Appendix 9G

Smelt Analysis

This appendix provides information about the methods and the assumptions used for the Remanded Biological Opinions on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Environmental Impact Statement (EIS) analysis of Delta Smelt entrainment and Longfin Smelt abundance.

This appendix is organized into two main sections that are briefly described below:

- Section 9G.1: Smelt Modeling Methodology
  - This section presents the entrainment analysis for Delta Smelt adult, and larvae and early juveniles. The Delta Smelt entrainment analysis is based on regression equations that take into account the combined Old and Middle River (OMR) flow and X2 location. This section also describes longfin smelt abundance analysis, which is based on a regression equation that correlates an abundance index based on the X2 location.
- Section 9G.2: Smelt Modeling Results
  - This section presents the simulated Delta Smelt entrainment percentages and longfin smelt abundance indexes for each EIS alternative.

9G.1 Smelt Modeling Methodology and Assumptions

This section summarizes the modeling methodology used for simulating Delta Smelt entrainment, and longfin smelt abundance for the No Action Alternative, Second Basis of Comparison, and other alternatives. It describes the approach used in the quantitative evaluation of potential impacts on Delta Smelt entrainment.

9G.1.1 Delta Smelt Entrainment

Assumptions for migrating and spawning adults and for larvae and early juveniles are separately discussed in the following sections.

9G.1.1.1 Methodology for Migrating and Spawning Adults (December-March)

The entrainment of migrating and spawning adult Delta Smelt is primarily affected by the combined OMR flow in December through March. Water exported at the Banks and Jones pumping plants typically flows through the Old and Middle River channels. A positive OMR flow indicates a northward flow in the natural direction, toward the San Francisco Bay, and contributing to the Delta outflow. A negative OMR flow indicates a southward flow induced by pumping, and away from the Delta outflow.

In order to simulate Delta Smelt entrainment as influenced by OMR flow, the U.S. Fish and Wildlife Service (2008) developed a regression model based on Kimmerer (2008). The equation developed by Kimmerer (2008) is based on the average December through March OMR flow (in units of cubic feet per second [cfs]) and yields the percentage of adult Delta Smelt that may become entrained in the pumps. The equation is:

*Adult entrainment loss [percentage] = 6.243 - 0.000957 * OMR Flow (average OMR from December through March)*

Further review by Kimmerer (2011) determined that the above equation has an upward bias. To correct this bias, the result from the above equation should be reduced by 24 percent. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

9G.1.1.2 Methodology for Larvae and Early Juveniles (March-June)

Larvae and early juvenile smelt are most prevalent in the Delta in the spring months of March through June. The U.S. Fish and Wildlife Service (2008) developed a regression model based on Kimmerer (2008) to calculate the percentage entrainment of larval and early juvenile Delta Smelt in South Delta pumping facilities. This regression is dependent on two variables: March through June average OMR flow, and March through June average X2:

*Larvae and early juvenile entrainment loss [percentage] = [0.00933 * X2 (March through June) - 0.0000207 * OMR Flow (March through June) - 0.556] * 100*

In the event that a negative entrainment percentage was calculated, the result was changed to zero. OMR and X2 values simulated in the CalSim II model for each alternative were used in estimating the entrainment loss.

9G.1.2 Delta Smelt Fall Abiotic Habitat Index

Feyrer et al. (2011) demonstrated that Delta Smelt abiotic habitat suitability in the fall in the West Delta, Suisun Bay, and Suisun Marsh subregions, as well as smaller portions of the Cache Slough, South Delta, and North Delta subregions, is correlated with X2 location. Feyrer et al. used X2 as an indicator of the suitable salinity and water transparency for rearing older juvenile Delta Smelt.

In evaluating the fall abiotic habitat availability for Delta Smelt under the alternatives, average September through December X2 position in kilometers was used. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared for the expected changes.

9G.1.3 Longfin Smelt Abundance

Kimmerer et al. (2009) correlated log-transformed Longfin Smelt abundance based on the Fall Midwater Trawl (FMWT) data with the winter and spring location of X2. The correlation is based on the following regression equation:

*Longfin Smelt abundance index value = 10 ^ [-0.05 * (January through June X2 average position) + 7]*

The equation is based on the assumption that a lower X2 value indicates higher flows transporting longfin farther downstream, which would lead to greater longfin smelt survival. The index value indicates the relative abundance of the Longfin Smelt and not the calculated population.

9G.2 Smelt Modeling Results

Modeling results are presented in tabular format for Delta Smelt entrainment, September through December X2, and Longfin Smelt abundance. The Delta Smelt analysis results show the percent entrainment for the long-term average and for each water year type for the No Action Alternative, Second Basis of Comparison, Alternative 3, and Alternative 5 in Tables B-1 and B-2. Each alternative is also compared to each of the bases of comparison (No Action Alternative and Second Basis of Comparison). Results are provided separately for the migrating and spawning adults, and for the larvae and early juveniles. Long-term average fall X2 (average September through December) and average for each water year type, in KM, are presented in Table B-3. The longfin smelt abundance shown in Table B-4 provides the abundance index value for long-term average and for each water year type for the different alternatives.

9G.3 References

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2011. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. *Estuaries and Coasts* 34:120–128.

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), 29.

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? *Coastal and Estuarine Research Federation, 2009*.

Kimmerer, W. J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. *San Francisco Estuary and Watershed Science* 9(1).

USFWS (U.S. Fish and Wildlife Service). 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP). Sacramento, CA.

Table B-1. Adult Delta Smelt Entrainment (Dec-Mar).

	Smelt Entrainment	Difference from No Action Alternative	Difference from Second Basis of Comparison
	Percent Entrainment	Percent Entrainment	Percent Entrainment
No Action Alternative			
Long-term Average	7.60	---	-1.41
Wet	6.94	---	-1.13
Above Normal	8.00	---	-1.77
Below Normal	8.28	---	-1.54
Dry	8.01	---	-1.65
Critical	7.30	---	-1.10
Second Basis of Comparison			
Long-term Average	9.01	1.41	
Wet	8.07	1.13	---
Above Normal	9.77	1.77	---
Below Normal	9.82	1.54	---
Dry	9.66	1.65	---
Critical	8.41	1.10	---
Alternative 3			
Long-term Average	7.85	0.25	-1.16
Wet	7.31	0.37	-0.76
Above Normal	8.41	0.41	-1.36
Below Normal	8.52	0.24	-1.30
Dry	8.09	0.08	-1.57
Critical	7.38	0.08	-1.02
Alternative 5			
Long-term Average	7.61	0.01	-1.40
Wet	6.94	0.00	-1.13
Above Normal	8.01	0.01	-1.76
Below Normal	8.30	0.02	-1.52
Dry	8.02	0.01	-1.64
Critical	7.31	0.01	-1.09

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-2. Juvenile Delta Smelt Entrainment (Mar-Jun).

	Smelt Entrainment	Difference from No Action Alternative	Difference from Second Basis of Comparison
	Percent Entrainment	Percent Entrainment	Percent Entrainment
No Action Alternative			
Long-term Average	8.59	---	-6.91
Wet	1.34	---	-5.56
Above Normal	3.64	---	-9.31
Below Normal	11.98	---	-9.38
Dry	12.99	---	-7.30
Critical	19.25	---	-4.32
Second Basis of Comparison			
Long-term Average	15.50	6.91	
Wet	6.90	5.56	---
Above Normal	12.95	9.31	---
Below Normal	21.36	9.38	---
Dry	20.29	7.30	---
Critical	23.58	4.32	---
Alternative 3			
Long-term Average	12.69	4.09	-2.82
Wet	5.64	4.30	-1.26
Above Normal	10.07	6.43	-2.88
Below Normal	16.93	4.95	-4.43
Dry	16.52	3.54	-3.76
Critical	20.50	1.25	-3.08
Alternative 5			
Long-term Average	7.72	-0.87	-7.78
Wet	1.23	-0.11	-5.67
Above Normal	3.39	-0.25	-9.56
Below Normal	11.01	-0.97	-10.35
Dry	11.27	-1.71	-9.01
Critical	17.56	-1.69	-6.01

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-3. X2 Position (Sep-Dec).

	X2 Position	Difference from No Action Alternative	Difference from Second Basis of Comparison
	km	km	km
No Action Alternative			
Long-term Average	84.0	---	-4.2
Wet	75.9	---	-9.8
Above Normal	81.2	---	-6.1
Below Normal	87.8	---	-0.6
Dry	89.1	---	-0.2
Critical	92.4	---	0.1
Second Basis of Comparison			
Long-term Average	88.1	4.2	
Wet	85.6	9.8	---
Above Normal	87.3	6.1	---
Below Normal	88.4	0.6	---
Dry	89.3	0.2	---
Critical	92.3	-0.1	---
Alternative 3			
Long-term Average	88.1	4.1	-0.1
Wet	85.5	9.7	-0.1
Above Normal	87.2	6.0	-0.1
Below Normal	88.1	0.3	-0.3
Dry	89.4	0.2	0.0
Critical	92.5	0.1	0.1
Alternative 5			
Long-term Average	83.9	0.0	-4.2
Wet	75.8	0.0	-9.8
Above Normal	81.2	0.0	-6.1
Below Normal	87.6	-0.2	-0.8
Dry	89.1	0.0	-0.2
Critical	92.3	-0.1	0.0

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-4. Longfin Smelt Abundance Index.

	Longfin Smelt Abundance Index Value	Percent Difference from No Action Alternative	Percent Difference from Second Basis of Comparison
No Action Alternative			
Long-term Average	7951	---	9.6%
Wet	16635	---	5.1%
Above Normal	8989	---	15.8%
Below Normal	3166	---	21.6%
Dry	2702	---	26.2%
Critical	1147	---	21.0%
Second Basis of Comparison			
Long-term Average	7257	-8.7%	
Wet	15822	-4.9%	---
Above Normal	7762	-13.7%	---
Below Normal	2604	-17.8%	---
Dry	2140	-20.8%	---
Critical	947	-17.4%	---
Alternative 3			
Long-term Average	7345	-7.6%	1.2%
Wet	15638	-6.0%	-1.2%
Above Normal	7882	-12.3%	1.5%
Below Normal	2857	-9.8%	9.7%
Dry	2435	-9.9%	13.8%
Critical	1094	-4.6%	15.5%
Alternative 5			
Long-term Average	8015	0.8%	10.4%
Wet	16683	0.3%	5.4%
Above Normal	9037	0.5%	16.4%
Below Normal	3231	2.0%	24.1%
Dry	2800	3.6%	30.8%
Critical	1204	5.0%	27.1%

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.