13 ~~n~~ a - E.3-13 d

Table E.3-13 ~~o~~a. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	5.86	5.79	-0.07 (-1%)
January	Above Normal	11.13	11.31	0.18 (2%)
January	Below Normal	19.01	19.51	0.50 (3%)
January	Dry	25.27	27.88	2.61 (10%)
January	Critical	24.64	26.25	1.61 (7%)
February	Wet	3.37	3.22	-0.15 (-4%)
February	Above Normal	7.90	7.52	-0.38 (-5%)
February	Below Normal	11.82	11.91	0.09 (1%)
February	Dry	19.67	20.61	0.94 (5%)
February	Critical	22.67	23.41	0.74 (3%)
March	Wet	3.24	2.13	-1.12 (-34%)
March	Above Normal	4.80	2.86	-1.94 (-40%)
March	Below Normal	11.17	7.88	-3.29 (-29%)
March	Dry	14.17	10.61	-3.55 (-25%)
March	Critical	12.30	15.02	2.72 (22%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-13 b. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	4.52	4.30	-0.21 (-5%)
January	Above Normal	9.55	9.68	0.12 (1%)
January	Below Normal	15.97	15.99	0.03 (0%)
January	Dry	23.43	24.19	0.76 (3%)
January	Critical	26.37	25.15	-1.22 (-5%)
February	Wet	2.19	1.89	-0.30 (-14%)
February	Above Normal	6.11	5.99	-0.11 (-2%)
February	Below Normal	9.38	9.43	0.05 (1%)
February	Dry	17.16	17.75	0.59 (3%)
February	Critical	23.38	23.66	0.28 (1%)
March	Wet	1.66	1.03	-0.63 (-38%)
March	Above Normal	3.15	1.74	-1.41 (-45%)
March	Below Normal	7.79	4.85	-2.93 (-38%)
March	Dry	12.89	8.82	-4.07 (-32%)
March	Critical	12.85	14.38	1.53 (12%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-13 c. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-13 d. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	84.70	84.90	0.20 (0%)
January	Above Normal	69.76	69.96	0.20 (0%)
January	Below Normal	51.08	51.50	0.42 (1%)
January	Dry	30.00	27.74	-2.26 (-8%)
January	Critical	22.89	23.22	0.33 (1%)
February	Wet	90.30	90.79	0.49 (1%)
February	Above Normal	79.31	80.01	0.71 (1%)
February	Below Normal	66.57	66.76	0.20 (0%)
February	Dry	44.38	43.28	-1.10 (-2%)
February	Critical	26.43	26.40	-0.02 (0%)
March	Wet	92.89	94.74	1.85 (2%)
March	Above Normal	88.53	92.27	3.74 (4%)
March	Below Normal	68.22	75.35	7.14 (10%)
March	Dry	48.74	56.86	8.13 (17%)
March	Critical	35.72	32.15	-3.56 (-10%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-14. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-14 ~~p~~ a - E.3-14 d

Table E.3-14 ~~q~~a. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	27.52	28.22	0.70 (3%)
January	Above Normal	35.75	35.86	0.11 (0%)
January	Below Normal	44.07	45.30	1.23 (3%)
January	Dry	41.57	43.84	2.27 (5%)
January	Critical	36.92	40.56	3.64 (10%)
February	Wet	24.75	22.78	-1.97 (-8%)
February	Above Normal	35.94	34.19	-1.75 (-5%)
February	Below Normal	41.13	40.69	-0.44 (-1%)
February	Dry	41.31	40.94	-0.37 (-1%)
February	Critical	37.44	37.65	0.21 (1%)
March	Wet	23.36	22.69	-0.67 (-3%)
March	Above Normal	31.33	30.93	-0.40 (-1%)
March	Below Normal	41.44	43.47	2.03 (5%)
March	Dry	37.84	39.04	1.21 (3%)
March	Critical	27.63	30.91	3.28 (12%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-14 b. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	22.36	20.65	-1.71 (-8%)
January	Above Normal	35.83	35.77	-0.06 (0%)
January	Below Normal	43.55	42.99	-0.56 (-1%)
January	Dry	48.32	46.85	-1.47 (-3%)
January	Critical	52.50	48.43	-4.07 (-8%)
February	Wet	14.57	13.31	-1.25 (-9%)
February	Above Normal	27.66	27.39	-0.26 (-1%)
February	Below Normal	33.57	32.28	-1.29 (-4%)
February	Dry	45.95	45.79	-0.16 (0%)
February	Critical	48.36	49.10	0.74 (2%)
March	Wet	11.31	11.33	0.03 (0%)
March	Above Normal	20.77	18.79	-1.98 (-10%)
March	Below Normal	30.30	27.36	-2.94 (-10%)
March	Dry	41.88	38.35	-3.53 (-8%)
March	Critical	39.06	40.33	1.26 (3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-14 c. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-14 d. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	37.69	38.35	0.66 (2%)
January	Above Normal	14.72	14.45	-0.27 (-2%)
January	Below Normal	0.50	0.60	0.09 (19%)
January	Dry	0.04	0.06	0.02 (67%)
January	Critical	0.00	0.00	0.00 (-100%)
February	Wet	46.73	48.53	1.79 (4%)
February	Above Normal	20.70	21.47	0.76 (4%)
February	Below Normal	8.44	8.88	0.44 (5%)
February	Dry	0.21	0.20	-0.01 (-6%)
February	Critical	0.02	0.02	0.00 (-10%)
March	Wet	45.01	47.48	2.47 (5%)
March	Above Normal	20.38	23.49	3.12 (15%)
March	Below Normal	0.96	1.66	0.70 (72%)
March	Dry	0.15	0.26	0.10 (66%)
March	Critical	0.02	0.01	-0.01 (-50%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-15. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-15 ~~r~~ a - E.3-15 d

Table E.3-15 ~~s~~a. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	10.50	10.56	0.07 (1%)
January	Above Normal	16.79	16.76	-0.03 (0%)
January	Below Normal	24.77	25.68	0.91 (4%)
January	Dry	30.69	33.07	2.38 (8%)
January	Critical	29.09	30.61	1.53 (5%)
February	Wet	7.76	7.41	-0.36 (-5%)
February	Above Normal	13.66	13.10	-0.55 (-4%)
February	Below Normal	18.34	18.10	-0.24 (-1%)
February	Dry	25.23	26.77	1.53 (6%)
February	Critical	27.50	28.23	0.73 (3%)
March	Wet	7.57	5.04	-2.53 (-33%)
March	Above Normal	10.56	6.88	-3.68 (-35%)
March	Below Normal	17.83	13.06	-4.77 (-27%)
March	Dry	20.72	16.53	-4.19 (-20%)
March	Critical	15.85	18.83	2.98 (19%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-15 b. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	7.41	7.19	-0.22 (-3%)
January	Above Normal	13.71	14.29	0.58 (4%)
January	Below Normal	20.96	20.51	-0.45 (-2%)
January	Dry	28.27	28.71	0.43 (2%)
January	Critical	31.27	28.84	-2.42 (-8%)
February	Wet	4.38	4.00	-0.38 (-9%)
February	Above Normal	9.65	9.64	-0.01 (0%)
February	Below Normal	13.26	13.80	0.54 (4%)
February	Dry	22.80	23.26	0.46 (2%)
February	Critical	28.08	28.73	0.65 (2%)
March	Wet	3.46	2.24	-1.22 (-35%)
March	Above Normal	6.16	3.86	-2.30 (-37%)
March	Below Normal	11.99	7.97	-4.02 (-34%)
March	Dry	18.76	13.26	-5.50 (-29%)
March	Critical	16.66	18.57	1.91 (11%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-15 c. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-15 d. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	77.07	77.33	0.25 (0%)
January	Above Normal	60.64	60.59	-0.05 (0%)
January	Below Normal	42.34	42.76	0.42 (1%)
January	Dry	24.18	22.41	-1.77 (-7%)
January	Critical	18.78	19.94	1.16 (6%)
February	Wet	83.59	84.36	0.76 (1%)
February	Above Normal	70.48	71.05	0.58 (1%)
February	Below Normal	57.21	57.46	0.26 (0%)
February	Dry	36.41	34.70	-1.72 (-5%)
February	Critical	22.07	21.94	-0.13 (-1%)
March	Wet	86.43	90.30	3.87 (4%)
March	Above Normal	79.51	85.81	6.29 (8%)
March	Below Normal	58.72	67.13	8.41 (14%)
March	Dry	40.96	49.58	8.63 (21%)
March	Critical	33.43	29.57	-3.85 (-12%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-16. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-16 t a - E.3-16 d

Table E.3-16 ua. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	31.93	32.48	0.55 (2%)
January	Above Normal	38.64	39.35	0.70 (2%)
January	Below Normal	44.37	46.03	1.66 (4%)
January	Dry	41.76	44.49	2.73 (7%)
January	Critical	37.28	41.25	3.97 (11%)
February	Wet	30.86	29.30	-1.56 (-5%)
February	Above Normal	39.82	38.15	-1.67 (-4%)
February	Below Normal	44.31	43.77	-0.54 (-1%)
February	Dry	42.03	41.80	-0.23 (-1%)
February	Critical	38.20	38.47	0.27 (1%)
March	Wet	30.29	28.31	-1.98 (-7%)
March	Above Normal	36.59	35.40	-1.19 (-3%)
March	Below Normal	44.56	46.08	1.52 (3%)
March	Dry	39.14	40.51	1.37 (4%)
March	Critical	28.69	31.70	3.01 (10%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-16 b. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	24.92	23.34	-1.58 (-6%)
January	Above Normal	37.68	37.45	-0.23 (-1%)
January	Below Normal	44.49	43.48	-1.01 (-2%)
January	Dry	49.38	47.42	-1.95 (-4%)
January	Critical	53.48	48.65	-4.83 (-9%)
February	Wet	17.04	15.39	-1.65 (-10%)
February	Above Normal	29.33	28.77	-0.55 (-2%)
February	Below Normal	34.62	33.71	-0.91 (-3%)
February	Dry	47.01	46.94	-0.07 (0%)
February	Critical	49.47	50.00	0.53 (1%)
March	Wet	12.93	12.67	-0.26 (-2%)
March	Above Normal	22.68	20.64	-2.04 (-9%)
March	Below Normal	31.32	28.40	-2.93 (-9%)
March	Dry	43.37	39.86	-3.51 (-8%)
March	Critical	40.29	41.57	1.27 (3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-16 c. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-16 d. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	32.66	33.54	0.88 (3%)
January	Above Normal	12.21	11.88	-0.33 (-3%)
January	Below Normal	0.47	0.48	0.01 (2%)
January	Dry	0.05	0.05	0.00 (-8%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	40.61	42.63	2.02 (5%)
February	Above Normal	17.95	19.15	1.19 (7%)
February	Below Normal	7.32	7.79	0.47 (6%)
February	Dry	0.24	0.17	-0.06 (-26%)
February	Critical	0.02	0.01	-0.01 (-64%)
March	Wet	40.15	43.38	3.23 (8%)
March	Above Normal	17.53	20.71	3.18 (18%)
March	Below Normal	1.00	1.86	0.86 (86%)
March	Dry	0.12	0.18	0.06 (48%)
March	Critical	0.02	0.02	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-17. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-17 a~~v~~ - E.3-17 d

Table E.3-17 ~~w~~a. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	28.64	28.61	-0.03 (0%)
January	Above Normal	37.74	38.20	0.46 (1%)
January	Below Normal	44.61	45.81	1.20 (3%)
January	Dry	47.66	50.32	2.66 (6%)
January	Critical	42.85	46.20	3.35 (8%)
February	Wet	24.46	23.40	-1.06 (-4%)
February	Above Normal	33.36	33.35	-0.01 (0%)
February	Below Normal	39.56	40.07	0.51 (1%)
February	Dry	46.52	46.70	0.18 (0%)
February	Critical	44.61	45.08	0.47 (1%)
March	Wet	22.38	17.07	-5.31 (-24%)
March	Above Normal	29.93	22.72	-7.21 (-24%)
March	Below Normal	39.47	34.50	-4.97 (-13%)
March	Dry	42.91	39.14	-3.77 (-9%)
March	Critical	31.15	34.07	2.92 (9%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-17 b. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	19.13	18.19	-0.94 (-5%)
January	Above Normal	29.91	30.38	0.48 (2%)
January	Below Normal	36.99	36.63	-0.36 (-1%)
January	Dry	43.60	42.31	-1.29 (-3%)
January	Critical	46.92	42.01	-4.91 (-10%)
February	Wet	12.79	11.81	-0.98 (-8%)
February	Above Normal	22.62	22.59	-0.04 (0%)
February	Below Normal	28.39	27.78	-0.61 (-2%)
February	Dry	41.41	42.35	0.94 (2%)
February	Critical	45.54	45.47	-0.07 (0%)
March	Wet	9.08	7.22	-1.86 (-20%)
March	Above Normal	16.64	12.01	-4.62 (-28%)
March	Below Normal	25.32	19.85	-5.48 (-22%)
March	Dry	37.94	32.21	-5.73 (-15%)
March	Critical	33.77	35.45	1.68 (5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-17 c. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-17 d. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	47.95	48.93	0.98 (2%)
January	Above Normal	26.91	26.20	-0.71 (-3%)
January	Below Normal	11.24	10.91	-0.33 (-3%)
January	Dry	2.82	2.45	-0.38 (-13%)
January	Critical	1.82	2.98	1.16 (63%)
February	Wet	58.82	60.70	1.87 (3%)
February	Above Normal	39.47	39.53	0.06 (0%)
February	Below Normal	25.86	25.82	-0.04 (0%)
February	Dry	5.65	4.73	-0.92 (-16%)
February	Critical	2.06	2.01	-0.05 (-2%)
March	Wet	64.79	72.08	7.29 (11%)
March	Above Normal	47.99	59.81	11.82 (25%)
March	Below Normal	25.84	33.67	7.83 (30%)
March	Dry	6.47	11.77	5.31 (82%)
March	Critical	7.47	5.49	-1.98 (-27%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-18. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Proposed Project vs. Existing - Table E.3-18 x a - E.3-18 d

Table E.3-18 ya. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	42.84	42.95	0.11 (0%)
January	Above Normal	47.30	47.00	-0.30 (-1%)
January	Below Normal	46.25	47.74	1.49 (3%)
January	Dry	43.19	46.29	3.10 (7%)
January	Critical	37.85	42.56	4.71 (12%)
February	Wet	43.95	42.07	-1.88 (-4%)
February	Above Normal	49.26	48.23	-1.03 (-2%)
February	Below Normal	51.22	51.21	-0.01 (0%)
February	Dry	44.28	44.17	-0.11 (0%)
February	Critical	40.14	40.51	0.37 (1%)
March	Wet	43.50	40.92	-2.58 (-6%)
March	Above Normal	50.03	50.34	0.31 (1%)
March	Below Normal	52.20	53.97	1.77 (3%)
March	Dry	42.98	44.30	1.32 (3%)
March	Critical	32.22	34.48	2.26 (7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-18 b. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	32.30	30.85	-1.45 (-5%)
January	Above Normal	43.51	43.57	0.06 (0%)
January	Below Normal	46.74	45.69	-1.05 (-2%)
January	Dry	50.53	48.25	-2.28 (-5%)
January	Critical	55.34	49.81	-5.53 (-10%)
February	Wet	23.02	21.17	-1.85 (-8%)
February	Above Normal	35.54	35.53	-0.01 (0%)
February	Below Normal	38.54	38.11	-0.43 (-1%)
February	Dry	49.94	50.08	0.14 (0%)
February	Critical	52.52	53.27	0.75 (1%)
March	Wet	16.71	16.24	-0.47 (-3%)
March	Above Normal	29.72	28.46	-1.26 (-4%)
March	Below Normal	36.15	32.62	-3.53 (-10%)
March	Dry	46.77	44.21	-2.55 (-5%)
March	Critical	44.07	45.98	1.91 (4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-18 c. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table E.3-18 d. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	18.47	19.63	1.16 (6%)
January	Above Normal	3.87	3.85	-0.02 (-1%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	26.10	28.71	2.61 (10%)
February	Above Normal	9.70	11.29	1.59 (16%)
February	Below Normal	3.27	3.54	0.27 (8%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	29.60	32.61	3.01 (10%)
March	Above Normal	8.65	8.90	0.25 (3%)
March	Below Normal	0.16	1.04	0.88 (536%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

RESULTS FOR REFINED ALTERNATIVE 2b

Table XE.3-5. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-5 b - E.3-5 d

Table XE.3-5 a. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.33	0.33	0.01 (2%)
January	Above Normal	0.86	0.92	0.06 (7%)
January	Below Normal	1.90	1.80	-0.10 (-5%)
January	Dry	3.01	3.49	0.48 (16%)
January	Critical	3.32	3.38	0.06 (2%)
February	Wet	0.06	0.08	0.01 (22%)
February	Above Normal	0.29	0.24	-0.05 (-18%)
February	Below Normal	0.68	0.61	-0.07 (-10%)
February	Dry	1.39	1.50	0.11 (8%)
February	Critical	2.21	2.07	-0.15 (-7%)
March	Wet	0.09	0.08	-0.02 (-18%)
March	Above Normal	0.10	0.06	-0.05 (-44%)
March	Below Normal	0.51	0.28	-0.23 (-45%)
March	Dry	0.72	0.45	-0.27 (-38%)
March	Critical	0.97	0.87	-0.10 (-10%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-5 b. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.27	0.24	-0.03 (-13%)
January	Above Normal	0.75	0.82	0.07 (10%)
January	Below Normal	1.53	1.59	0.06 (4%)
January	Dry	2.92	3.18	0.26 (9%)
January	Critical	3.56	3.57	0.01 (0%)
February	Wet	0.06	0.05	-0.01 (-21%)
February	Above Normal	0.26	0.21	-0.05 (-21%)
February	Below Normal	0.56	0.65	0.09 (17%)
February	Dry	1.29	1.35	0.06 (5%)
February	Critical	2.38	2.56	0.18 (7%)
March	Wet	0.05	0.04	-0.01 (-27%)
March	Above Normal	0.06	0.06	0.00 (-3%)
March	Below Normal	0.42	0.28	-0.15 (-35%)
March	Dry	0.75	0.47	-0.28 (-37%)
March	Critical	0.93	1.09	0.15 (16%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-5 c. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	1.54	1.46	-0.08 (-5%)
January	Above Normal	1.61	1.60	-0.01 (-1%)
January	Below Normal	1.91	1.76	-0.15 (-8%)
January	Dry	2.09	2.03	-0.06 (-3%)
January	Critical	1.74	1.77	0.03 (2%)
February	Wet	1.54	1.50	-0.04 (-2%)
February	Above Normal	1.58	1.61	0.03 (2%)
February	Below Normal	1.78	1.83	0.05 (3%)
February	Dry	1.44	1.40	-0.05 (-3%)
February	Critical	1.30	1.15	-0.14 (-11%)
March	Wet	1.47	1.49	0.02 (1%)
March	Above Normal	1.68	1.57	-0.11 (-7%)
March	Below Normal	2.08	2.06	-0.02 (-1%)
March	Dry	1.52	1.35	-0.16 (-11%)
March	Critical	0.79	0.82	0.03 (4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-5 d. Percentage of Neutrally Buoyant Particles Injected at Station 716 (Cache Slough at Liberty Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	92.34	92.51	0.17 (0%)
January	Above Normal	86.53	87.13	0.60 (1%)
January	Below Normal	80.40	81.36	0.96 (1%)
January	Dry	68.70	66.94	-1.76 (-3%)
January	Critical	62.09	60.22	-1.87 (-3%)
February	Wet	93.90	93.94	0.04 (0%)
February	Above Normal	91.41	91.78	0.38 (0%)
February	Below Normal	86.16	86.22	0.06 (0%)
February	Dry	79.71	79.40	-0.31 (0%)
February	Critical	67.77	68.20	0.43 (1%)
March	Wet	96.16	96.20	0.05 (0%)
March	Above Normal	95.87	95.96	0.08 (0%)
March	Below Normal	91.56	92.35	0.78 (1%)
March	Dry	86.49	87.41	0.92 (1%)
March	Critical	75.64	74.46	-1.18 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-6. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-6 a - E.3-6 d

Table XE.3-6 a. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	1.02	1.02	0.00 (0%)
January	Above Normal	0.98	1.04	0.06 (6%)
January	Below Normal	0.99	1.24	0.25 (25%)
January	Dry	0.37	0.42	0.05 (14%)
January	Critical	0.31	0.30	-0.01 (-3%)
February	Wet	0.76	0.60	-0.16 (-21%)
February	Above Normal	1.33	1.25	-0.07 (-6%)
February	Below Normal	1.20	1.03	-0.17 (-14%)
February	Dry	0.50	0.41	-0.09 (-18%)
February	Critical	0.24	0.29	0.05 (19%)
March	Wet	0.38	0.33	-0.05 (-14%)
March	Above Normal	0.48	0.32	-0.16 (-33%)
March	Below Normal	0.22	0.16	-0.06 (-29%)
March	Dry	0.24	0.12	-0.12 (-50%)
March	Critical	0.09	0.08	0.00 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-6 b. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.87	0.85	-0.02 (-3%)
January	Above Normal	0.90	1.03	0.13 (15%)
January	Below Normal	0.85	1.06	0.21 (24%)
January	Dry	0.49	0.47	-0.02 (-4%)
January	Critical	0.45	0.45	0.00 (0%)
February	Wet	0.42	0.40	-0.02 (-5%)
February	Above Normal	1.10	1.06	-0.04 (-4%)
February	Below Normal	1.16	0.87	-0.29 (-25%)
February	Dry	0.79	0.73	-0.06 (-7%)
February	Critical	0.37	0.38	0.00 (1%)
March	Wet	0.21	0.23	0.02 (10%)
March	Above Normal	0.35	0.40	0.05 (14%)
March	Below Normal	0.22	0.23	0.00 (2%)
March	Dry	0.23	0.24	0.01 (5%)
March	Critical	0.09	0.15	0.06 (71%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-6 c. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	1.96	1.89	-0.07 (-3%)
January	Above Normal	2.77	2.64	-0.12 (-4%)
January	Below Normal	3.54	3.34	-0.20 (-6%)
January	Dry	2.90	2.97	0.07 (2%)
January	Critical	1.72	1.88	0.17 (10%)
February	Wet	1.77	1.74	-0.03 (-2%)
February	Above Normal	2.50	2.49	-0.01 (0%)
February	Below Normal	3.01	2.98	-0.03 (-1%)
February	Dry	0.79	0.79	0.00 (0%)
February	Critical	0.35	0.42	0.08 (22%)
March	Wet	2.54	2.33	-0.21 (-8%)
March	Above Normal	3.28	3.10	-0.17 (-5%)
March	Below Normal	4.94	4.96	0.02 (1%)
March	Dry	1.25	1.17	-0.08 (-6%)
March	Critical	0.28	0.20	-0.08 (-29%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-6 d. Percentage of Surface-Oriented Particles Injected at Station 716 (Cache Slough at Liberty Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	73.50	74.65	1.15 (2%)
January	Above Normal	49.84	50.58	0.74 (1%)
January	Below Normal	11.72	13.24	1.52 (13%)
January	Dry	5.31	5.15	-0.16 (-3%)
January	Critical	0.10	0.12	0.02 (21%)
February	Wet	75.05	76.15	1.09 (1%)
February	Above Normal	57.91	58.81	0.90 (2%)
February	Below Normal	25.76	28.82	3.06 (12%)
February	Dry	8.62	8.79	0.17 (2%)
February	Critical	0.94	0.99	0.05 (5%)
March	Wet	61.93	62.58	0.65 (1%)
March	Above Normal	45.26	47.10	1.84 (4%)
March	Below Normal	4.23	3.87	-0.36 (-9%)
March	Dry	4.45	4.49	0.03 (1%)
March	Critical	0.80	0.64	-0.16 (-20%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-7. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-7 a - E.3-7 d

Table XE.3-7 a. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.42	0.39	-0.03 (-8%)
January	Above Normal	0.93	1.02	0.09 (10%)
January	Below Normal	2.39	2.26	-0.13 (-6%)
January	Dry	3.61	4.32	0.70 (19%)
January	Critical	4.02	3.97	3-0.05 (-1%)
February	Wet	0.06	0.07	0.01 (13%)
February	Above Normal	0.35	0.30	-0.05 (-14%)
February	Below Normal	0.90	0.90	0.00 (0%)
February	Dry	1.81	1.89	0.08 (5%)
February	Critical	2.89	2.79	-0.10 (-4%)
March	Wet	0.10	0.06	-0.05 (-43%)
March	Above Normal	0.12	0.05	-0.07 (-56%)
March	Below Normal	0.67	0.31	-0.37 (-54%)
March	Dry	0.99	0.61	-0.38 (-38%)
March	Critical	1.20	1.31	0.10 (9%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-7 b. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.35	0.28	-0.07 (-19%)
January	Above Normal	0.89	0.96	0.07 (7%)
January	Below Normal	1.97	1.98	0.01 (1%)
January	Dry	3.51	3.83	0.32 (9%)
January	Critical	4.28	4.24	-0.04 (-1%)
February	Wet	0.06	0.06	-0.01 (-9%)
February	Above Normal	0.28	0.23	-0.05 (-18%)
February	Below Normal	0.81	0.89	0.08 (10%)
February	Dry	1.66	1.79	0.13 (8%)
February	Critical	3.16	3.39	0.23 (7%)
March	Wet	0.06	0.03	-0.04 (-57%)
March	Above Normal	0.09	0.08	-0.01 (-7%)
March	Below Normal	0.51	0.32	-0.19 (-37%)
March	Dry	0.96	0.61	-0.35 (-37%)
March	Critical	1.45	1.51	0.06 (4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-7 c. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.11	0.08	-0.03 (-23%)
January	Above Normal	0.26	0.22	-0.04 (-14%)
January	Below Normal	0.35	0.32	-0.03 (-10%)
January	Dry	0.40	0.41	0.01 (3%)
January	Critical	0.39	0.42	0.03 (7%)
February	Wet	0.05	0.05	0.00 (2%)
February	Above Normal	0.12	0.11	-0.01 (-5%)
February	Below Normal	0.27	0.24	-0.03 (-11%)
February	Dry	0.29	0.25	-0.04 (-13%)
February	Critical	0.24	0.26	0.02 (10%)
March	Wet	0.08	0.09	0.01 (12%)
March	Above Normal	0.11	0.11	0.00 (2%)
March	Below Normal	0.36	0.32	-0.04 (-11%)
March	Dry	0.28	0.22	-0.06 (-21%)
March	Critical	0.17	0.19	0.02 (11%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-7 d. Percentage of Neutrally Buoyant Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	93.51	93.74	0.23 (0%)
January	Above Normal	88.03	88.34	0.31 (0%)
January	Below Normal	81.30	81.82	0.51 (1%)
January	Dry	70.49	68.94	-1.54 (-2%)
January	Critical	64.71	63.56	-1.15 (-2%)
February	Wet	95.62	95.60	-0.02 (0%)
February	Above Normal	93.12	93.34	0.22 (0%)
February	Below Normal	88.05	88.18	0.13 (0%)
February	Dry	81.42	81.24	-0.18 (0%)
February	Critical	70.65	70.68	0.02 (0%)
March	Wet	98.38	98.43	0.05 (0%)
March	Above Normal	98.14	98.26	0.12 (0%)
March	Below Normal	95.73	96.74	1.01 (1%)
March	Dry	92.33	93.17	0.84 (1%)
March	Critical	84.48	83.26	-1.22 (-1%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-8. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing – Table XE.3-8 a - d

Table XE.3-8 a. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	4.44	4.61	0.16 (4%)
January	Above Normal	9.64	8.83	-0.82 (-8%)
January	Below Normal	14.73	15.24	0.51 (3%)
January	Dry	12.66	12.38	-0.28 (-2%)
January	Critical	10.36	9.33	-1.03 (-10%)
February	Wet	2.88	2.59	-0.29 (-10%)
February	Above Normal	6.62	6.10	-0.52 (-8%)
February	Below Normal	10.29	9.09	-1.20 (-12%)
February	Dry	12.98	12.73	-0.25 (-2%)
February	Critical	11.22	10.87	-0.35 (-3%)
March	Wet	3.04	2.92	-0.12 (-4%)
March	Above Normal	3.90	2.62	-1.27 (-33%)
March	Below Normal	9.38	6.98	-2.41 (-26%)
March	Dry	8.92	7.04	-1.88 (-21%)
March	Critical	5.55	5.24	-0.31 (-6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-8 b. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	3.76	3.74	-0.02 (-1%)
January	Above Normal	9.21	8.80	-0.41 (-4%)
January	Below Normal	13.56	12.83	-0.73 (-5%)
January	Dry	14.75	14.52	-0.23 (-2%)
January	Critical	14.62	12.38	-2.25 (-15%)
February	Wet	2.09	1.72	-0.37 (-18%)
February	Above Normal	6.14	5.52	-0.62 (-10%)
February	Below Normal	8.65	8.71	0.06 (1%)
February	Dry	13.83	12.98	-0.86 (-6%)
February	Critical	14.04	15.23	1.19 (8%)
March	Wet	2.03	2.04	0.00 (0%)
March	Above Normal	3.12	2.73	-0.39 (-12%)
March	Below Normal	8.03	8.09	0.05 (1%)
March	Dry	10.85	9.64	-1.21 (-11%)
March	Critical	7.06	8.09	1.04 (15%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-8 c. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.36	0.33	-0.03 (-8%)
January	Above Normal	0.94	0.89	-0.05 (-6%)
January	Below Normal	1.20	0.98	-0.22 (-19%)
January	Dry	1.38	1.41	0.03 (2%)
January	Critical	1.06	1.07	0.01 (1%)
February	Wet	0.08	0.10	0.02 (23%)
February	Above Normal	0.35	0.29	-0.05 (-16%)
February	Below Normal	0.72	0.78	0.06 (8%)
February	Dry	0.26	0.30	0.04 (15%)
February	Critical	0.12	0.17	0.05 (38%)
March	Wet	0.28	0.26	-0.02 (-8%)
March	Above Normal	0.34	0.36	0.02 (5%)
March	Below Normal	1.58	1.44	-0.14 (-9%)
March	Dry	0.48	0.33	-0.14 (-30%)
March	Critical	0.11	0.06	-0.04 (-41%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-8 d. Percentage of Surface-Oriented Particles Injected at Station 711 (Sacramento River near Cache Slough confluence) That Passed Chipps Island

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	77.16	77.76	0.60 (1%)
January	Above Normal	51.37	52.45	1.08 (2%)
January	Below Normal	17.27	19.79	2.52 (15%)
January	Dry	6.41	6.17	-0.24 (-4%)
January	Critical	0.43	0.46	0.03 (8%)
February	Wet	83.65	84.35	0.71 (1%)
February	Above Normal	64.73	65.82	1.10 (2%)
February	Below Normal	40.83	42.67	1.84 (5%)
February	Dry	14.97	14.93	-0.05 (0%)
February	Critical	2.63	2.72	0.09 (3%)
March	Wet	78.34	79.57	1.23 (2%)
March	Above Normal	69.90	73.35	3.45 (5%)
March	Below Normal	23.04	25.96	2.91 (13%)
March	Dry	11.47	12.77	1.30 (11%)
March	Critical	3.72	3.64	-0.08 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-9. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing – Table XE.3-9 a - E.3-9 d

Table XE.3-9 a. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.01	0.01	0.00 (-15%)
January	Above Normal	0.04	0.03	-0.01 (-18%)
January	Below Normal	0.12	0.13	0.00 (1%)
January	Dry	0.16	0.22	0.06 (38%)
January	Critical	0.21	0.21	0.00 (2%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.01	0.00 (50%)
February	Below Normal	0.02	0.02	0.00 (-10%)
February	Dry	0.04	0.05	0.01 (30%)
February	Critical	0.10	0.09	-0.01 (-14%)
March	Wet	0.00	0.00	0.00 (-100%)
March	Above Normal	0.00	0.00	0.00 (-100%)
March	Below Normal	0.01	0.01	0.00 (40%)
March	Dry	0.02	0.02	-0.01 (-27%)
March	Critical	0.03	0.03	0.00 (-6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-9 b. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.02	0.01	-0.01 (-35%)
January	Above Normal	0.03	0.05	0.03 (100%)
January	Below Normal	0.10	0.10	0.00 (2%)
January	Dry	0.17	0.21	0.04 (26%)
January	Critical	0.24	0.26	0.02 (8%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.01	0.02	0.01 (43%)
February	Dry	0.04	0.06	0.02 (63%)
February	Critical	0.15	0.15	0.00 (-1%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.01	0.00 (-20%)
March	Dry	0.02	0.01	-0.01 (-36%)
March	Critical	0.03	0.04	0.01 (31%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-9 c. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-9 d. Percentage of Neutrally Buoyant Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	94.87	95.07	0.21 (0%)
January	Above Normal	91.45	91.70	0.25 (0%)
January	Below Normal	86.50	86.87	0.36 (0%)
January	Dry	81.15	80.33	-0.82 (-1%)
January	Critical	78.49	76.96	-1.52 (-2%)
February	Wet	96.63	96.69	0.06 (0%)
February	Above Normal	94.68	95.14	0.46 (0%)
February	Below Normal	91.55	91.74	0.19 (0%)
February	Dry	87.77	87.54	-0.23 (0%)
February	Critical	81.69	81.98	0.29 (0%)
March	Wet	98.61	98.58	-0.03 (0%)
March	Above Normal	98.65	98.62	-0.03 (0%)
March	Below Normal	99.17	99.13	-0.04 (0%)
March	Dry	99.07	99.05	-0.02 (0%)
March	Critical	98.09	98.01	-0.08 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-10. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing – Table XE.3-10 a - E.3-10 d

Table XE.3-10 a. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	3.16	2.73	-0.43 (-14%)
January	Above Normal	8.10	7.64	-0.46 (-6%)
January	Below Normal	15.90	15.93	0.03 (0%)
January	Dry	21.30	22.84	1.54 (7%)
January	Critical	21.36	21.33	-0.03 (0%)
February	Wet	0.89	0.85	-0.04 (-5%)
February	Above Normal	3.93	3.05	-0.88 (-22%)
February	Below Normal	9.23	6.96	-2.26 (-25%)
February	Dry	14.24	13.34	-0.90 (-6%)
February	Critical	15.00	14.22	-0.78 (-5%)
March	Wet	0.77	0.92	0.14 (19%)
March	Above Normal	0.80	0.44	-0.35 (-44%)
March	Below Normal	4.93	3.74	-1.19 (-24%)
March	Dry	7.64	5.75	-1.89 (-25%)
March	Critical	9.31	8.19	-1.13 (-12%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-10 b. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	2.55	2.23	-0.32 (-13%)
January	Above Normal	7.48	7.64	0.16 (2%)
January	Below Normal	14.41	13.93	-0.48 (-3%)
January	Dry	24.50	25.31	0.80 (3%)
January	Critical	28.37	26.98	-1.38 (-5%)
February	Wet	0.84	0.57	-0.27 (-32%)
February	Above Normal	3.59	2.99	-0.60 (-17%)
February	Below Normal	6.82	7.26	0.44 (7%)
February	Dry	14.80	13.50	-1.30 (-9%)
February	Critical	19.48	21.28	1.80 (9%)
March	Wet	0.66	0.75	0.09 (14%)
March	Above Normal	0.87	0.67	-0.20 (-23%)
March	Below Normal	5.06	5.16	0.10 (2%)
March	Dry	10.03	8.08	-1.95 (-19%)
March	Critical	11.88	11.64	-0.24 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-10 c. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (-100%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.01	0.01 (300%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.01	0.00	0.00 (-50%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.01	0.01 (100%)
March	Dry	0.00	0.00	0.00 (-100%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-10 d. Percentage of Surface-Oriented Particles Injected at Station 704 (Sacramento River at Sherman Lake) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	82.10	82.60	0.50 (1%)
January	Above Normal	56.95	58.90	1.95 (3%)
January	Below Normal	22.70	26.07	3.37 (15%)
January	Dry	6.46	6.27	-0.19 (-3%)
January	Critical	0.83	0.96	0.13 (15%)
February	Wet	88.98	89.18	0.20 (0%)
February	Above Normal	73.33	74.43	1.10 (2%)
February	Below Normal	49.97	52.39	2.42 (5%)
February	Dry	20.67	20.83	0.16 (1%)
February	Critical	3.80	3.97	0.17 (4%)
March	Wet	86.52	87.64	1.12 (1%)
March	Above Normal	84.57	87.50	2.93 (3%)
March	Below Normal	37.35	42.16	4.81 (13%)
March	Dry	17.83	20.67	2.83 (16%)
March	Critical	6.53	6.32	-0.21 (-3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-11. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-11 a - E.3-11 d

Table XE.3-11 a. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.96	0.94	-0.02 (-2%)
January	Above Normal	1.99	1.98	-0.01 (-1%)
January	Below Normal	4.35	4.50	0.16 (4%)
January	Dry	6.86	8.08	1.22 (18%)
January	Critical	6.85	6.89	0.04 (1%)
February	Wet	0.22	0.21	0.00 (-2%)
February	Above Normal	0.97	0.92	-0.04 (-5%)
February	Below Normal	2.01	2.00	-0.01 (0%)
February	Dry	4.00	4.11	0.11 (3%)
February	Critical	5.68	5.44	-0.24 (-4%)
March	Wet	0.26	0.17	-0.10 (-37%)
March	Above Normal	0.37	0.20	-0.16 (-44%)
March	Below Normal	1.53	0.81	-0.72 (-47%)
March	Dry	2.11	1.30	-0.81 (-38%)
March	Critical	2.43	2.60	0.17 (7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-11 b. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.77	0.71	-0.06 (-8%)
January	Above Normal	1.81	2.03	0.21 (12%)
January	Below Normal	3.85	3.89	0.04 (1%)
January	Dry	6.51	7.16	0.65 (10%)
January	Critical	7.34	6.80	-0.55 (-7%)
February	Wet	0.15	0.14	-0.01 (-7%)
February	Above Normal	0.81	0.80	-0.01 (-1%)
February	Below Normal	1.71	1.97	0.26 (15%)
February	Dry	3.51	3.83	0.32 (9%)
February	Critical	5.87	6.32	0.45 (8%)
March	Wet	0.17	0.10	-0.08 (-44%)
March	Above Normal	0.26	0.18	-0.08 (-30%)
March	Below Normal	1.16	0.73	-0.43 (-37%)
March	Dry	2.04	1.26	-0.78 (-38%)
March	Critical	2.56	3.04	0.48 (19%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-11 c. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-11 d. Percentage of Neutrally Buoyant Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	93.10	93.33	0.23 (0%)
January	Above Normal	86.18	86.44	0.26 (0%)
January	Below Normal	77.81	78.57	0.76 (1%)
January	Dry	64.65	62.58	-2.06 (-3%)
January	Critical	59.64	59.38	-0.26 (0%)
February	Wet	95.87	96.02	0.15 (0%)
February	Above Normal	91.84	92.27	0.44 (0%)
February	Below Normal	86.08	86.20	0.12 (0%)
February	Dry	77.42	76.95	-0.47 (-1%)
February	Critical	64.72	64.32	-0.40 (-1%)
March	Wet	98.38	98.62	0.24 (0%)
March	Above Normal	97.95	98.25	0.29 (0%)
March	Below Normal	94.37	96.09	1.72 (2%)
March	Dry	89.18	91.64	2.46 (3%)
March	Critical	81.11	78.68	-2.43 (-3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-12. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-12 a - E.3-12 h

Table XE.3-12 a. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	13.49	13.39	-0.10 (-1%)
January	Above Normal	23.36	23.31	-0.05 (0%)
January	Below Normal	37.59	38.86	1.26 (3%)
January	Dry	37.53	39.62	2.09 (6%)
January	Critical	34.41	36.17	1.76 (5%)
February	Wet	8.50	7.72	-0.79 (-9%)
February	Above Normal	18.99	17.57	-1.42 (-7%)
February	Below Normal	28.53	25.49	-3.04 (-11%)
February	Dry	34.66	34.15	-0.51 (-1%)
February	Critical	33.24	31.83	-1.41 (-4%)
March	Wet	9.05	8.47	-0.58 (-6%)
March	Above Normal	12.68	8.23	-4.45 (-35%)
March	Below Normal	26.79	21.59	-5.20 (-19%)
March	Dry	29.40	24.59	-4.81 (-16%)
March	Critical	22.12	20.96	-1.16 (-5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-12 b. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	11.54	10.74	-0.80 (-7%)
January	Above Normal	23.63	23.64	0.01 (0%)
January	Below Normal	36.47	35.45	-1.02 (-3%)
January	Dry	43.67	43.13	-0.54 (-1%)
January	Critical	47.84	43.22	-4.62 (-10%)
February	Wet	6.05	5.00	-1.05 (-17%)
February	Above Normal	16.51	15.73	-0.78 (-5%)
February	Below Normal	25.05	23.90	-1.16 (-5%)
February	Dry	38.72	37.62	-1.10 (-3%)
February	Critical	42.67	44.93	2.26 (5%)
March	Wet	5.79	5.88	0.10 (2%)
March	Above Normal	10.08	8.09	-1.99 (-20%)
March	Below Normal	22.04	22.78	0.74 (3%)
March	Dry	33.57	30.73	-2.84 (-8%)
March	Critical	31.73	33.20	1.48 (5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-12 c. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (-100%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (-100%)
January	Dry	0.01	0.01	0.00 (33%)
January	Critical	0.00	0.01	0.01 (150%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (-100%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.01	0.02	0.00 (25%)
March	Dry	0.00	0.00	0.00 (-50%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-12 d. Percentage of Surface-Oriented Particles Injected at Station 809 (San Joaquin River near Jersey Point) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	63.60	64.23	0.63 (1%)
January	Above Normal	35.21	35.65	0.44 (1%)
January	Below Normal	5.17	5.56	0.39 (8%)
January	Dry	1.15	1.08	-0.07 (-6%)
January	Critical	0.08	0.09	0.02 (22%)
February	Wet	74.93	76.24	1.30 (2%)
February	Above Normal	46.38	46.65	0.26 (1%)
February	Below Normal	23.16	25.88	2.71 (12%)
February	Dry	4.13	3.54	-0.58 (-14%)
February	Critical	0.44	0.45	0.01 (2%)
March	Wet	64.99	66.77	1.78 (3%)
March	Above Normal	48.39	54.99	6.60 (14%)
March	Below Normal	9.62	12.14	2.52 (26%)
March	Dry	2.08	2.93	0.85 (41%)
March	Critical	0.70	0.65	-0.06 (-8%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-13. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-13 a - E.3-13 d

Table XE.3-13 a. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	5.86	5.95	0.09 (1%)
January	Above Normal	11.13	11.20	0.07 (1%)
January	Below Normal	19.01	19.64	0.64 (3%)
January	Dry	25.27	28.07	2.80 (11%)
January	Critical	24.64	24.79	0.16 (1%)
February	Wet	3.37	3.21	-0.17 (-5%)
February	Above Normal	7.90	7.70	-0.19 (-2%)
February	Below Normal	11.82	11.40	-0.42 (-4%)
February	Dry	19.67	20.56	0.89 (5%)
February	Critical	22.67	22.21	-0.47 (-2%)
March	Wet	3.24	2.00	-1.25 (-38%)
March	Above Normal	4.80	2.77	-2.03 (-42%)
March	Below Normal	11.17	6.31	-4.87 (-44%)
March	Dry	14.17	9.12	-5.05 (-36%)
March	Critical	12.30	12.00	-0.29 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-13 b. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	4.52	4.20	-0.32 (-7%)
January	Above Normal	9.55	9.65	0.09 (1%)
January	Below Normal	15.97	15.53	-0.43 (-3%)
January	Dry	23.43	24.15	0.72 (3%)
January	Critical	26.37	23.69	-2.68 (-10%)
February	Wet	2.19	1.85	-0.34 (-15%)
February	Above Normal	6.11	5.94	-0.16 (-3%)
February	Below Normal	9.38	9.58	0.20 (2%)
February	Dry	17.16	17.58	0.43 (2%)
February	Critical	23.38	25.00	1.62 (7%)
March	Wet	1.66	1.02	-0.63 (-38%)
March	Above Normal	3.15	1.78	-1.37 (-44%)
March	Below Normal	7.79	5.05	-2.73 (-35%)
March	Dry	12.89	8.19	-4.70 (-36%)
March	Critical	12.85	14.76	1.91 (15%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-13 c. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-13 d. Percentage of Neutrally Buoyant Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	84.70	84.91	0.21 (0%)
January	Above Normal	69.76	69.94	0.18 (0%)
January	Below Normal	51.08	51.76	0.68 (1%)
January	Dry	30.00	27.62	-2.38 (-8%)
January	Critical	22.89	24.56	1.67 (7%)
February	Wet	90.30	90.76	0.46 (1%)
February	Above Normal	79.31	79.64	0.33 (0%)
February	Below Normal	66.57	66.57	0.00 (0%)
February	Dry	44.38	43.23	-1.14 (-3%)
February	Critical	26.43	25.78	-0.65 (-2%)
March	Wet	92.89	94.89	2.00 (2%)
March	Above Normal	88.53	92.07	3.54 (4%)
March	Below Normal	68.22	76.58	8.36 (12%)
March	Dry	48.74	58.53	9.79 (20%)
March	Critical	35.72	33.48	-2.24 (-6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-14. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-14 a - E.3-14 d

Table XE.3-14 a. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	27.52	28.02	0.50 (2%)
January	Above Normal	35.75	35.98	0.23 (1%)
January	Below Normal	44.07	45.87	1.80 (4%)
January	Dry	41.57	43.72	2.16 (5%)
January	Critical	36.92	40.27	3.35 (9%)
February	Wet	24.75	23.14	-1.60 (-6%)
February	Above Normal	35.94	34.65	-1.28 (-4%)
February	Below Normal	41.13	40.06	-1.07 (-3%)
February	Dry	41.31	40.46	-0.85 (-2%)
February	Critical	37.44	36.62	-0.82 (-2%)
March	Wet	23.36	20.12	-3.23 (-14%)
March	Above Normal	31.33	24.63	-6.70 (-21%)
March	Below Normal	41.44	35.50	-5.94 (-14%)
March	Dry	37.84	34.32	-3.52 (-9%)
March	Critical	27.63	26.05	-1.58 (-6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-14 b. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	22.36	20.94	-1.42 (-6%)
January	Above Normal	35.83	35.97	0.14 (0%)
January	Below Normal	43.55	42.21	-1.34 (-3%)
January	Dry	48.32	47.35	-0.97 (-2%)
January	Critical	52.50	46.97	-5.53 (-11%)
February	Wet	14.57	13.27	-1.30 (-9%)
February	Above Normal	27.66	27.68	0.02 (0%)
February	Below Normal	33.57	33.12	-0.45 (-1%)
February	Dry	45.95	45.52	-0.44 (-1%)
February	Critical	48.36	50.19	1.83 (4%)
March	Wet	11.31	11.54	0.23 (2%)
March	Above Normal	20.77	19.28	-1.49 (-7%)
March	Below Normal	30.30	31.51	1.21 (4%)
March	Dry	41.88	39.33	-2.55 (-6%)
March	Critical	39.06	41.23	2.17 (6%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-14 c. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-14 d. Percentage of Surface-Oriented Particles Injected at Station 812 (San Joaquin River at Twitchell Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	37.69	38.35	0.66 (2%)
January	Above Normal	14.72	14.46	-0.26 (-2%)
January	Below Normal	0.50	0.62	0.12 (23%)
January	Dry	0.04	0.05	0.01 (33%)
January	Critical	0.00	0.01	0.01 (300%)
February	Wet	46.73	48.29	1.56 (3%)
February	Above Normal	20.70	21.15	0.44 (2%)
February	Below Normal	8.44	8.59	0.15 (2%)
February	Dry	0.21	0.19	-0.02 (-10%)
February	Critical	0.02	0.02	0.00 (0%)
March	Wet	45.01	47.69	2.68 (6%)
March	Above Normal	20.38	24.27	3.90 (19%)
March	Below Normal	0.96	1.61	0.64 (67%)
March	Dry	0.15	0.24	0.09 (58%)
March	Critical	0.02	0.02	0.00 (10%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-15. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-15 a - E.3-15 d

Table XE.3-15 a. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	10.50	10.68	0.18 (2%)
January	Above Normal	16.79	16.81	0.02 (0%)
January	Below Normal	24.77	25.96	1.19 (5%)
January	Dry	30.69	33.57	2.88 (9%)
January	Critical	29.09	28.66	-0.42 (-1%)
February	Wet	7.76	7.52	-0.24 (-3%)
February	Above Normal	13.66	13.54	-0.12 (-1%)
February	Below Normal	18.34	17.70	-0.64 (-3%)
February	Dry	25.23	26.25	1.01 (4%)
February	Critical	27.50	27.26	-0.24 (-1%)
March	Wet	7.57	4.83	-2.74 (-36%)
March	Above Normal	10.56	6.33	-4.23 (-40%)
March	Below Normal	17.83	11.54	-6.28 (-35%)
March	Dry	20.72	14.66	-6.06 (-29%)
March	Critical	15.85	15.43	-0.42 (-3%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-15 b. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	7.41	7.17	-0.24 (-3%)
January	Above Normal	13.71	14.04	0.32 (2%)
January	Below Normal	20.96	20.41	-0.55 (-3%)
January	Dry	28.27	28.63	0.35 (1%)
January	Critical	31.27	27.35	-3.91 (-13%)
February	Wet	4.38	3.94	-0.44 (-10%)
February	Above Normal	9.65	9.69	0.04 (0%)
February	Below Normal	13.26	14.18	0.91 (7%)
February	Dry	22.80	23.04	0.24 (1%)
February	Critical	28.08	29.86	1.78 (6%)
March	Wet	3.46	2.25	-1.21 (-35%)
March	Above Normal	6.16	3.82	-2.34 (-38%)
March	Below Normal	11.99	8.37	-3.62 (-30%)
March	Dry	18.76	13.02	-5.73 (-31%)
March	Critical	16.66	18.80	2.14 (13%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-15 c. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-15 d. Percentage of Neutrally Buoyant Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	77.07	77.07	-0.01 (0%)
January	Above Normal	60.64	60.82	0.18 (0%)
January	Below Normal	42.34	42.28	-0.06 (0%)
January	Dry	24.18	21.98	-2.21 (-9%)
January	Critical	18.78	21.05	2.28 (12%)
February	Wet	83.59	84.26	0.67 (1%)
February	Above Normal	70.48	70.56	0.09 (0%)
February	Below Normal	57.21	57.23	0.03 (0%)
February	Dry	36.41	35.17	-1.24 (-3%)
February	Critical	22.07	21.47	-0.60 (-3%)
March	Wet	86.43	90.45	4.02 (5%)
March	Above Normal	79.51	86.06	6.55 (8%)
March	Below Normal	58.72	67.95	9.23 (16%)
March	Dry	40.96	50.82	9.86 (24%)
March	Critical	33.43	30.44	-2.99 (-9%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-16. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-16 a - E.3-16 d

Table XE.3-16 a. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	31.93	32.54	0.61 (2%)
January	Above Normal	38.64	38.91	0.27 (1%)
January	Below Normal	44.37	46.45	2.07 (5%)
January	Dry	41.76	44.23	2.47 (6%)
January	Critical	37.28	40.67	3.39 (9%)
February	Wet	30.86	29.23	-1.63 (-5%)
February	Above Normal	39.82	38.09	-1.73 (-4%)
February	Below Normal	44.31	43.29	-1.03 (-2%)
February	Dry	42.03	41.39	-0.64 (-2%)
February	Critical	38.20	37.23	-0.97 (-3%)
March	Wet	30.29	25.92	-4.37 (-14%)
March	Above Normal	36.59	29.83	-6.76 (-18%)
March	Below Normal	44.56	38.14	-6.42 (-14%)
March	Dry	39.14	35.76	-3.37 (-9%)
March	Critical	28.69	26.71	-1.98 (-7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-16 b. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	24.92	23.47	-1.46 (-6%)
January	Above Normal	37.68	37.79	0.11 (0%)
January	Below Normal	44.49	42.84	-1.65 (-4%)
January	Dry	49.38	47.72	-1.65 (-3%)
January	Critical	53.48	47.76	-5.72 (-11%)
February	Wet	17.04	15.42	-1.62 (-10%)
February	Above Normal	29.33	29.32	-0.01 (0%)
February	Below Normal	34.62	34.21	-0.41 (-1%)
February	Dry	47.01	46.50	-0.52 (-1%)
February	Critical	49.47	51.35	1.88 (4%)
March	Wet	12.93	13.07	0.14 (1%)
March	Above Normal	22.68	22.07	-0.61 (-3%)
March	Below Normal	31.32	33.02	1.70 (5%)
March	Dry	43.37	40.69	-2.68 (-6%)
March	Critical	40.29	43.11	2.82 (7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-16 c. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-16 d. Percentage of Surface-Oriented Particles Injected at Station 815 (San Joaquin River at Potato Slough) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	32.66	33.16	0.50 (2%)
January	Above Normal	12.21	11.82	-0.39 (-3%)
January	Below Normal	0.47	0.44	-0.03 (-6%)
January	Dry	0.05	0.03	-0.02 (-38%)
January	Critical	0.00	0.01	0.00 (0%)
February	Wet	40.61	42.71	2.10 (5%)
February	Above Normal	17.95	18.96	1.01 (6%)
February	Below Normal	7.32	7.40	0.08 (1%)
February	Dry	0.24	0.18	-0.06 (-24%)
February	Critical	0.02	0.03	0.00 (9%)
March	Wet	40.15	43.61	3.45 (9%)
March	Above Normal	17.53	21.09	3.56 (20%)
March	Below Normal	1.00	1.77	0.77 (77%)
March	Dry	0.12	0.19	0.07 (63%)
March	Critical	0.02	0.01	0.00 (-22%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-17. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-17 a - E.3-17 d

Table XE.3-17 a. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	28.64	28.46	-0.17 (-1%)
January	Above Normal	37.74	37.97	0.24 (1%)
January	Below Normal	44.61	46.02	1.42 (3%)
January	Dry	47.66	50.10	2.44 (5%)
January	Critical	42.85	44.80	1.95 (5%)
February	Wet	24.46	23.53	-0.94 (-4%)
February	Above Normal	33.36	33.19	-0.17 (-1%)
February	Below Normal	39.56	39.35	-0.21 (-1%)
February	Dry	46.52	46.12	-0.40 (-1%)
February	Critical	44.61	43.28	-1.32 (-3%)
March	Wet	22.38	16.31	-6.07 (-27%)
March	Above Normal	29.93	20.86	-9.06 (-30%)
March	Below Normal	39.47	30.67	-8.80 (-22%)
March	Dry	42.91	35.87	-7.04 (-16%)
March	Critical	31.15	29.66	-1.49 (-5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-17 b. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	19.13	18.44	-0.69 (-4%)
January	Above Normal	29.91	30.59	0.68 (2%)
January	Below Normal	36.99	36.25	-0.74 (-2%)
January	Dry	43.60	42.63	-0.97 (-2%)
January	Critical	46.92	39.71	-7.20 (-15%)
February	Wet	12.79	11.61	-1.18 (-9%)
February	Above Normal	22.62	22.87	0.25 (1%)
February	Below Normal	28.39	28.06	-0.33 (-1%)
February	Dry	41.41	41.75	0.34 (1%)
February	Critical	45.54	47.21	1.67 (4%)
March	Wet	9.08	7.26	-1.81 (-20%)
March	Above Normal	16.64	12.62	-4.02 (-24%)
March	Below Normal	25.32	21.99	-3.33 (-13%)
March	Dry	37.94	31.95	-5.99 (-16%)
March	Critical	33.77	35.45	1.68 (5%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-17 c. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-17 d. Percentage of Neutrally Buoyant Particles Injected at Station 906 (San Joaquin River near Medford Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	47.95	48.74	0.78 (2%)
January	Above Normal	26.91	26.24	-0.67 (-2%)
January	Below Normal	11.24	10.93	-0.31 (-3%)
January	Dry	2.82	2.28	-0.54 (-19%)
January	Critical	1.82	3.97	2.14 (117%)
February	Wet	58.82	60.72	1.89 (3%)
February	Above Normal	39.47	39.32	-0.14 (0%)
February	Below Normal	25.86	26.05	0.19 (1%)
February	Dry	5.65	5.15	-0.50 (-9%)
February	Critical	2.06	1.94	-0.11 (-5%)
March	Wet	64.79	72.50	7.71 (12%)
March	Above Normal	47.99	60.02	12.03 (25%)
March	Below Normal	25.84	33.98	8.14 (31%)
March	Dry	6.47	12.51	6.04 (93%)
March	Critical	7.47	6.24	-1.23 (-16%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table XE.3-18. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay, Central Valley Project (Jones Pumping Plant), and Barker Slough Pumping Plant; or That Passed Chipps Island: Refined Alternative 2b vs. Existing - Table XE.3-18 a - E.3-18 d

Table XE.3-18 a. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	42.84	43.69	0.85 (2%)
January	Above Normal	47.30	47.33	0.03 (0%)
January	Below Normal	46.25	48.23	1.98 (4%)
January	Dry	43.19	45.53	2.34 (5%)
January	Critical	37.85	42.24	4.39 (12%)
February	Wet	43.95	41.85	-2.09 (-5%)
February	Above Normal	49.26	47.71	-1.55 (-3%)
February	Below Normal	51.22	50.86	-0.36 (-1%)
February	Dry	44.28	44.16	-0.12 (0%)
February	Critical	40.14	38.98	-1.16 (-3%)
March	Wet	43.50	38.69	-4.81 (-11%)
March	Above Normal	50.03	45.35	-4.68 (-9%)
March	Below Normal	52.20	46.94	-5.26 (-10%)
March	Dry	42.98	41.16	-1.82 (-4%)
March	Critical	32.22	29.87	-2.36 (-7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-18 b. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Central Valley Project (Jones Pumping Plant).

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	32.30	30.64	-1.66 (-5%)
January	Above Normal	43.51	43.25	-0.26 (-1%)
January	Below Normal	46.74	45.31	-1.43 (-3%)
January	Dry	50.53	49.10	-1.43 (-3%)
January	Critical	55.34	48.35	-6.99 (-13%)
February	Wet	23.02	21.19	-1.83 (-8%)
February	Above Normal	35.54	36.01	0.48 (1%)
February	Below Normal	38.54	38.41	-0.13 (0%)
February	Dry	49.94	49.80	-0.14 (0%)
February	Critical	52.52	54.78	2.26 (4%)
March	Wet	16.71	16.54	-0.17 (-1%)
March	Above Normal	29.72	29.68	-0.04 (0%)
March	Below Normal	36.15	37.09	0.94 (3%)
March	Dry	46.77	44.89	-1.88 (-4%)
March	Critical	44.07	47.28	3.21 (7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-18 c. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Were Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.00	0.00	0.00 (0%)
January	Above Normal	0.00	0.00	0.00 (0%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	0.00	0.00	0.00 (0%)
February	Above Normal	0.00	0.00	0.00 (0%)
February	Below Normal	0.00	0.00	0.00 (0%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	0.00	0.00	0.00 (0%)
March	Above Normal	0.00	0.00	0.00 (0%)
March	Below Normal	0.00	0.00	0.00 (0%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table XE.3-18 d. Percentage of Surface-Oriented Particles Injected at Station 906 (San Joaquin River near Medford Island) That Passed Chipps Island.

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	18.47	18.97	0.50 (3%)
January	Above Normal	3.87	3.90	0.03 (1%)
January	Below Normal	0.00	0.00	0.00 (0%)
January	Dry	0.00	0.00	0.00 (0%)
January	Critical	0.00	0.00	0.00 (0%)
February	Wet	26.10	29.28	3.18 (12%)
February	Above Normal	9.70	11.37	1.67 (17%)
February	Below Normal	3.27	3.38	0.12 (4%)
February	Dry	0.00	0.00	0.00 (0%)
February	Critical	0.00	0.00	0.00 (0%)
March	Wet	29.60	32.68	3.07 (10%)
March	Above Normal	8.65	9.05	0.40 (5%)
March	Below Normal	0.16	0.80	0.64 (388%)
March	Dry	0.00	0.00	0.00 (0%)
March	Critical	0.00	0.00	0.00 (0%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

E.3.1.5 CENTRAL VALLEY PROJECT RESULTS

Results of the PTM analysis for entrainment into the SWP's Clifton Court Forebay and Barker Slough Pumping Plant are presented in Section 4.4 of the DEIR. Tables E.3-19 and E.3-20 provides results for the CVP Jones Pumping Plant for consideration of cumulative impacts in the DEIR Section 4.6.

Table E.3-19. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into the Central Valley Project Jones Pumping Plant.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.54	0.51	-0.04 (-7%)
January	Above Normal	1.01	1.06	0.05 (4%)
January	Below Normal	1.64	1.68	0.04 (2%)
January	Dry	2.47	2.57	0.10 (4%)
January	Critical	2.80	2.76	-0.04 (-2%)
February	Wet	0.29	0.26	-0.03 (-11%)
February	Above Normal	0.64	0.62	-0.02 (-3%)
February	Below Normal	0.94	0.98	0.03 (4%)
February	Dry	1.63	1.70	0.08 (5%)
February	Critical	2.33	2.35	0.02 (1%)
March	Wet	0.23	0.16	-0.06 (-27%)
March	Above Normal	0.41	0.28	-0.13 (-32%)
March	Below Normal	0.77	0.53	-0.24 (-31%)
March	Dry	1.21	0.88	-0.33 (-27%)
March	Critical	1.23	1.37	0.14 (11%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table E.3-20. Percentage of Surface-Oriented Particles Entrained Over 45 Days into the Central Valley Project Jones Pumping Plant.

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.06	2.84	-0.21 (-7%)
January	Above Normal	6.18	6.08	-0.10 (-2%)
January	Below Normal	9.40	9.15	-0.25 (-3%)
January	Dry	12.40	12.34	-0.06 (0%)
January	Critical	13.84	12.81	-1.03 (-7%)
February	Wet	1.63	1.41	-0.22 (-14%)
February	Above Normal	4.05	3.76	-0.30 (-7%)
February	Below Normal	6.05	5.74	-0.30 (-5%)
February	Dry	9.85	9.55	-0.30 (-3%)
February	Critical	11.53	11.87	0.34 (3%)
March	Wet	1.37	1.37	0.00 (0%)
March	Above Normal	2.35	2.00	-0.35 (-15%)
March	Below Normal	5.08	4.59	-0.50 (-10%)
March	Dry	7.93	6.85	-1.08 (-14%)
March	Critical	8.05	8.35	0.30 (4%)

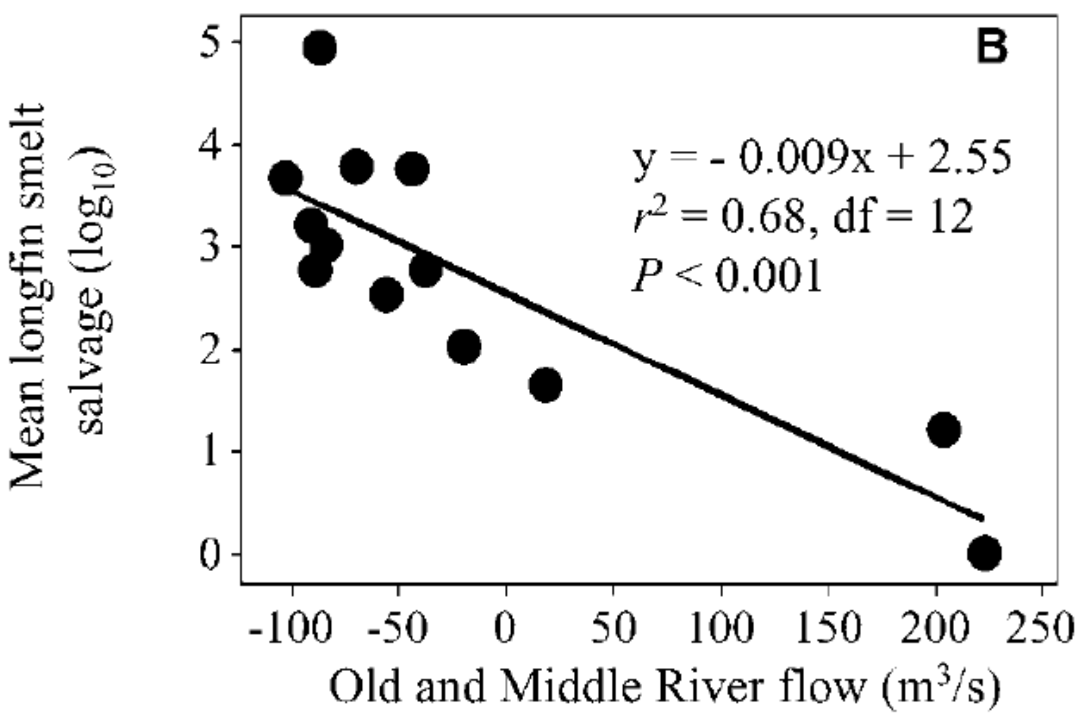
Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

E.3.2 SALVAGE-OLD AND MIDDLE RIVER FLOW ANALYSIS (BASED ON GRIMALDO ET AL. 2009)

Grimaldo et al. (2009: their Figure 7B) found a significant relationship between juvenile Longfin Smelt salvage in April and May as a function of mean April–May Old and Middle River flows. In order to assess potential differences in salvage between Existing, ~~and~~ PP, and Refined Alternative 2b scenarios, the regression of Grimaldo et al. (2009) was recreated in order to be able to fully account for sources of error in the predictions; this allowed calculation of prediction intervals from CalSim-derived estimates of Old and Middle River flows for Existing, ~~and~~ PP, and Refined Alternative 2b scenarios, as recommended by Simenstad et al. (2016).

Longfin Smelt salvage data for April and May 1993–2005 were obtained from the DFW salvage monitoring website[9]. Consistent with Grimaldo et al. (2009), a record of 616 Longfin Smelt salvaged on April 7, 1998, was assumed to be in error, and was converted to zero for the analysis. Old and Middle River flow data were provided by Smith (pers. comm.)**Error! Bookmark not defined.**. Following Grimaldo et al. (2009), $\log_{10}$(total salvage) was regressed against mean April–May Old and Middle River flow (converted to cubic meters/second). The resulting regression equation was very similar to that obtained by Grimaldo et al. (2009; Figure E.3-4):

$\log_{10}$(April–May total Longfin Smelt salvage) = 2.5454 (± 0.2072 SE) – 0.0100 (± 0.0020 SE)*(Mean April–May Old and Middle River flow); r^2 = 0.70, 12 degrees of freedom.



Source: Grimaldo et al. (2009)

Figure E.3-4. Regression of April–May Longfin Smelt Salvage as a Function of Old and Middle River Flow

[9] http://www.dfg.ca.gov/delta/apps/salvage/SalvageExportChart.aspx?Species=1&SampleDate=1%2f22%2f2016&Facility=1, accessed January 1, 2016, and August 17, 2016 (salvage for Longfin Smelt at both facilities was selected).

For the comparison of Existing, and PP, and Refined Alternative 2b scenarios, CalSim data outputs were used to calculate mean April–May Old and Middle River flows for each year of the 1922–2003 simulation. The salvage-Old and Middle River flow regression calculated as above was used to estimate salvage for the Existing, PP, and Refined Alternative 2b Existing and PP scenarios. The log-transformed salvage estimates were back-transformed to a linear scale for comparison of Existing, PP, and Refined Alternative 2bExisting and PP. In order to illustrate the variability in predictions from the salvage-Old and Middle River flow regression, annual estimates were made for the mean and upper and lower 95% prediction limits of the salvage estimates, as recommended by Simenstad et al. (2016). Means and predictions limits giving negative estimates of salvage were converted to zero before statistical summary. Statistical analyses were conducted with PROC GLM and PROC PLM in SAS/STAT software, Version 9.4 of the SAS System for Windows.[10]

E.3.3 Delta Outflow-Abundance Analysis (Based on Nobriga and Rosenfield 2016)

This analysis used the Nobriga and Rosenfield (2016) Longfin Smelt population dynamics model to assess potential effects of the PP and Refined Alternative 2b as a function of changes in winter/spring outflow.

E.3.3.1 Reproduction of Nobriga and Rosenfield (2016) Model

This analysis reproduced the methods described in Nobriga and Rosenfield (2016) for calculation of the two-life-stage model referred to as the "2abc" model, which includes the embedded hypotheses that understanding the trend in age-0 LFS relative abundance requires explicit modeling of spawning and recruit relative abundance; that the production of age-0 fish is density dependent; and that juvenile survival from age 0 to age 2 has changed over time. For purposes of this effects analysis, the "2abc" model was selected because its median predictions visually fit recent years of empirical data better than the other model evaluated (Figure E.3-5)[11].

Model input data used to reproduce the "2abc" model were as provided in Table 2 of Nobriga and Rosenfield (2016). The input data are provided in Appendix A of Greenwood and Phillis (2018). The analyses were run in R software (R Core Team 2016).

Graphical comparison of the reproduction of the "2abc" model to the original Nobriga and Rosenfield (2016) "2abc" model (Figure E.3-5) suggests that the reproduced model was a reasonable approximation of the original model (i.e., the reproduction of the method was reasonably successful). It should be noted that the original "2abc" model 95% confidence intervals are wider than the reproduction utilized in this analysis. However, the model coefficients and standard errors are identical between the original and reproduced models. Therefore, the reproduced "2abc" model utilized in this

[10] Copyright 2002–2010, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA

[11] Comments on the DEIR suggested that a form of stock-recruitment function other than the Ricker method used by Nobriga and Rosenfield (2016) would be appropriate for exploration, such as the Beverton-Holt method. This was undertaken for the FEIR but showed that the Beverton-Holt method (explanation of historical fall midwater trawl data based on mean predictions: $r^2 = 0.22$) was not a better fit to the data than the Ricker method ($r^2 = 0.60$), so the Ricker method consistent with Nobriga and Rosenfield (2016) was retained.

analysis is considered appropriate, and the differences in 95% confidence intervals among the original and reproduced models do not affect the comparison of the scenarios discussed below.

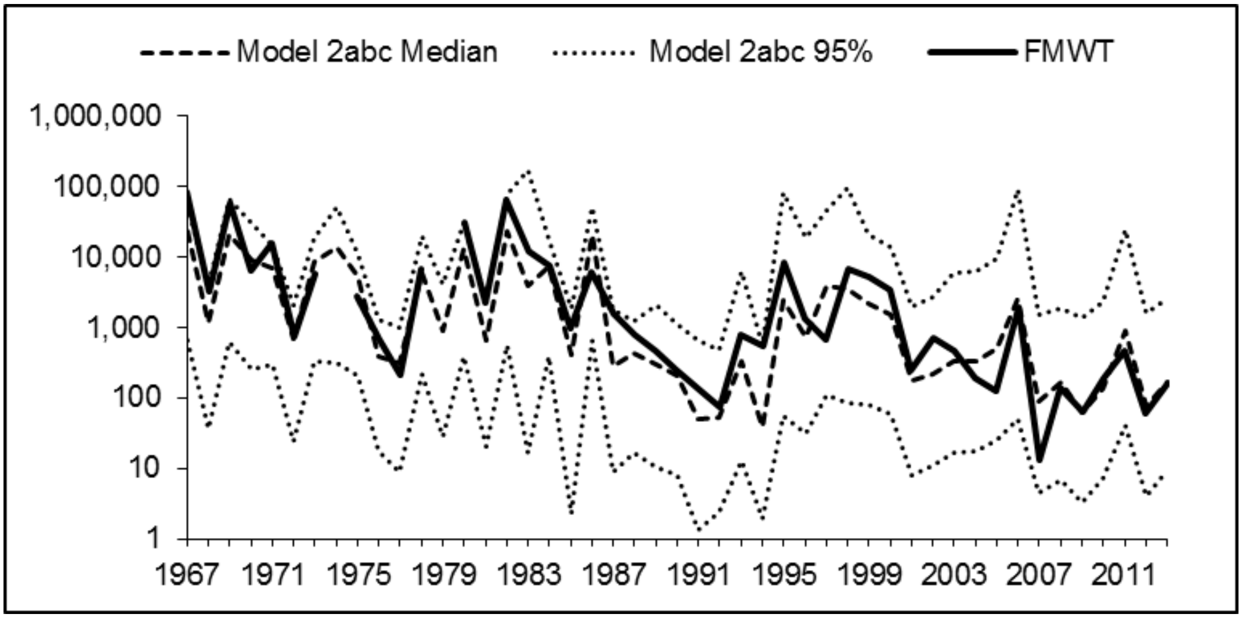


Figure E.3-5 a. Reproduction of Nobriga and Rosenfield (2016) 2abc Model Predictions Compared to Historical Fall Midwater Trawl Survey Longfin Smelt Abundance Index.

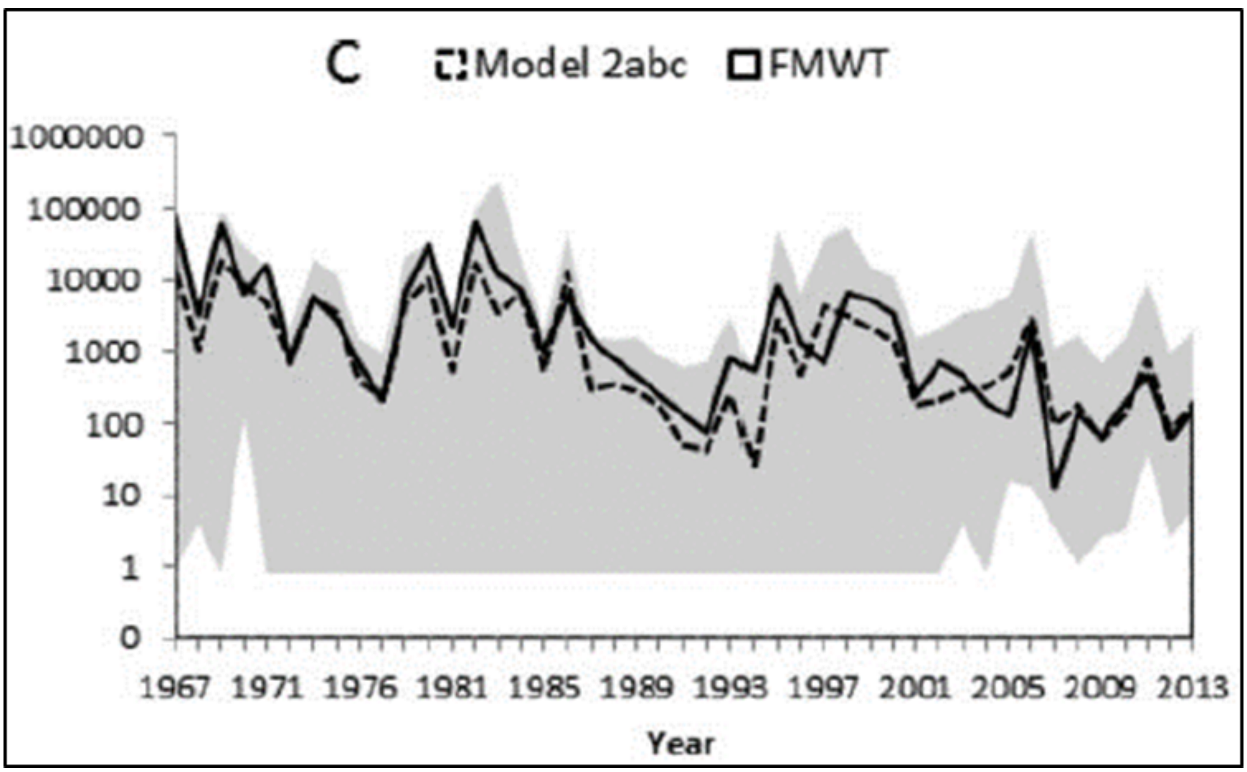


Figure E.3-5 b. Original (Figure 6c of Nobriga and Rosenfield 2016) 2abc Model Predictions Compared to Historical Fall Midwater Trawl Survey Longfin Smelt Abundance Index. Grey shading indicates 95% interval.

E.3.3.2 CALCULATION OF DELTA OUTFLOW MODEL INPUTS FOR SCENARIO COMPARISON

To obtain the required first principal component (PC1) model inputs for comparison of the Refined Alternative 2b, PP, and Existing scenarios, it was first necessary to reproduce the principal components analysis (PCA). Following Nobriga and Rosenfield (2016), historical daily Delta outflow data were acquired from the DAYFLOW database[12]. Flow data were averaged for December to May by month and year and the Principal Component Analysis was conducted using the 'PCA' function in the R package FactoMineR (Le et al. 2008) on water years 1956-2013. The resulting PC1 outputs were very similar to the original values computed by Nobriga and Rosenfield (2016), suggesting that the reported method had been successfully reproduced[13]. The 'predict PCA' function was then used to predict PC1 values for the PP, Refined Alternative 2b, and Existing scenarios for water years ~~1956-2017~~1922–2003 on the same projection as the PCA. The resulting PC1 values were used as the input for the model simulation of the flow scenarios described in the next section.

E.3.3.3 MODEL SIMULATION TO COMPARE SCENARIOS

Model simulation to compare the Existing Conditions, ~~Proposed Project~~PP, ~~Alternative 2a,~~ and Refined Alternative 2b~~, and Alternative 3~~ scenarios used the PC1 flow inputs. To produce a simulation for the 1922-2003 time series, and consistent with Nobriga and Rosenfield (2016), the model was initiated with 2 years (i.e., years 1922 and 1923) of Fall Mid-water Trawl (FMWT) indices equal to 798, which represents the median observed FMWT index from 1967 to 2013. The simulation was conducted for two juvenile survival functions:

- 'good', which used the pre-1991 relatively high survival for simulation over the full 1922-2003 time series;
- 'poor', which used the post-1991 relatively low survival for simulation over the full 1922-2003 simulation time series.

Following Nobriga and Rosenfield (2016), 1,000 stochastic simulations were conducted in which random draws were made based on the mean and standard error of the model parameters. Consistent with Nobriga and Rosenfield (2016), the variability among the estimates was examined using the 95% intervals. Violin plots were used to illustrate the distribution of simulated FMWT indices.

E.4 SALMONIDS

E.4.1 SALVAGE-DENSITY METHOD

The basic procedure used for the salvage-density method was an update of previous methods, such as that used in the California WaterFix ITP Application. The updated method reflected more recently available data and was as follows:

[12] https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data

[13] The small differences may have arisen because of varying PCA algorithms in different statistical software packages, for example.

- All data were downloaded from https://apps.wildlife.ca.gov/Salvage[14];
- Water years 1994–2018 were included as these water years were complete and the water year type was known (http://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST);
- Fish with clipped and unclipped adipose fins were included, as together they represent hatchery-origin and wild fish that are all part of the Evolutionary Significant Unit (ESU);
- Daily loss density (fish per thousand acre feet (taf) of water exported) was calculated for the SWP south Delta export facility (Clifton Court Forebay, Skinner fish facility, and Banks pumping plant)[15], month, and water year type;

The daily loss density values for each month, facility, and water year type were multiplied by the CalSim-modeled exports for the Existing, ~~and~~ PP, and Refined Alternative 2b scenarios to give estimates of fish loss.

Results of the loss density analysis for entrainment into the SWP's south Delta export facility are presented in Section 4.4 of the DEIR. Tables E.4-1 and E.4-2 provide results for the CVP south Delta export facility for consideration of cumulative impacts in the DEIR Section 4.6.

E.4.2 Salvage Analysis (Based on Zeug and Cavallo 2014)

An analysis to evaluate differences in entrainment (salvage) at the south Delta export facilities between the existing condition (EXG), PP, and Refined Alternative 2b was done following the statistical models of salvage of marked (coded wire tags) hatchery-reared Chinook salmon published by Zeug and Cavallo (2014). This analysis focused on winter-run Chinook salmon; spring-run Chinook salmon were not included because very few marked individuals were salvaged, and the statistical models could not be fit successfully (Zeug and Cavallo 2014). Several modifications to the methods of Zeug and Cavallo (2014) were employed to focus on relevant model predictors. First, statistical models of the empirical data were constructed using only releases of winter-run Chinook salmon raised at the Livingston Stone Hatchery. Second, salvage at the SWP south Delta export facilities and SWP-specific exports were modeled in addition to combined values from both the SWP and CVP facilities. This was done to focus on effects of the SWP to the greatest extent possible and provide context with total salvage. Some variables were excluded from the statistical models because they were not significant in the original analysis or they were not relevant in this context. For example, the original analysis used the variable "distance of release from the facilities". However, winter-run Chinook salmon were only released from a single location, making this predictor irrelevant. Finally, to determine which hydrologic variables were the best predictors of salvage, a model selection exercise was performed using the original data from Zeug and Cavallo (2014). The model selection exercise included five potential hydrologic predictor variables including; Old and Middle River flows (OMR), inflow-export ratio (I-E), total south Delta exports, San Joaquin River flow, Sacramento River flow and one biological variable (mean fork length at release). Most of these variables were strongly correlated so models were constructed only with

[14] This website includes salvage density for all species, and loss density for salmonids; the latter was used in this analysis.

[15] Loss density was also calculated for the CVP Jones Pumping Plant in consideration of cumulative effects.

variables that had correlation coefficients <|0.70|. One million individuals were used as the total release size (offset variable) for each candidate model with standardized predictors for both the count

Table E.4-1. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.4-1 a – E.4-1 f

Table E.4-1 a. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	232	97	187	31	1	0	0	0	0	0	0	57
Proposed Project	220	88	179	68	2	0	0	0	0	0	0	56

Table E.4-1 b. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	659	184	212	19	9	2	0	0	0	0	0	137
Proposed Project	663	183	198	55	30	2	0	0	0	0	0	136

Table E.4-1 c. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	273	255	288	14	0	0	0	0	0	0	0	14
Proposed Project	271	254	238	35	0	0	0	0	0	0	0	14

Table E.4-1 d. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	238	331	497	25	0	0	0	0	0	0	0	41
Proposed Project	235	337	416	45	0	0	0	0	0	0	0	40

Table E.4-1 e. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	294	529	403	37	0	0	0	0	0	0	0	26
Proposed Project	271	521	411	48	0	0	0	0	0	0	0	26

Table E.4-1 f. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	604	1,222	845	1,132	1,289
Proposed Project	613	1,266	811	1,073	1,278
Proposed Project vs. Existing	10 (2%)	44 (4%)	-34 (-4%)	-58 (-5%)	-11 (-1%)

Table E.4-2. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.4-2 a – E.4-2 f

Table E.4-2 a. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	15	2,242	5,412	4,268	803	0	0	0	0	0	1
Proposed Project	1	14	2,147	11,924	9,748	792	0	0	0	0	0	1

Table E.4-2 b. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7	19	2,256	3,713	916	17	0	0	0	0	0	0
Proposed Project	7	18	2,108	10,632	3,039	17	0	0	0	0	0	0

Table E.4-2 c. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	5	663	761	379	9	0	0	0	0	0	0
Proposed Project	1	5	548	1,877	1,214	8	0	0	0	0	0	0

Table E.4-2 d. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4	3	418	1,762	234	6	0	0	0	0	0	0
Proposed Project	4	3	350	3,164	510	6	0	0	0	0	0	0

Table E.4-2 e. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	123	770	406	2	0	0	0	0	0	0
Proposed Project	0	2	126	984	490	2	0	0	0	0	0	0

Table E.4-2 f. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	12,742	6,928	1,818	2,427	1,303
Proposed Project	24,626	15,822	3,654	4,036	1,604
Proposed Project vs. Existing	11,884 (93%)	8,894 (128%)	1,836 (101%)	1,609 (66%)	300 (23%)

Table E.4-3. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.4-3 a – E.4-3 f

Table E.4-3 a. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4,914	8,489	1,030	1,736	7,256	9,000	161	4	2	18	19	82
Proposed Project	4,667	7,713	986	3,824	16,571	8,875	158	4	2	19	20	81

Table E.4-3 b. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	176	6,119	1,617	1,253	3,273	1,296	14	0	44	28	40	0
Proposed Project	177	6,072	1,511	3,589	10,864	1,266	15	0	43	29	42	0

Table E.4-3 c. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9	58	1,515	385	824	201	2	0	0	1	1	0
Proposed Project	9	57	1,252	948	2,639	196	2	0	0	1	2	0

Table E.4-3 d. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	31	27	519	2,084	1,149	383	1	2	0	4	1	14
Proposed Project	31	28	435	3,741	2,503	371	1	2	0	4	1	14

Table E.4-3 e. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	8	18	12	225	907	56	0	0	0	0	43	42
Proposed Project	7	18	12	287	1,094	52	0	0	0	0	49	43

Table E.4-3 f. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	32,711	13,862	2,996	4,217	1,311
Proposed Project	42,919	23,609	5,106	7,131	1,563
Proposed Project vs. Existing	10,208 (31%)	9,747 (70%)	2,110 (70%)	2,914 (69%)	252 (19%)

Table E.4-4. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.4-4 a – f

Table E.4-4 a. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	182	2	0	0	0	1	0	0	0	0	6	263
Proposed Project	173	2	0	1	0	1	0	0	0	0	6	260

Table E.4-4 b. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	104	0	0	0	0	16	0	0	0	2	13	116
Proposed Project	104	0	0	0	0	16	0	0	0	2	14	115

Table E.4-4 c. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	96	9	1	0	0	0	0	0	0	0	0	15
Proposed Project	95	9	1	1	0	0	0	0	0	0	0	14

Table E.4-4 d. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9	0	0	0	0	0	0	0	0	0	5	65
Proposed Project	9	0	0	0	0	0	0	0	0	0	5	65

Table E.4-4 e. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	68	9	2	0	0	0	0	0	0	0	1	76
Proposed Project	63	9	2	0	0	0	0	0	0	0	1	78

Table E.4-4 f. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	454	251	121	79	157
Proposed Project	443	251	120	78	153
Proposed Project vs. Existing	-12 (-3%)	0 (0%)	-2 (-1%)	-1 (-1%)	-3 (-2%)

Table E.4-5. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.4-5 a – E.4-5 f

Table E.4-5 a. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	129	210	271	76	35	53	4	0	0	0	1	5
Proposed Project	123	191	259	167	80	52	4	0	0	0	1	5

Table E.4-5 b. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,109	797	413	63	40	8	2	0	0	0	7	31
Proposed Project	1,117	791	386	181	134	8	2	0	0	0	7	31

Table E.4-5 c. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	56	960	386	47	29	9	0	0	0	0	0	1
Proposed Project	56	955	319	116	93	9	0	0	0	0	0	1

Table E.4-5 d. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	60	571	790	125	21	17	0	0	0	0	1	5
Proposed Project	59	581	662	224	46	16	0	0	0	0	1	5

Table E.4-5 g. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	76	396	135	31	8	6	0	0	0	0	0	0
Proposed Project	70	391	138	39	10	5	0	0	0	0	0	0

Table E.4-5 f. Estimates of Steelhead Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	785	2,472	1,489	1,590	652
Proposed Project	883	2,658	1,549	1,595	653
Proposed Project vs. Existing	98 (13%)	186 (8%)	61 (4%)	5 (0%)	1 (0%)

and zero-inflation portion of the models. To select the best approximating model, Akaike's Information Criterion (AIC) was calculated for each model. The model with the lowest AIC value was identified as the best approximating model. The AIC value of all other models was subtracted from the value of the best approximating model to calculate the ΔAIC. Any model that had a ΔAIC value ≤ 2.0 was considered a competing model with the best approximating model. Salvage Analysis (Based on Zeug and Cavallo 2014)

An analysis to evaluate differences in entrainment (salvage) at the south Delta export facilities between the existing condition (EXG), and the PP, and Refined Alternative 2b was done following the statistical models of salvage of marked (coded wire tags) hatchery-reared Chinook salmon published by Zeug and Cavallo (2014). This analysis focused on winter-run Chinook salmon; spring-run Chinook salmon were not included because very few marked individuals were salvaged, and the statistical models could not be fit successfully (Zeug and Cavallo 2014). Several modifications to the methods of Zeug and Cavallo (2014) were employed to focus on relevant model predictors. First, statistical models of the empirical data were constructed using only releases of winter-run Chinook salmon raised at the Livingston Stone Hatchery. Second, salvage at the SWP south Delta export facilities and SWP-specific exports were modeled in addition to combined values from both the SWP and CVP facilities. This was done to focus on effects of the SWP to the greatest extent possible and provide context with total salvage. Some variables were excluded from the statistical models because they were not significant in the original analysis or they were not relevant in this context. For example, the original analysis used the variable "distance of release from the facilities". However, winter-run Chinook salmon were only released from a single location, making this predictor irrelevant. Finally, to determine which hydrologic variables were the best predictors of salvage, a model selection exercise was performed using the original data from Zeug and Cavallo (2014). The model selection exercise included five potential hydrologic predictor variables including; Old and Middle River flows (OMR), inflow-export ratio (I-E), total south Delta exports, San Joaquin River flow, Sacramento River flow and one biological variable (mean fork length at release). Most of these variables were strongly correlated so models were constructed only with variables that had correlation coefficients <|0.70|. One million individuals were used as the total release size (offset variable) for each candidate model with standardized predictors for both the count and zero-inflation portion of the models. To select the best approximating model, Akaike's Information Criterion (AIC) was calculated for each model. The model with the lowest AIC value was identified as the best approximating model. The AIC value of all other models was subtracted from the value of the best approximating model to calculate the ΔAIC. Any model that had a ΔAIC value ≤ 2.0 was considered a competing model with the best approximating model.

A single best model of salvage was selected with no other model having a ΔAIC <2.8. This model had three predictor variables for the count model and zero inflation models including mean fork length of fish at release, Sacramento River flow, and total exports. The final count model indicated that non-zero salvage was greater when fish were released at a larger size, flow in the Sacramento River was higher, and exports were higher. For the zero inflation model, coefficients indicated zero salvage was more likely when fish were released at a smaller size, Sacramento River flow was higher, and exports were lower.

To predict salvage under the existing condition, ~~and the~~ Proposed Project, and Refined Alternative 2b scenarios, daily flow and export data from DSM2 output was aggregated into 7-day running means and standardized to the same scale as the empirical data. This was done to mimic the way data were aggregated in the original publication (7-day means) and the winter-run specific models described above. A 7-day mean was used because an acoustic tagging study revealed that was the approximate mean time Chinook salmon smolts spent transiting through the Delta (Zeug and Cavallo 2014). The total number of fish entering the Delta in a season was then multiplied by the daily entry proportion defined by the same distribution used in the Delta Passage Model. The log-transformed product of this calculation was used as the offset on each day. The distribution did not weight the result but simply distributed the fish over time.

The values described above (DSM2 data, offset, fish fork length) are used as inputs in the ZINB model to predict the mean salvage for each day. The size of fish entering the delta was set as the midpoint size on the 15th of each month using the Delta length-at-date model. After January, the midpoint value was higher than the observed sizes at release and the model was set to the maximum observed fork length from February–June (95 mm). However, it should be noted that the statistical model uses size at release in the Sacramento River near Redding, CA, and fish are assumed to grow between release and the salvage facilities. The mean daily salvage values were then summarized by month and reported as the proportion of total annual salvage observed in each month. Additionally, the annual predicted value of salvage in each of the 82 water years was plotted for the Existing, ~~and~~ PP, and Refined Alternative 2b scenarios.

Results of the analysis for salvage at the SWP are presented in Section 4.4 of the DEIR. For consideration of cumulative impacts in the DEIR Section 4.6, calculations were also made for combined salvage at the SWP + CVP south Delta facilities. Across the 82-year DSM2 simulation period, salvage of juvenile Winter Run Chinook Salmon was predicted to be less than 0.04% of the total juvenile population for both facilities combined. Predicted salvage at both facilities combined was slightly lower for the PP (0.353%) relative to Existing (0.380%) over the entire modeling period. Despite the trend of lower salvage under the PP across all years, there was variation in which scenario produced lower salvage in individual years (Figure E.4-1).

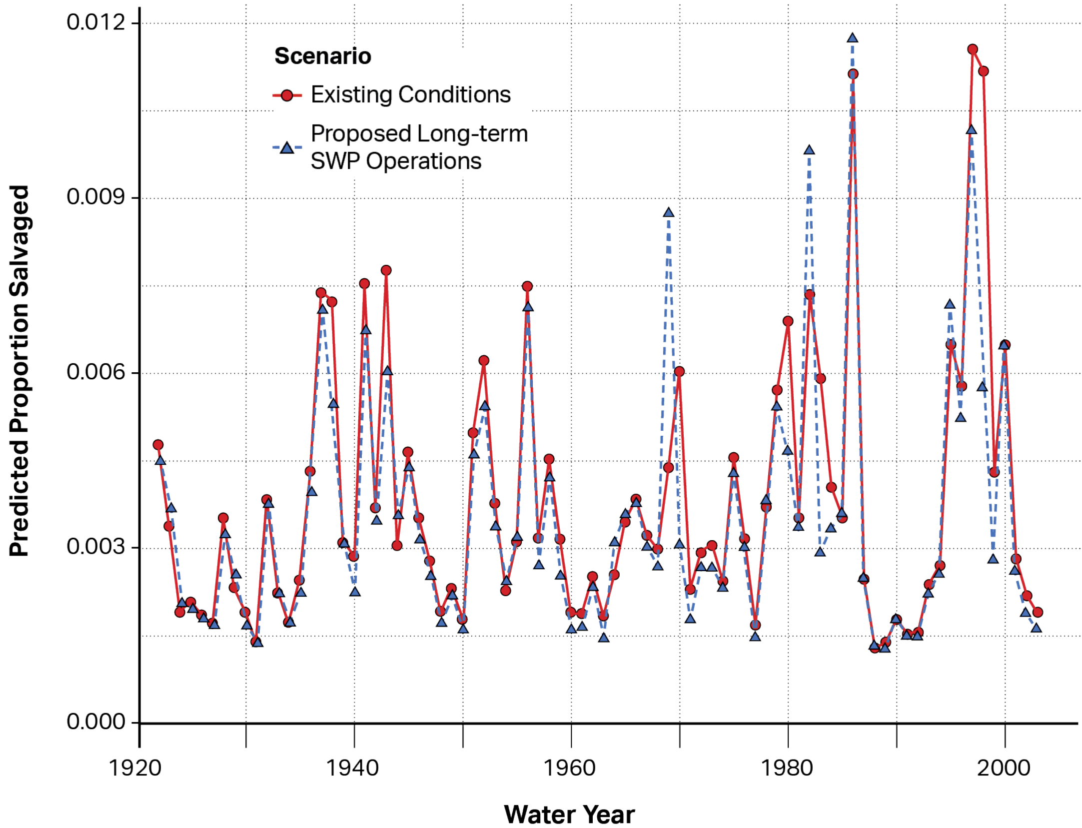
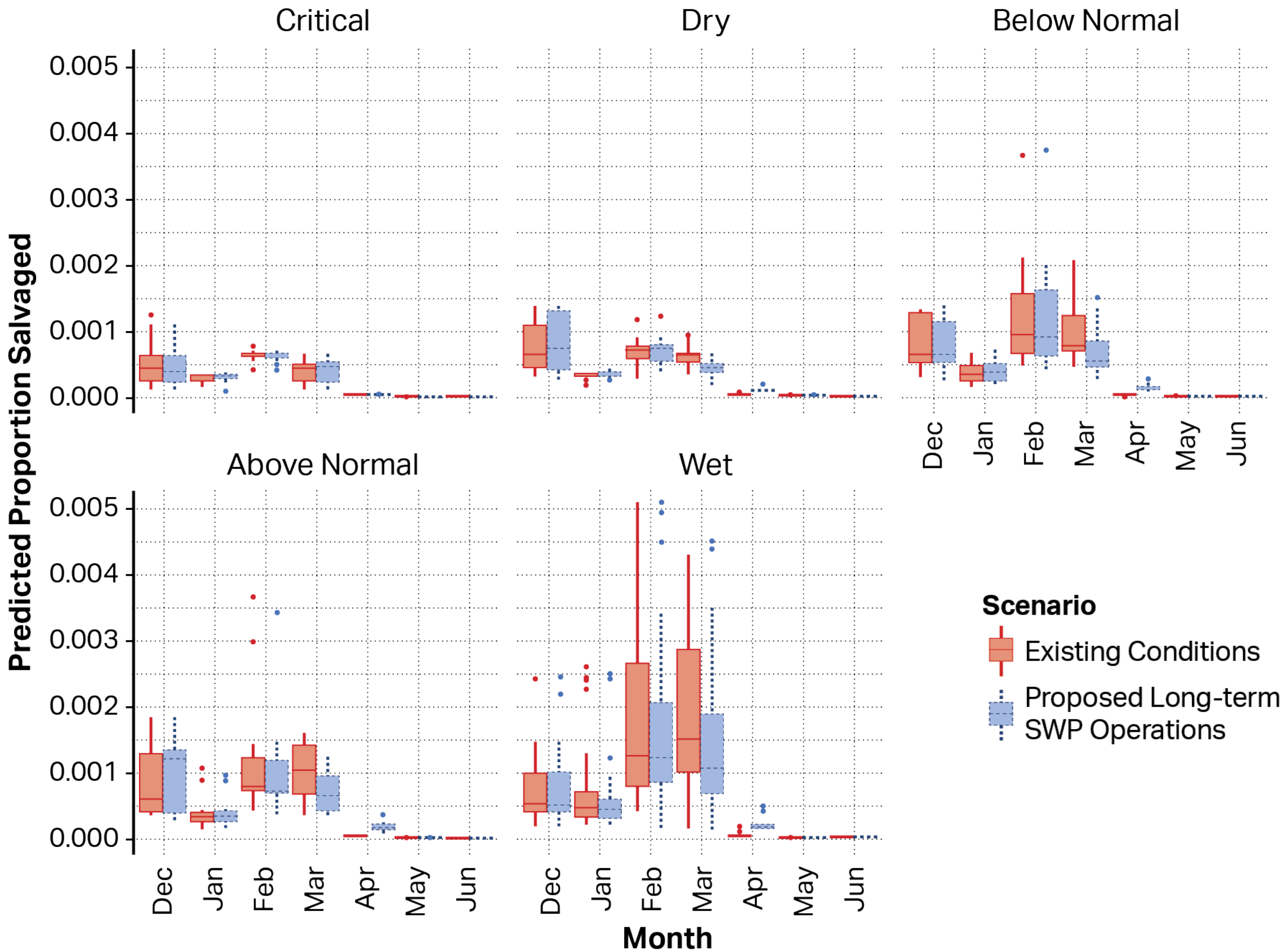


Figure E.4-1. Predicted proportion of Juvenile Winter-Run Chinook Salmon salvage at the Skinner Delta Fish Protective Facility of the State Water Project under the Existing and Proposed Project scenarios across the 82-year DSM2 simulation period.

The highest median salvage for the combined facilities occurred in wet water years; however, salvage did not exceed 0.625% in any month (Figure E.4-2). Within wet water years, the interquartile range of salvage at the combined facilities for both scenarios overlapped considerably in all months except February and March, which were the months with the highest salvage. In February, 75th percentile values of combined salvage were greater under Existing than PP and in March, 25th, median, and 75th percentile values of salvage were greater under Existing (Figure E.4-2). In above normal years salvage at the combined facilities was greatest in December for both scenarios though values were below 0.2% of all juveniles and interquartile ranges were similar between the two scenarios. In March, all interquartile values were greater for the existing condition (Figure E.4-2). The interquartile range of combined salvage was higher for the PP in April but the total value of salvage in this month was low. In below normal years salvage at the combined facilities was similar between scenarios in all months except March when interquartile values for Existing were greater than PP (Figure E.4-2). In dry years salvage was greatest in December and median and 75th percentile values were greater for the PP in that month. In March of dry years, predicted combined salvage was lower under PP than Existing. In all other months of dry years salvage was low and similar between scenarios. The lowest salvage at the combined facilities for both scenarios occurred in critical water years (Figure E.4-2).



Note: The horizontal line is the median value, the box defines the interquartile range and vertical lines define the minimum and maximum values. Single points are outliers.

Figure E.4-2. Box and whisker plots of predicted proportion of juvenile Winter-Run Chinook Salmon salvaged at the Skinner Delta Fish Protective Facility of the State Water Project and the Tracy Fish Facility of the Central Valley Project as a function of SWP exports and Sacramento River flow for Existing and PP scenarios.

~~E.4.2~~E.4.3 Delta Hydrodynamic Assessment and Junction Routing Analysis

~~E.4.2.1~~E.4.3.1 Velocity Assessment

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, and 2) “far-field” mortality resulting from altered hydrodynamics. Near-field or entrainment effects of proposed seasonal operations can be assessed by examining patterns of proportional population entrainment available from decades of coded wire tag studies (e.g., Zeug and Cavallo 2014). A foundation for assessing far-field effects has been provided by work of the Collaborative Adaptive Management Team’s (CAMT) Salmonid Scoping Team (SST). The SST completed a thorough review of this subject and defined a driver-linkage-outcome (DLO) framework for specifying how water project operations (the “driver”) can influence juvenile salmonid behavior (the “linkage”) and potentially cause changes in survival or routing (the “outcome”). The SST concluded altered “Channel Velocity” and altered “Flow Direction” were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta. Figure E.4-3 provides a simplified conceptual model of the DLO defined by the CAMT SST.

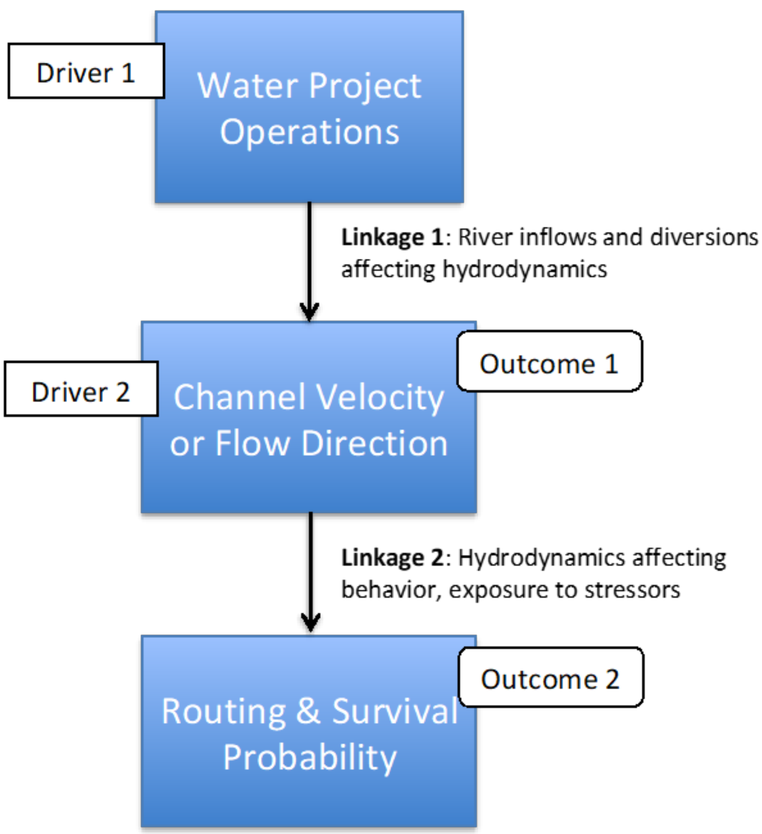


Figure E.4-3. Conceptual Model for Far-field Effects of Water Project Operations on Juvenile Salmonids in the Delta. This CM is a Simplified Version of the Information Provided by the CAMT SST

In order to assess the potential for water project operations to influence survival and routing, Delta hydrodynamic conditions were analyzed by creating maps from DSM2 Hydro modeling. The maps are based on a comparative metric, proportion overlap (more below), to capture channel-level hydrodynamic details as a single number for color-scale mapping of Delta channels.

The objective of the comparative metric is to summarize the water velocity time series for each channel and scenario such the channel-level comparison is captured in a single number. For the proportion overlap metric, kernel density estimates are calculated on each time series. The kernel density estimates represent a non-parametric smoothing of the empirical distribution of time series values. The proportion overlap of two kernel density estimates is calculated with the following steps: 1) -calculate the total area under the curve (AUC_t) as the sum of the AUC for each density estimate, 2) -calculate the AUC of the overlapping portions (AUC_o) of the two density distributions being compared, and 3) calculate the overlapping proportion of the density distributions as AUC_o/AUC_t. Proportion overlap is naturally bound by zero and one; a value of zero indicates no overlap and a value of one indicates complete overlap. Lower values of proportion overlap identify channels demonstrating larger differences in a scenario comparison.

The proportion overlap metric is best applied over relatively short time periods because seasonal and annual variation in water velocity can overwhelm differences between scenarios. Thus, the proportion overlap for every DSM2 channel for two seasons (December-February, March-May) in each water year (1922-2003) was calculated. DSM2 output was excluded from water year 1921 to allow for an extensive burn-in period. The proportion overlap was calculated based on hourly DSM2 output. Because each season was roughly 90 days, each comparison involved roughly 4,300 DSM2 values (2 scenarios * 24 hours * 90 days) for each channel.

Because the proportion overlap was calculated for each channel in each water year, the proportion overlap values were summarized prior to mapping (i.e., not feasible to map proportion overlap for every comparison in every water year). To summarize, the minimum and median proportion overlap for each channel for each water year type for each comparison was found. The minimum values represent the maximum expected effect. The median values represent the average expected effect. Note that the year with the minimum (or median) proportion overlap for one channel might not be the same year as for another channel.

~~E.4.2.2~~E.4.3.2 Routing Analysis

Many routes can potentially be used by fish migrating through the Delta and survival through these routes can be significantly different (Newman 2008; Perry et al. 2010). Thus, routing of fish at junctions and how routing could be affected by project operations has the potential to influence through-Delta survival. In general, routes that keep fish in the mainstem Sacramento and San Joaquin Rivers are superior to routes leading into the interior Delta (Hankin et al. 2010; Perry et al. 2010), although some recent findings for the San Joaquin River have not supported this generality (Buchanan et al. 2013). Perry (2010) found that the routing of fish into the interior delta through the combined junction of Georgiana Slough and the Delta Cross Channel was a function of the total flow entering the interior delta through both of those junctions. This is the function represented in Figure 6.7 within Perry (2010). This function indicated that the slope of the relationship was less than 1.

Cavallo et al. (2015) performed a meta-analysis of routing at 6 Delta junctions and found that the proportion of flow entering a junction explained 70% of the variation in routing. Similar to the Perry (2010) study, the slope of this relationship was less than 1 suggesting fish move into junctions at a rate less than the proportion of flow. Both of these studies present strong evidence that routing at junctions is a function of the proportion of flow into that junction.

For the present analysis of ~~the~~ PP and Refined Alternative 2b, flow routing into junctions was based on the proportion of flow entering a junction away from the main stem, from DSM2-HYDRO outputs. Fifteen-minute data were used to calculate the daily proportion of flow that enters the junction, following the methods of Cavallo et al. (2015). Similar to the analysis of velocity described previously, the daily value calculated from the 15-minute data was used to calculate summary statistics (box plots) for each month (December–June) and water year-type. If the median entrainment values under EXG ~~and~~ vs. PP and EXG vs. Refined Alternative 2b differed by ≥ 5% for any month, greater detail in the description of results was provided, based on a comparison of minimum values, maximum values, 25th quantile, 75th quantile, and median values.

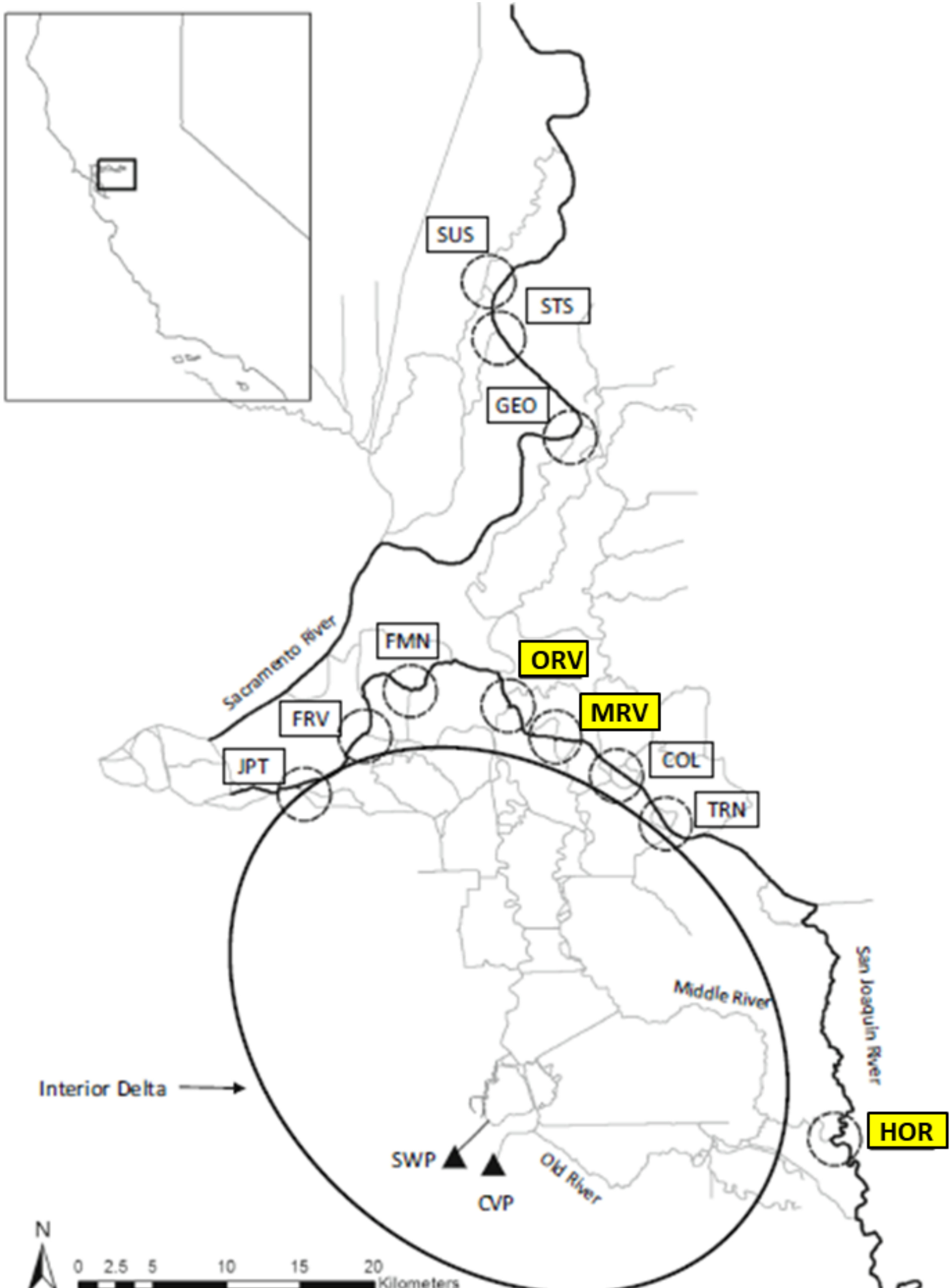
Flow into three junctions of interest with respect to movement towards the south Delta were included in this analysis: the head of Old River (HOR), the mouth of Old River (ORV), and the mouth of Middle River (MRV) (Figure E.4-4).

The combined evidence from the literature strongly indicates routing is a function of flow. Thus, it can be assumed routing of fish toward the interior delta will increase as the proportion of flow entering the junction increases. However, the slope of the relationship will be less than 1.

~~E.4.3~~E.4.4 DELTA PASSAGE MODEL

~~E.4.3.1~~E.4.4.1 INTRODUCTION

The DPM simulates migration of Chinook salmon smolts entering the Delta from the Sacramento River basin and estimates survival to Chipps Island. The DPM uses available time-series data and values taken from empirical studies or other sources to parameterize model relationships and inform uncertainty, thereby using the greatest amount of data available to dynamically simulate responses of smolt survival to changes in water management. Although the DPM is based primarily on studies of winter-run Chinook salmon smolt surrogates (late fall–run Chinook salmon), it is applied here for winter-run, spring-run, fall-run, and late fall–run Chinook salmon by adjusting emigration timing and assuming that all migrating Chinook salmon smolts will respond similarly to Delta conditions. The DPM results presented here reflect the current version of the model, which continues to be reviewed and refined, and for which a sensitivity analysis has been completed to examine various aspects of uncertainty related to the model's inputs and parameters.



Source: Adapted from Cavallo et al. (2015). Note: Only highlighted junctions were examined in this analysis, i.e., ORV (mouth of Old River), MRV (mouth of Middle River), and HOR (head of Old River).

Figure E.4-4. Highlighted Junctions Examined in the Routing Analysis

Although studies have shown considerable variation in emigrant size, with Central Valley Chinook salmon migrating as fry, parr, or smolts (Brandes and McLain 2001; Williams 2001), the DPM relies predominantly on data from acoustic-tagging studies of large (>140 mm) smolts, and therefore should be applied very cautiously to pre-smolt migrants. Salmon juveniles less than 70 mm are more likely to exhibit rearing behavior in the Delta (Moyle 2002) and thus likely will be represented poorly by the DPM. It has been assumed that the downstream emigration of fry, when spawning grounds are well upstream, is probably a dispersal mechanism that helps distribute fry among suitable rearing habitats. However, even when rearing habitat does not appear to be a limiting factor, downstream movement of fry still may be observed, suggesting that fry emigration is a viable alternative life-history strategy (Healy 1980; Healey and Jordan 1982; Miller et al. 2010). Unfortunately, survival data are lacking for small (fry-sized) juvenile emigrants because of the difficulty of tagging such small individuals. Therefore, the DPM should be viewed as a smolt survival model only, with its survival relationships generally having been derived from larger smolts (>140 mm), with the fate of pre-smolt emigrants not incorporated into model results.

The DPM has undergone substantial revisions based on comments received through the Bay Delta Conservation Plan preliminary proposal anadromous team meetings and in particular through feedback received during a workshop held on August 24, 2010, a 2-day workshop held June 23–24, 2011, and since then from various meetings of a workgroup consisting of agency biologists and consultants during preparation of the California WaterFix Biological Assessment. This effects analysis uses the most recent version of the DPM as of September 2015, with updates as noted below. The DPM is viewed as a simulation framework that can be changed as more data or new hypotheses regarding smolt migration and survival become available. The results are based on these revisions.

Survival estimates generated by the DPM are not intended to predict future outcomes. Instead, the DPM provides a simulation tool that compares the effects of different water management options on smolt migration survival, with accompanying estimates of uncertainty. The DPM was used to evaluate overall through-Delta survival for the COS, PA and WOA scenarios. Note that the DPM is a tool to compare different scenarios and is not intended to predict actual through-Delta survival under current or future conditions. In keeping with other methods found in the effects analysis, it is possible that underlying relationships (e.g., flow-survival) that are used to inform the DPM will change in the future; there is an assumption of stationarity of these basic relationships to allow scenarios to be compared for the current analysis, recognizing that it may be necessary to re-examine the relationships as new information becomes available.

~~E.4.3.2~~E.4.4.2 MODEL OVERVIEW

The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions. The biological functionality of the DPM is based on the foundation provided by Perry et al. (2010) as well as other acoustic tagging–based studies (San Joaquin River Group Authority 2008, 2010; Holbrook et al. 2009) and coded wire tag (CWT)–based studies (Newman and Brandes 2010; Newman 2008). Uncertainty is explicitly modeled in the DPM by incorporating environmental stochasticity and estimation error whenever available.

The major model functions in the DPM are as follows.

1. Delta Entry Timing, which models the temporal distribution of smolts entering the Delta for each race of Chinook salmon.
2. Fish Behavior at Junctions, which models fish movement as they approach river junctions.
3. Migration Speed, which models reach-specific smolt migration speed and travel time.
4. Route-Specific Survival, which models route-specific survival response to non-flow factors.
5. Flow-Dependent Survival, which models reach-specific survival response to flow.
6. Export-Dependent Survival, which models survival response to water export levels in the Interior Delta reach (see Table E.4-6 for reach description).

Functional relationships are described in detail in the Section discussing *Model Functions*.

Model Time Step

The DPM operates on a daily time step using simulated daily average flows and Delta exports as model inputs. The DPM does not attempt to represent sub-daily flows or diel salmon smolt behavior in response to the interaction of tides, flows, and specific channel features. The DPM is intended to represent the net outcome of migration and mortality occurring over days, not three dimensional movements occurring over minutes or hours (e.g., Blake and Horn 2003). It is acknowledged that finer scale modeling with a shorter time step may match the biological processes governing fish movement better than a daily time step (e.g., because of diel activity patterns; Plumb et al. 2015) and that sub-daily differences in flow proportions into junctions make daily estimates somewhat coarse (Cavallo et al. 2015).

Spatial Framework

The DPM is composed of nine reaches and four junctions (Figure E.4-5; Table E.4-6) selected to represent primary salmonid migration corridors where high-quality data were available for fish and hydrodynamics. For simplification, Sutter Slough and Steamboat Slough are combined as the reach SS; and Georgiana Slough, the Delta Cross Channel (DCC), and the forks of the Mokelumne River to which the DCC leads are combined as Geo/DCC. The Geo/DCC reach can be entered by Sacramento runs through the combined junction of Georgiana Slough and DCC (Junction C). The Interior Delta reach can be entered from Geo/DCC. The entire Interior Delta region is treated as a single model reach3. The four distributary junctions (channel splits) depicted in the DPM are (A) Sacramento River at Fremont Weir (head of Yolo Bypass), (B) Sacramento River at head of Sutter and Steamboat Sloughs, and (C) Sacramento River at the combined junction with Georgiana Slough and DCC (Figure E.4-5, Table E.4-6).

Flow Input Data

Water movement through the Delta as input to the DPM is derived from daily (tidally averaged) flow output produced by the hydrology module of the Delta Simulation Model II (DSM2- HYDRO; <http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/>) or from CALSIM-II.

Table E.4-6. Description of Modeled Reaches and Junctions in the Delta Passage Model

Reach/ Junction	Description	Reach Length (km)
Sac1	Sacramento River from Freeport to junction with Sutter/Steamboat Sloughs	19.33
Sac2	Sacramento River from Sutter/Steamboat Sloughs junction to junction with Delta Cross Channel/Georgiana Slough	10.78
Sac3	Sacramento River from Delta Cross Channel junction to Rio Vista, California	22.37
Sac4	Sacramento River from Rio Vista, California to Chipps Island	23.98
Yolo	Yolo Bypass from entrance at Fremont Weir to Rio Vista, California	NA[a]
Verona	Fremont Weir to Freeport	57
SS	Combined reach of Sutter Slough and Steamboat Slough ending at Rio Vista, California	26.72
Geo/DCC	Combined reach of Georgiana Slough, Delta Cross Channel, and South and North Forks of the Mokelumne River ending at confluence with the San Joaquin River in the Interior Delta	25.59
Interior Delta	Begins at end of reach Geo/DCC, San Joaquin River via Junction D, or Old River via Junction D, and ends at Chipps Island	NAb
A	Junction of the Yolo Bypass[c] and the Sacramento River	NA
B	Combined junction of Sutter Slough and Steamboat Slough with the Sacramento River	NA
C	Combined junction of the Delta Cross Channel and Georgiana Slough with the Sacramento River	NA

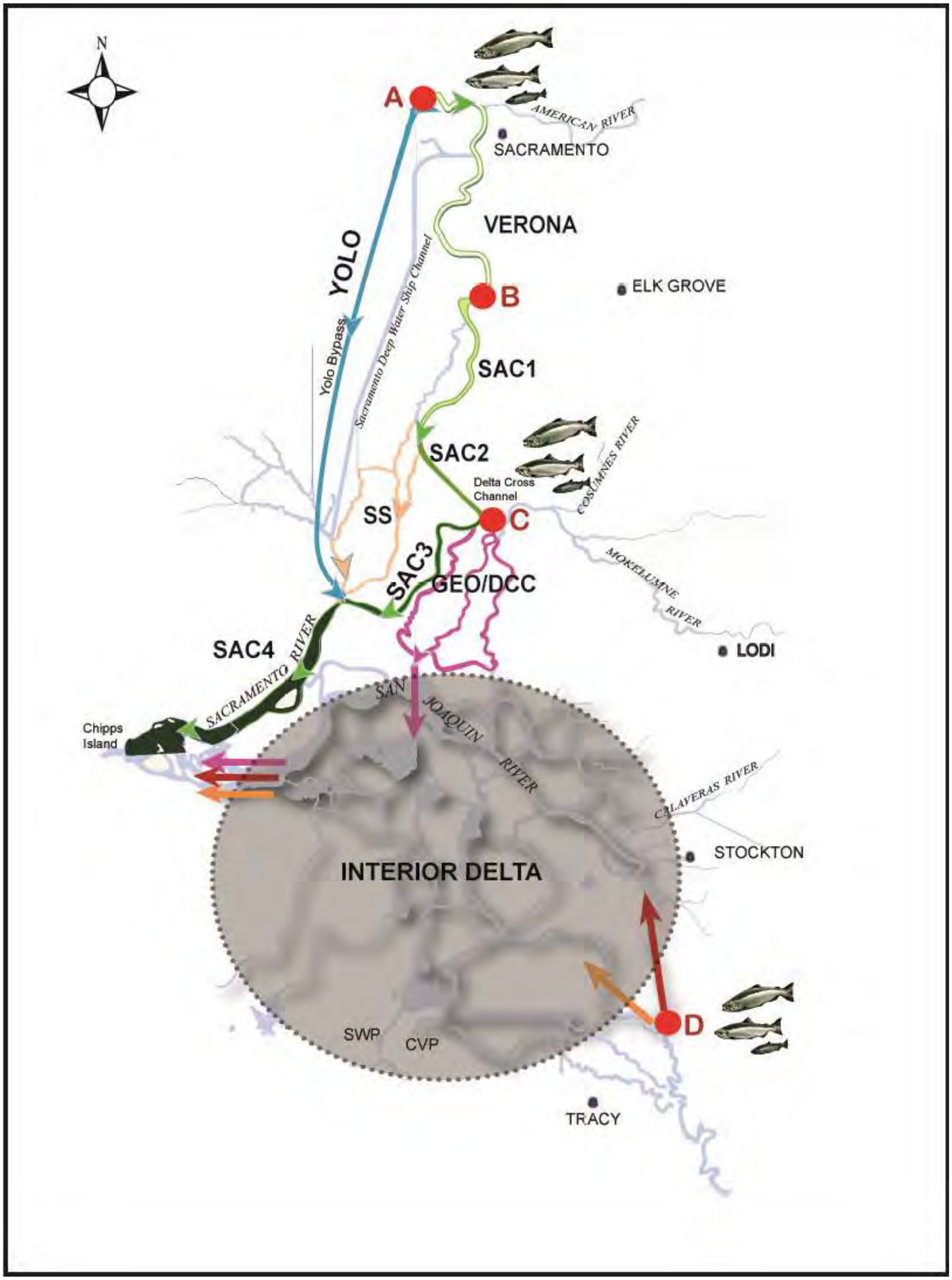
[a] Reach length for Yolo Bypass is undefined because reach length currently is not used to calculate Yolo Bypass speed and ultimate travel time.
[b] Reach length for the Interior Delta is undefined because salmon can take multiple pathways. Also, timing through the Interior Delta does not affect Delta survival because there are no Delta reaches located downstream of the Interior Delta.
[c] Flow into the Yolo Bypass is primarily via the Fremont Weir but flow via Sacramento Weir is also included.

The nodes in the DSM2-HYDRO and CALSIM II models that were used to provide flow for specific reaches in the DPM are shown in Table E.4-7.

Table E.4-7. Delta Passage Model Reaches and Associated Output Locations from DSM2-HYDRO and CALSIM II Models

DPM Reach or Model Component	DSM2 Output Locations	CALSIM Node
Sac1	rsac155	--
Sac2	rsac128	--
Sac3	rsac123	--
Sac4	rsac101	--
Yolo	--	d160a+d166aa
Verona	--	C160a
SS	slsbt011	--
Geo/DCC	dcc+georg_sl	--
South Delta Export Flow	Clifton Court Forebay + Delta Mendota Canal	--
Sacramento River flow at Fremont Weir	--	C129a

Note:
"–" indicates the cell is blank.



Bold headings label modeled reaches, and red circles indicate model junctions. Salmonid icons indicate locations where smolts enter the Delta in the DPM. Smolts enter the Interior Delta from the Geo/DCC reach. Because of the lack of data informing specific routes through the Interior Delta, and tributary specific survival, the entire Interior Delta region is treated as a single model reach. Note that junction D is not modeled for fish entering the Delta from the Sacramento River basin, as in this analysis.

Figure E.4-5. Map of the Sacramento–San Joaquin River Delta Showing the Modeled Reaches and Junctions of the Delta Applied in the Delta Passage Model

~~E.4.3.3~~E.4.4.3 MODEL FUNCTIONS

Delta Entry Timing

Recent sampling data on Delta entry timing of emigrating juvenile smolts for six Central Valley Chinook salmon runs were used to inform the daily proportion of juveniles entering the Delta for each run (Table E.4-8). Because the DPM models the survival of smolt-sized juvenile salmon, pre-smolts were removed from catch data before creating entry timing distributions. The lower 95th percentile of the range of salmon fork lengths visually identified as smolts by the USFWS in Sacramento trawls was used to determine the lower length cutoff for smolts. A lower fork length cutoff of 70 mm for smolts was applied, and all catch data of fish smaller than 70 mm were eliminated. To isolate wild production, all fish identified as having an adipose-fin clip (hatchery production) were eliminated, recognizing that most of the fall-run hatchery fish released upstream of Sacramento are not marked. Daily catch data for each brood year were divided by total annual catch to determine the daily proportion of smolts entering the Delta for each brood year. Sampling was not conducted daily at most stations and catch was not expanded for fish caught but not measured. Finally, the daily proportions for all brood years were plotted for each race, and a normal distribution was visually approximated to obtain the daily proportion of smolts entering the DPM for each run (Figure E.4-6). Because a bi-modal distribution appeared evident for winter-run entry timing, a generic probability density function was fit to the winter-run daily proportion data using the package "sm" in R software (R Core Team 2012). The R fitting procedure estimated the best-fit probability distribution of the daily proportion of fish entering the DPM for winter-run. A sensitivity analysis of this assumption was undertaken and showed that patterns in results would be expected to be similar for a range of entry distribution assumptions.

For the current analysis, the most recent data from the Sacramento Trawl survey was added to the previous data to determine if entry distributions had shifted since the original fitting. Only late fall Chinook Salmon exhibited substantial change from the original fit and the entry distribution for that race was updated (Figure E.4-6).

Table E.4-8. Sampling Gear Used to Create Juvenile Delta Entry Timing Distributions for Each Central Valley Run of Chinook Salmon

Chinook Salmon Run	Gear	Agency	Brood Years
Sacramento River Winter Run	Trawls at Sacramento	USFWS	1995–2009
Sacramento River Spring Run	Trawls at Sacramento	USFWS	1995–2005
Sacramento River Fall Run	Trawls at Sacramento	USFWS	1995–2005
Sacramento River Late Fall Run	Trawls at Sacramento	USFWS	1995–2005

Agencies that conducted sampling are listed: USFWS = U.S. Fish and Wildlife Service.

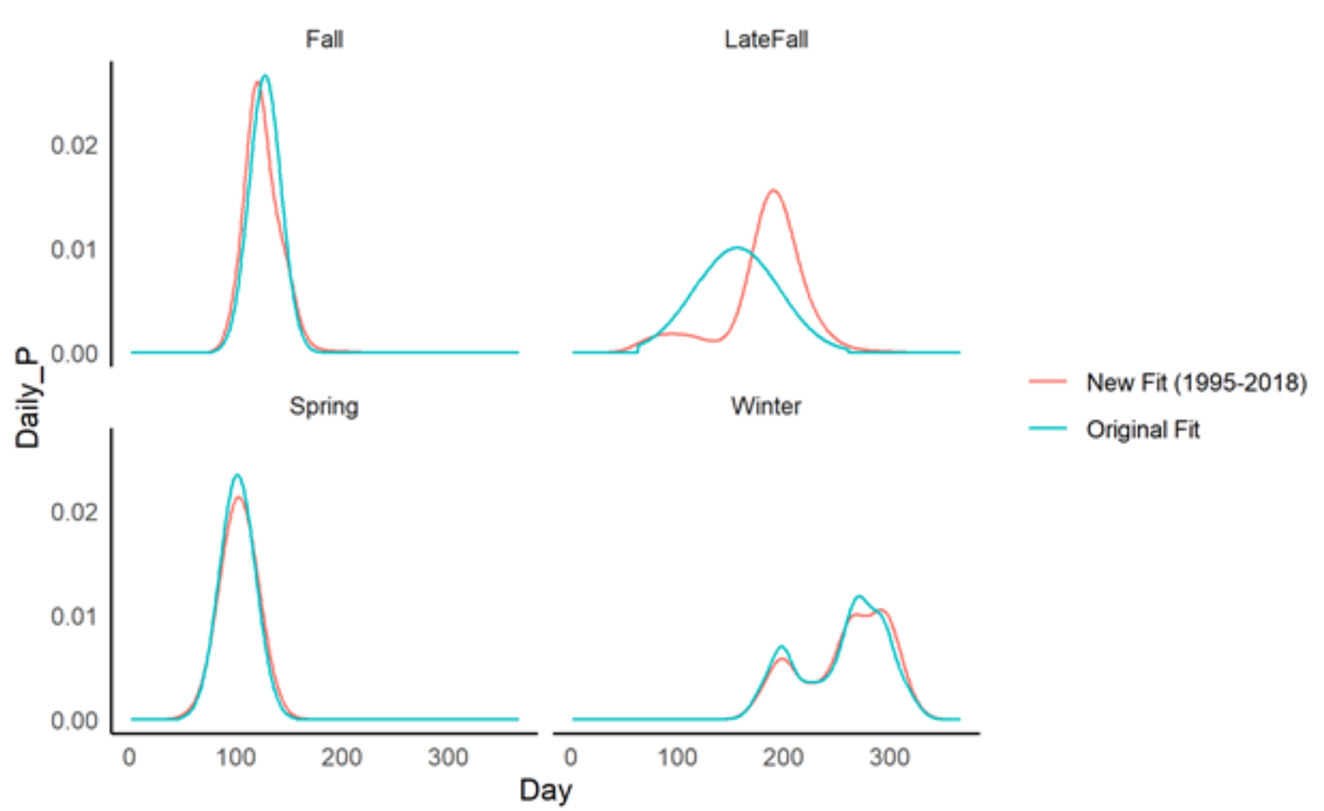


Figure E.4-6. Delta Entry Distributions for Chinook Salmon Smolts Applied in the Delta Passage Model for Sacramento River Winter-Run, Central Valley Spring-Run (from the Sacramento River basin), Central Valley Fall-Run (from the Sacramento River basin), and Central Valley Late Fall–Run

Migration Speed

The DPM assumes a net daily movement of smolts in the downstream direction. The rate of smolt movement in the DPM affects the timing of arrival at Delta junctions and reaches, which can affect route selection and survival as flow conditions or water project operations change.

Smolt movement in all reaches except Yolo Bypass and the Interior Delta is a function of reach-specific length and migration speed as observed from acoustic-tagging results. Reach-specific length (kilometers [km]) (Table E.4-6) is divided by reach migration speed (km/day) the day smolts enter the reach to calculate the number of days smolts will take to travel through the reach.

For north Delta reaches Verona, Sac1, Sac2, SS, and Geo/DCC, mean migration speed through the reach is predicted as a function of flow. Many studies have found a positive relationship between juvenile Chinook salmon migration rate and flow in the Columbia River Basin (Raymond 1968; Berggren and Filardo 1993; Schreck et al. 1994), with Berggren and Filardo (1993) finding a logarithmic relationship for Snake River yearling Chinook salmon. Ordinary least squares regression was used to test for a logarithmic relationship between reach-specific migration speed (km/day) and average daily reach-specific flow (cubic meters per second [m3/sec]) for the first day smolts entered a particular reach for reaches where acoustic-tagging data was available (Sac1, Sac2, Sac3, Sac4, Geo/DCC, and SS):

$$Speed = \beta_0 \ln(flow) + \beta_1$$

Where β_0 is the slope parameter and β_1 is the intercept.

Individual smolt reach-specific travel times were calculated from detection histories of releases of acoustically tagged smolts conducted in December and January for three consecutive winters (2006/2007, 2007/2008, and 2008/2009) (Perry 2010). Reach-specific migration speed (km/day) for each smolt was calculated by dividing reach length by travel days (Table E.4-9). Flow data was queried from the California Department of Water Resources (DWR's) California Data Exchange website (<http://cdec.water.ca.gov/>).

Table E.4-9. Reach-Specific Migration Speed and Sample Size of Acoustically-Tagged Smolts Released during December and January for Three Consecutive Winters (2006/2007, 2007/2008, and 2008/2009)

Reach	Gauging Station ID	Release Dates	Sample Size	Avg Speed (km/day)	Min Speed (km/day)	Max Speed (km/day)	SD Speed (km/day)
Sac1	FPT	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	452	13.32	0.54	41.04	9.29
Sac2	SDC	1/17/07–1/18/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	294	9.29	0.34	10.78	3.09
Sac3	GES	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	102	9.24	0.37	22.37	7.33
Sac4	GES[a]	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	62	8.60	0.36	23.98	6.79
Geo/DCC	GSS	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	86	14.20	0.34	25.59	8.66
SS	FPT-SDC[b]	12/05/06–12/06/06, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	30	9.41	0.56	26.72	7.42

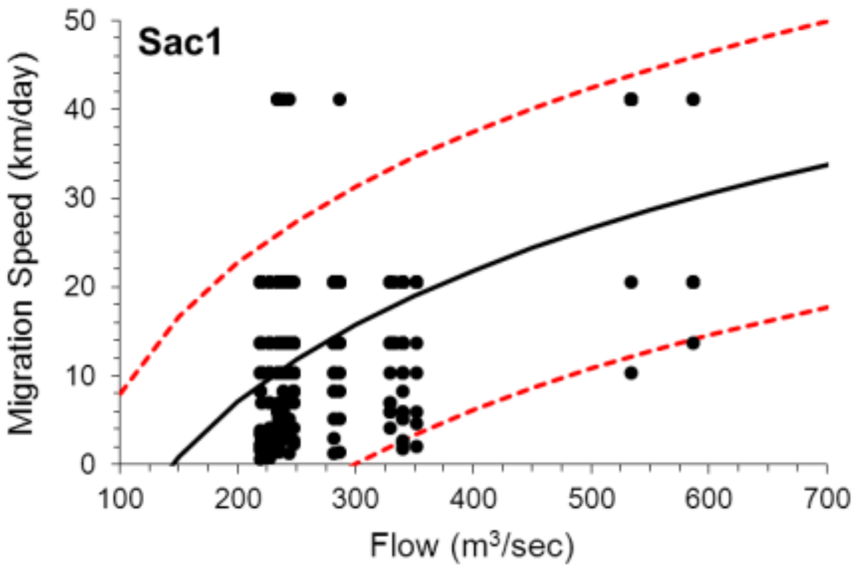
a Sac3 flow is used for Sac4 because no flow gauging station is available for Sac4.

b SS flow is calculated by subtracting Sac2 flow (SDC) from Sac1 flow (FPT).

Migration speed was significantly related to flow for reaches Sac1 ($df = 450$, $F = 164.36$, $P < 0.001$), Sac2 ($df = 292$, $F = 4.17$, $P = 0.042$), and Geo/DCC ($df = 84$, $F = 13.74$, $P < 0.001$). Migration speed increased as flow increased for all three reaches (Table E.4-10, Figure E.4-7). Therefore, for reaches Sac1, Sac2, and Geo/DCC, the regression coefficients shown in Table E.4-10 are used to calculate the expected average migration rate given the input flow for the reach and the associated standard error of the regressions is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determine their migration speed throughout the reach. The minimum migration speed for each reach is set at the minimum reach-specific migration speed observed from the acoustic-tagging data (Table E.4-4). The flow-migration rate relationship that was used for Sac1 also was applied for the Verona reach.

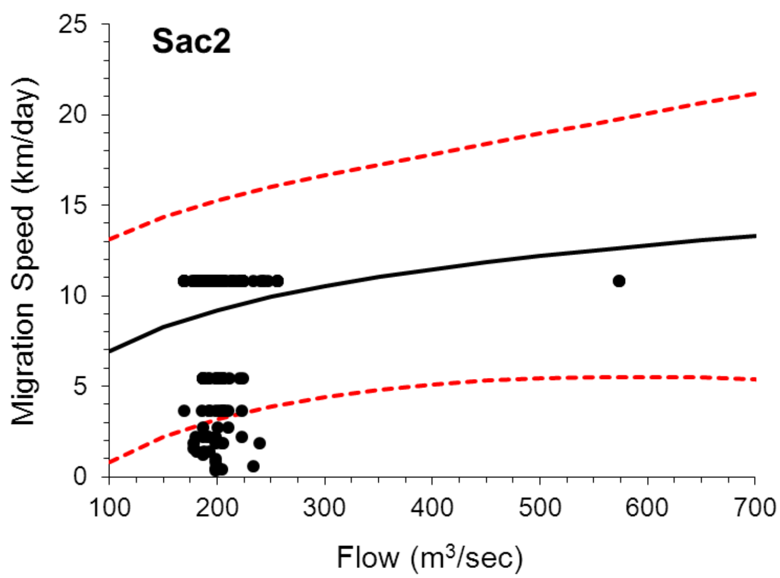
Table E.4-10. Sample Size (N) and Slope (β0) and Intercept (β1) Parameter Estimates with Associated Standard Error (in Parenthesis) for the Relationship between Migration Speed and Flow for Reaches Sac1, Sac2, and Geo/DCC

Reach	Sample Size (N)	Slope [β_0] (with standard error)	Intercept [β_1] (with standard error)
Sac1	452	21.34 (1.66)	-105.98 (9.31)
Sac2	294	3.25 (1.59)	-8.00 (8.46)
Geo/DCC	86	11.08 (2.99)	-33.52 (12.90)



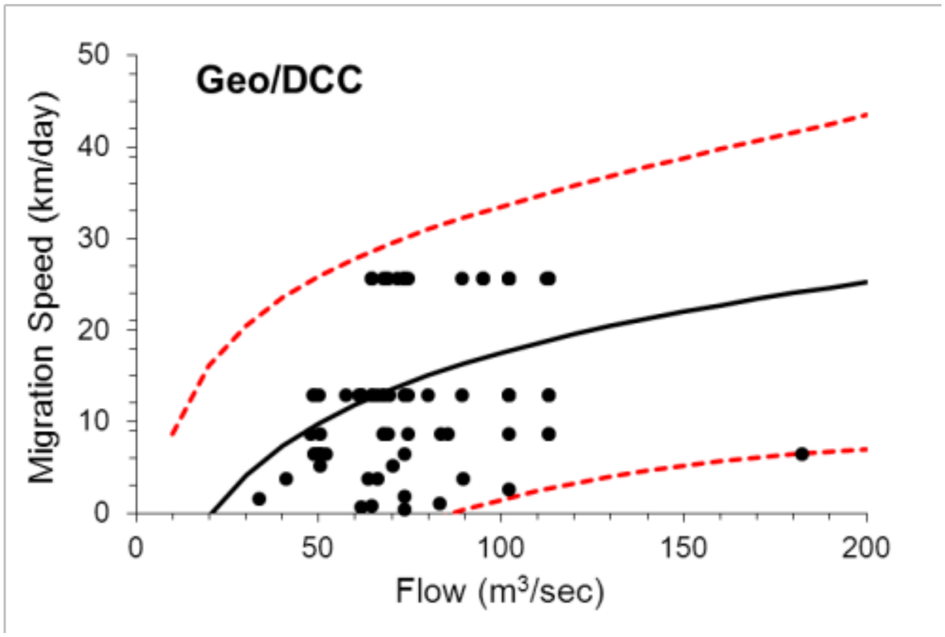
Circles are observed migration speeds of acoustically tagged smolts from acoustic-tagging studies from Perry (2010), solid lines are predicted mean migration speed, and dotted lines are 95% prediction intervals used to inform uncertainty.

Figure E.4-7 a. Reach-Specific Migration Speed (km/day) as a Function of Flow (m^3/sec) Applied in Reach Sac1



Circles are observed migration speeds of acoustically tagged smolts from acoustic-tagging studies from Perry (2010), solid lines are predicted mean reach survival curves, and dotted lines are 95% prediction intervals used to inform uncertainty.

Figure E.4-7 b. Reach-Specific Migration Speed (km/day) as a Function of Flow (m^3/sec) Applied in Reach Sac2



Circles are observed migration speeds of acoustically tagged smolts from acoustic-tagging studies from Perry (2010), solid lines are predicted mean reach survival curves, and dotted lines are 95% prediction intervals used to inform uncertainty.

Figure E.4-7 c. Reach-Specific Migration Speed (km/day) as a Function of Flow (m^3/sec) Applied in Reach Geo/DCC

No significant relationship between migration speed and flow was found for reaches Sac3 (df = 100, F = 1.13, P =0.29), Sac4 (df = 60, F = 0.33, P = 0.57), and SS (df = 28, F = 0.86, P = 0.36). Therefore, for these reaches the observed mean migration speed and associated standard deviation (Table E.4-9) is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determine their migration speed throughout the reach. As applied for reaches Sac1, Sac2, and Geo/DCC, the minimum migration speed for reaches Sac3, Sac4, and SS is set at the minimum reach-specific migration speed observed from the acoustic-tagging data (Table E.4-9).

Yolo Bypass travel time data from Sommer et al. (2005) for acoustic-tagged, fry-sized (mean size = 57 mm fork length [FL]) Chinook salmon were used to inform travel time through the Yolo Bypass in the DPM. Because the DPM models the migration and survival of smolt-sized juveniles, the range of the shortest travel times observed across all three years (1998–2000) by Sommer et al. (2005) was used to inform the bounds of a uniform distribution of travel times (range = 4–28 days), on the assumption that smolts would spend less time rearing, and would travel faster than fry. On the day smolts enter the Yolo Bypass, their travel time through the reach is calculated by sampling from this uniform distribution of travel times.

The travel time of smolts migrating through the Interior Delta in the DPM is informed by observed mean travel time (7.95 days) and associated standard deviation (6.74) from North Delta acoustic-tagging studies (Perry 2010). However, the timing of smolt passage through the Interior Delta does not affect Delta survival because there are no Delta reaches located downstream of the Interior Delta.

Fish Behavior at Junctions (Channel Splits)

Perry et al. (2010) found that acoustically-tagged smolts arriving at Delta junctions exhibited inconsistent movement patterns in relation to the flow being diverted. For Junction A (entry into the Yolo Bypass at Fremont Weir), the following relationships were used.

- Proportion of smolts entering Yolo Bypass = Fremont Weir spill[1] / (Fremont Weir spill + Sacramento River at Verona flows).

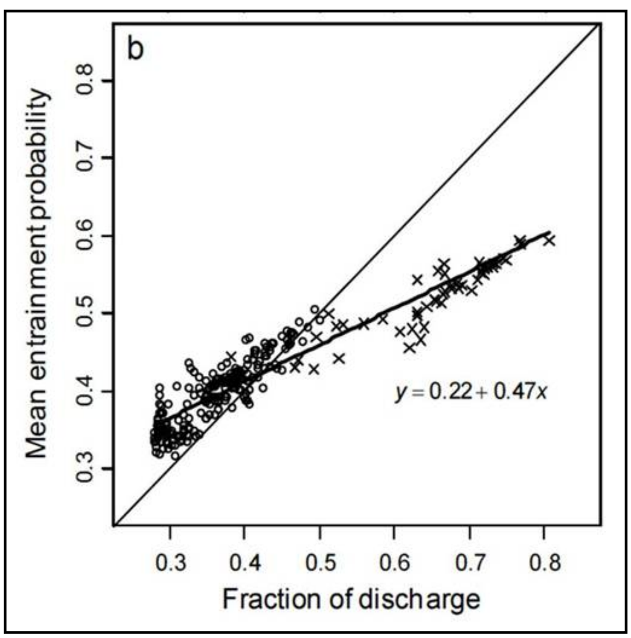
As noted above in *Flow Input Data*, the flow data informing Yolo Bypass entry were obtained by disaggregating CALSIM estimates using historical daily patterns of variability because DSM2 does not provide daily flow data for these locations.

For Junction B (Sacramento River-Sutter/Steamboat Sloughs), Perry et al. (2010) found that smolts consistently entered downstream reaches in proportion to the flow being diverted. Therefore, smolts arriving at Junction B in the model were assumed to move proportionally with flow. Similarly, with data lacking to inform the nature of the relationship, a proportional relationship between flow and fish movement for Junction D (San Joaquin River–Old River) also was applied. Note that the operation of the Head of Old River gate proposed under the PA is accounted for in the DSM2 flow input data (i.e., with a closed gate, relatively more flow [and therefore smolts] remains in the San Joaquin River).

For Junction C (Sacramento River–Georgiana Slough/DCC), Perry (2010) found a linear, nonproportional relationship between flow and fish movement. This relationship for Junction C was applied in the DPM:

$$y = 0.22 + 0.47x;$$

where *y* is the proportion of fish diverted into Geo/DCC and *x* is the proportion of flow diverted into Geo/DCC (Figure E.4-8).



Note: Circles Depict DCC Gates Closed, Crosses Depict DCC Gates Open.

Figure E.4-8. Figure from Perry (2010) Depicting the Mean Entrainment Probability (Proportion of Fish Being Diverted into Reach Geo/DCC) as a Function of Fraction of Discharge (Proportion of Flow Entering Reach Geo/DCC)

In the DPM, this linear function is applied to predict the daily proportion of fish movement into Geo/DCC as a function of the proportion of flow into Geo/DCC.

Route-Specific Survival

Survival through a given route (individual reach or several reaches combined) is calculated and applied the first day smolts enter the reach. For reaches where literature showed support for reach-level responses to environmental variables, survival is influenced by flow (Sac1, Sac2, Sac3 and Sac4 combined, SS and Sac 4 combined, Interior Delta via San Joaquin River, and Interior Delta via Old River) or south Delta water exports (Interior Delta via Geo/DCC). For these reaches, daily flow or exports occurring the day of reach entry are used to predict reach survival during the entire migration period through the reach (Table E.4-11). For all other reaches (Geo/DCC and Yolo), reach survival is assumed to be unaffected by Delta conditions and is informed by means and standard deviations of survival from acoustic-tagging studies.

Table E.4-11. Route-Specific Survival and Parameters Defining Functional Relationships or Probability Distributions for Each Chinook Salmon Run and Methods Section Where Relationship is Described

Route	Chinook Salmon Run	Survival[a]	Methods Section Description
Verona	All Sacramento runs	0.931 (0.02)	This section
Sac1	All Sacramento runs	Function of flow	Flow-Dependent Survival
Sac2	All Sacramento runs	Function of flow	Flow-Dependent Survival
Sac3 and Sac4 combined	All Sacramento runs	Function of flow	Flow-Dependent Survival
Yolo	All Sacramento runs	Various	This section
Sac4 via Yolo[b]	All Sacramento runs	0.698 (0.153)	This section
SS and Sac4 combined	All Sacramento runs	Function of flow	Flow-Dependent Survival
Geo/DCC	All Sacramento runs	0.65 (0.126)	This section
Interior Delta	All Sacramento runs	Function of exports	Export-Dependent Survival
Interior Delta	San Joaquin fall-run via Old River	Function of flow	Flow-Dependent Survival
Interior Delta	San Joaquin fall-run via San Joaquin River	Function of flow	Flow-Dependent Survival

[a] For routes where survival is uninfluenced by Delta conditions, mean survival and associated standard deviation (in parentheses) observed during acoustic-tagging studies (Michel 2010; Perry 2010) are used to define a normal probability distribution that is sampled from the day smolts enter a reach to calculate reach survival.

[b] Although flow influences survival of fish migrating through the combined routes of SS–Sac4 and Sac3–Sac4, flow does not influence Sac4 survival for fish arriving from Yolo.

For reaches Geo/DCC, Yolo, and Sac4 via Yolo, no empirical data were available to support a relationship between survival and Delta flow conditions (channel flow, exports). Therefore, for these reaches mean reach survival is used along with reach-specific standard deviation to define a normal probability distribution that is sampled from when smolts enter the reach to determine reach survival (Table E.4-11).

Mean reach survival and associated standard deviation for Geo/DCC are informed by survival data from smolt acoustic-tagging studies from Perry (2010; Table E.4-12). Smolts migrating down the Sacramento River during the acoustic-tagging studies could enter the DCC or Georgiana Slough when the DCC was open (December releases), therefore, group survivals for both routes are used to inform the mean survival and associated standard deviation for the Geo/DCC reach for Sacramento River runs.

Smolt survival data for the Yolo Bypass were obtained from the UC Davis Biotelemetry Laboratory (M. Johnston pers. comm.). These data included survival estimates for five reaches from release near the head of the bypass to the base of the bypass. The means (and standard errors) of these estimates defined normal probability distributions from which daily value for the DPM were drawn, and were as follows: reach 1 (release site): 1.00; reach 2 (release site to I-80): 0.96 (SE = 0.059); reach 3 (I-80 to screw trap): 0.96 (0.064); reach 4 (screw trap to base of Toe Drain): 0.94 (0.107); reach 5 (base of Toe Drain to base of Bypass): 0.88 (0.064). Fish leaving the Yolo reach in the model then entered Sac4 and were subject to survival at the rate shown in Table E.4-11.

Mean survival and associated standard deviation for the Verona reach between Fremont Weir and Yolo Bypass were derived from the 2007–2009 acoustic-tag study reported by Michel (2010), who did not find a flow-survival relationship for that reach.

Table E.4-12. Individual Release-Group Survival Estimates, Release Dates, Data Sources, and Associated Calculations Used to Inform Reach-Specific Mean Survivals and Standard Deviations Used in the Delta Passage Model for Reaches Where Survival Is Uninfluenced by Delta Conditions - Tables E.4-12 a -and E.4--12 -b

Table E.4-12 a. Individual Release-Group Survival Estimates, Release Dates, Data Sources, and Associated Calculations Used to Inform Reach-Specific Mean Survivals and Standard Deviations Used in the Delta Passage Model for Reaches Where Survival Is Uninfluenced by Delta Conditions - Geo/DCC via Sacramento River

Survival	Release Dates	Survival Calculation	Mean	Standard Deviation
0.648	12/05/06	S_{D1}	0.559	0.194
0.600	12/04/07–12/06/07	$S_{D1,SAC}*S_{D2}$	0.559	0.194
0.762	1/15/08–1/17/08	$S_{D1,SAC}*S_{D2}$	0.559	0.194
0.774	11/31/08–12/06/08	$S_{D1,SAC}*S_{D2}$	0.559	0.194
0.467	1/13/08–1/19/09	$S_{D1,SAC}*S_{D2}$	0.559	0.194
0.648	12/05/06	$S_{C1}* S_{C2}$	0.559	0.194
0.286	12/04/07–12/06/07	S_{C1}	0.559	0.194
0.286	11/31/08–12/06/08	S_{C1}	0.559	0.194

Source: Perry 2010.

Table E.4-12 b. Individual Release-Group Survival Estimates, Release Dates, Data Sources, and Associated Calculations Used to Inform Reach-Specific Mean Survivals and Standard Deviations Used in the Delta Passage Model for Reaches Where Survival Is Uninfluenced by Delta Conditions - Sac4 via Yolo

Survival	Release Dates	Survival Calculation	Mean	Standard Deviation
0.714	12/5/2006	$S_{A6}*S_{A7}$	0.698	0.153
0.858	1/17/2007	$S_{A6}*S_{A7}$	0.698	0.153
0.548	12/4/07-12/6/07	$S_{A7}*S_{A8}$	0.698	0.153
0.488	1/15/08-1/17/08	$S_{A7}*S_{A8}$	0.698	0.153
0.731	11/31/08-12/06/08	$S_{A7}*S_{A8}$	0.698	0.153
0.851	1/13/09-1/19/09	$S_{A7}*S_{A8}$	0.698	0.153

Source: Perry 2010.

Flow-Dependent Survival

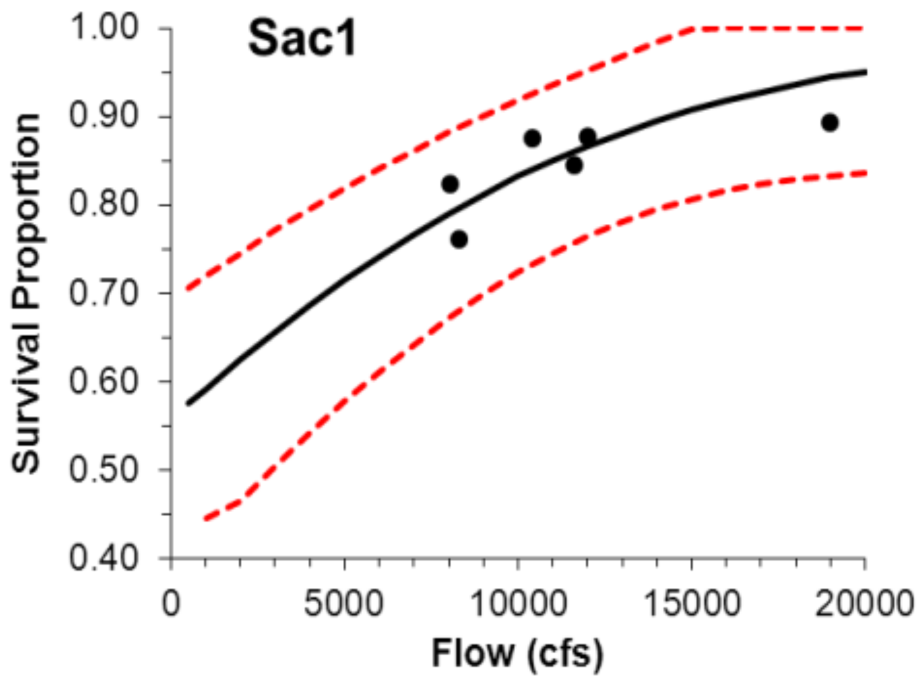
For reaches Sac1, Sac2, Sac3 and Sac4 combined, and SS and Sac4 combined, flow values on the day of route entry are used to predict route survival (Figure E.4-9). Perry (2010) evaluated the relationship between survival among acoustically-tagged Sacramento River smolts and Sacramento River flow measured below Georgiana Slough (DPM reach Sac3) and found a significant relationship between survival and flow during the migration period for smolts that migrated through Sutter and Steamboat Sloughs to Chipps Island (Sutter and Steamboat route; SS and Sac4 combined) and smolts that migrated from the junction with Georgiana Slough to Chipps Island (Sacramento River route; Sac3 and Sac4 combined). Therefore, for route Sac3 and Sac4 combined and route SS and Sac4 combined, the logit survival function from Perry (2010) was used to predict mean reach survival (S) from reach flow (flow):

$$S = \frac{e^{(\beta_0 + \beta_1 flow)}}{1 + e^{(\beta_0 + \beta_1 flow)}}$$

where β_0 (SS and Sac4 = -0.175, Sac3 and Sac4 = -0.121) is the reach coefficient and β_1 (0.26) is the flow coefficient, and *flow* is average Sacramento River flow in reach Sac3 during the experiment standardized to a mean of 0 and standard deviation of 1.

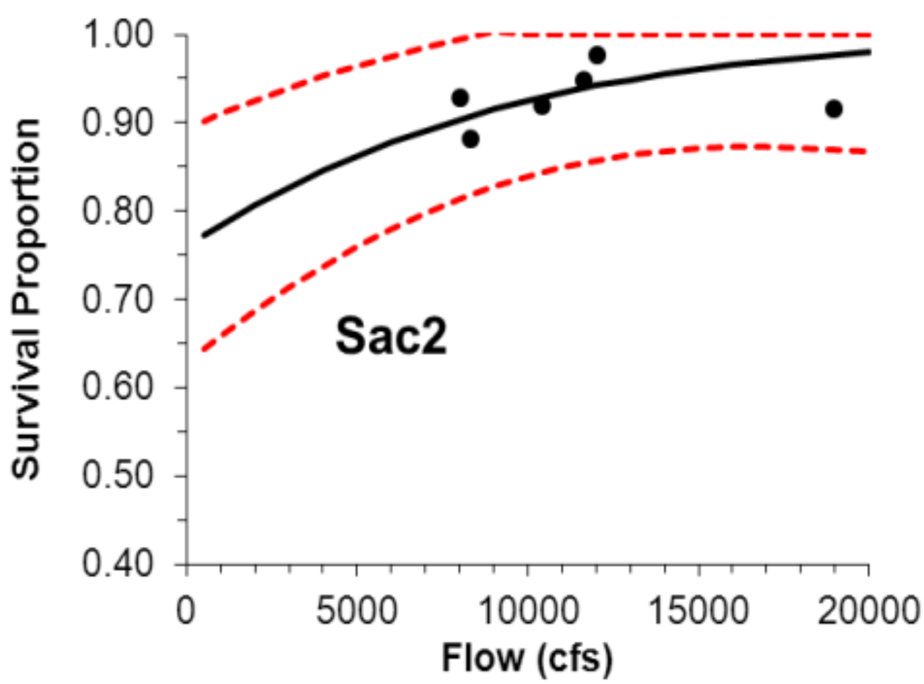
Perry (2010) estimated the global flow coefficient for the Sutter Steamboat route and Sacramento River route as 0.52. For the Sac3 and Sac4 combined route and the SS and Sac4 combined route, mean survival and associated standard error predicted from each flow-survival relationship is used to inform a normal probability distribution that is sampled from the day smolts enter the route to determine their route survival.

With a flow-survival relationship appearing evident for group survival data of acoustically-tagged smolts in reaches Sac1 and Sac2, Perry's (2010) relationship was applied to Sac1 and Sac2 while adjusting for the mean reach-specific survivals for Sac1 and Sac2 observed during the acoustic-tagging studies (Figure E4.-9; Table E.4-13). The flow coefficient was held constant at 0.52 and the residual sum of squares of the logit model was minimized about the observed Sac1 and Sac2 group survivals, respectively, while varying the reach coefficient. The resulting reach coefficients for Sac1 and Sac2 were 1.27 and 2.16, respectively. Mean survival and associated standard error predicted from the flow-survival relationship is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determining Sac1 and Sac2 reach survival.



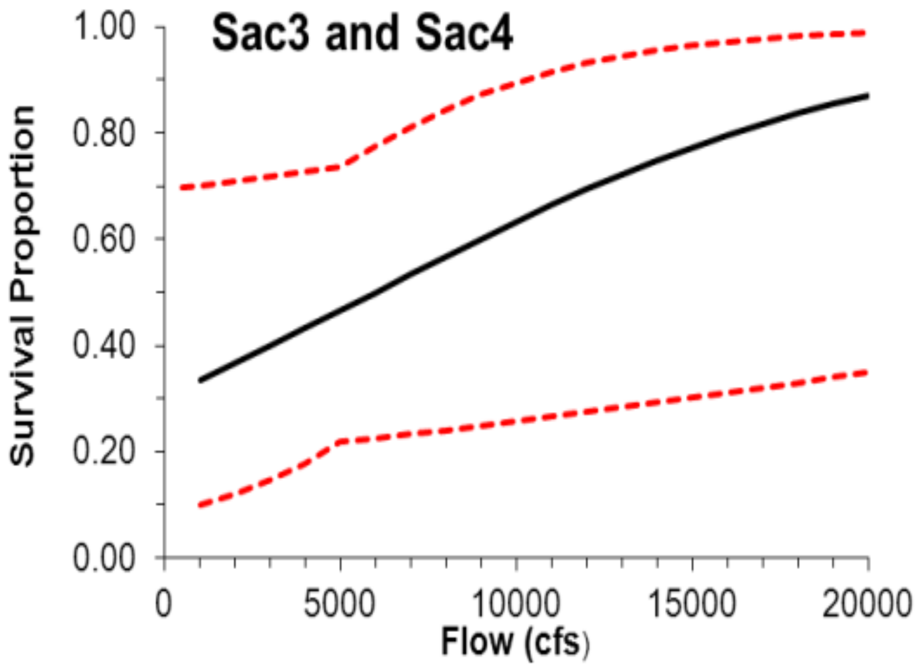
Circles are observed group survivals from acoustic-tagging studies from Perry (2010). Solid lines are predicted mean route survival curves, and dotted lines are 95% confidence bands used to inform uncertainty.

Figure E.4-9 a. Route Survival as a Function of Flow Applied in Sac 1 Reach.



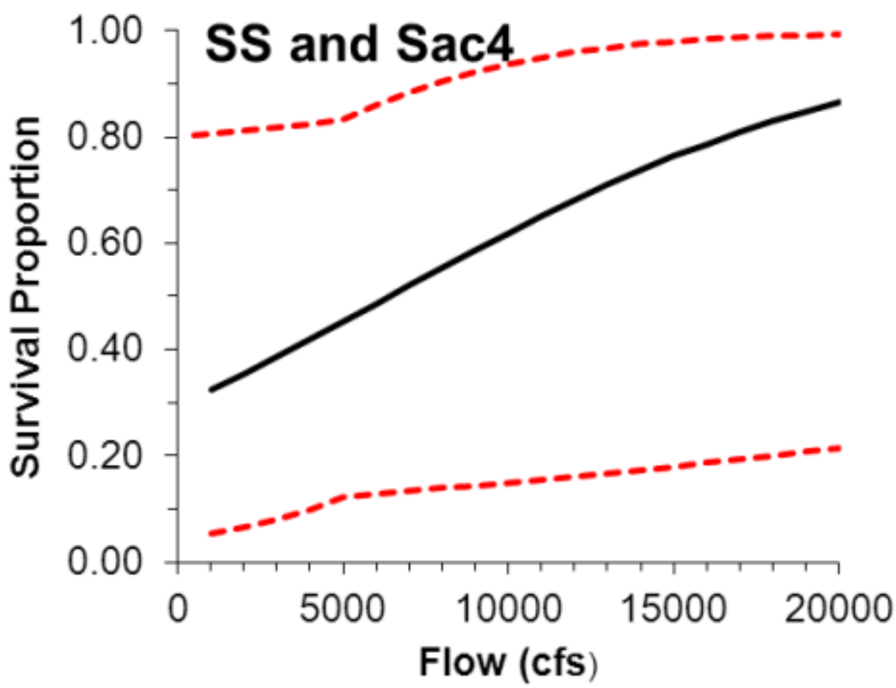
Circles are observed group survivals from acoustic-tagging studies from Perry (2010). Solid lines are predicted mean route survival curves, and dotted lines are 95% confidence bands used to inform uncertainty.

Figure E.4-9 b. Route Survival as a Function of Flow Applied in Sac 2 Reach.



Solid lines are predicted mean route survival curves, and dotted lines are 95% confidence bands used to inform uncertainty.

Figure E.4-9 c. Route Survival as a Function of Flow Applied in combined Sac3 and Sac4 Reach.



Solid lines are predicted mean route survival curves, and dotted lines are 95% confidence bands used to inform uncertainty.

Figure E.4-9 d. Route Survival as a Function of Flow Applied in combined SS and Sac4 reach.

Table E.4-13. Group Survival Estimates of Acoustically-Tagged Chinook Salmon Smolts from Perry (2010) and Associated Calculations Used to Inform Flow-Dependent Survival Relationships for Reaches Sac1 and Sac2

DPM Reach	Survival	Release Dates	Survival Calculation
Sac1	0.844	12/5/06	SA1 *SA2
Sac1	0.876	1/17/07	SA1 *SA2
Sac1	0.874	12/4/07-12/6/07	SA1 *SA2
Sac1	0.892	1/15/08-1/17/08	SA1 *SA2
Sac1	0.822	11/31/08-12/06/08	SA1 *SA2
Sac1	0.760	1/13/09-1/19/09	SA1 *SA2
Sac2	0.947	12/5/06	SA3
Sac2	0.976	1/17/07	SA3
Sac2	0.919	12/4/07-12/6/07	SA3
Sac2	0.915	1/15/08-1/17/08	SA3
Sac2	0.928	11/31/08-12/06/08	SA3
Sac2	0.881	1/13/09-1/19/09	SA3

Source: Perry 2010.

Export-Dependent Survival

As migratory juvenile salmon enter the Interior Delta from Geo/DCC for Sacramento River Chinook Salmon, they transition to an area strongly influenced by tides and where south Delta water exports may influence survival. The export–survival relationship described by Newman and Brandes (2010) was applied as follows:

$$\theta = 0.5948 * e^{(-0.000065 * Total\_Exports)}$$

where ϑ is the ratio of survival between coded wire tagged smolts released into Georgiana Slough and smolts released into the Sacramento River and Total Exports is the flow of water (cfs) pumped from the Delta from the State and Federal facilities. ϑ is a ratio and ranges from just under 0.6 at zero south Delta exports to ~0.27 at 12,000-cfs south Delta exports (Table E.4-6).

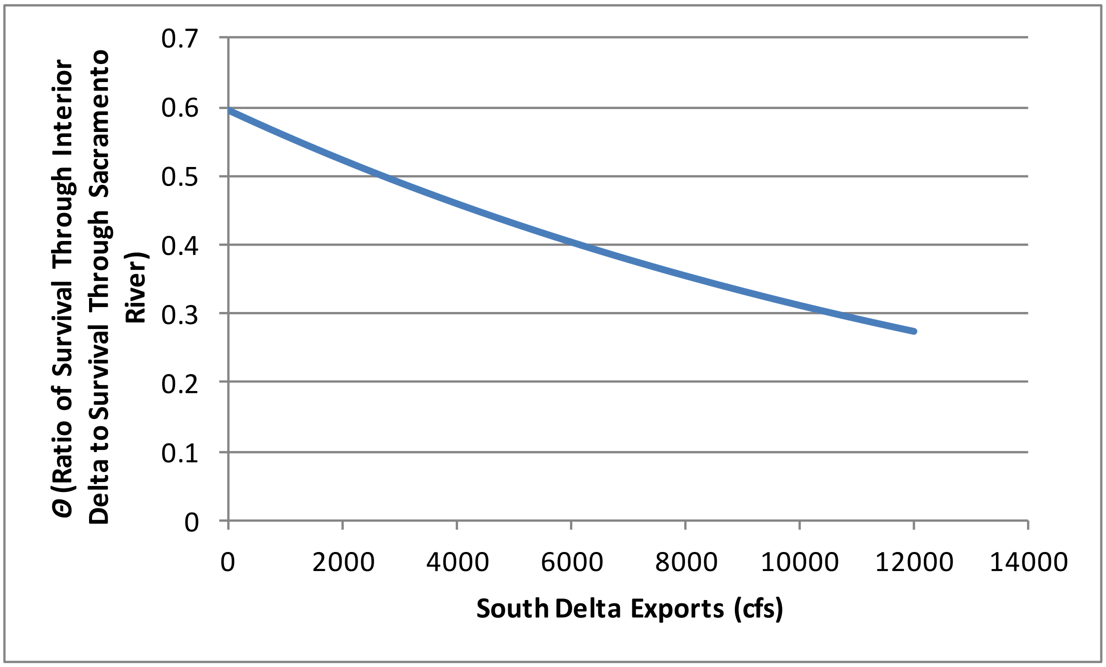
ϑ was converted from a ratio into a value of survival through the Interior Delta using the equation:

$$S_{ID} = \frac{\theta}{S_{Geo/DCC}} * (S_{Sac3} * S_{Sac4})$$

where S_{ID} is survival through the Interior Delta, ϑ is the ratio of survival between Georgiana Slough and Sacramento River smolt releases, $S_{Geo/DCC}$ is the survival of smolts in the Georgiana Slough/Delta Cross Channel reach, S_{Sac3} * S_{Sac4} is the combined survival in reaches Sac 3 and Sac 4 (Figure E. 5-11)[16].

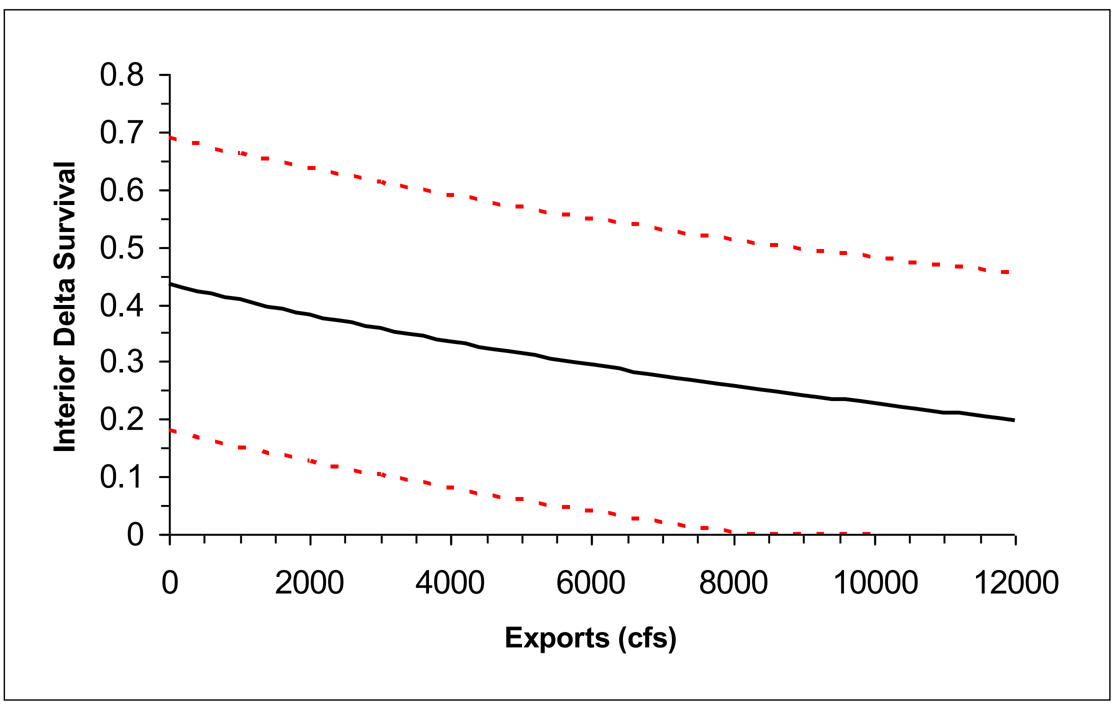
[16] Although daily survivals in Sac3/Sac4 are used to calculate Sacramento River survival for Sacramento River runs (winter-run, spring-run, Sacramento fall-run, and late fall–run), the combined Sac3/Sac4 survival used to calculate Sacramento River survival would be slightly different than that used to calculate interior Delta survival because of the travel time required for smolts to reach the interior Delta via Geo/DCC.

Uncertainty is represented in this relationship by using the estimated value of θ and the standard error of the equation to define a normal distribution bounded by the 95% prediction interval of the model that is then re-sampled each day to determine the value of θ.



Source: Newman and Brandes 2010

Figure E.4-10. Relationship between θ (Ratio of Survival through the Interior Delta to Survival through Sacramento River) and South Delta Export Flows



Survival values in reaches Sac3, Sac4, and Geo/DCC were held at mean values observed during acoustic-tag studies (Perry 2010) to depict export effect on Interior Delta survival in this plot. Dashed lines are 95% prediction bands used to inform uncertainty in the relationship.

Figure E.4-11. Interior Delta Survival as a Function of Delta Exports (Newman and Brandes 2010) as Applied for Sacramento Races of Chinook Salmon Smolts Migrating through the Interior Delta via Reach Geo/DCC

~~E.4.4~~E.4.5 SURVIVAL, TRAVEL TIME, AND ROUTING ANALYSIS (STARS, BASED ON PERRY ET AL. 2018)

Detailed methods and results for the STARS model are presented in Attachment 1 *Using the STARS Model to Evaluate the Effects of the Proposed Project on Juvenile Salmon Survival, Travel Time, and Migration Routing for the Long-Term Operation of the State Water Project Incidental Take Permit Application and CEQA Compliance*.

~~E.4.5~~E.4.6 STRUCTURED DECISION MODEL (CHINOOK SALMON ROUTING APPLICATION)

The Delta Structured Decision Model Chinook Salmon Routing Application was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the effect of different management decisions on the survival and routing of juvenile Fall-Run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin Rivers and at the state and federal south Delta export facilities. Here only the results from the San Joaquin River sub model were reported, with separate analyses conducted for Fall-Run and Spring-Run Chinook Salmon. The model and documentation has not been finalized and the code for the most recent model version used here used was accessed at https://github.com/FlowWest/chinookRoutingApp. Total South Delta Survival probability was unmodified from the Routing Application's original "SouFish" equation, which defines survival to Chipps Island for South Delta-routed fish as:

SouFish =

(S_prea * psi_sjr1 * S_a * psi_sjr2 * S_bc) + (S_prea * psi_sjr1 * S_a * psi_TC * S_efc) +

(S_prea * psi_OR * S_d * psi_ORN * S_efc) + (S_prea * psi_OR * S_d * psi_CVP * S_CVP) +

(S_prea * psi_OR * S_d * psi_SWP * S_SWP).

Model functions, parameters, and inputs used for this analysis are described in Table E.4-14. Where inputs were not available, they were assumed to be the mean values for the studies used to establish the model parameters. For implementation of the effects analysis, the model was run using DPM Delta entry weightings for Fall-Run Chinook Salmon from the San Joaquin River basin; Delta entry weightings for Spring-Run Chinook Salmon from the Sacramento River basin were assumed to be representative of daily weightings of Spring-Run Chinook Salmon from the San Joaquin River basin.

Table E.4-14. Functions, Parameter Calculations, and Inputs Used in the Structured Decision Model Chinook Salmon Routing Application San Joaquin Sub Model

Function	Parameters	Inputs
S_prea = survival through the tributaries to the Head of Old River (HOR)	inv.logit(5.77500 + 0.00706 * Q_vern - 0.32810 * Temp_vern + 0.152 *(FL-155.1) / 21.6)	Q_vern (Flow at Vernalis): DSM2 Temp_vern (Temperature at Vernalis): 16.7C FL (Fork length): 120mm
psi_sjr1 = probability of remaining in SJR at HOR	inv.logit(-0.75908 + 1.72020 * hor_barr + 0.00361 * Q_vern + 0.02718 * hor_barr * Q_vern)	hor_barr (Head of Old River barrier): DSM2 (Existing), 0 (Proposed) Q_vern: DSM2
S_a = survival from the HOR to Turner Cut	inv.logit(-2.90330 + 0.01059 * Q_vern + 0.152 * (FL - 155.1) / 21.6)	Q_vern: DSM2 FL: 120mm
psi_sjr2 = the probability of remaining in SJR at Turner Cut	inv.logit(5.83131 - 0.037708993 * Q_stck)	Q_stck (Flow at Stockton): DSM2
S_bc = survival from SJR Turner Cut to Chipps	inv.logit(13.41840 - 0.90070 * Temp_pp + 0.152 * (FL - 155.1) / 21.6)	Temp_pp: 17.8C FL: 120mm
psi_TC = probability of taking Turner Cut	psi_TC <- 1 - psi_sjr2	See psi_sjr2 above
psi_OR = probability of entering Old River	1 - psi_sjr1	See psi_sjr1 above
S_d = Survival down OR to HOR to CVP	inv.logit(2.16030 - 0.20500 * Temp_vern + 0.152 * (FL - 155.1)/21.6)	Temp_vern: 16.7C FL: 120mm
psi_ORN = probability of remaining in Old River North	1 - psi_CVP - psi_SWP	See psi_CVP and psi_SWP, below
S_efc = Survival from Old River North to Chipps Island (San Joaquin River Group Authority)	0.01	0.01
psi_CVP = probability of entrainment at CVP	inv.logit(-3.9435 + 2.9025 * no.pump - 0.3771 * no.pump ^ 2)	no.pump (Number of CVP pumps in operation): DSM2*
psi_SWP = probability of entrainment at SWP	(1 - psi_CVP) * inv.logit(-1.48969 + 0.016459209 * SWP_exp)	SWP_exp (SWP exports): DSM2
S_CVP = survival through CVP (Karp et al. 2017)	inv.logit(-3.0771 + 1.8561 * no.pump - 0.2284 * no.pump ^ 2)	no.pump: DSM2*
S_SWP = survival through SWP (Gingras 1997)	0.1325	0.1325

*The model calculates the number of pumps based on DSM2 export inputs (cfs)

E.5 OTHER SPECIES

Quantitative analyses for other species focused on the salvage-density method, as described above for salmonids. Results of the salvage-density method for the SWP south Delta export facility are presented in ~~Section~~ FEIR Part III, -Chapters 4.4 and 5.3~~of the DEIR~~. Results for the CVP south Delta export facility are presented below in consideration of potential cumulative impacts in the DEIR Section 4.6.

Table E.5-1. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-1 a-f

Table E.5-1 a. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	1	2	7	14	5	8	5	3	7
Proposed Project	0	0	0	1	4	7	14	5	8	6	3	7

Table E.5-1 b. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-1 c. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-1 d. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	0	0	0	0	0	0	0	0	12	14	5
Proposed Project	2	0	0	0	0	0	0	0	0	12	15	5

Table E.5-1 e. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	1	0	0	1	0	0	0	0	0	0	0	0

Table E.5-1 f. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	50	0	0	33	2
Proposed Project	53	0	0	34	2
Proposed Project vs. Existing	3 (6%)	0 (0%)	0 (0%)	1 (3%)	0 (3%)

Table E.5-2. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-2 a-f

Table E.5-2 ~~g~~a. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	5	3	8	2	1	13	33	29	34	37	20	8
Proposed Project	5	3	8	4	2	13	32	29	34	39	20	8

Table E.5-2 ~~h~~b. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	1	0	3	0	0	0	0	4	0
Proposed Project	0	0	0	4	0	3	0	0	0	0	4	0

Table E.5-2 ~~i~~c. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	4	0	0	0	0	0	0	0	11	0	2
Proposed Project	0	4	0	0	1	0	0	0	0	12	0	2

Table E.5-2 ~~j~~d. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	5	2	0	0	4	2	0	0	1	0
Proposed Project	0	2	4	3	0	0	3	2	0	0	1	0

Table E.5-2 ~~k~~e. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	2	0	7
Proposed Project	0	0	0	0	0	0	0	0	0	2	0	8

Table E.5-2 ~~l~~f. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	193	9	17	15	10
Proposed Project	197	11	19	15	10
Proposed Project vs. Existing	4 (2%)	2 (28%)	2 (10%)	0 (2%)	0 (1%)

Table E.5-3. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-3 a-f

Table E.5-3 ~~m~~a. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4,449	2,103	140	22	36	75	7	4	2	3	0	308
Proposed Project	4,225	1,911	134	48	81	74	7	4	2	3	0	304

Table E.5-3 ~~n~~b. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	869	1,059	818	14	0	13	25	0	9	16	54	124
Proposed Project	875	1,051	764	41	0	13	25	0	8	17	56	122

Table E.5-3 ~~o~~c. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,126	52	204	23	9	0	15	1	0	0	0	0
Proposed Project	1,116	52	169	57	29	0	13	1	0	0	0	0

Table E.5-3 ~~p~~d. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	297	117	505	22	38	17	2	4	0	0	5	623
Proposed Project	293	119	422	39	83	16	2	4	0	0	5	616

Table E.5-3 ~~q~~e. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	273	75	33	18	54	9	6	0	2	0	0	4
Proposed Project	252	74	34	23	65	9	6	0	2	0	0	4

Table E.5-3 ~~r~~f. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	7,148	2,999	1,431	1,628	474
Proposed Project	6,793	2,972	1,437	1,600	468
Proposed Project vs. Existing	-355 (-5%)	-28 (-1%)	7 (0%)	-29 (-2%)	-6 (-1%)

Table E.5-4. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-4 a-f

Table E.5-4 ~~s~~a. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	339	290	647	2,144	1,026,062	1,597,642	183,091	3,072	414	198	56	55
Proposed Project	322	263	620	4,725	2,343,301	1,575,358	179,416	3,072	416	211	58	54

Table E.5-4 ~~t~~b. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	593	482	496	360	15,330	100,172	5,680	128	33	26	37	23
Proposed Project	597	479	463	1,031	50,877	97,892	5,796	130	32	27	38	23

Table E.5-4 ~~u~~c. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	123	69	273	22	20,749	9,423	625	15	20	28	6	7
Proposed Project	122	68	226	54	66,483	9,190	548	15	21	31	7	6

Table E.5-4 ~~v~~d. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	159	69	221	114	110	1,596	265	14	22	9	6	51
Proposed Project	157	71	185	204	240	1,544	244	14	22	10	6	51

Table E.5-4 ~~w~~e. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	94	151	81	9	73	760	59	0	0	0	2	0
Proposed Project	87	149	83	12	88	699	62	0	0	0	2	0

Table E.5-4 ~~x~~f. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	2,814,011	123,360	31,360	2,638	1,230
Proposed Project	4,107,815	157,386	76,772	2,749	1,182
Proposed Project vs. Existing	1,293,804 (46%)	34,026 (28%)	45,412 (145%)	111 (4%)	-49 (-4%)

Table E.5-5. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-5 a-f

Table E.5-5 ~~y~~a. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	52	0	2	0	0	0	0	2
Proposed Project	0	0	0	0	120	0	1	0	0	0	0	2

Table E.5-5 ~~z~~b. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-5 ~~aa~~c. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-5 ~~bb~~d. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	2	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	2	0

Table E.5-5 ~~cc~~e. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-5 ~~dd~~f. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	56	0	0	2	0
Proposed Project	123	0	0	2	0
Proposed Project vs. Existing	67 (121%)	0 (0%)	0 (0%)	0 (6%)	0 (0%)

Table E.5-6. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-6 a-f

Table E.5-6 ~~ee~~a. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	24,573	8,196	2,995	1,012	6,786	122,629	65,760	22,753	9,581	6,670	5,532	7,769
Proposed Project	23,335	7,447	2,868	2,229	15,497	120,919	64,440	22,753	9,615	7,081	5,690	7,687

Table E.5-6 ~~ff~~b. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	16,266	14,619	10,428	729	3,807	183,978	52,413	13,561	8,156	3,645	6,443	9,306
Proposed Project	16,380	14,508	9,743	2,089	12,633	179,792	53,478	13,768	7,987	3,854	6,696	9,207

Table E.5-6 ~~gg~~c. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7,372	8,990	16,854	684	7,485	97,565	25,430	6,872	2,168	1,518	2,326	2,282
Proposed Project	7,308	8,945	13,928	1,685	23,984	95,158	22,322	6,774	2,216	1,643	2,593	2,173

Table E.5-6 ~~hh~~d. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7,739	10,823	14,078	1,353	47,382	343,380	70,333	4,586	1,870	3,120	10,403	8,435
Proposed Project	7,637	11,028	11,785	2,430	103,169	332,250	64,873	4,558	1,864	3,157	11,068	8,344

Table E.5-6 ~~ii~~e. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9,097	9,320	3,808	656	25,703	437,821	88,970	10,667	2,823	5,023	3,798	4,024
Proposed Project	8,392	9,183	3,889	839	31,025	402,384	92,609	11,346	2,859	4,881	4,348	4,122

Table E.5-6 ~~jj~~f. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	284,256	323,352	179,545	523,503	601,710
Proposed Project	289,561	330,134	188,729	562,163	575,877
Proposed Project vs. Existing	5,306 (2%)	6,782 (2%)	9,184 (5%)	38,660 (7%)	-25,833 (-4%)

Table E.5-7. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-7 a-f

Table E.5-7 ~~kk~~a. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	26,327	2,298	133	30	77	4,524	90,570	93,052	16,365	89,273	110,438	62,996
Proposed Project	25,001	2,088	127	67	175	4,460	88,753	93,052	16,424	94,774	113,590	62,334

Table E.5-7 ~~ll~~b. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	32,461	3,725	289	15	4	5,094	123,350	43,344	19,347	16,992	124,899	60,781
Proposed Project	32,687	3,696	270	42	14	4,978	125,856	44,006	18,946	17,963	129,804	60,135

Table E.5-7 ~~mm~~c. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	13,436	5,335	563	87	34	1,604	13,704	10,999	2,279	4,312	44,751	24,258
Proposed Project	13,318	5,308	465	215	109	1,565	12,029	10,842	2,330	4,667	49,884	23,107

Table E.5-7 ~~nn~~d. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	12,944	2,396	379	102	8	700	10,828	7,739	1,381	40,646	57,836	54,623
Proposed Project	12,772	2,441	317	182	17	677	9,987	7,691	1,376	41,136	61,535	54,038

Table E.5-7 ~~ee~~e. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	8,063	1,890	87	21	4	129	14,951	7,102	1,886	2,910	24,166	16,697
Proposed Project	7,438	1,862	89	27	5	119	15,563	7,554	1,910	2,828	27,667	17,106

Table E.5-7 ~~pp~~f. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	496,083	430,301	121,363	189,582	77,905
Proposed Project	500,844	438,398	123,840	192,171	82,167
Proposed Project vs. Existing	4,761 (1%)	8,097 (2%)	2,477 (2%)	2,589 (1%)	4,261 (5%)

Table E.5-8. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-8 a-f

Table E.5-8 ~~qq~~a. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	682	479	346	163	2,378	24,440	15,273	2,600	1,007	750	739	676
Proposed Project	647	435	332	359	5,432	24,099	14,967	2,600	1,010	797	760	668

Table E.5-8 ~~rr~~b. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	316	578	487	67	746	19,773	4,647	651	422	1,586	2,629	1,162
Proposed Project	318	574	455	192	2,475	19,323	4,742	661	413	1,677	2,733	1,149

Table E.5-8 ~~ss~~c. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,497	478	329	69	2,840	41,325	9,484	1,378	448	424	1,934	1,434
Proposed Project	1,484	476	272	171	9,101	40,305	8,325	1,358	458	459	2,156	1,366

Table E.5-8 ~~tt~~d. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	818	845	465	101	2,680	23,244	8,640	789	238	1,632	965	704
Proposed Project	807	861	389	182	5,835	22,490	7,969	784	237	1,652	1,026	697

Table E.5-8 ~~uu~~e. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,271	1,523	382	117	5,048	13,658	3,711	939	250	599	942	651
Proposed Project	1,173	1,500	390	149	6,093	12,553	3,862	999	253	582	1,078	667

Table E.5-8 ~~vv~~f. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	49,534	33,065	61,639	41,121	29,090
Proposed Project	52,106	34,712	65,929	42,930	29,299
Proposed Project vs. Existing	2,573 (5%)	1,647 (5%)	4,290 (7%)	1,809 (4%)	210 (1%)

Table E.5-9. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-9 a-f

Table E.5-9 ~~ww~~a. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	5	5	0	0	0	3	2	2	5	9	0	2
Proposed Project	5	5	0	0	0	3	1	2	5	10	0	2

Table E.5-9 ~~xx~~b. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	7	0	0	0	3	0
Proposed Project	0	0	0	0	0	0	7	0	0	0	4	0

Table E.5-9 ~~yy~~c. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	1	2	0	2	0	0	0	0	0	0	0
Proposed Project	1	1	1	0	6	0	0	0	0	0	0	0

Table E.5-9 ~~zz~~d. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table E.5-9 ~~aaa~~e. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	7	4	0	0	0	4	22	2	0	4	0
Proposed Project	0	7	4	0	0	0	4	24	2	0	5	0

Table E.5-9 ~~bbb~~f. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	32	10	5	0	43
Proposed Project	32	11	9	0	45
Proposed Project vs. Existing	0 (-1%)	0 (3%)	4 (73%)	0 (0%)	2 (5%)

Table E.5-10. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table E.5-10a-f

Table E.5-10 ~~ccc~~a. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	1	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	1	0	0	0	0	0	0	0	0	0	0

Table E.5-10 ~~ddd~~b. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	44	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	46	0

Table E.5-10 ~~eee~~c. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	2	1	0	0	0	0	0	0	0	2
Proposed Project	0	0	1	2	0	0	0	0	0	0	0	2

Table E.5-10 ~~fff~~d. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	4	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	4	0

Table E.5-10 ~~ggg~~e. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	2	1	0	0	0	0	0
Proposed Project	0	0	0	0	0	2	2	0	0	0	0	0

Table E.5-10 ~~hhh~~f. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1	44	5	4	4
Proposed Project	1	46	6	4	4
Proposed Project vs. Existing	0 (-9%)	2 (4%)	1 (16%)	0 (6%)	0 (-3%)

E.6 REFERENCES

E.6.1 PRINTED REFERENCES

Bennett, W. A., W. J. Kimmerer, and J. R. Burau. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low-salinity zone. *Limnology and Oceanography* 47(5):1496-1507.

Berggren, T. J., and M. J. Filardo. 1993. An Analysis of Variables Influencing the Migration of Juvenile Salmonids in the Columbia River Basin. *North American Journal of Fisheries Management* 13(1):48–63.

Blake, A., and M. J. Horn. 2003. *Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of the Delta Cross Channel, Sacramento River, California – 2001 Study Results*. U.S. Bureau of Reclamation Technical Memorandum No.8220-04-04.

Buchanan, R. A., J. R. Skalski, P. L. Brandes, and A. Fuller. 2013. Route Use and Survival of Juvenile Chinook Salmon through the San Joaquin River Delta. North American Journal of Fisheries Management 33(1):216-229.

California Department of Fish and Game. 2009a. California Endangered Species Act Incidental Take Permit No. 2081-2009-001-03. Department of Water Resources California State Water Project Delta Facilities and Operations. Yountville, CA: California Department of Fish and Game, Bay Delta Region.

California Department of Fish and Game. 2009b. A Status Review of the Longfin Smelt (*Spirinchus thaleichthys*) in California. Report to the Fish and Game Commission. January 23. California Department of Fish and Game.

Cavallo, B., P. Gaskill, J. Melgo, and S. C. Zeug. 2015. Predicting juvenile Chinook Salmon routing in riverine and tidal channels of a freshwater estuary. Environmental Biology of Fishes 98(6):1571-1582.

Eijkelkamp Agrisearch Equipment. [no date]. Digital flowmeter mechanical and electronic operators manual, article no. 13.14, mechanical current meter with propeller, model 2030R. Available: http://cce.lternet.edu/docs/data/methods/M2-1314e%20Mechanical%20flowmeter.pdf, accessed 2015.10.29.

Gingras, M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screening Loss to Juvenile Fishes: 1976-1993. Technical Report 55. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, CA.

Greenwood, M. 2018. Potential Effects on Zooplankton from California WaterFix Operations. Technical Memorandum to California Department of Water Resources. July 2. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/part2_rebuttal/dwr_1349.pdf Accessed: November 30, 2018.

Greenwood, M., and C. Phillis. 2018. Comparison of Predicted Longfin Smelt Fall Midwater Trawl Index for Existing Conditions, No Action Alternative, and California WaterFix CWF H3+ Operational Scenarios Using the Nobriga and Rosenfield (2016) Population Dynamics Model. Technical Memorandum to California Department of Water Resources. Sacramento, CA: ICF. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/part2_rebuttal/dwr_1352.pdf Accessed: September 24, 2019.

Grimaldo, L. F., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. B. Moyle, B. Herbold, and P. Smith. 2009. Factors Affecting Fish Entrainment into Massive Water Diversions in a Freshwater Tidal Estuary: Can Fish Losses be Managed? North American Journal of Fisheries Management 29:1253–1270.

Grimaldo, L.F., F. Feyrer, J. Burns, and D. Maniscalco. 2014. Sampling Uncharted Waters: Examining Longfin Smelt Rearing Habitat in Fringe Marshes of the Low Salinity Zone. Oral presentation at the Annual Bay-Delta Science Conference.

Hankin, D., D. Dauble, J. Pizzimenti, and P. Smith. 2010. The Vernalis adaptive management program (VAMP): report of the 2010 review panel. Prepared for the Delta Science Program. May 11.

Healey, M. C. and F. P. Jordan. 1982. Observations on juvenile chum and Chinook and spawning Chinook in the Nanaimo River, British Columbia, during 1975-1981. Canadian Manuscript report of Fisheries and Aquatic Sciences No. 1659. Available: http://publications.gc.ca/collections/collection_2013/mpo-dfo/Fs97-4-1659-eng.pdf. Accessed: September 24, 2019.

Healy, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile Chinook salmon, *Oncorhynchus tshawytscha*. Fisheries Bulletin 77:653-668.

Holbrook, C.M., R.W. Perry, and N.S Adams. 2009. Distribution and joint fish-tag survival of juvenile Chinook salmon migrating through the Sacramento-San Joaquin River Delta, California, 2008. U.S. Geological Survey Open-File Report 2009–1204

ICF International. 2016. Biological Assessment for the California WaterFix. July. (ICF 00237.15.) Sacramento, CA. Prepared for United States Department of the Interior, Bureau of Reclamation, Sacramento, CA.

Karp, C., B. J. Wu, and K. Kumagai. 2017. Juvenile Chinook Salmon, Steelhead, and Adult Striped Bass Movements and Facility Efficiency at the Tracy Fish Collection Facility. Tracy Technical Bulletin 2017-1. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region, Denver, CO.

Kimmerer, W. J. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2).

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 6(1).

Kimmerer, W. J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science 9(1).

Le, S., J. Josse, and F. Husson. 2008. FactoMineR: An R Package for Multivariate Analysis. Journal of Statistical Software 25(1): 1-18.

Michel, C. J. 2010. *River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (Oncorhynchus tshawytscha) Smolts and the Influence of Environment.* Master's thesis. University of California, Santa Cruz. Santa Cruz, CA.

Miller, J. A., A. Gray, and J. Merz. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon *Oncorhynchus tshawytscha*. Marine Ecology Progress Series 408: 227–240.

Moyle, P. B. 2002. Inland Fishes of California. Revised and expanded. Edition 2. University of California Press. May.

Mueller-Solger, A. 2012. Unpublished estimates of X2 presented in Excel workbook <FullDayflowAndX2WithNotes1930-2011_3-6-2012.xlsx>.

Newman, K.B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. March 31, 2008. Available at https://water.ca.gov/LegacyFiles/iep/docs/Newman_2008.pdf. Accessed: September 24, 2019.

Newman, K. B., and P. L. Brandes. 2010. Hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports. *North American Journal of Fisheries Management* 30:157–169.

Nobriga, M. L., Z. Matica, and Z. P. Hymanson. 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. American Fisheries Society Symposium 39:281-295.

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. Transactions of the American Fisheries Society 145(1):44-58.

Perry, R. W. 2010. Survival and Migration Dynamics of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin River Delta. Ph.D. Dissertation. University of Washington, Seattle, WA.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta. North American Journal of Fisheries Management 30(1):142-156.

Plumb, J. M, N. S. Adams, R. W. Perry, C. M. Holbrook, J. G. Romine, A. R. Blake, and J. R. Burau. 2015. Diel activity patterns of juvenile late fall-run Chinook salmon with implications for operation of a gated water diversion in the Sacramento-San Joaquin River Delta. Available: https://s3.amazonaws.com/academia.edu.documents/42733819/Diel_Activity_Patterns_of_Juvenile_Late_20160216-11099-1bwy7l4.pdf?response-content-disposition=inline%3B%20filename%3DDiel_Activity_Patterns_of_Juvenile_Late.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20190924%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20190924T210601Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=0a84939ed6814d32e4ca9a3e0fdd1baf48cd435bc8cf75f352e0b7d57a9bd83d. Accessed: September 24, 2019.

Raymond, H. L. 1968. Migration Rates of Yearling Chinook Salmon in Relation to Flows and Impoundments in the Columbia and Snake Rivers. *Transactions of the American Fisheries Society* 97:356–359.

R Core Team. 2012. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Available: <http://www.R-project.org>.

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.Rproject.org/

Rosenfield, J. A., and R. D. Baxter. 2007. Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136(6):1577-1592.

Saha, S. 2008. Delta Volume Calculation. Bay Delta Office, California Department of Water Resources. Available: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup/VolumeCalculation.pdf. Accessed: September 28, 2015.

San Joaquin River Group Authority. 2008. 2007 Annual technical report. On implementation and monitoring of the San Joaquin River agreement and the Vernalis Adaptive Management Plan. January. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/sjrga_2008.pdf. Accessed: September 24, 2019.

San Joaquin River Group Authority. 2010. 2009 Annual technical report. On implementation and monitoring of the San Joaquin River agreement and the Vernalis Adaptive Management Plan. January. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/sjrga_2010.pdf. Accessed: September 24, 2019.

Schreck, C. B., J. C. Snelling, R. E. Ewing, C. S. Bradford, L. E. Davis, and C. H. Slater. 1994. *Migratory Characteristics of Juvenile Spring Chinook Salmon in the Willamette River*. Completion Report. Bonneville Power Administration.

Simenstad, C., J. Van Sickle, N. Monsen, E. Peebles, G.T. Ruggerone, and H. Gosnell. 2016. Independent Review Panel Report for the 2016 California WaterFix Aquatic Science Peer Review. Sacramento, CA: Delta Stewardship Council, Delta Science Program.

Sommer, T. R., W. C. Harrell, and M. L. Nobriga. 2005. Habitat Use and Stranding Risk of Juvenile Chinook Salmon on a Seasonal Floodplain. *North American Journal of Fisheries Management* 25:1493–1504.

Wang, J. C. S. 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. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region, Denver, CO.

Williams, J. G. 2001. Chinook salmon in the lower American River, California's largest urban stream. Fish Bulletin 179, v2. Sacramento, California Department of Fish and Game.

Zeug, S. C., and B. J. Cavallo. 2014. Controls on the Entrainment of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) into Large Water Diversions and Estimates of Population-Level Loss. PLoS One 9(7):E.101479.

E.6.2 Personal Communications

Johnston, Myfanwy. University of California Davis, Biotelemtery Lab. 2012—Email preliminary movement and survival estimates for late-fall chinook smolts in Yolo Bypass to Steve Zeug, Senior Fisheries Scientist, Cramer Sciences.

Smith, Peter. US Geological Survey. 2012—Spreadsheet with Old and Middle River daily flows for WY 1979-2012, sent to Lenny Grimaldo, US Bureau of Reclamation, Sacramento, CA.

ATTACHMENT 1
STARS Model Methodologies and Results

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Copy of attachment is available upon request.
Please contact the Lead Agency at LTO@water.gov.

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ATTACHMENT 2
Analysis with X2-Longfin Smelt Abundance Index Relationship

PURPOSE OF THIS MEMORANDUM

California Department of Fish and Wildlife (CDFW) representatives have requested that the California Department of Water Resources (DWR) undertake additional analysis of Longfin Smelt abundance for inclusion in the Incidental Take Permit (ITP) Application and in the Final Environmental Impact Report (FEIR). Specifically, CDFW requested that DWR undertake a "Kimmerer regression to analyze the relationship between X2 and Longfin smelt abundance." In the spirit of cooperation, DWR has undertaken the requested analysis with respect to the Proposed Project and the Refined Alternative 2b from the FEIR. By undertaking the "Kimmerer regression"[17], DWR does not agree that the "Kimmerer regression" is the best available science or that any decisions should be made based on the "Kimmerer regressions" as further explained below:

1. DWR has already completed a robust abundance analysis based on a 2016 Longfin Smelt population dynamics modeling study by Nobriga and Rosenfield (2016). Nobriga and Rosenfeld (2016) represents the best available science for this type of analysis and presents the best fit, based on current information, for analyzing Longfin Smelt abundance under the Proposed Project and applicable mitigation measures. The "Kimmerer regression" approach does not take into account stock size of the Longfin Smelt population; whereas the Nobriga and Rosenfield (2016) approach does so, and therefore more accurately reflects how this species will respond to different conditions.
2. The results from the Nobriga and Rosenfield (2016) approach show the same general differences and level of uncertainty between the different alternatives as the "Kimmerer regression" approach. Hence, DWR considers that the "Kimmerer regression" analysis does not add value to the comparison of alternatives.

This memo presents the results of the "Kimmerer regression" approach for the Proposed Project, Existing Conditions, and Refined Alternative 2b[18].

Methods

The method is the same as that used in the California WaterFix (CWF) Incidental Take Permit (ITP) Application (ICF International 2016). The methods described herein are the same as those used in that application; the methods description below was adapted from ICF International (2016).

The analysis essentially updated previously described X2-abundance index regressions (Kimmerer et al. 2009; Mount et al. 2013) by adding additional years of data. Updating the analysis allowed full accounting of sources of error in the predictions, allowing calculation of prediction intervals from

[17] The origin of the term "Kimmerer regression" reflects previous analyses, e.g., Kimmerer (2002) and Kimmerer et al. (2009); the approach is technically a general linear model, as described later in this attachment.

[18] Modeling assumptions for the Proposed Project, Existing Conditions, and Alternative 2b are provided in Appendix H, "CalSim II and DSM2 Model Descriptions and Assumptions". Note that the Refined Alternative 2b scenario is generally referred to as Alternative 2b in this attachment.

estimates of X2, as recommended by Simenstad et al. (2016), for the Existing Conditions ('Existing'), Proposed Project ('PP'), and Refined Alternative 2b scenarios.

Longfin Smelt fall-mid-water trawl index data were obtained (http://www.dfg.ca.gov/delta/data/fmwt/indices.asp?view=single), including indices for 1967–2014 (excluding 1974 and 1979, when there was no sampling). For each index year, mean X2 during January–June was calculated based on X2 from the DAYFLOW database (https://data.cnra.ca.gov/dataset/dayflow), in addition to calculated X2 for earlier years[19].

Similar to Mount et al. (2013), GLMs were run, predicting Longfin Smelt fall midwater trawl relative abundance index as a function of X2 and step changes in 1987/1988 and 2002/2003:

$$\text{Log}_{10}(\text{FMWT index}_y) = a + b\cdot(\text{mean X2}_y) + c\cdot\text{period}_y$$

Where *y* indicates year, *a* is the intercept, *b* is the coefficient applied to the mean Delta outflow, and *c* takes one of three values for period: 0 for the Pre-*Potamocorbula* period (1967–1987), and values to be estimated for Post-*Potamocorbula* (1988–2002) and Pelagic Organism Decline (POD; 2003–2014) periods.

Regarding the months used for mean X2, Mount et al. (2013: 67) noted the following:

> *The months selected in the original analysis [by Jassby et al. 1995] were based on the assumption that the (unknown) X2 mechanism operated during early life history of Longfin Smelt, which smelt experts linked to this period. Autocorrelation in the X2 values through months means that statistical analysis provides little guidance for improving the selection of months. A better understanding of the mechanism(s) underlying the relationship would probably allow this period to be narrowed and focused, but for now there is little basis for selecting a narrower period for averaging X2.*

Mount et al. (2013) compared the fit of X2 averaging periods for January–June (i.e., the original period used by Jassby et al. 1995, also used by Kimmerer et al. 2009) and March–May; they selected the former because the fit to the empirical data was slightly superior. In the present analysis, both the January–June and March–May averaging periods were compared for their adequacy of fit, using standard criteria (Akaike's Information Criterion adjusted for small sample sizes, AIC_c; and variation explained, r^2). This showed that the January–June X2 averaging period was better supported in terms of explaining variability in the FWMT index (Table E-1; Figure E-1), so this averaging period was used in the subsequent comparison of the Existing, PP, and PP-spring scenarios based on CalSim outputs.

[19] DAYFLOW provides X2 estimates from water year 1997 onwards, so the DAYFLOW equation (X2(t) = 10.16 + 0.945*X2(t-1) – 1.487log(QOUT(t))) was used to provide X2 for earlier years, based on a starting unpublished estimate of X2 (Mueller-Solger 2012).

Table E-1. Parameter Coefficients for General Linear Models Explaining Longfin Smelt Fall Midwater Trawl Index as a Function of Mean January–June and March–May X2 and Step Changes in 1987/1988 (Potamocorbula Invasion) and 2002/2003 (Pelagic Organism Decline).

Parameter	January–June Estimate	January–June Standard Error	January–June *P*	March–May Estimate	March–May Standard Error	March–May *P*
a (Intercept)	7.3059	0.3299	< 0.0001	6.8100	0.3224	< 0.0001
b (X2)	-0.0542	0.0049	< 0.0001	-0.0475	0.0047	< 0.0001
c (Period: Post-*Potamocorbula*)	-0.5704	0.1174	< 0.0001	-0.6368	0.1271	< 0.0001
c (Period: POD)	-1.4067	0.1244	< 0.0001	-1.4581	0.1351	< 0.0001
Fit	-	-	-	-	-	-
AIC_c[1]	-47.4904	-47.4904	-47.4904	-39.5492	-39.5492	-39.5492
r^2	0.8666	0.8666	0.8666	0.8414	0.8414	0.8414

Note:
[1] The difference of ~8 AIC_c units between the two GLMs indicates that the January–June mean X2 GLM is better supported in terms of explaining the patterns in the data (Burnham et al. 2011).

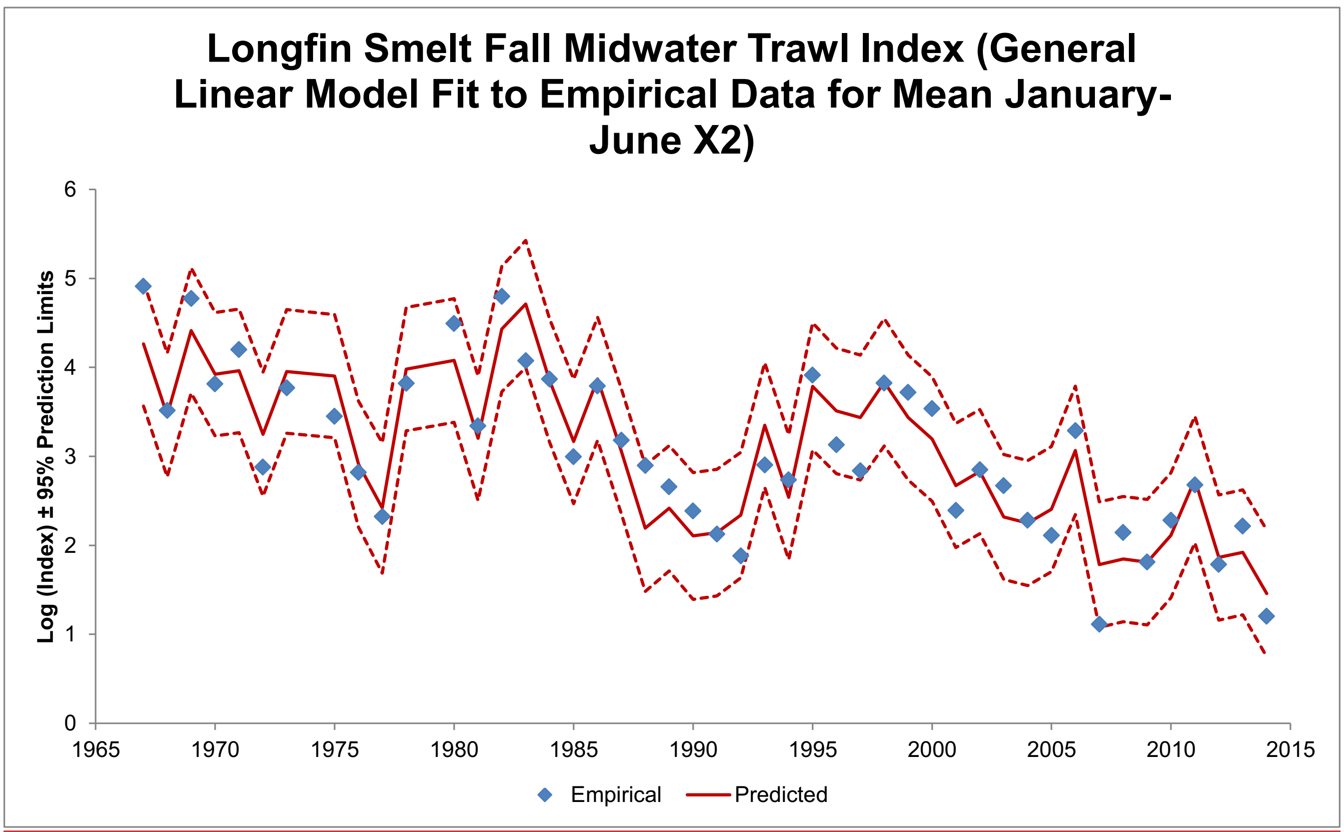


Figure E-1. Fit to Empirical Data of General Linear Model Predicting Longfin Smelt Fall Midwater Trawl Relative Abundance Index as a Function of Mean January–June X2 and Step Changes for *Potamocorbula* and Pelagic Organism Decline.

For the comparison of Existing, PP, and Alt 2b scenarios, mean January–June X2 was calculated for each year of the 1922–2003 simulation. Two sets of analyses were undertaken, to account for different methods of X2 calculation. The first set of analyses used the X2 outputs from CalSim modeling (see Appendix C). For consistency with the CESA ITP Application analysis, the second set of analyses was based on X2 estimated from CalSim-modeled Delta outflow and the previous month's X2, using a starting value of X2 = 80 km to initiate the calculations, using the equation similar to Kimmerer and Monismith (see p.A-8 of Appendix A of Schubel 1993):

$$X2 = 122.2 + 0.3278*(X2 \text{ during previous month}) - 17.65*\log(\text{Delta outflow})$$

The X2-abundance index GLM calculated as above was used to estimate abundance index for the scenarios, based on the POD period coefficient in addition to the intercept and X2 slope terms. The basic equation used was (see also Table E-1):

$$\log_{10}(\text{Longfin Smelt FMWT index}) = 7.3059 - 0.0542*(\text{January-June X2}) - 1.4067$$

The log-transformed abundance indices were back-transformed to a linear scale for comparison of scenarios. In order to illustrate the variability in predictions from the X2-abundance index GLM, annual estimates were made for the mean and upper and lower 95% prediction limits of the abundance indices, as recommended by Simenstad et al. (2016). Statistical analyses were conducted with PROC GLM and PROC PLM in SAS/STAT software, Version 9.4 of the SAS System for Windows.[20]

Results

CalSim-Based X2 Analysis

There was considerable overlap in predictions of Longfin Smelt fall midwater trawl index between scenarios for the CalSim-based X2 analysis (Figures E-2, E-3, E-4, and E-5). The difference between Existing and Refined Alternative 2b was similar to the difference between Existing and PP, although the differences were small in all cases, particularly when accounting for the signal to noise in the estimates (Table E-2).

Equation-Based X2 Analysis

Consistent with the CalSim-based X2 analysis, there was considerable overlap in predictions of Longfin Smelt fall midwater trawl index between scenarios for the equation-based X2 analysis (Figures E-6, E-7, E-8, and E-9). The difference between the mean of Existing and Refined Alternative 2b was less than the difference between Existing and PP, although again the differences were small in all cases, particularly when accounting for the signal to noise in the estimates (Table E-3).

[20] Copyright 2002–2010, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA

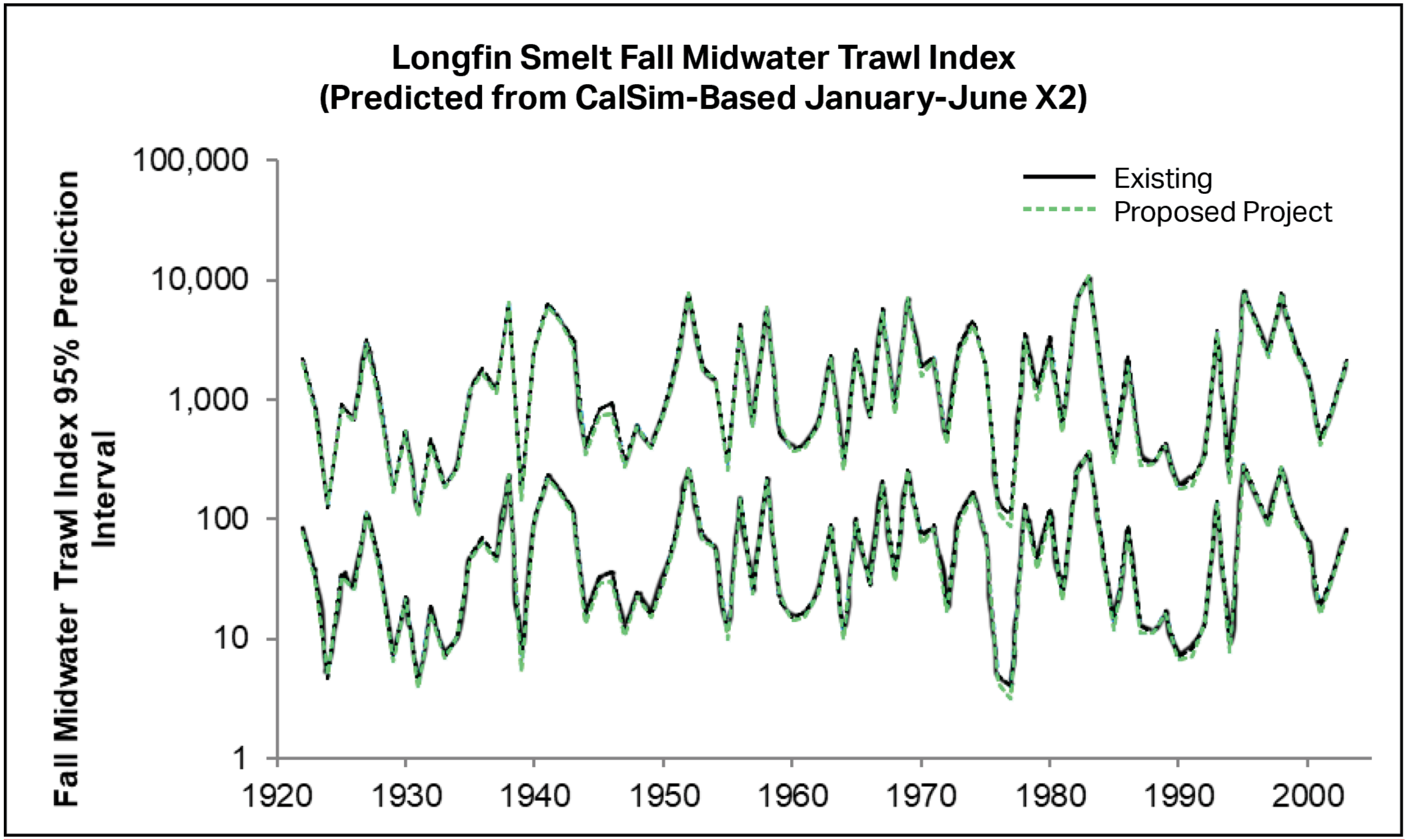


Figure E-2. Time Series of 95% Prediction Interval Longfin Smelt Bay Midwater Trawl Index, from the General Linear Model Including Mean January–June X2 (from CalSim), Comparing Existing and Proposed Project (PP) Scenarios.

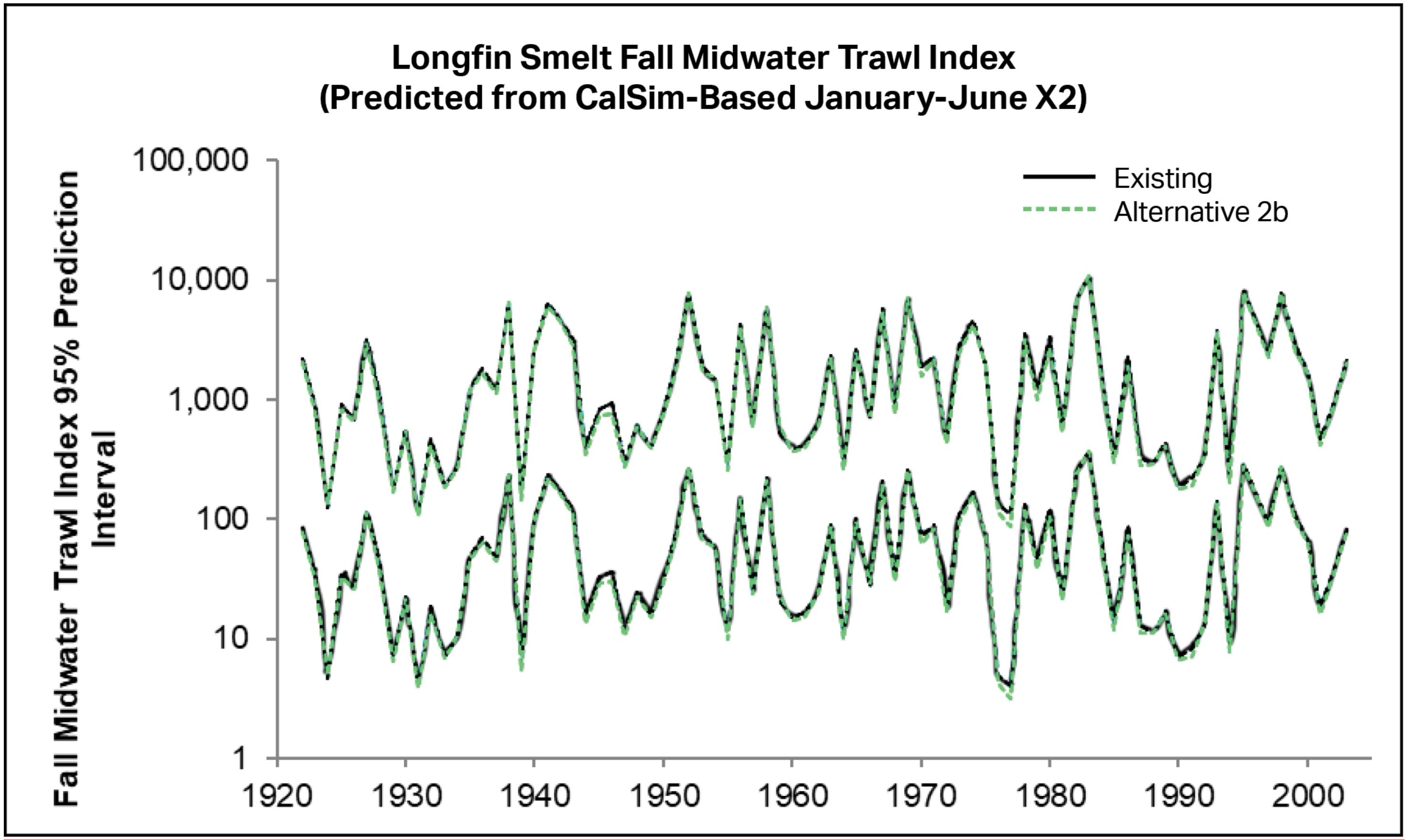
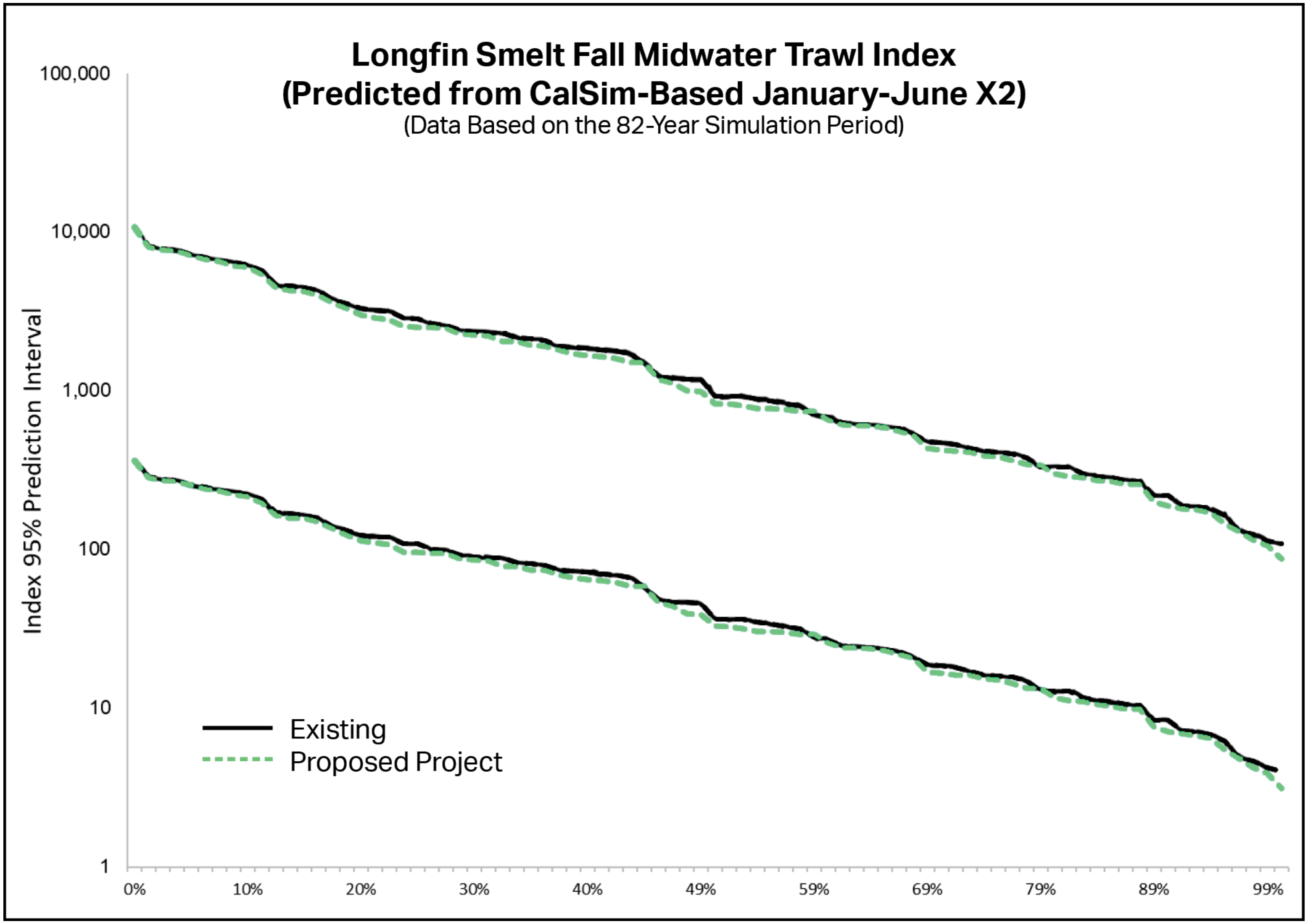
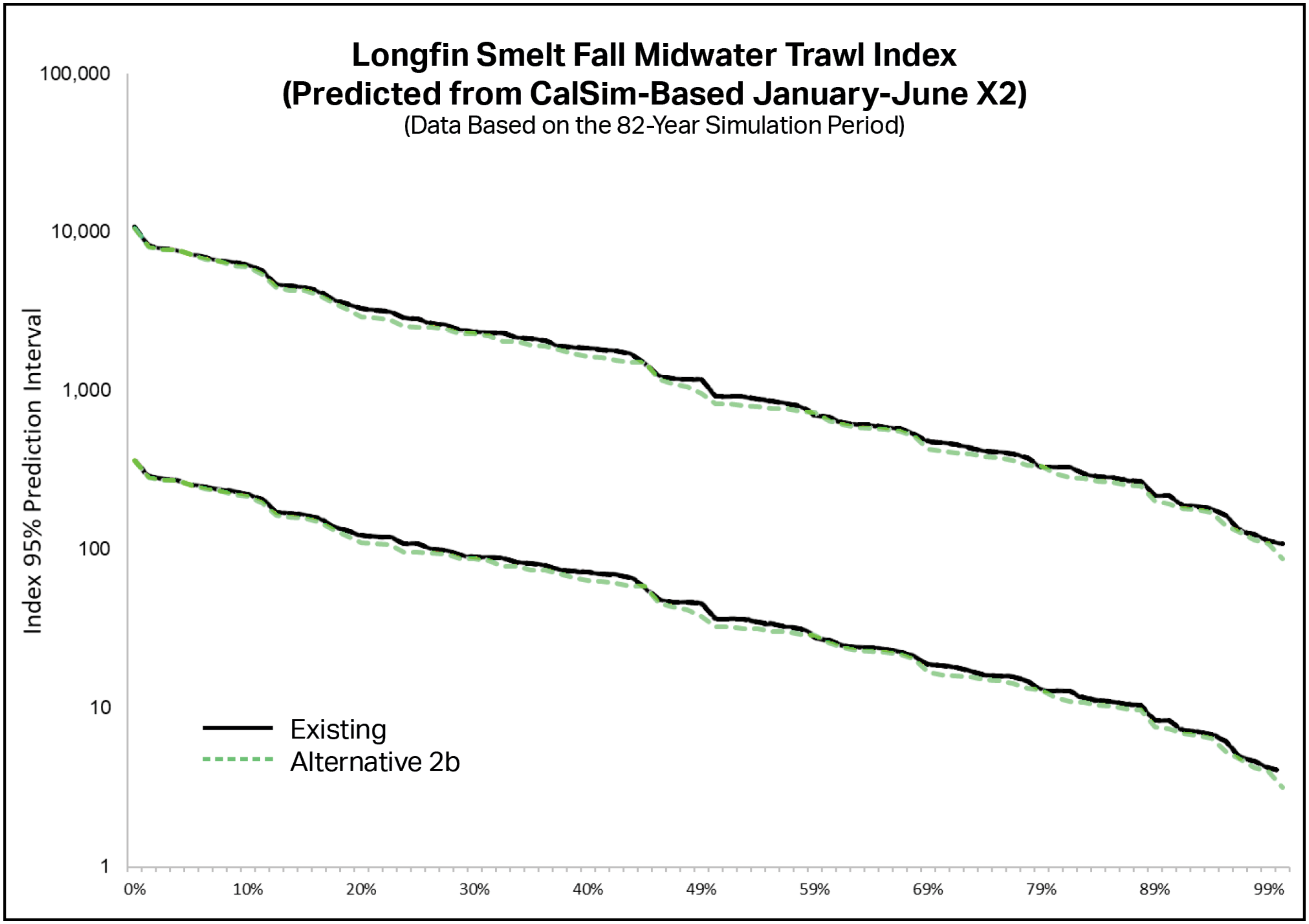


Figure E-3. Time Series of 95% Prediction Interval Longfin Smelt Bay Midwater Trawl Index, from the General Linear Model Including Mean January–June X2 (from CalSim), Comparing Existing and Refined Alternative 2b Scenarios.



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure E-4. Exceedance Plot of Longfin Smelt Fall Midwater Trawl Relative Abundance Index, Estimated from the General Linear Model Including Mean January–June X2 (from CalSim), Comparing Existing and Proposed Project (PP) Scenarios.



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure E-5. Exceedance Plot of Longfin Smelt Fall Midwater Trawl Relative Abundance Index, Estimated from the General Linear Model Including Mean January–June X2 (from CalSim), Comparing Existing and Refined Alternative 2b Scenarios.

Table E-2. Predicted Mean Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on General Linear Model Including Mean January–June X2 (from CalSim), Comparing Existing, Proposed Project, and Refined Alternative 2b Scenarios.

Year Type	Existing	PP	Alternative 2b	PP vs. Existing[1]	PP vs. Existing[2]	Refined Alternative 2b vs. Existing[1]	Refined Alternative 2b vs. Existing[2]
Wet Year	880	845	846	-34 (-4%)	-34 (0%)	-34 (-4%)	-34 (0%)
Above Normal Year	445	413	412	-32 (-7%)	-32 (0%)	-33 (-7%)	-33 (0%)
Below Normal Year	180	167	165	-13 (-7%)	-13 (0%)	-14 (-8%)	-14 (0%)
Dry Year	92	84	83	-8 (-8%)	-8 (0%)	-8 (-9%)	-8 (0%)
Critical Year	38	37	37	-2 (-5%)	-2 (0%)	-2 (-5%)	-2 (0%)

Notes: [1] Difference is absolute difference between mean estimates, with values in parentheses representing % difference in mean. Equivalent comparisons are shown with gray shading.
[2] Difference is absolute difference between mean estimates, with values in parentheses representing mean % difference based on difference between Proposed Project scenarios and Existing, divided by the mean Existing 95% confidence interval, which is an indicator of signal to noise. Equivalent comparisons are shown with blue shading.

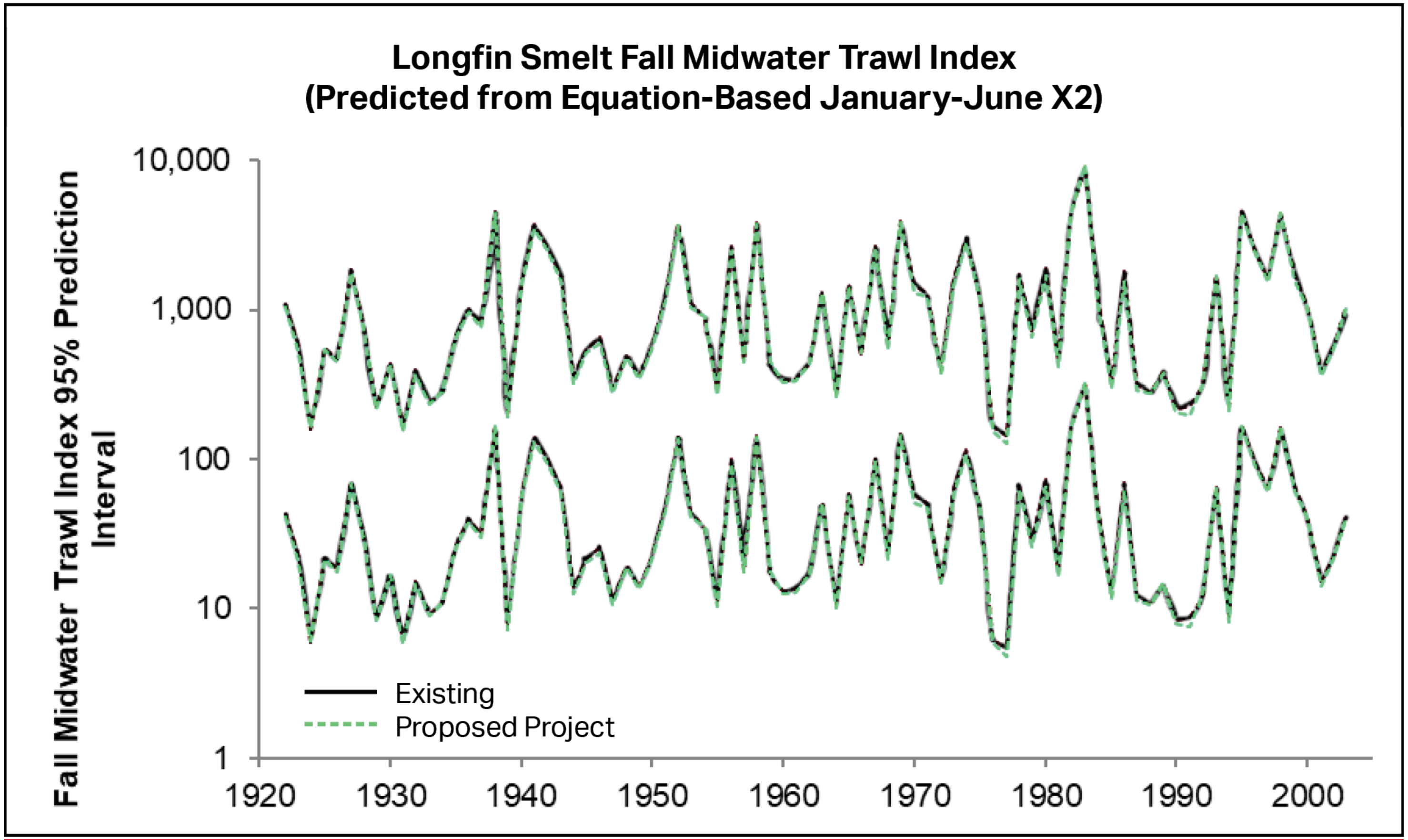


Figure E-6. Time Series of 95% Prediction Interval Longfin Smelt Bay Midwater Trawl Index, from the General Linear Model Including Mean January–June X2 (from Equation), Comparing Existing and Proposed Project (PP) Scenarios.

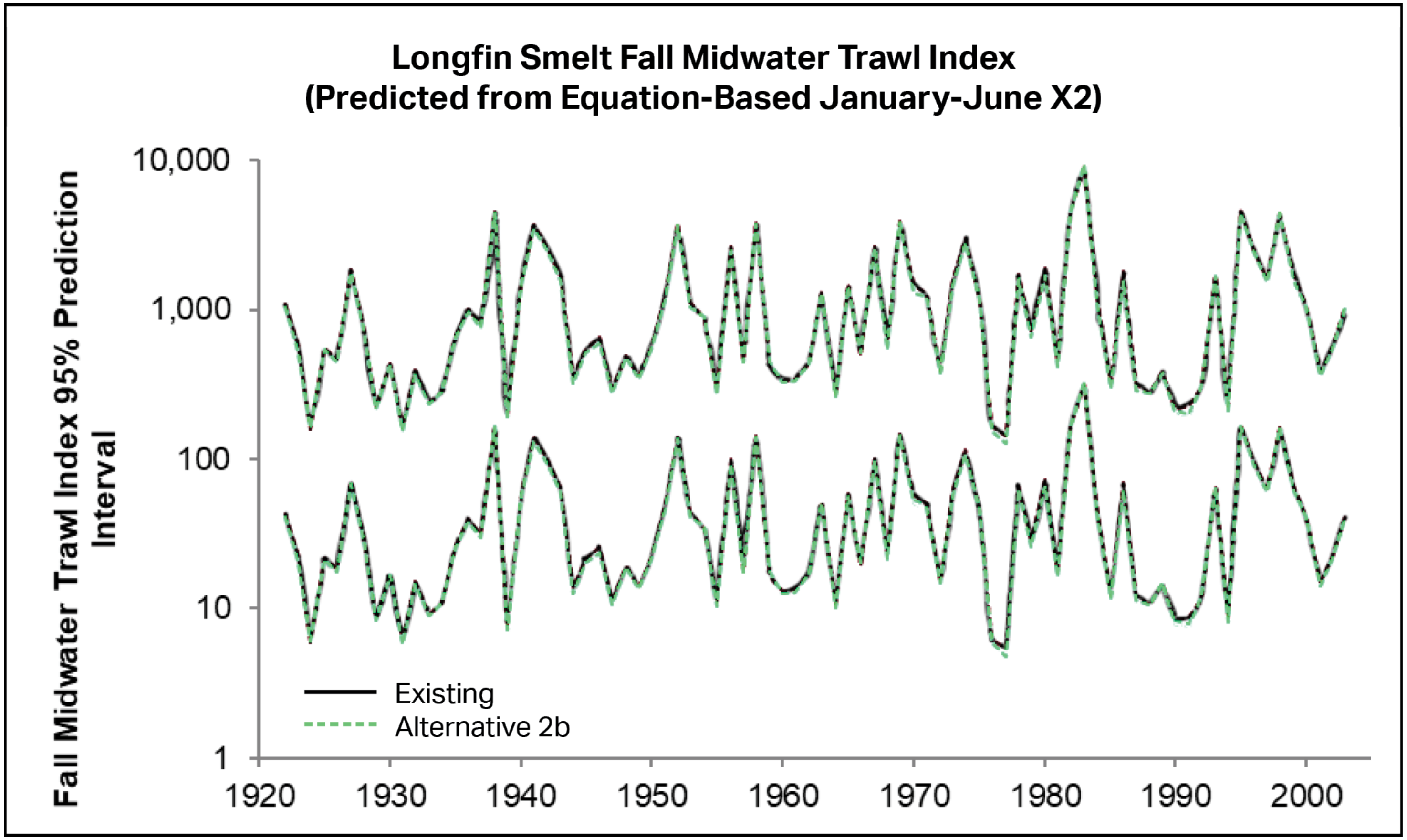
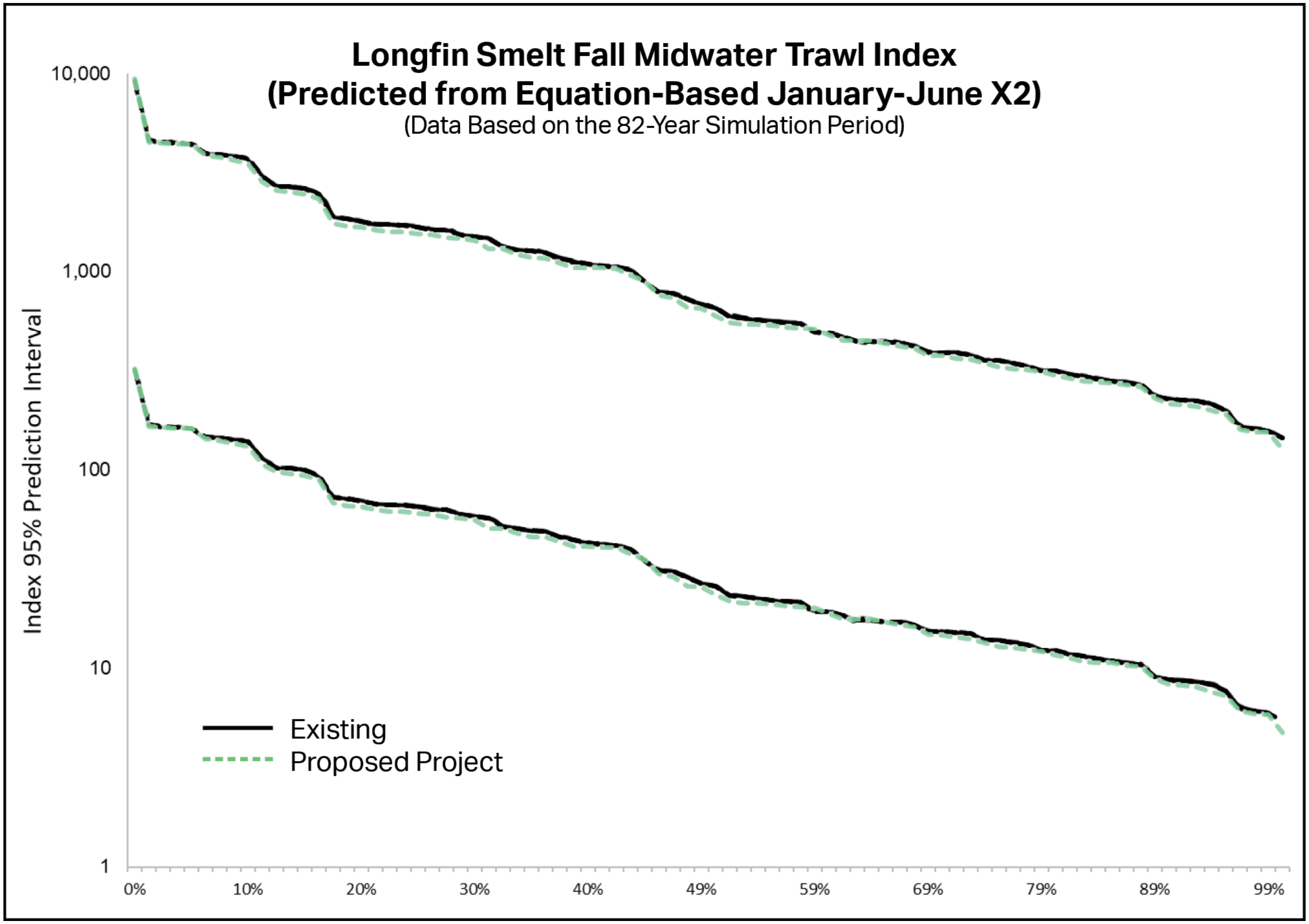
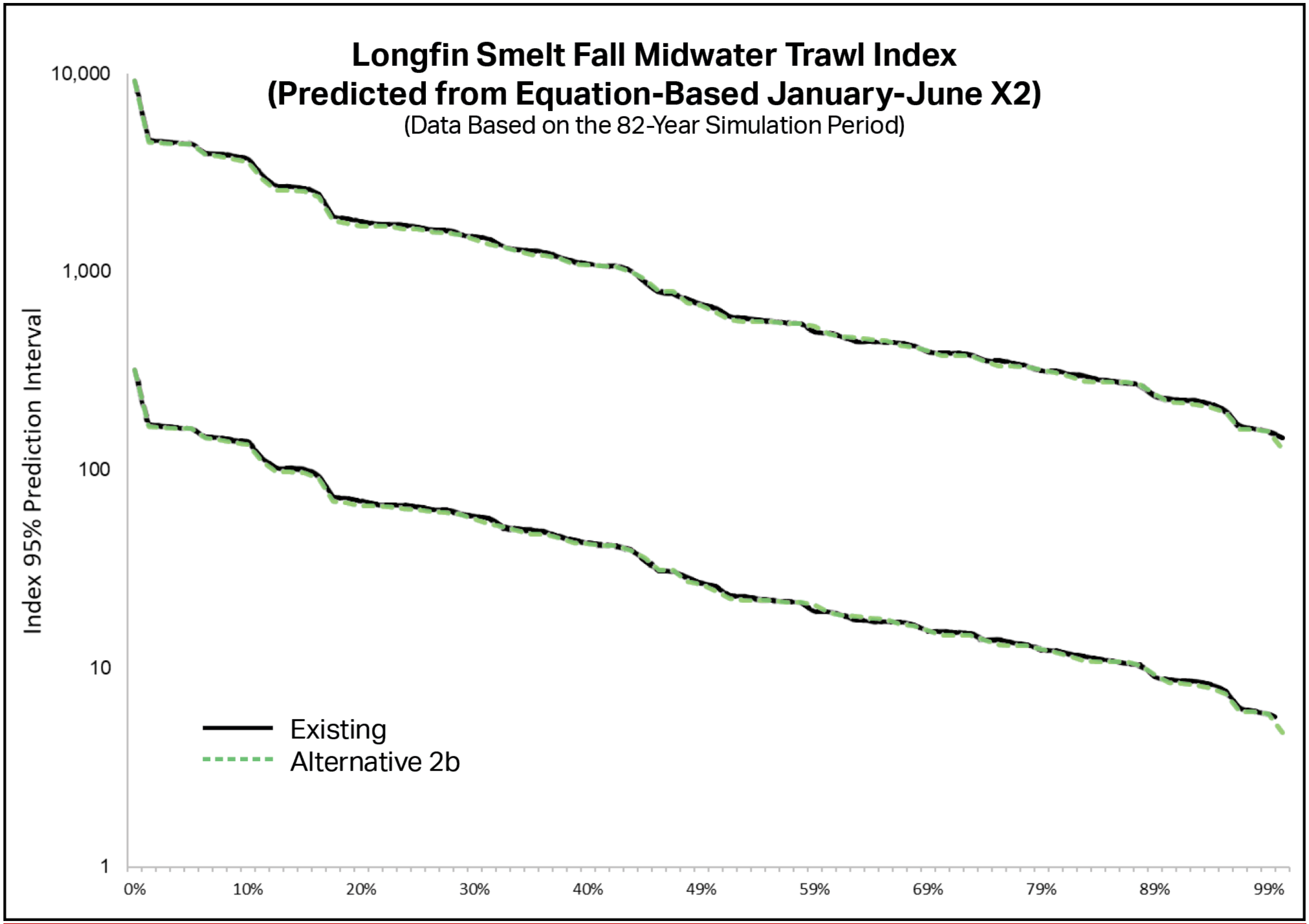


Figure E-7. Time Series of 95% Prediction Interval Longfin Smelt Bay Midwater Trawl Index, from the General Linear Model Including Mean January–June X2 (from Equation), Comparing Existing and Refined Alternative 2b Scenarios.



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure E-8. Exceedance Plot of Longfin Smelt Fall Midwater Trawl Relative Abundance Index, Estimated from the General Linear Model Including Mean January–June X2 (from Equation), Comparing Existing and Proposed Project (PP) Scenarios.



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure E-9. Exceedance Plot of Longfin Smelt Fall Midwater Trawl Relative Abundance Index, Estimated from the General Linear Model Including Mean January–June X2 (from Equation), Comparing Existing and Refined Alternative 2b Scenarios.

Table E-3. Predicted Mean Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on General Linear Model Including Mean January–June X2 (from Equation), Comparing Existing, Proposed Project, and Refined Alternative 2b Scenarios.

Year Type	Existing	PP	Refined Alternative 2b	PP vs. Existing[1]	PP vs. Existing[2]	Refined Alternative 2b vs. Existing[1]	Refined Alternative 2b vs. Existing[2]
Wet Year	550	530	537	-20 (-4%)	-20 (0%)	-12 (-2%)	-12 (0%)
Above Normal Year	249	236	246	-13 (-5%)	-13 (0%)	-3 (-1%)	-3 (0%)
Below Normal Year	119	114	118	-5 (-4%)	-5 (0%)	-1 (-1%)	-1 (0%)
Dry Year	74	70	72	-4 (-5%)	-4 (0%)	-2 (-3%)	-2 (0%)
Critical Year	43	41	42	-1 (-3%)	-1 (0%)	-1 (-1%)	-1 (0%)

Notes: [1] Difference is absolute difference between mean estimates, with values in parentheses representing % difference in mean. Equivalent comparisons are shown with gray shading.
[2] Difference is absolute difference between mean estimates, with values in parentheses representing mean % difference based on difference between Proposed Project scenarios and Existing, divided by the mean Existing 95% confidence interval, which is an indicator of signal to noise. Equivalent comparisons are shown with blue shading.

References

Burnham, K. P., D. R. Anderson, and K. P. Huyvaert. 2011. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology 65(1):23-35.

ICF International. 2016. State Incidental Take Permit Application for the Construction and Operation of Dual Conveyance Facilities of the State Water Project. Draft. October. (ICF 00443.12.) Sacramento, CA. Prepared for California Department of Water Resources, Sacramento, CA.

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. Ecological Applications 5(1): 272-289.

Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? Marine Ecology Progress Series 243: 39-55.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts 32(2):375-389.

Mount, J., W. Fleenor, B. Gray, B. Herbold, and W. Kimmerer. 2013. Panel Review of the draft Bay-Delta Conservation Plan. Prepared for the Nature Conservancy and American Rivers. September. Saracino & Mount, LLC, Sacramento, CA.

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. Transactions of the American Fisheries Society 145(1):44-58.

Schubel, J. R. 1993. Managing Freshwater Discharge to the San Francisco Bay/Sacramento San Joaquin Delta Estuary: The Scientific Basis for an Estuarine Standard. Conclusions and Recommendations of Members of the Scientific, Policy, and Management Communities of the Bay/Delta Estuary. San Francisco Estuary Project, San Francisco, CA.

Simenstad, C., J. Van Sickle, N. Monsen, E. Peebles, G.T. Ruggerone, and H. Gosnell. 2016. Independent Review Panel Report for the 2016 California WaterFix Aquatic Science Peer Review. Sacramento, CA: Delta Stewardship Council, Delta Science Program.