Methods and Modeling

Conceptual models of impacts from drought management actions were presented in the Biological Reviews for the February-March Project Description (Reclamation 2015). The potential effects of the proposed OMR management action are considered in the context of these conceptual models. Additionally, the biological opinions (NMFS 2009, USFWS 2008) were reviewed regarding biological linkage to the considered action.

DSM2 Modeling

To evaluate potential effects of the Proposed Action's management of the transition period and averaging period for OMR calculations on potential Delta hydrodynamics, Delta Simulation Model II (DSM2) simulations were performed and evaluated for two operational management scenarios (Table 1). The first scenario represents a baseline with constant OMR values of -5,000 cfs, while the proposed action includes a five-day period with OMR values of -6,250 cfs. Other input values remained constant and reflected the best information available to DWR modelers when models were run on February 6, 2015. These flows do not necessarily reflect current forecast information and actual conditions have and will differ from the modeled scenarios. This increases the uncertainty of assessments of impacts to all species reviewed.

Table 1. DSM2 Model input for scenarios evaluated in biological reviews.

			Baseline			Proposed Action		
Date	Freeport Flow (cfs)	Vernalis Flow (cfs)	Outflow (cfs)	Combined Exports (cfs)	OMR	Outflow (cfs)	Combined Exports (cfs)	OMR
6-Feb	9,543	890	7,219	2,575	~-2000	7,219	2,575	~-2000
7-Feb	10,640	870	11,238	4,075	-3,500	11,238	4,075	-3,500
8-Feb	22,738	940	14,421	5,175	-4,500	14,421	5,175	-4,500
9-Feb	48,840	1,230	33,223	5,775	-5,000	33,223	5,775	-5,000
10-Feb	54,900	2,590	62,620	6,000	-5,000	62,620	6,000	-5,000
11-Feb	53,900	2,500	65,480	6,500	-5,000	65,480	6,500	-5,000
12-Feb	52,900	2,400	57,685	6,600	-5,000	56,285	8,000	-6,250
13-Feb	49,900	2,300	54,344	6,500	-5,000	52,944	7,900	-6,250
14-Feb	46,900	2,200	45,980	6,500	-5,000	44,630	7,850	-6,250
15-Feb	43,900	2,100	42,560	6,400	-5,000	41,135	7,825	-6,250
16-Feb	40,900	2,000	39,360	6,400	-5,000	37,960	7,800	-6,250
17-Feb	37,900	1,900	36,310	6,300	-5,000	36,310	6,300	-5,000
18-Feb	34,900	1,800	33,210	6,300	-5,000	33,210	6,300	-5,000
19-Feb	31,900	1,700	30,110	6,300	-5,000	30,110	6,300	-5,000
20-Feb	28,900	1,600	27,035	6,275	-5,000	27,035	6,275	-5,000
21-Feb	25,900	1,500	24,035	6,175	-5,000	24,035	6,175	-5,000
22-Feb	24,900	1,400	20,885	6,175	-5,000	20,885	6,175	-5,000
23-Feb	24,900	1,300	19,985	5,975	-5,000	19,985	5,975	-5,000
24-Feb	24,900	1,200	19,885	5,975	-5,000	19,885	5,975	-5,000
25-Feb	24,900	1,100	19,785	5,975	-5,000	19,785	5,975	-5,000
26-Feb	24,900	1,000	19,885	5,775	-5,000	19,885	5,775	-5,000
27-Feb	24,900	900	19,785	5,775	-5,000	19,785	5,775	-5,000
28-Feb	24,900	800	19,685	5,775	-5,000	19,685	5,775	-5,000

Table 2. Actual hydrodynamic characteristics compared to modeled conditions.

Date	Modeled Outflow (cfs)	Actual Outflow(cfs)	Modeled Freeport (cfs)	Actual Freeport (cfs)	Modeled Vernalis (cfs)	Actual Vernalis (cfs)	Modeled Combined Exports (cfs)	Actual Combined Exports (cfs)	OMR	Updated OMR (Index)
6-Feb	7,219	7,197	9,543	9,522	890	887	2,575	2,595	~-2000	-2109
7-Feb	11,238	8,537	10,640	13,048	870	889	4,075	4,083	-3,500	-3461
8-Feb	14,421	18,215	22,738	17,623	940	927	5,175	5,186	-4,500	-4465

DSM2 modeling outputs for each scenario were used to evaluate the distribution of 15-minute flow and velocity values for multiple channels, including:

- Upstream of Head of Old River on San Joaquin (Channel 6)
- Downstream of Head of Old River on San Joaquin (Channel 9)
- Upstream of Stockton Deepwater Shipping Channel (Channel 12)
- Downstream of Stockton Deepwater Shipping Channel (Channel 21)
- Jersey Point on San Joaquin River (Channel 49)
- Sherman Island on San Joaquin River (Channel 50)
- Downstream of Head of Old River on Old River (Channel 54)
- Grant Line Canal (Channel 81)
- Old River south of Railroad Cut (Channel 94)
- Old River north of Railroad Cut (Channel 107)
- Old River at San Joaquin River (Channel 124)
- Middle River north of Railroad Cut (Channel 148)
- Columbia Cut (Channel 160)
- Turner Cut (Channel 173)
- Three Mile Slough near San Joaquin River (Channel 310)
- Sacramento River upstream of Delta Cross Channel (Channel 421)
- Sacramento River upstream of Georgiana Slough (Channel 422)
- Sacramento river downstream of Georgiana Slough (Channel 423)
- Sacramento River near Cache Slough (Channel 429)
- Sherman Island on Sacramento River (Channel 434)

Hydrodynamic Metrics

Hydrodynamic metrics, such as mean daily proportion positive velocity, daily mean velocity, and daily mean flow were used to assess changes in the Delta at these locations. These were calculated over three periods:

(1) a 6 day period in the Proposed Action with rapid transition to a 5 day period of OMR flows of -6250 cfs from February 12 to 17 (Table 2)
(2) the following 11 day period in the Proposed Action with a modified 14-day averaging period and constant OMR flows of -5000cfs from February 18 to 29 (Table 3)
(3) The complete modeled period from December 29 to March 1 (Table 4).

These data are also visualized spatially at both temporal steps to assess regional impacts and more complex hydrodynamics around the Delta Cross Channel and Head of Old River under the scenario (5-Day: Figures 1-2; 11 day: Figure 3-4; and complete modeling period: Figure 5-6).

Daily proportion positive velocity is the percentage of the day that river flows have a positive velocity value (flows in downstream direction). Daily mean velocity and mean flow are the average of all values summed over the 24 hour period, which takes into account the effects of tidal stage on velocity magnitudes. These daily values are then averaged for the period of interest. The difference in the values of these hydrodynamic metrics between the baseline and proposed action model was calculated to assess how the metric was affected by the proposed action (Table 3-5).

Channel nodes along Old and Middle showed increasing negative differences between the baseline and Proposed Action modeling further south along the corridor between the San Joaquin River and southerly Old and Middle rivers nodes. Of nodes modeled, differences in daily values of OMR flows were greater during Old and Middle River conditions of 5 days at -6250 cfs compared to the 11 day period when the 14-day average OMR value was returning to -5000 cfs (Table 6). Modeling shows a shift of up greater than 1000 cfs more negative in daily average flow differences between baseline and Proposed Action modeling during the 5 day period of OMR values modeled at -6, 250 cfs. For the remainder of February, there are shifts in daily average flows typically less the 100 cfs more negative between baseline and Proposed Action modeling. These differences are most dramatic along the Old and Middle River corridor. Daily velocities at these modeled nodes did not show any difference during either of the Proposed Action’s periods including both the 5 day -6,250 cfs OMR and 12 day -5,000 OMR flow phases that were modeled (Table 7).

Density plots of DSM2 modeled 15-minute velocity data were also developed for the twenty channel nodes modeled for the two scenarios. Figures 7-14 show representative nodes from two temporal scales of model results including the 5 day period and seasonal period. These were representative of channels from the San Joaquin, South Delta, Central Delta, and North Delta since they were channels showing greatest regional differences in the modeled mean daily flow values. These plots show no measureable differences in 15-minute velocity plots due to processes such as tidal hydrodynamics and channel morphology forcing channel velocities more so than the operational differences captured in the data from the difference temporal scales assessed.

Table 3. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for the a 5-day period with OMR flows of -6250 cfs [1]. Outflow, OMR, and cumulative exports vary between scenarios; see Table 1 for details. The DJFMP Seine Region Containing the Channel Node was identified from USFWS metadata.

		Mean Daily Proportion Positive Flows			Average Daily Flow (cfs)			Average Daily Velocity (ft/s)		
Channel Node	DJFMP Seine Region	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Flex	Difference between Proposed and Baseline
6	San Joaquin	1.00	1.00	0.00	2236	2237	1	1.09	1.09	0.00
9	San Joaquin	0.69	0.67	-0.01	730	699	-31	0.51	0.49	-0.02
12	South Delta	0.63	0.61	-0.01	753	723	-31	0.42	0.41	-0.01
21	South Delta	0.59	0.58	0.00	933	904	-30	0.07	0.07	0.00
49	Central Delta	0.55	0.55	0.00	9339	8383	-956	0.15	0.13	-0.01
50	Central Delta	0.55	0.55	0.00	9556	8550	-1006	0.15	0.14	-0.01
54	San Joaquin	1.00	1.00	0.00	1510	1543	33	0.84	0.86	0.02
81	South Delta	0.50	0.49	-0.01	-503	-500	3	-0.13	-0.13	0.00
94	South Delta	0.47	0.44	-0.03	-2266	-2938	-672	-0.28	-0.37	-0.10
107	South Delta	0.52	0.49	-0.02	-720	-895	-176	-0.18	-0.23	-0.05
124	South Delta	0.42	0.41	-0.01	-4265	-4585	-320	-0.13	-0.14	-0.01
148	South Delta	0.51	0.49	-0.01	-1095	-1393	-298	-0.10	-0.14	-0.03
160	South Delta	0.52	0.51	0.00	-560	-700	-140	-0.04	-0.06	-0.02
173	South Delta	0.50	0.49	-0.01	-462	-558	-96	-0.09	-0.11	-0.02
310	Central Delta	0.51	0.50	-0.01	-1213	-1434	-221	-0.05	-0.06	-0.02
421	North Delta	1.00	1.00	0.00	25904	25908	4	2.76	2.76	0.00
422	North Delta	1.00	1.00	0.00	25929	25933	4	2.44	2.44	0.00
423	North Delta	1.00	1.00	0.00	18317	18313	-4	2.56	2.56	0.00
429	North Delta	1.00	1.00	0.00	18398	18394	-3	2.28	2.28	0.00
434	Central Delta	0.62	0.62	0.00	41250	41034	-216	0.51	0.50	0.00

[1] A map of DSM2 node locations is available at: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2v6/DSM2_Grid2.0.pdf

Table 4. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for the 11 day period in the Proposed Action with a modified 14-day averaging period and constant OMR flows of -5000 cfs [2]. Outflow, OMR, and cumulative exports vary between scenarios; see Table 1 for details. The DJFMP Seine Region Containing the Channel Node was identified from USFWS metadata.

		Mean Daily Proportion Positive Flows			Average Daily Flow (cfs)			Avergae Daily Velocity (ft/s)		
Channel Node	DJFMP Seine Region	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Flex	Difference between Proposed and Baseline
6	San Joaquin	0.97	0.97	0.00	1405.63	1405.21	-0.42	0.75	0.75	0.00
9	San Joaquin	0.58	0.58	0.00	293.67	292.59	-1.08	0.23	0.23	0.00
12	South Delta	0.56	0.56	0.00	293.31	291.98	-1.32	0.21	0.21	0.00
21	South Delta	0.55	0.55	0.00	314.11	312.44	-1.67	0.03	0.03	0.00
49	Central Delta	0.53	0.53	0.00	2297.84	2251.01	-46.84	0.06	0.06	0.00
50	Central Delta	0.53	0.53	0.00	2184.21	2132.77	-51.44	0.07	0.07	0.00
54	San Joaquin	0.96	0.96	0.00	1117.73	1118.02	0.28	0.65	0.65	0.00
81	South Delta	0.48	0.48	0.00	-730.69	-732.97	-2.28	-0.19	-0.19	0.00
94	South Delta	0.48	0.48	0.00	-2472.43	-2498.14	-25.71	-0.30	-0.31	0.00
107	South Delta	0.50	0.50	0.00	-863.36	-873.82	-10.46	-0.22	-0.22	0.00
124	South Delta	0.43	0.43	0.00	-3875.09	-3895.33	-20.25	-0.11	-0.11	0.00
148	South Delta	0.50	0.49	0.00	-1272.55	-1283.00	-10.45	-0.12	-0.12	0.00
160	South Delta	0.52	0.52	0.00	-492.43	-497.11	-4.68	-0.03	-0.03	0.00
173	South Delta	0.50	0.50	0.00	-492.54	-494.26	-1.72	-0.09	-0.09	0.00
310	Central Delta	0.50	0.50	0.00	-1744.71	-1758.94	-14.23	-0.08	-0.08	0.00
421	North Delta	1.00	1.00	0.00	15802.93	15803.30	0.37	1.84	1.84	0.00
422	North Delta	1.00	1.00	0.00	15811.64	15811.99	0.34	1.62	1.62	0.00
423	North Delta	1.00	1.00	0.00	10957.60	10956.72	-0.88	1.65	1.65	0.00
429	North Delta	1.00	1.00	0.00	10964.44	10963.40	-1.04	1.40	1.40	0.00
434	Central Delta	0.57	0.57	0.00	21844.12	21823.61	-20.51	0.29	0.29	0.00

[2] A map of DSM2 node locations is available at: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2v6/DSM2_Grid2.0.pdf

Table 5. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node[3] for the entire modeled period. Outflow, OMR, and cumulative exports vary between scenarios; see Table 1 for details. The DJFMP Seine Region Containing the Channel Node was identified from USFWS metadata.

		Mean Daily Proportion Positive Flows			Mean Daily Flow (cfs)			Mean Daily Velocity (ft/s)		
Channel Node	DJFMP Seine Region	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Proposed Action	Difference between Proposed and Baseline	Baseline	Flex	Difference between Proposed and Baseline
6	San Joaquin	0.92	0.92	0.00	1182	1182	0.00	0.64	0.64	0.00
9	San Joaquin	0.58	0.58	0.00	252	249	-2.68	0.20	0.20	0.00
12	South Delta	0.55	0.55	0.00	254	252	-2.68	0.19	0.18	0.00
21	South Delta	0.54	0.54	0.00	314	312	-2.68	0.03	0.03	0.00
49	Central Delta	0.53	0.53	0.00	2463	2378	-84.78	0.06	0.06	0.00
50	Central Delta	0.53	0.53	0.00	2460	2371	-89.64	0.07	0.07	0.00
54	San Joaquin	0.93	0.93	0.00	930	933	2.68	0.55	0.55	0.00
81	South Delta	0.40	0.40	0.00	-1006	-1006	-0.21	-0.27	-0.27	0.00
94	South Delta	0.47	0.46	0.00	-2094	-2153	-58.22	-0.25	-0.26	-0.01
107	South Delta	0.49	0.49	0.00	-747	-763	-15.93	-0.19	-0.19	0.00
124	South Delta	0.43	0.43	0.00	-3334	-3364	-29.22	-0.10	-0.10	0.00
148	South Delta	0.49	0.48	0.00	-1084	-1110	-25.61	-0.10	-0.11	0.00
160	South Delta	0.51	0.51	0.00	-401	-413	-12.00	-0.02	-0.03	0.00
173	South Delta	0.49	0.49	0.00	-420	-428	-7.94	-0.08	-0.08	0.00
310	Central Delta	0.50	0.50	0.00	-1212	-1233	-20.26	-0.05	-0.05	0.00
421	North Delta	0.95	0.95	0.00	11130	11130	0.35	1.30	1.30	0.00
422	North Delta	0.94	0.94	0.00	11131	11131	0.35	1.15	1.15	0.00
423	North Delta	0.84	0.84	0.00	7439	7438	-0.46	1.13	1.13	0.00
429	North Delta	0.80	0.80	0.00	7446	7446	-0.46	0.97	0.97	0.00
434	Central Delta	0.55	0.55	0.00	15701	15680	-21.08	0.22	0.22	0.00

[3] A map of DSM2 node locations is available at:
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2v6/DSM2_Grid2.0.pdf

Table 6. Daily mean flows from 8 DSM2 Channel Nodes (See Table 1) between February 12-28.

Date	Node 12			Node 49			Node 50			Node 94		
	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference
12-Feb	968	959	-9	8592	8068	-525	7989	7438	-551	-2121	-2536	-415
13-Feb	855	823	-32	10695	9656	-1039	10902	9812	-1091	-2198	-2932	-734
14-Feb	760	724	-36	10613	9542	-1071	11240	10110	-1129	-2264	-2999	-734
15-Feb	634	597	-37	9918	8838	-1080	10597	9459	-1137	-2282	-3028	-746
16-Feb	523	484	-39	8531	7481	-1050	9177	8070	-1108	-2586	-3315	-729
17-Feb	458	435	-24	6501	6142	-359	7369	6965	-403	-2700	-2767	-67
18-Feb	406	401	-6	3927	3890	-38	4925	4882	-43	-2711	-2711	0
19-Feb	358	352	-5	1823	1811	-12	2318	2295	-23	-2736	-2733	4
20-Feb	324	320	-4	694	640	-53	576	526	-50	-2696	-2720	-23
21-Feb	298	294	-3	-66	-107	-41	-559	-590	-31	-2632	-2694	-63
22-Feb	263	262	-1	-981	-970	11	-1689	-1691	-2	-2761	-2742	19
23-Feb	284	294	9	-1091	-1154	-64	-1992	-2048	-56	-2459	-2567	-108
24-Feb	296	310	13	-1707	-1708	-2	-2603	-2606	-3	-2291	-2345	-54
25-Feb	321	325	4	778	775	-3	-281	-286	-4	-2068	-2078	-11
26-Feb	259	258	-1	5025	5011	-15	4565	4550	-16	-2067	-2075	-8
27-Feb	178	178	0	6515	6514	-1	6801	6801	-1	-2179	-2179	0
28-Feb	106	106	0	6515	6515	0	7124	7124	0	-2237	-2237	0

Date	Node 124			Node 148			Node 422			Node 423		
	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference
12-Feb	-4318	-4504	-186	-1008	-1190	-182	28755	28758	3	20317	20316	-1
13-Feb	-4196	-4566	-370	-1054	-1375	-321	27564	27568	3	19496	19493	-3
14-Feb	-4174	-4523	-349	-1081	-1407	-327	26025	26029	4	18407	18403	-4
15-Feb	-4296	-4645	-349	-1101	-1435	-334	24461	24465	4	17279	17274	-5
16-Feb	-4418	-4758	-340	-1278	-1602	-324	22890	22894	4	16127	16122	-5
17-Feb	-4500	-4584	-84	-1391	-1411	-20	21322	21323	0	14966	14963	-4
18-Feb	-4534	-4546	-12	-1420	-1412	8	19761	19762	1	13807	13807	-1
19-Feb	-4512	-4521	-9	-1440	-1432	8	18205	18206	1	12655	12655	-1
20-Feb	-4378	-4407	-30	-1432	-1434	-2	16645	16646	1	11507	11506	-1
21-Feb	-4195	-4243	-48	-1393	-1430	-37	15078	15079	0	10354	10353	-1
22-Feb	-4254	-4237	17	-1475	-1463	12	14223	14224	0	9718	9717	-1
23-Feb	-3931	-3987	-56	-1346	-1413	-67	14068	14068	0	9624	9623	-1
24-Feb	-3541	-3552	-11	-1234	-1259	-25	14096	14096	0	9679	9678	-1
25-Feb	-3133	-3142	-10	-1014	-1015	-1	14133	14133	0	9763	9762	0
26-Feb	-3132	-3137	-4	-975	-978	-3	14144	14144	0	9845	9845	0
27-Feb	-3080	-3080	0	-1028	-1028	0	14113	14113	0	9858	9858	0
28-Feb	-3216	-3216	0	-1055	-1055	0	14062	14062	0	9807	9807	0

Table 7. Daily mean velocities from 8 DSM2 Channel Nodes (See Table 1) between February 12-28.

Date	Node 12			Node 49			Node 50			Node 94		
	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference
12-Feb	0.53	0.53	0.00	0.13	0.13	0.00	0.13	0.13	0.00	-0.27	-0.27	0.00
13-Feb	0.47	0.47	0.00	0.16	0.16	0.00	0.16	0.16	0.00	-0.27	-0.27	0.00
14-Feb	0.43	0.43	0.00	0.16	0.16	0.00	0.17	0.17	0.00	-0.27	-0.27	0.00
15-Feb	0.37	0.37	0.00	0.16	0.16	0.00	0.16	0.16	0.00	-0.27	-0.27	0.00
16-Feb	0.31	0.31	0.00	0.14	0.14	0.00	0.15	0.15	0.00	-0.31	-0.31	0.00
17-Feb	0.28	0.28	0.00	0.12	0.12	0.00	0.14	0.14	0.00	-0.33	-0.33	0.00
18-Feb	0.26	0.26	0.00	0.09	0.09	0.00	0.12	0.12	0.00	-0.33	-0.33	0.00
19-Feb	0.24	0.24	0.00	0.06	0.06	0.00	0.09	0.09	0.00	-0.33	-0.33	0.00
20-Feb	0.23	0.23	0.00	0.04	0.04	0.00	0.07	0.07	0.00	-0.32	-0.32	0.00
21-Feb	0.22	0.22	0.00	0.03	0.03	0.00	0.05	0.05	0.00	-0.32	-0.32	0.00
22-Feb	0.20	0.20	0.00	0.02	0.02	0.00	0.03	0.03	0.00	-0.34	-0.34	0.00
23-Feb	0.20	0.20	0.00	0.01	0.01	0.00	0.02	0.02	0.00	-0.30	-0.30	0.00
24-Feb	0.21	0.21	0.00	0.00	0.00	0.00	0.01	0.01	0.00	-0.28	-0.28	0.00
25-Feb	0.22	0.22	0.00	0.03	0.03	0.00	0.04	0.04	0.00	-0.25	-0.25	0.00
26-Feb	0.19	0.19	0.00	0.09	0.09	0.00	0.09	0.09	0.00	-0.25	-0.25	0.00
27-Feb	0.15	0.15	0.00	0.11	0.11	0.00	0.11	0.11	0.00	-0.27	-0.27	0.00
28-Feb	0.11	0.11	0.00	0.11	0.11	0.00	0.12	0.12	0.00	-0.27	-0.27	0.00

Date	Node 124			Node 148			Node 422			Node 423		
	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference	Base Model	Proposed Action	Difference
12-Feb	-0.13	-0.13	0.00	-0.10	-0.10	0.00	2.66	2.66	0.00	2.79	2.79	0.00
13-Feb	-0.13	-0.13	0.00	-0.10	-0.10	0.00	2.57	2.57	0.00	2.69	2.69	0.00
14-Feb	-0.12	-0.12	0.00	-0.10	-0.10	0.00	2.45	2.45	0.00	2.57	2.57	0.00
15-Feb	-0.13	-0.13	0.00	-0.10	-0.10	0.00	2.33	2.33	0.00	2.44	2.44	0.00
16-Feb	-0.13	-0.13	0.00	-0.12	-0.12	0.00	2.21	2.21	0.00	2.30	2.30	0.00
17-Feb	-0.13	-0.13	0.00	-0.13	-0.13	0.00	2.08	2.08	0.00	2.15	2.15	0.00
18-Feb	-0.13	-0.13	0.00	-0.14	-0.14	0.00	1.95	1.95	0.00	2.01	2.01	0.00
19-Feb	-0.13	-0.13	0.00	-0.14	-0.14	0.00	1.82	1.82	0.00	1.86	1.86	0.00
20-Feb	-0.13	-0.13	0.00	-0.14	-0.14	0.00	1.69	1.69	0.00	1.72	1.72	0.00
21-Feb	-0.12	-0.12	0.00	-0.13	-0.13	0.00	1.56	1.56	0.00	1.57	1.57	0.00
22-Feb	-0.13	-0.13	0.00	-0.14	-0.14	0.00	1.48	1.48	0.00	1.49	1.49	0.00
23-Feb	-0.12	-0.12	0.00	-0.13	-0.13	0.00	1.48	1.48	0.00	1.48	1.48	0.00
24-Feb	-0.10	-0.10	0.00	-0.12	-0.12	0.00	1.48	1.48	0.00	1.49	1.49	0.00
25-Feb	-0.09	-0.09	0.00	-0.10	-0.10	0.00	1.49	1.49	0.00	1.50	1.50	0.00
26-Feb	-0.09	-0.09	0.00	-0.09	-0.09	0.00	1.49	1.49	0.00	1.52	1.52	0.00
27-Feb	-0.09	-0.09	0.00	-0.10	-0.10	0.00	1.48	1.48	0.00	1.52	1.52	0.00
28-Feb	-0.09	-0.09	0.00	-0.10	-0.10	0.00	1.48	1.48	0.00	1.51	1.51	0.00

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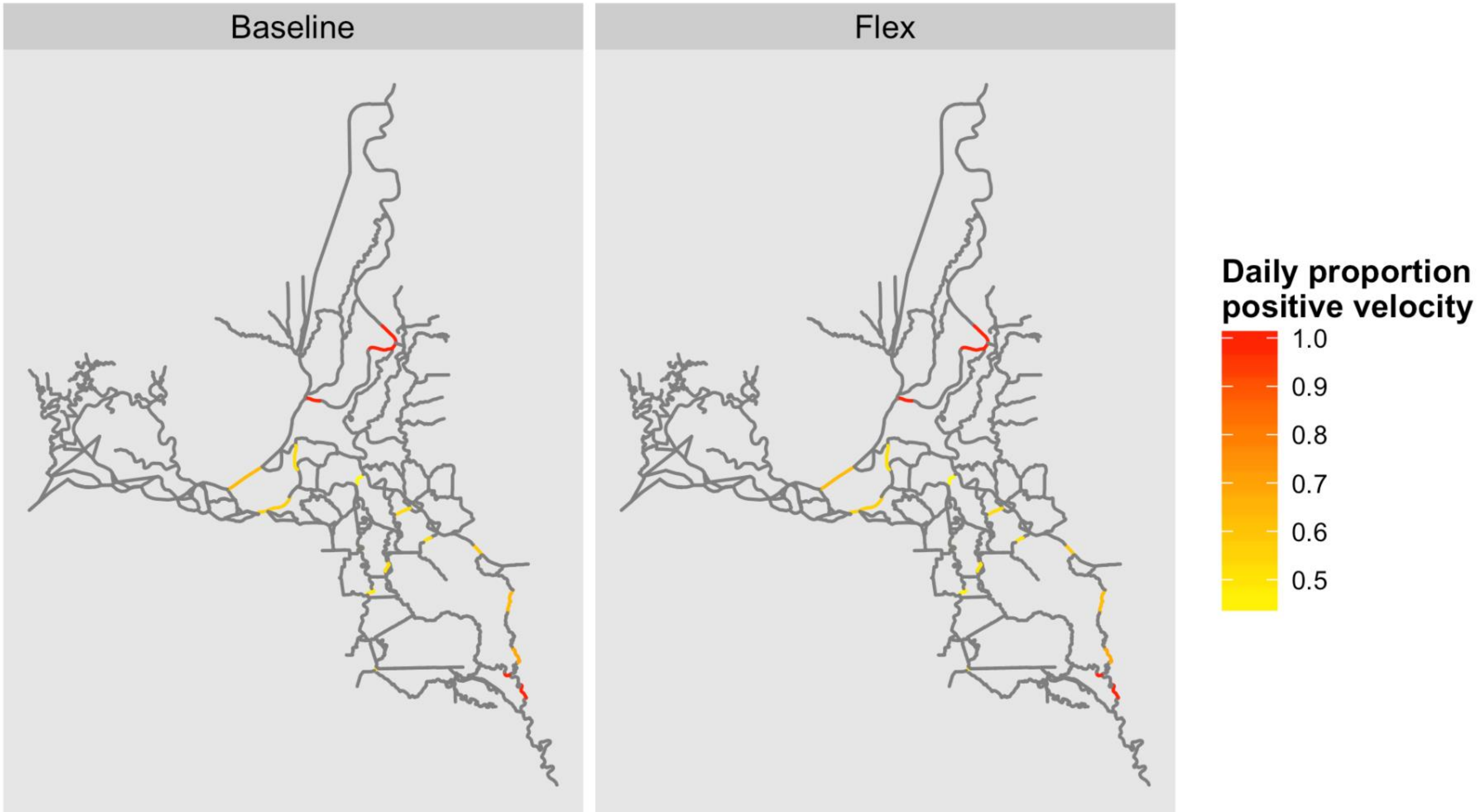

Figure 1. **Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity under two scenarios only including the 5-day period with OMR flows at -6250 cfs.**

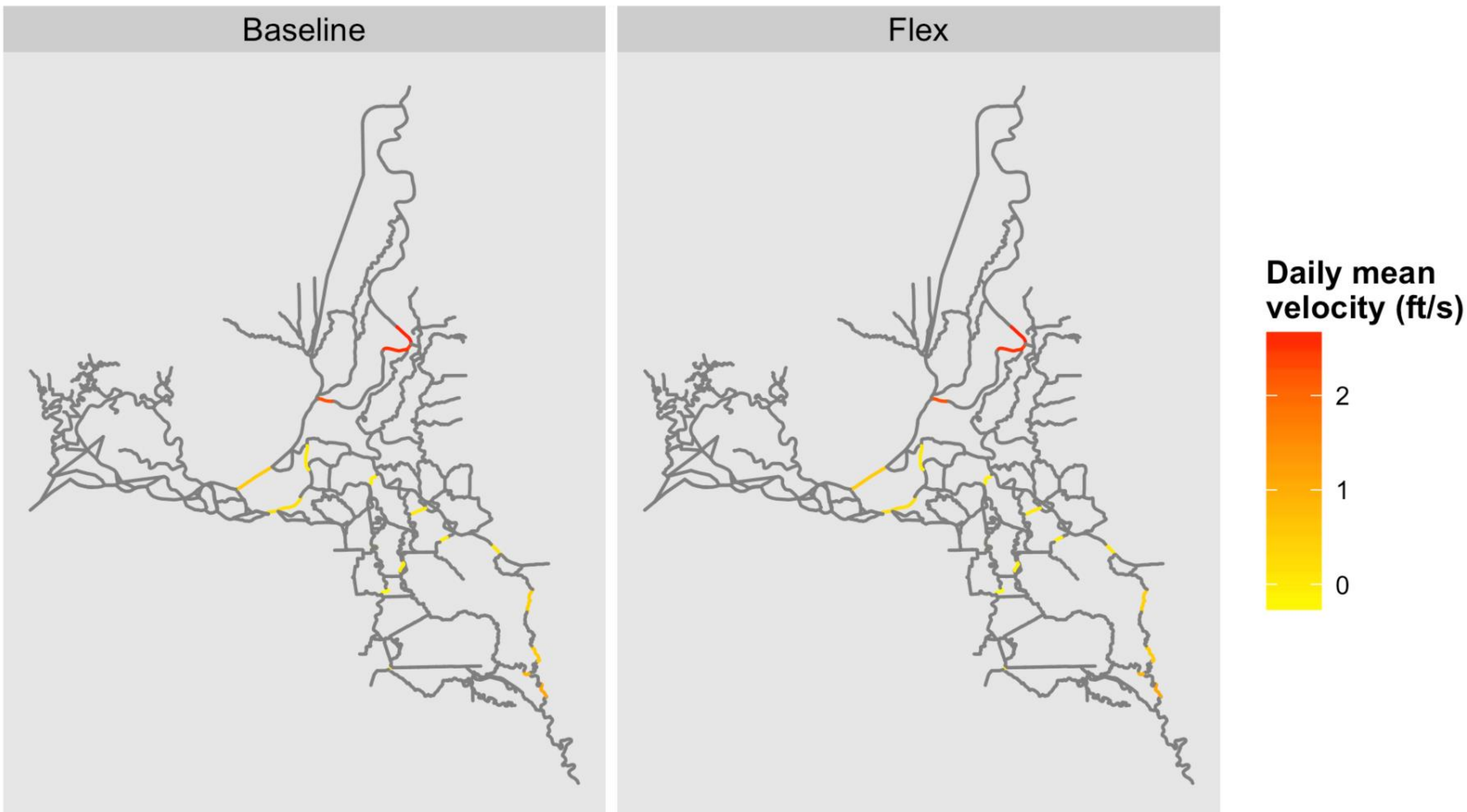

Figure 2. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity under two scenarios only including the 5-day period with OMR flows at -6250 cfs.

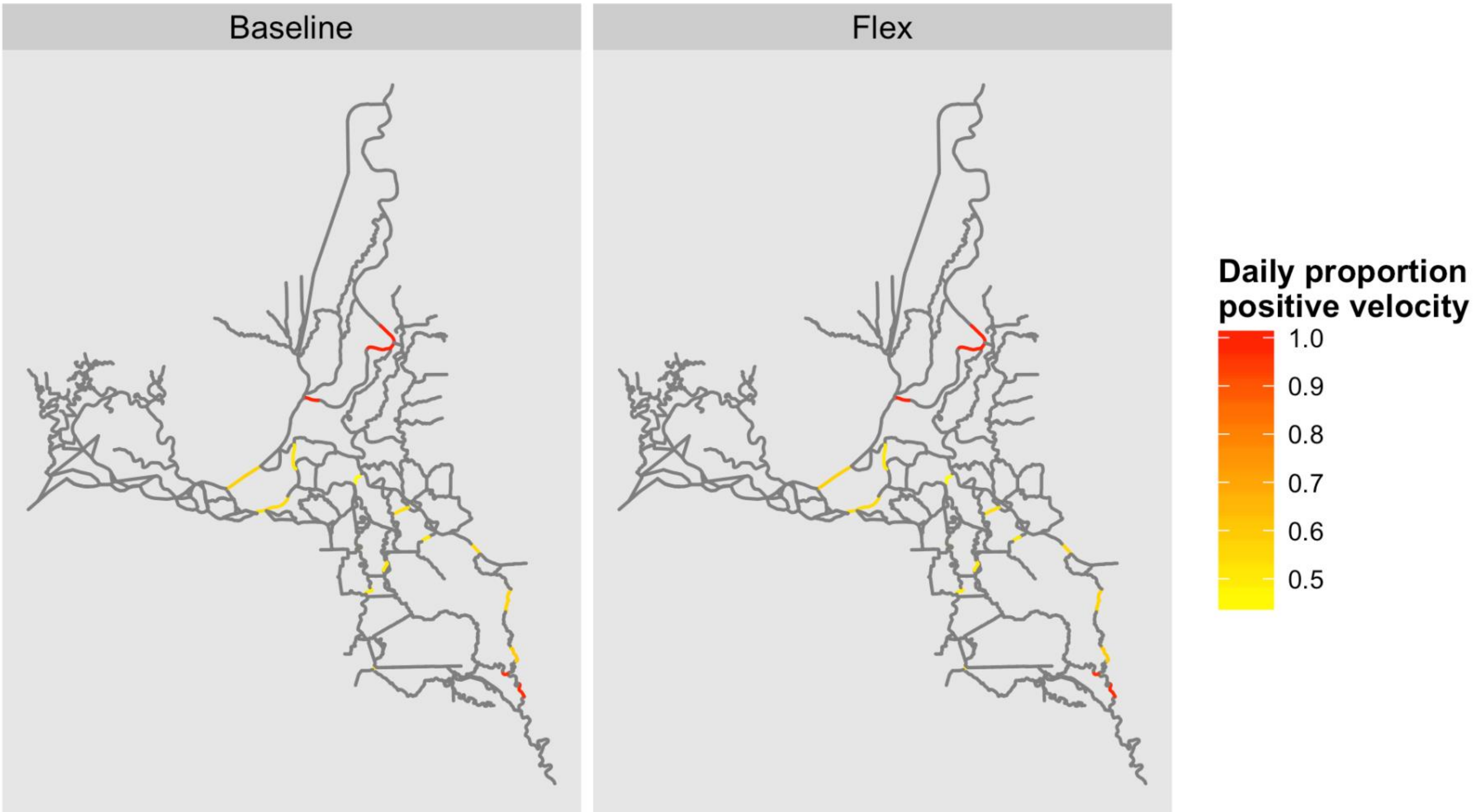

Figure 3. **Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity under two scenarios for the 12 day period with OMR flows at -5000 cfs.**

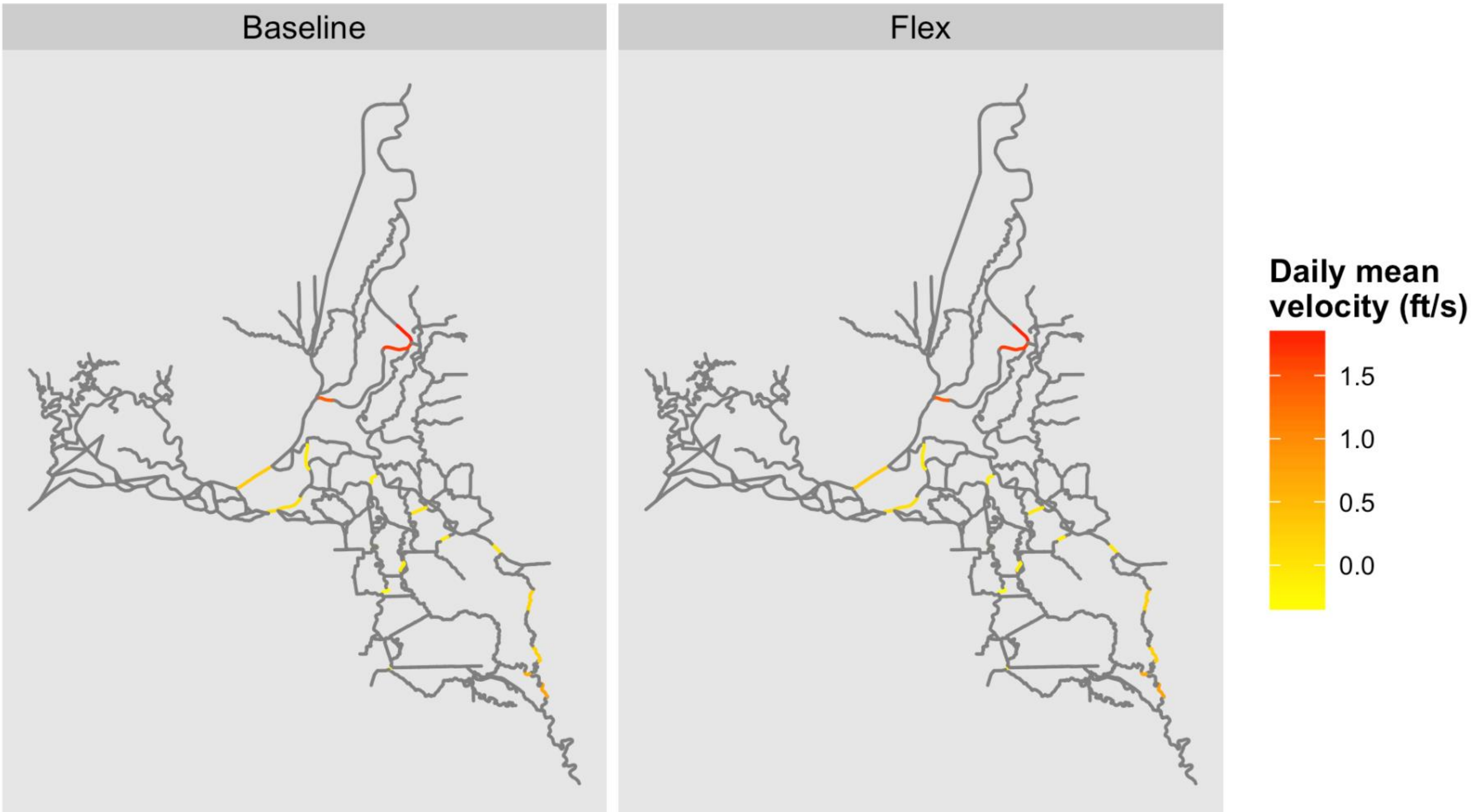

Figure 4. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity under two scenarios for the 12 day period with OMR flows at -5000 cfs.

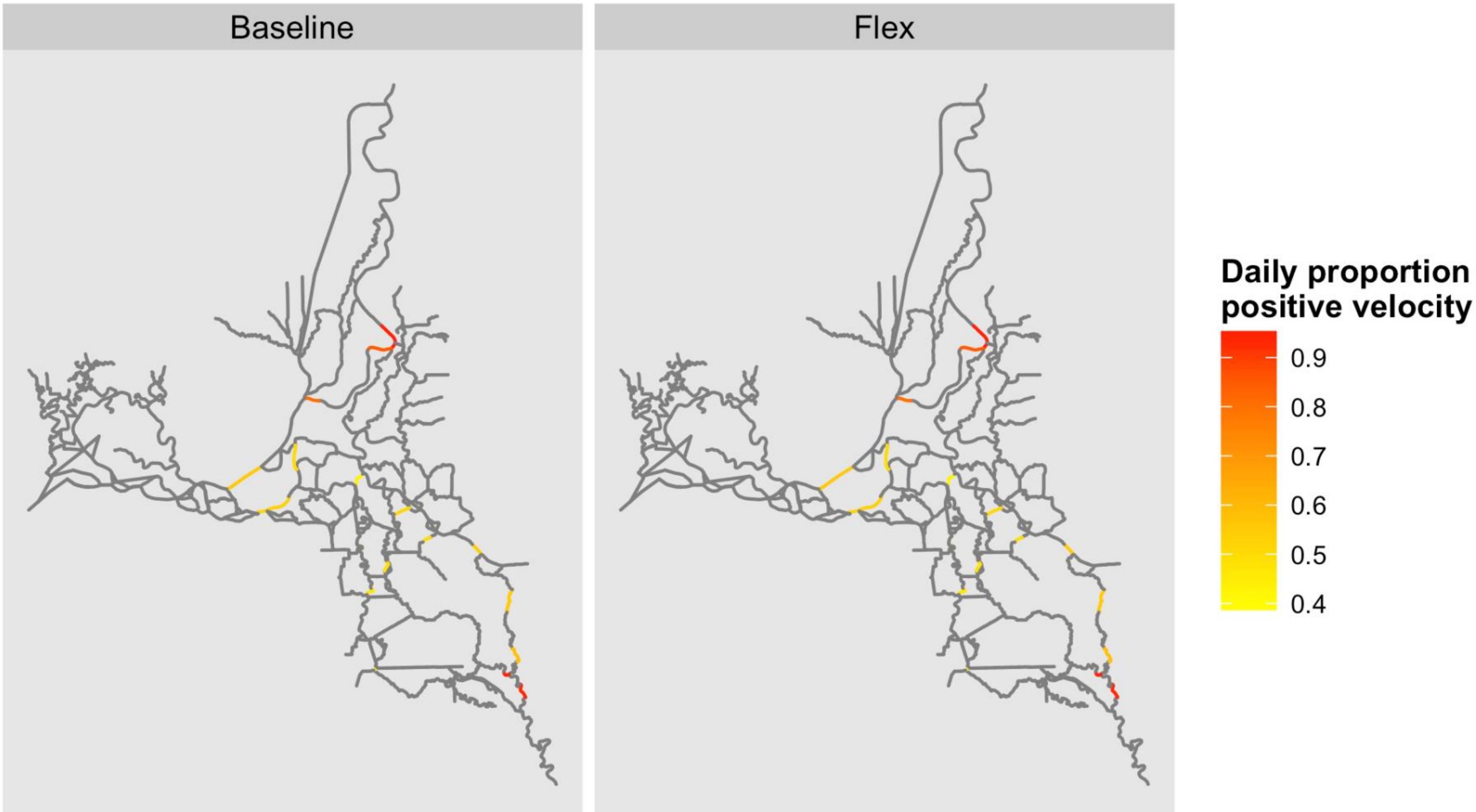

Figure 5. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity under two scenarios between December 29 and March 1.

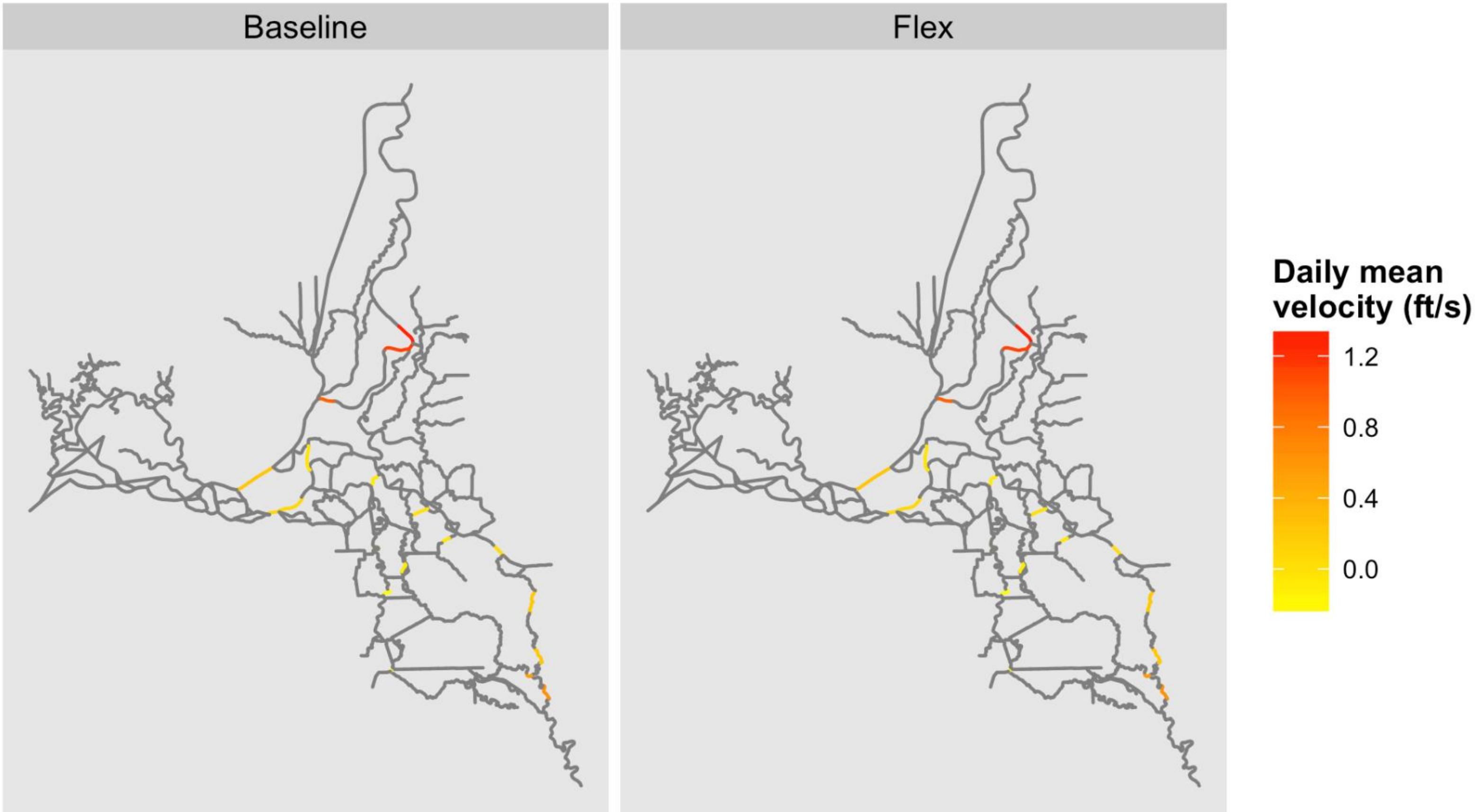

Figure 6. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity under two scenarios between December 29 and March 1.

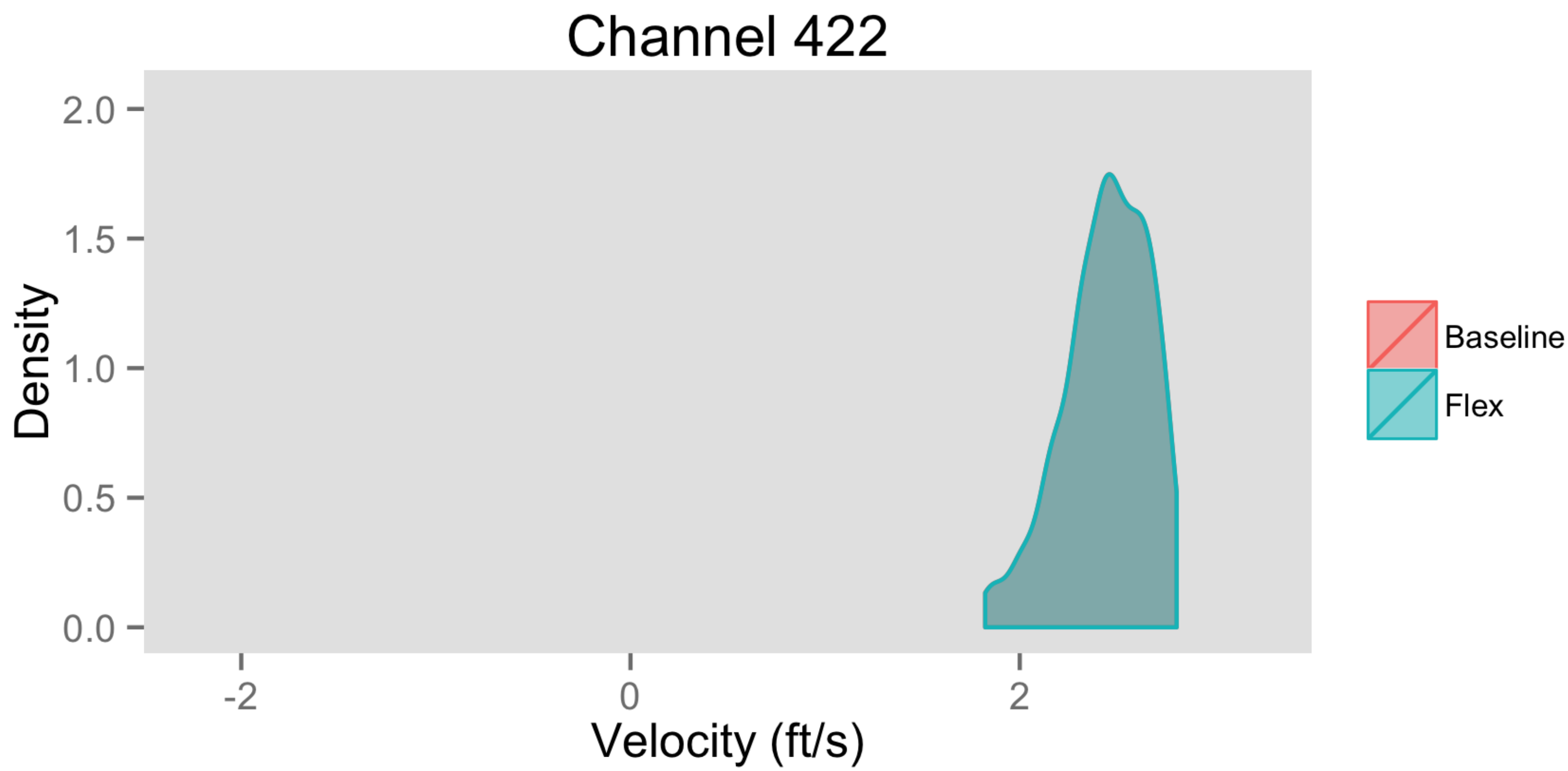

Figure 7. Density plot of velocity (ft/s) observed at DSM2 Channel Node 422 under two scenarios including only data from the 5-day period with OMR flows at -6250 cfs (Sacramento River upstream of Georgiana Slough; North Delta).

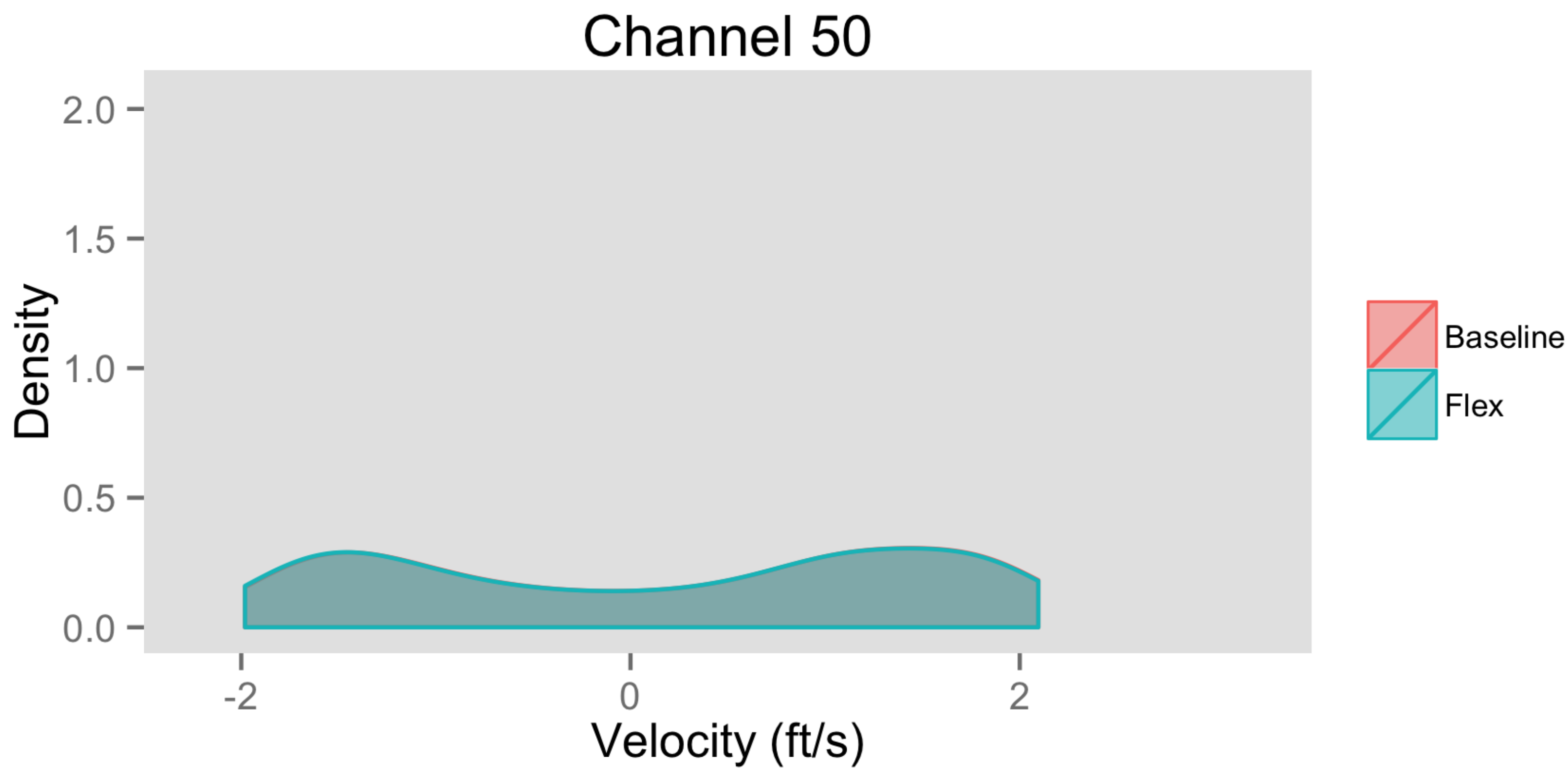

Figure 8. Density plot of velocity (ft/s) observed at DSM2 Channel Node 50 under two scenarios including only data for the 5-day period with OMR flows at -6250 cfs. (Sherman Island on San Joaquin River; Central Delta).

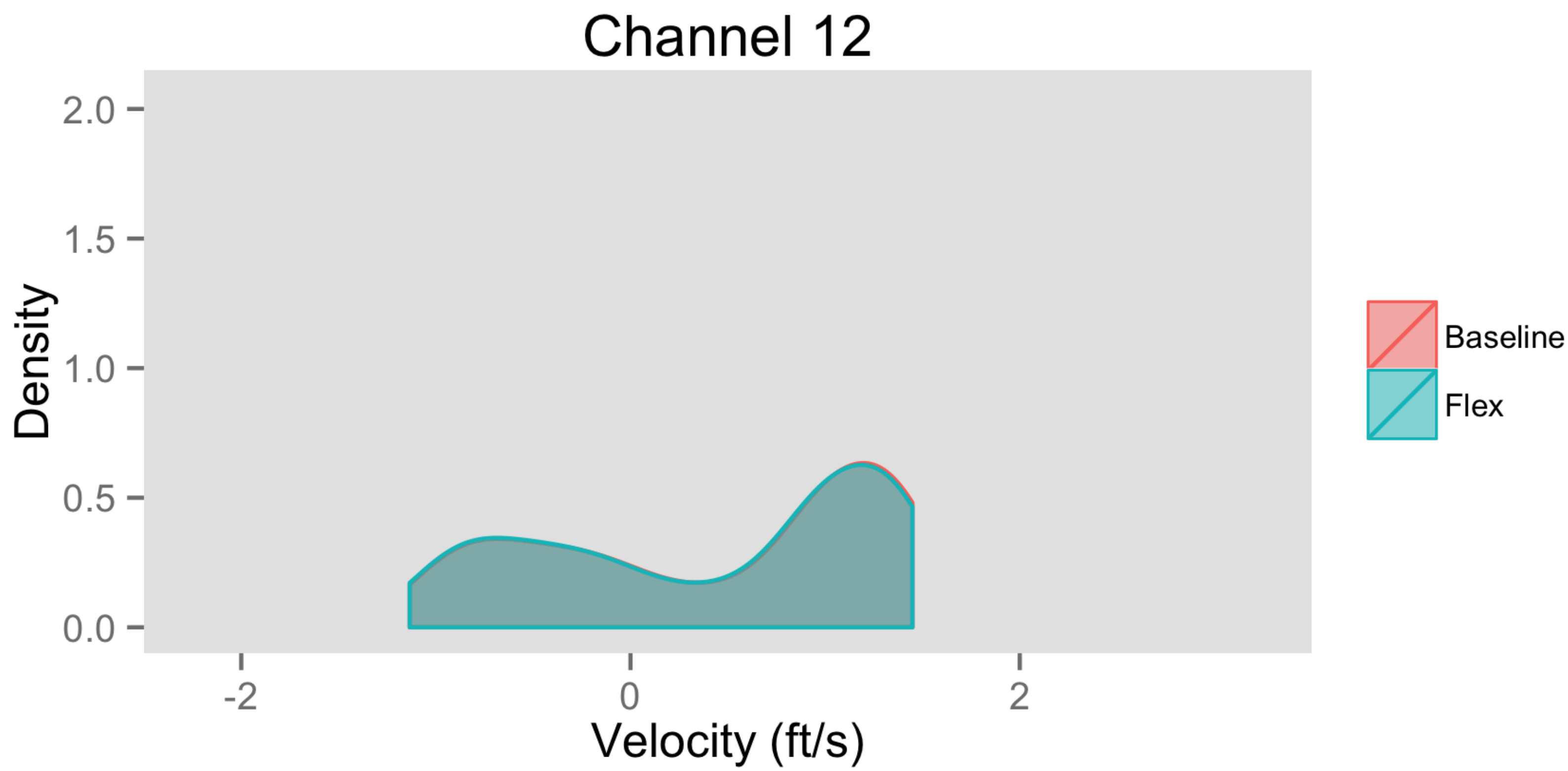

Figure 9. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 under two scenarios including only data from the 5-day period with OMR flows at -6250 cfs (Upstream of Stockton Deepwater Ship Channel; San Joaquin).

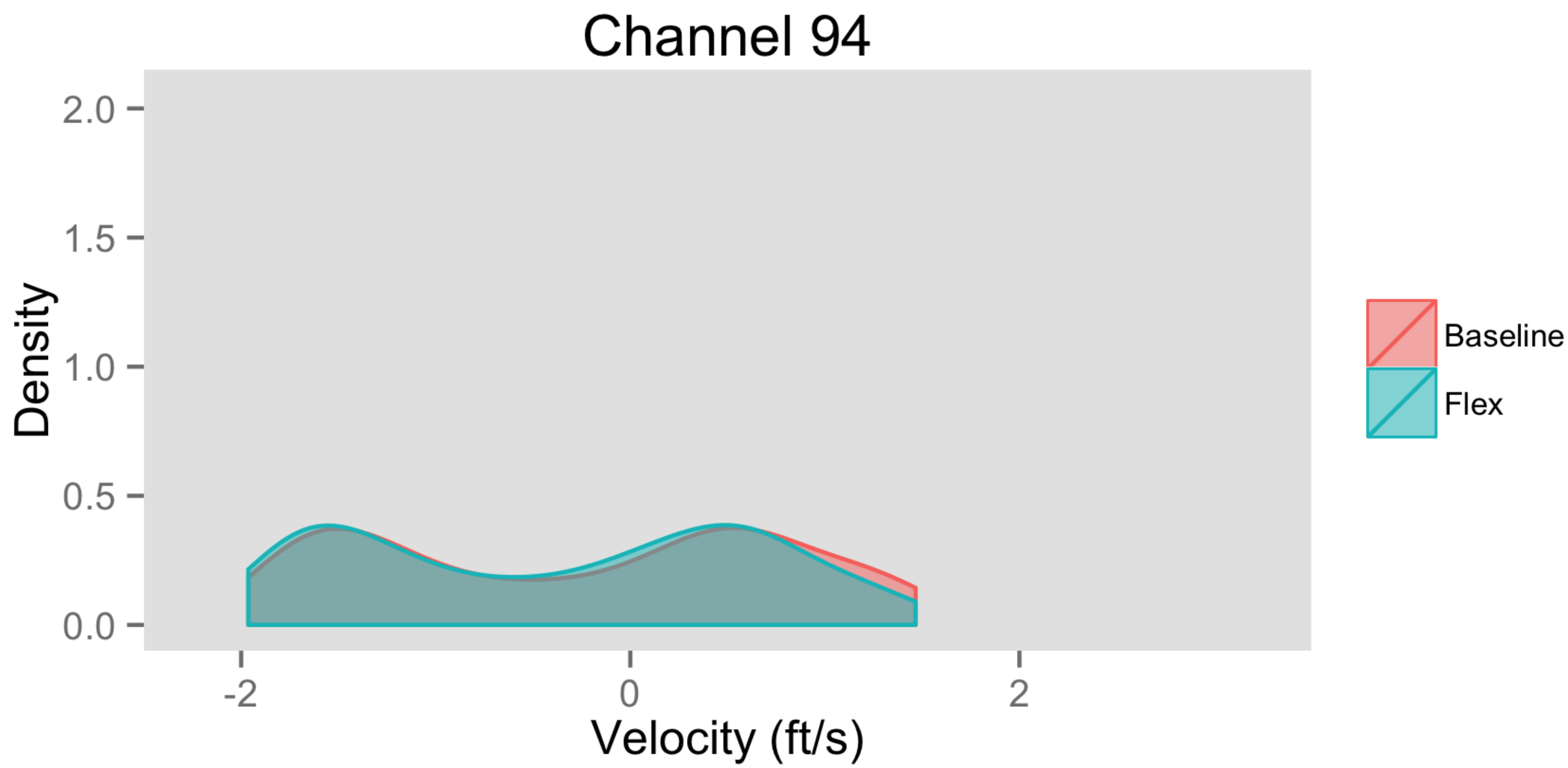

Figure 10. Density plot of velocity (ft/s) observed at DSM2 Channel Node 94 under two scenarios including only data from the 5-day period with OMR flows at -6250 (Old River south of Railroad Cut, South Delta).

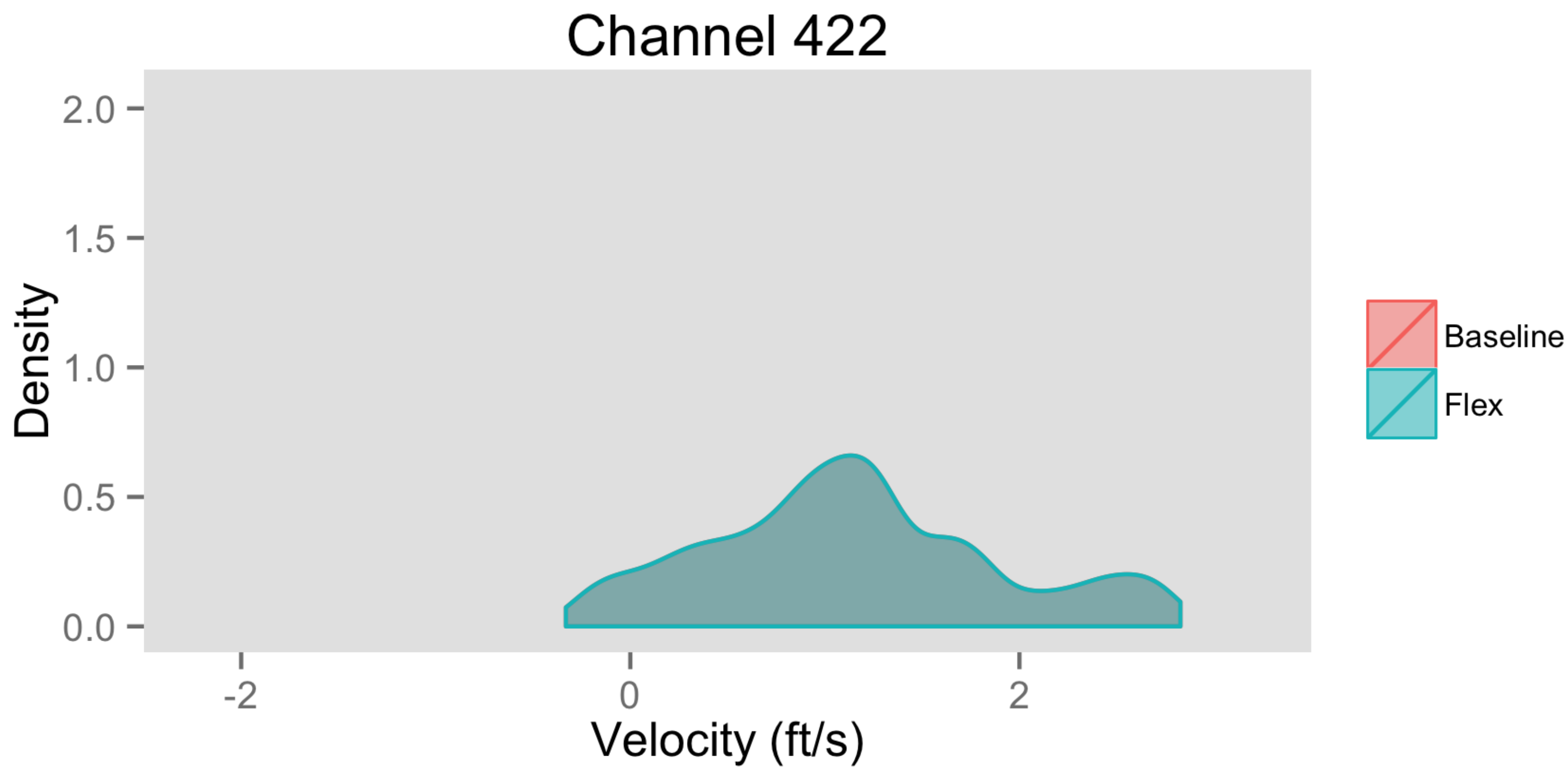

Figure 11. Density plot of velocity (ft/s) observed at DSM2 Channel Node 422 under two scenarios between December 29 and March 1 (Sacramento River upstream of Georgiana Slough; North Delta).

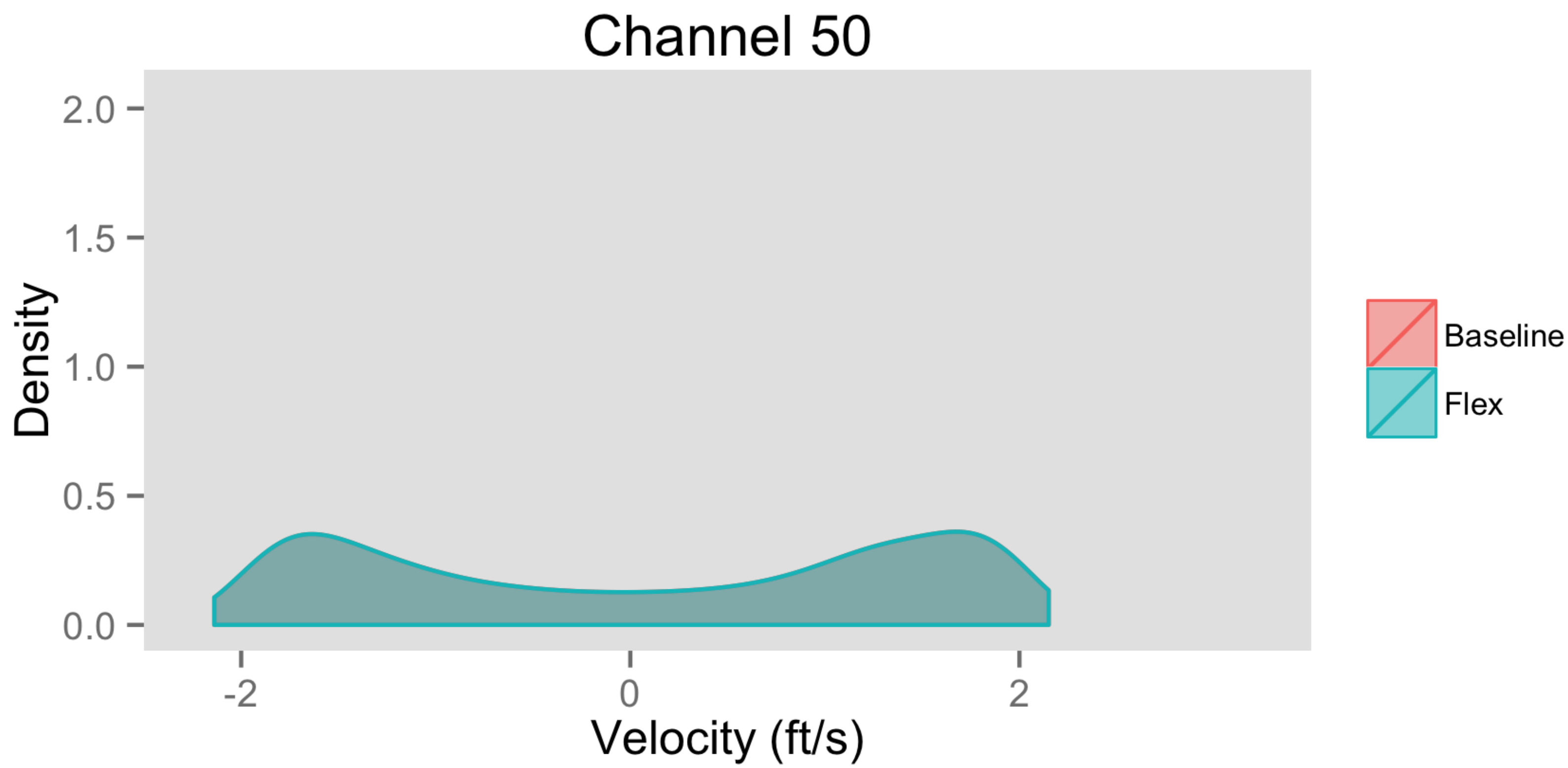

Figure 12. Density plot of velocity (ft/s) observed at DSM2 Channel Node 50 under two scenarios between December 29 and March 1 (Sherman Island on San Joaquin River; Central Delta).

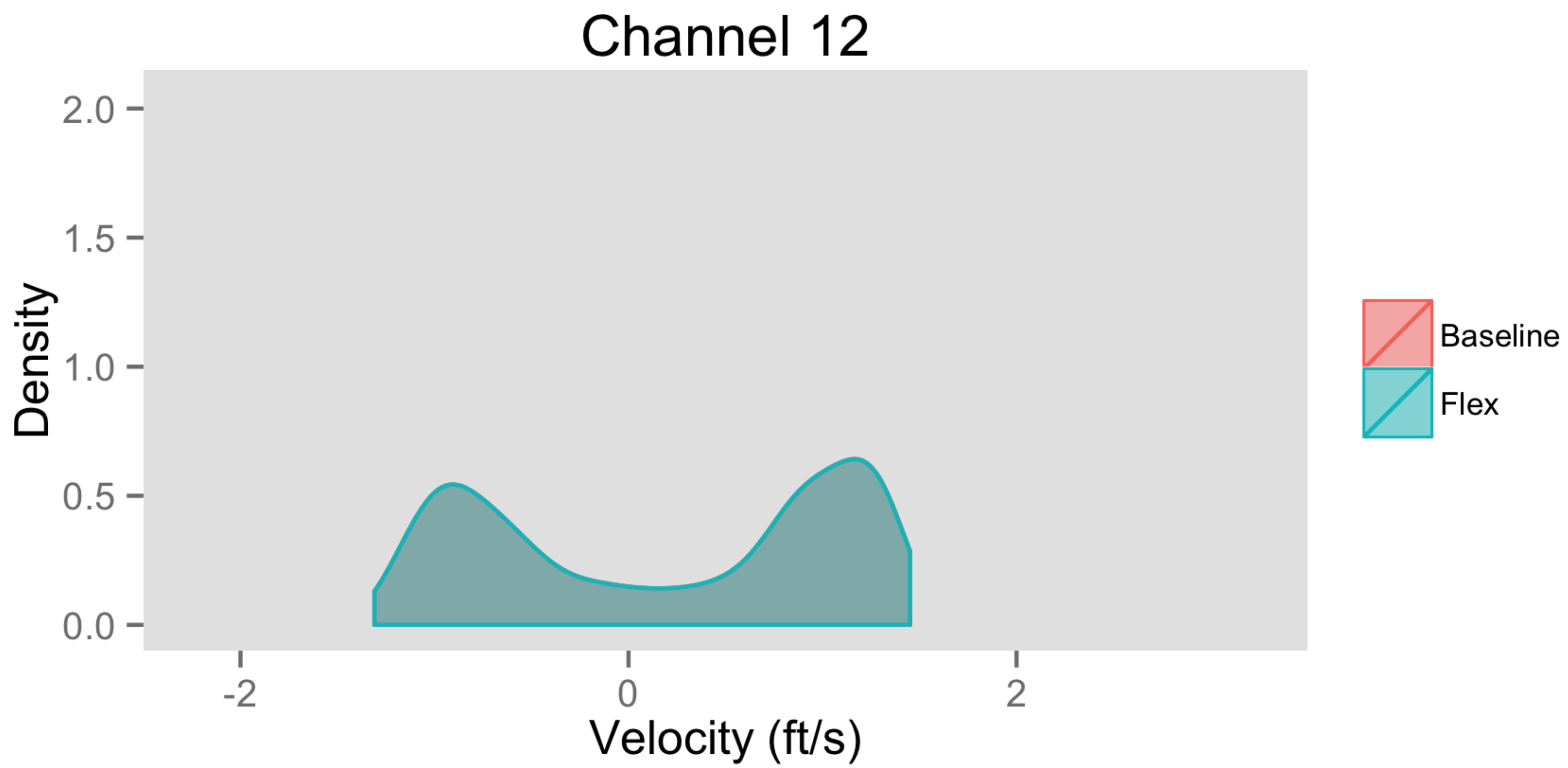

Figure 13. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 between December 29 and March 1 (Upstream of Stockton Deepwater Ship Channel; San Joaquin).

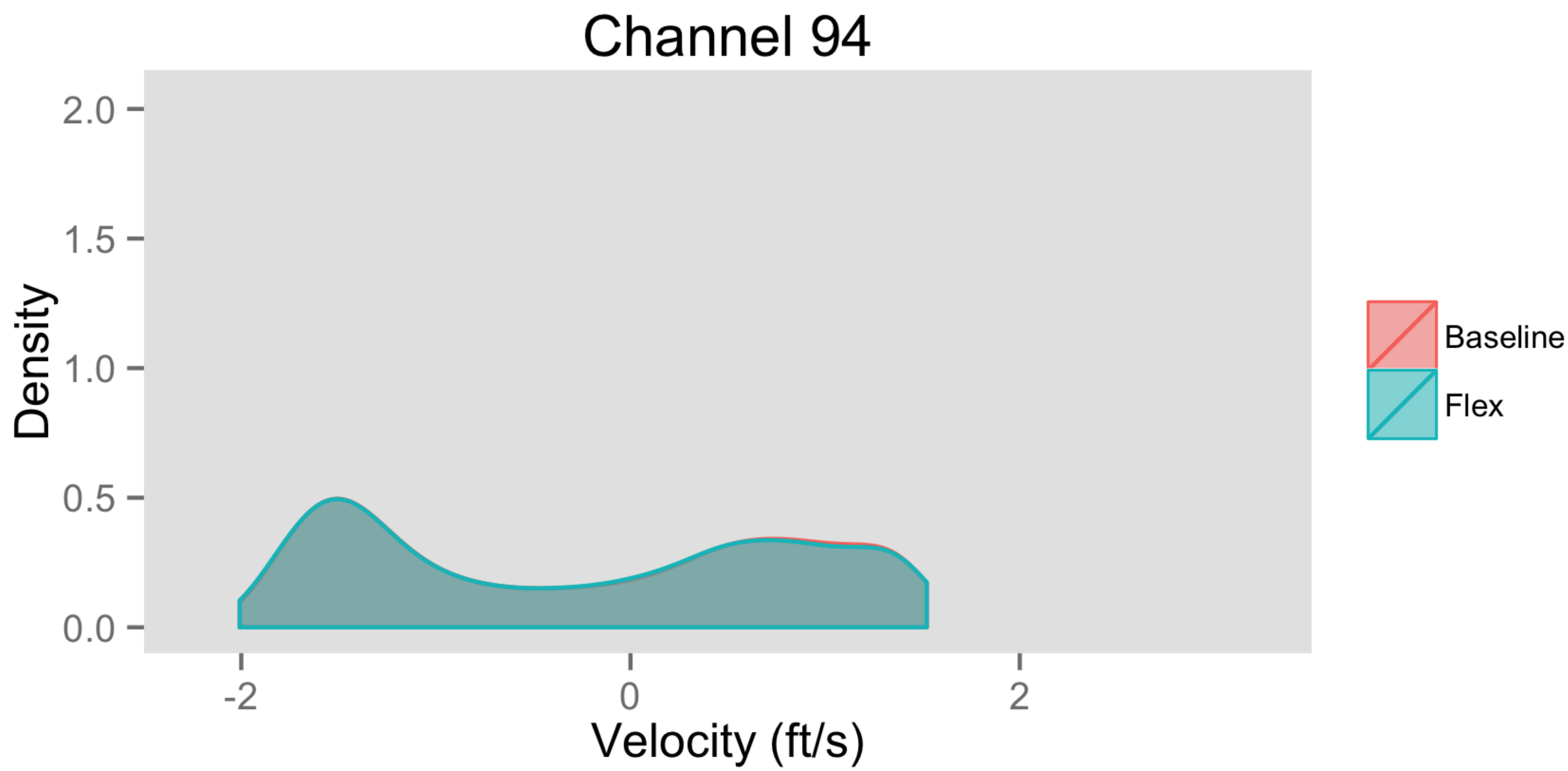

Figure 14. Density plot of velocity (ft/s) observed at DSM2 Channel Node 94 between December 29 and March 1 (Old River south of Railroad Cut, South Delta).

<u>Particle Tracking Modeling</u>

For the purposes of this review, particle "entrainment" was assessed for the two scenarios (Table 1). Although the DSM2 particle tracking model does not currently incorporate a behavioral component, particles are considered dependable proxies for the relative effect of hydrological conditions on early-stage larval movement because larvae are weak swimmers and are only minimally capable of selectively maintaining a position in the water column [*i.e.*, they tend to behave a lot like neutrally buoyant particles; see Kimmerer (2008). Three injection locations and seven flux locations were assessed (Figure 15). Particles were injected into the model on February 11 (Table 1). Daily entrainment flux fate at the CVP/SWP projects at the end of the model period (February 28) was considered and graphed for cumulative daily flux (Figure 16). Combined entrainment was highest in both scenarios for particles inserted at Station 815 (near Prisoners Point on the San Joaquin River). The flux of particles from all injections points past Chipps Island, Old River near Franks Tract, and Holland Tract are shown in Figure 17 through 22 for both the modeled baseline and proposed action scenarios.

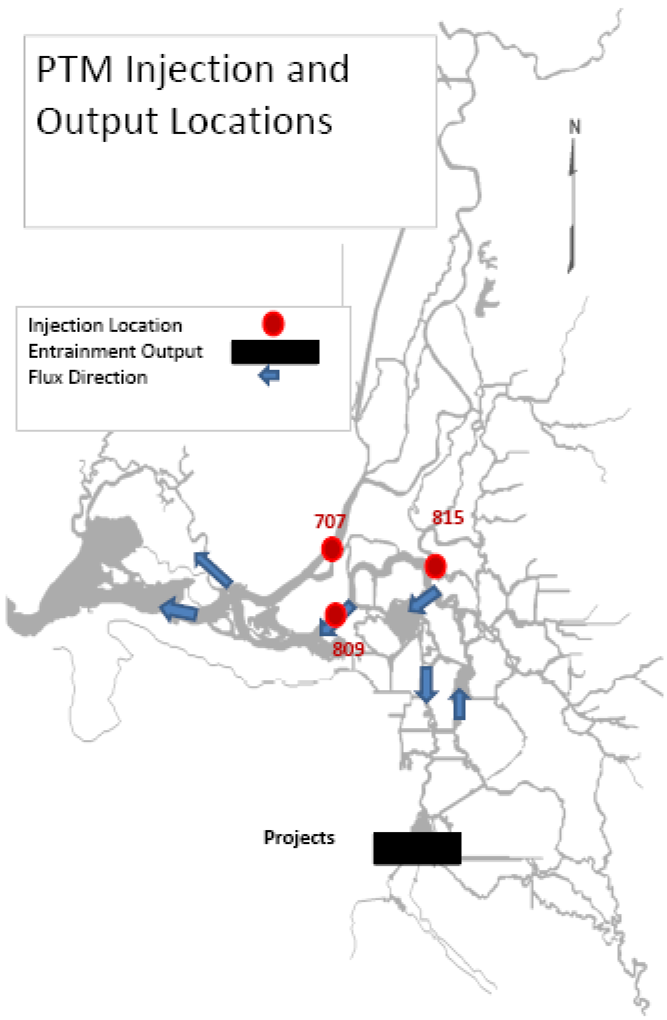

Figure 15. PTM Model Injection and Output Locations. Three Injection Points are Evaluated.

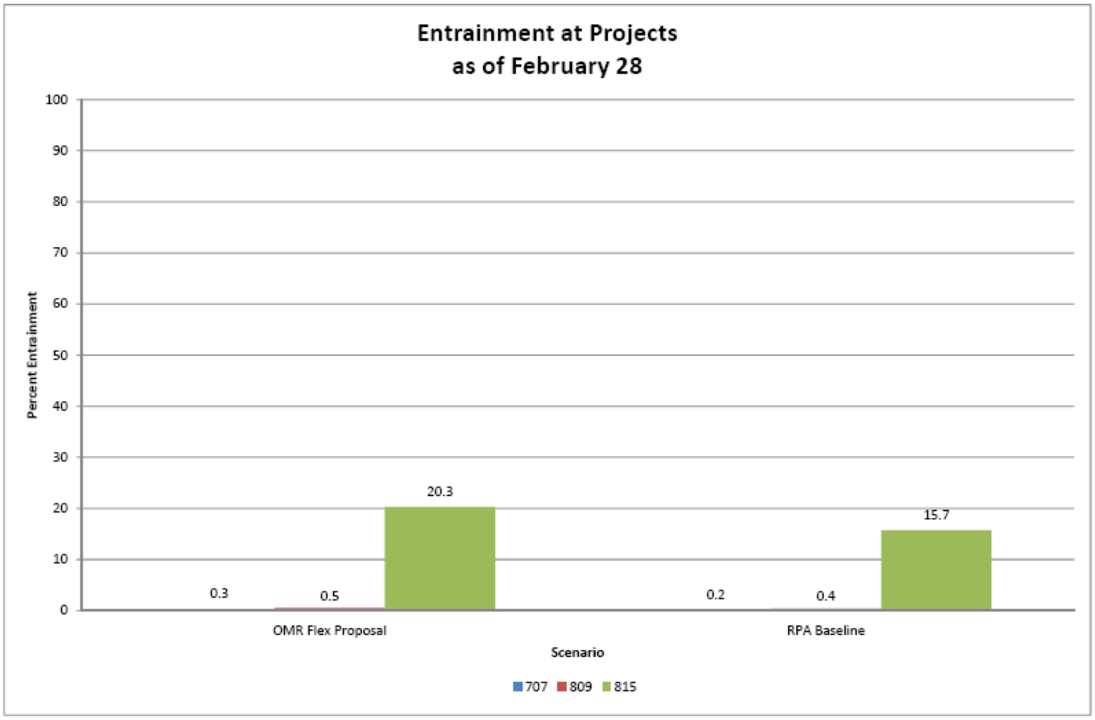

Figure 16. Entrainment at Projects from Three Injection Locations under the Proposed Project (OMR Flex Proposal) and Baseline (RPA Baseline) model scenarios.

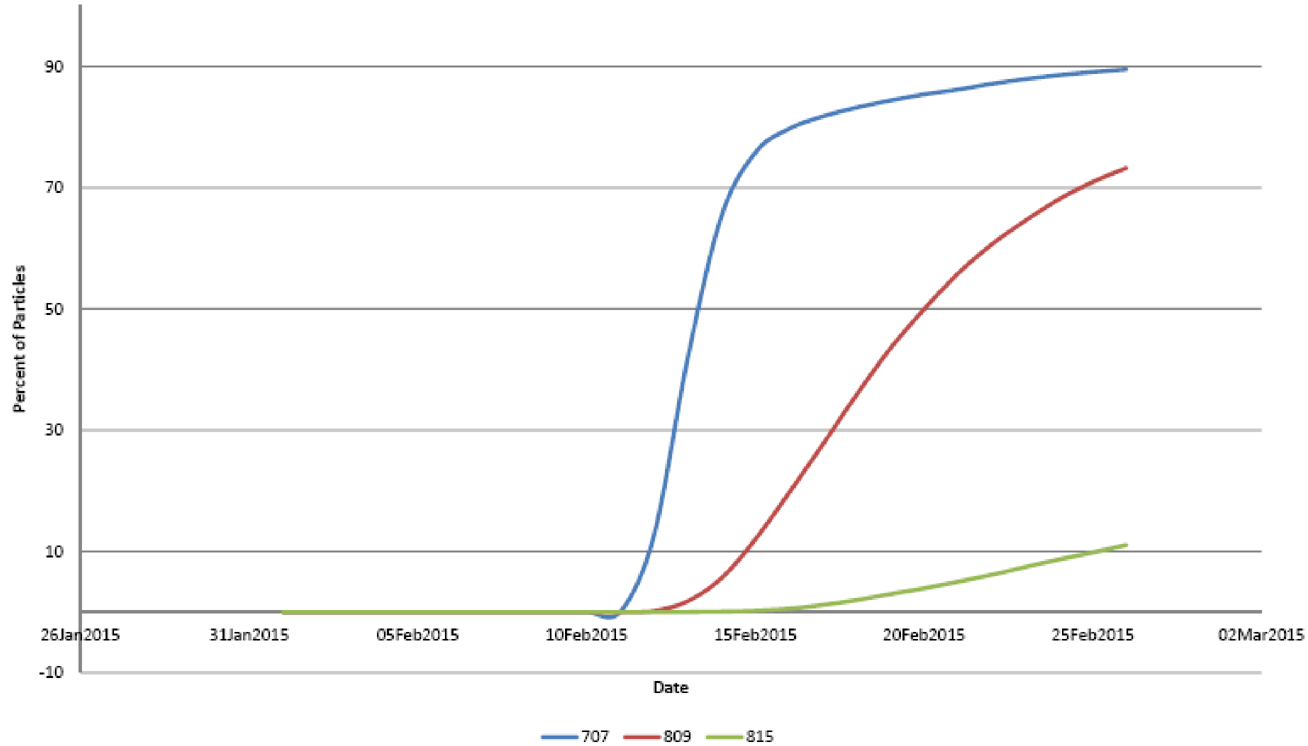

Figure 17. Flux Fate Past Chipps Island under the modeled Baseline Scenario for Three Injection Locations.

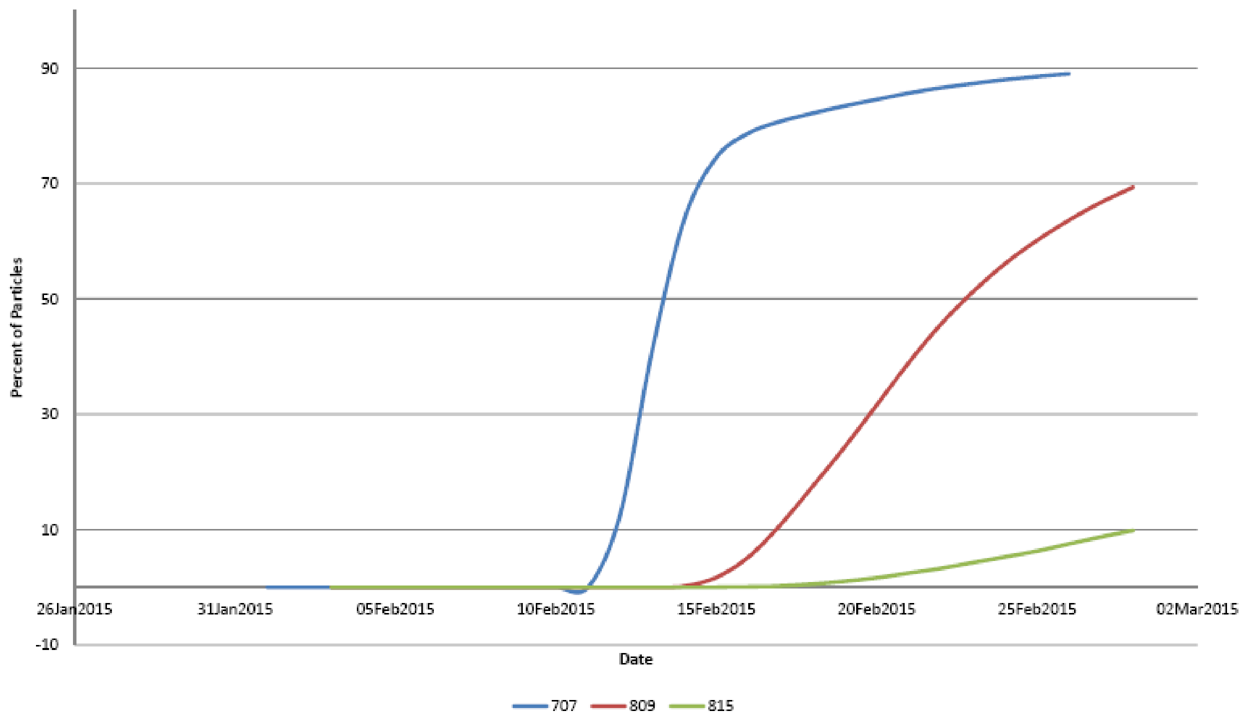

Figure 18. Flux Fate Past Chipps Island under the modeled Proposed Action Scenario for Three Injection Locations.

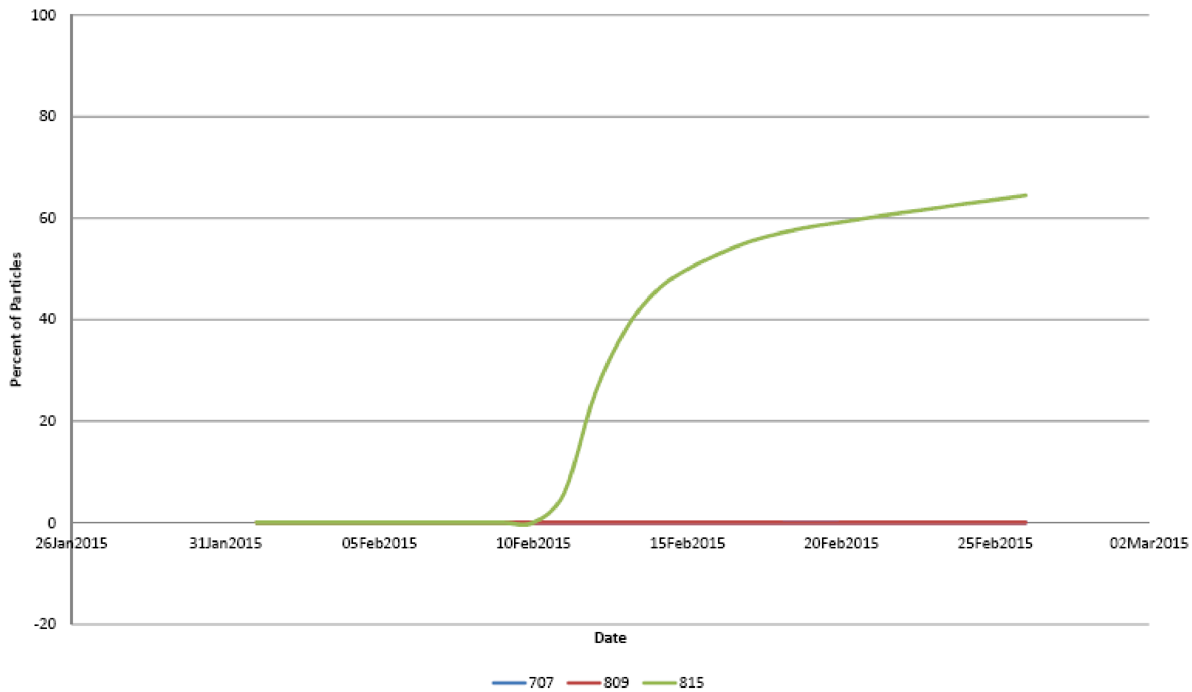

Figure 19. Flux Fate Past Old River near Franks Tract under the modeled Baseline Scenario for Three Injection Locations.

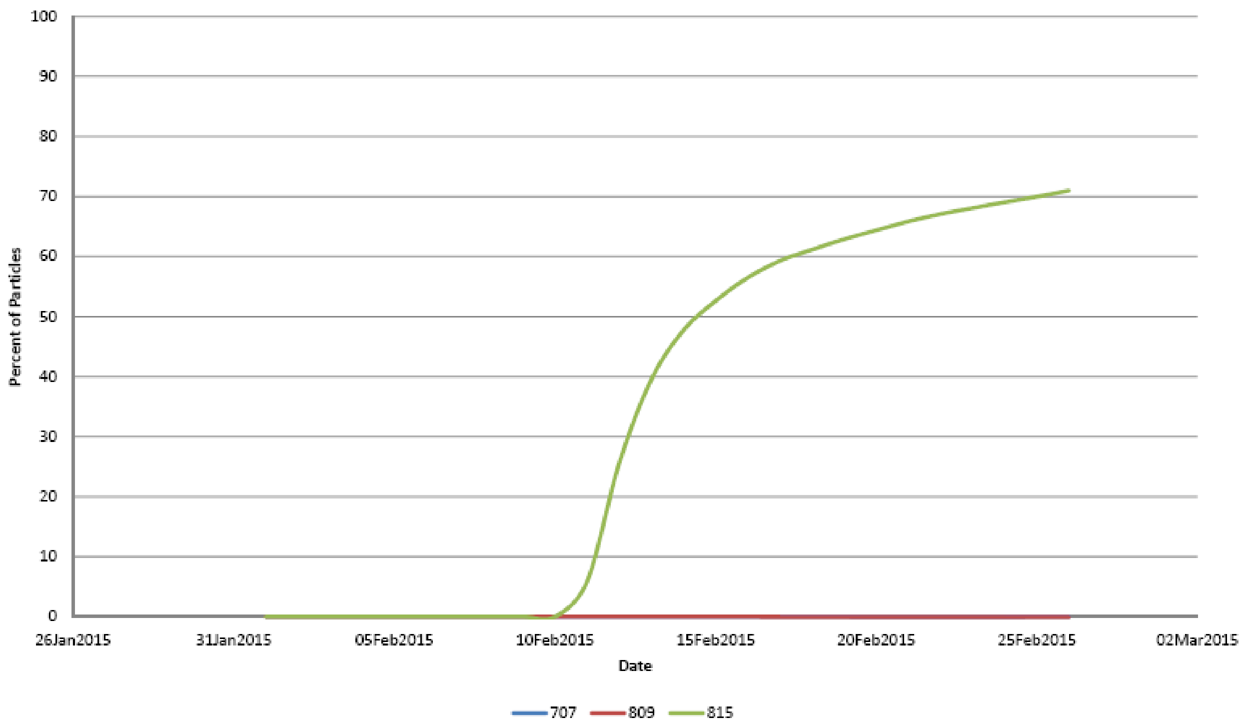

Figure 20. Flux Fate Past Old River near Franks Tract under the modeled Proposed Action Scenario for Three Injection Locations.

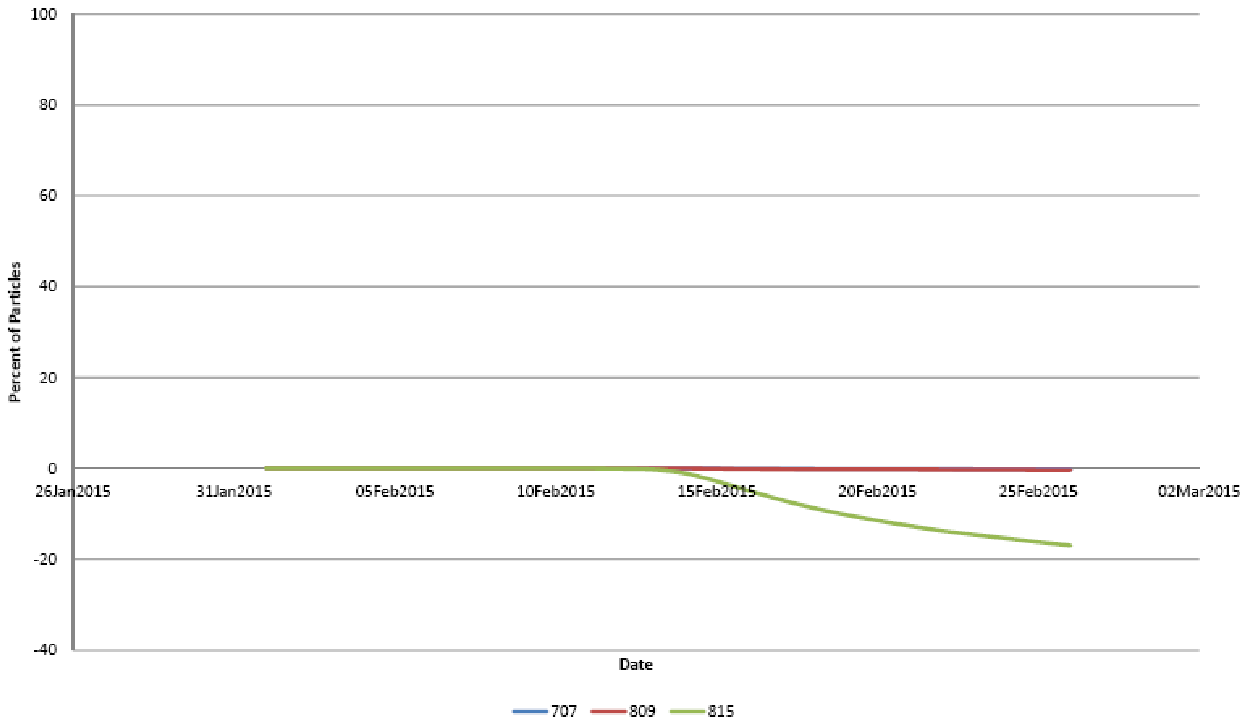

Figure 21. Flux Fate Past Holland Tract under the modeled Baseline Scenario for Three Injection Locations.

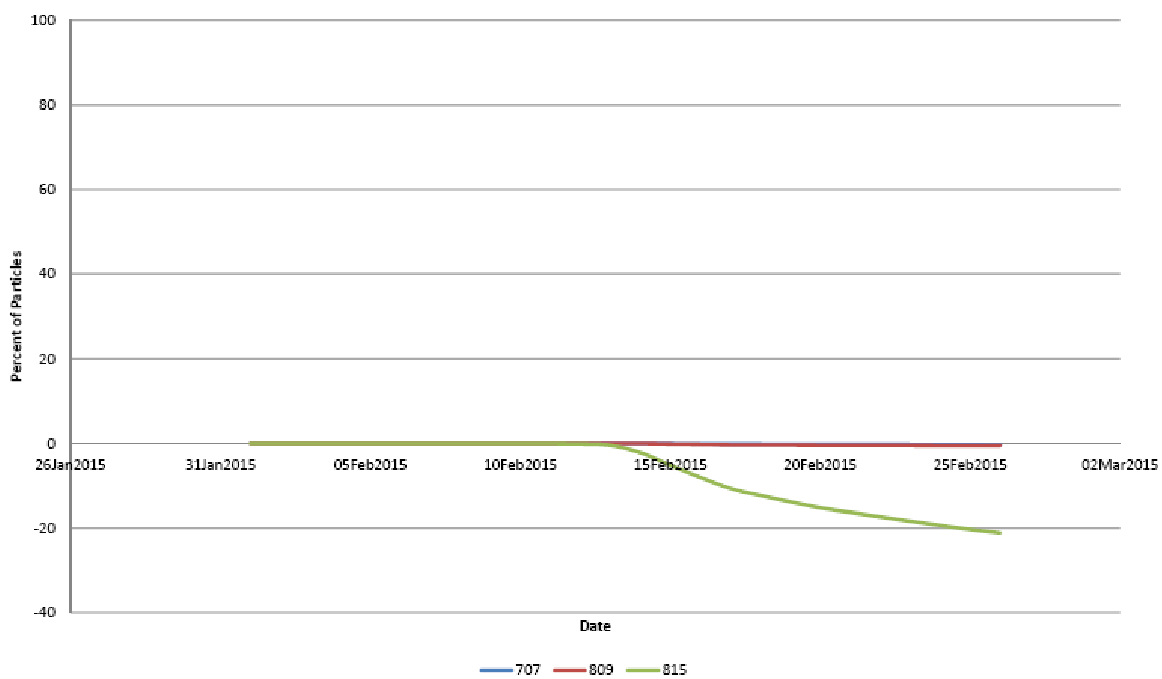

Figure 22. Flux Fate Past Holland Tract under the modeled Proposed Action Scenario for Three Injection Locations.

Biological Review of Winter-run Chinook Salmon

Table 8. Predicted Distribution of Winter-run Chinook Salmon During the Proposed Action Period and Potential Effects Based on the Most Recently Available Survey Data. Prediction of distribution is through February 16 and based on monitoring data through February 8.

Winter-run Chinook Salmon	Life Stage Affected?	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Egg	This life stage is not present in the Delta			
Natural-origin Juvenile	Wild winter-run Chinook are distributed broadly from the Sacramento River through the Delta			
<5% upstream of the Delta in the Sacramento River	No	No Change	No Change	Moderate
>95% in the Delta	Yes	Increased	Increased	High
<5% past Chipps Island	No	No Change	No Change	High
Hatchery Juveniles	Hatchery winter-run Chinook were released by February 6 in the upper Sacramento River			
>95% upstream of the Delta in the Sacramento River	No	No Change	No Change	Moderate
<5% in the Delta	Yes	Increased	No Change	High
0% past Chipps Island	No	No Change	No Change	High
Adults	No	No Change	No Change	High

Updated Status of Winter-run Chinook Salmon

Monitoring data suggest that the majority of natural-origin juvenile winter-run Chinook Salmon are currently residing in the North Delta and Lower Sacramento River. Detections of winter-run sized juveniles in the Chipps Island trawl monitoring have been low, indicating that few have left the Delta. Historical patterns indicate that the majority of out-migration typically occurs in March and is not complete until early spring (del Rosario *et al*. 2013). A low level of salvage of winter-run sized juveniles has occurred during the winter, with a cumulative loss of 102 natural-origin winter-run sized juvenile Chinook, as of February 8, 2015.

The entire production population of hatchery-origin winter-run Chinook Salmon were released into the upper Sacramento River in Redding on February 4-6. As of February 8, 37 hatchery-origin Chinook Salmon were counted at the Tisdale Weir rotary screw trap and based upon their size range they are likely to have originated from the Livingston Stone Hatchery winter-run release. This segment of the winter-run population is expected to begin entering the north Delta one to two weeks after the release date (possibly as soon as February 12) based on the magnitude of the predicted flow increase, and previously-observed travel times for hatchery produced fish following release. A subset of this release group are tagged with acoustic telemetry transmitters (n=570) that will provide another means of tracking the downstream migration rate of the hatchery-origin winter-run juveniles, in addition to the standard river, Delta, and salvage fish monitoring efforts already in place. In concert with more frequent trawl and beach seine sampling efforts in the lower Sacramento River, these data will provide improved assessments of juvenile winter-run Chinook Salmon distribution. The natural-origin juvenile winter-run Chinook

Salmon remaining upstream of the Delta are anticipated to migrate with the projected flow pulse into the Delta and lower Sacramento River tributaries to rear over the next several weeks as well.

Effects of Proposed Action on Winter-run Chinook

Reclamation and DWR are currently operating consistent with RPA actions in the NMFS BiOp (NMFS 2009). Action IV.2.3 is in place January 1 through June 15 to reduce the vulnerability of emigrating salmonids to entrainment into the central and south Delta and loss at the facilities. During February, this RPA primarily protects winter-run and spring-run Chinook salmon and steelhead. Reclamation and DWR propose to modify this action to allow for a 14 day running average OMR flow of no more negative than -5,500 cfs (Table 1) while natural and abandoned flow allow for outflow of 7,100 cfs of greater from the storms of February 6-9. If density triggers as described in Action IV.2.3 are exceeded, negative OMR flows will be reduced consistent with the NMFS BiOp (NMFS 2009).

Due to changes in Delta conditions (*i.e*., flows, temperatures, and turbidity) during the storm, changes in migratory behavior of juveniles will increase risks of entrainment into the central and south Delta and loss at the CVP/SWP fish collection facilities regardless of the Proposed Action. Additionally, since the majority of natural-origin winter-run are currently rearing in the Delta and fish have already been salvaged at the CVP/SWP fish collection facilities this season, the current distribution in the central/south Delta suggests the likelihood for further entrainment into the central and south Delta, as well as entrainment at the CVP/SWP fish collection facilities, is high.

Hydrodynamic modeling of the Proposed Action’s management for OMR flows (allowing more rapid transition to more negative OMR values for 5 days and subsequently operating to daily 14-day average OMR values that are more negative than -5,000 cfs) did not predict differences in average daily velocities or average daily proportion positive flows in channels measured across the North Delta, Central Delta, South Delta and San Joaquin regions (Table 3-4). Average daily flows during the modeled 5-day period at OMR values of -6,250 cfs were significantly more negative between the baseline and Proposed Action models at channel nodes in the central and south Delta, particularly along the Old and Middle river corridor (Table 3). Average daily flow during the modeled 12-day period at OMR values of -5,000 cfs were not greater than 51cfs in these same channels through the central and south Delta (Table 4).

Changes in the daily average flow at node 49 (Jersey Point on San Joaquin) and Node 50 (Sherman Island on San Joaquin) are approximately 1,100 cfs more negative for the Proposed Action than the baseline modeling, although following return to OMR values of -5,000 cfs daily flow differences are less than -350 cfs (Table 6-7). These patterns and magnitudes are similar in other nodes the Old and Middle river corridors. During the initial 5 day period of the Proposed Action, Three Mile Slough (node 310) had a daily average flow that was approximately 250 cfs more negative under the Proposed Action than baseline scenario, indicating river flows were moving through the slough from the Sacramento River to the San Joaquin River. Likewise, flows in Columbia and Turner cuts were predicted to be more negative by up to several hundred cfs during the 5-day period of OMR flows at -6,250 cfs. Although no differences in average daily velocities are observable to the hundredths of a foot per second in the modeling, the changes in flows indicates some potential change in the maximum and minimum velocities during a 24 hour period (Table 7).

The Proposed Action is expected to cause hydrodynamic changes that enhance the risk of entrainment of juveniles into the central and south Delta and may cause greater loss at the CVP/SWP fish collection facilities (Table 8) during the 5 days of more negative OMR flows and possibly to a lesser extent, over the extended period of the Proposed Action, which incorporates the 14-day averaging period. The distributions of winter-run Chinook Salmon are likely to change after February 16 and may affect the risks of entrainment into the south and central Delta and loss at the facilities. Adult winter-run Chinook Salmon are likely migrating through the Delta into the Sacramento River with the increased inflows associated with the storm of February 6-8. The described hydrodynamic changes are not expected to change migration behavior of adult winter-run Chinook Salmon. There is moderate certainty in our understanding of how hydrodynamic affects juvenile winter-run Chinook behavior and distribution.

Summary of Effects on Winter-run Chinook

Winter-run Chinook Salmon will be present in the Delta during the Proposed Action (Table 8). Due to the low production of natural origin winter-run, the population entering the Delta is very low. As such, implementation of the NMFS Biological Opinion (NMFS 2009) uses the default minimum older juvenile Chinook Salmon density trigger (2.5 fish/TAF). Maintaining a short period of OMR flows more negative than -5,000 cfs increases risks of entrainment into the central and south Delta and loss at the CVP/SWP fish collection facilities since current environmental conditions and the species' periodicity are optimal for smolt migration and continued rearing of juvenile winter-run Chinook Salmon. Due to insensitive analytical tools, uncertainty concerning realized flows, and actual juvenile distributions the increase in vulnerability is difficult to quantify.

The hydrodynamic changes associated with rapid transitioning and limited duration of greater negative OMR flows and consequential exceedance of 14-day average OMR are not likely to result in changes to the primary constituent elements of freshwater migratory corridors, rearing habitats, and estuarine areas beyond those analyzed in the NMFS BiOp (NMFS 2009). Thus, the likely Proposed Action conditions are unlikely to further impair functioning of habitats designated as winter-run Chinook salmon critical habitat.

Biological Review of Spring-run Chinook Salmon

Table 9. Predicted Distribution of Sacramento Basin Spring-run Chinook Salmon During the Proposed Action Period and Potential Effects Based on the Most Recently Available Survey Data. Prediction of distribution are through February 16 and based on monitoring data through February 8.

Spring-run Chinook Salmon	Life Stage Affected?	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Eggs	This life stage is not present in the Delta			
Wild YOY Juveniles	Wild spring-run Chinook salmon are distributed broadly from the Sacramento River through the Delta			
25-35% upstream of the Delta in the Sacramento River	No	No Change	No Change	Low
65-75% in the Delta	Yes	Increased	Increased	High
<5% past Chipps Island	No	No Change	No Change	High
Wild Yearlings	Wild yearling spring-run Chinook salmon are distributed broadly from the Sacramento River through the Delta			
<5% upstream of the Delta in the Sacramento River	No	No Change	No Change	Low
80-90% in the Delta	Yes	Increased	Increased	High
<15% past Chipps	No	No Change	No Change	High
Hatchery spring-run Surrogates	Hatchery spring-run Chinook salmon surrogate group #3 was released on February 5 in Battle Creek. Detections of the first two release groups have occurred at the facilities.			
10-20% upstream of the Delta (3rd release group)	No	No Change	No Change	Low
80-90% in the Delta	Yes	Increased	Increased	High
<5% past Chipps	No	No Change	No Change	High
Adults	No	No Change	No Change	High

Updated Status of Spring-run Chinook Salmon

The impact of the drought on spring-run Chinook Salmon appears to be substantial for the 2014 brood year (BY). Spring-run Chinook Salmon eggs in the upper mainstem Sacramento River experienced very high mortality due to high water temperatures downstream of Keswick Dam. Limited observation of juvenile spring-run Chinook Salmon migrating downstream past Red Bluff Diversion Dam this water year during high winter flows, which is when young-of-the-year (YOY) spring-run Chinook Salmon from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed to out-migrate past this point, indicate that there was very low early survival of BY 2014. Monitoring data suggest that the majority of surviving natural-origin YOY juveniles are currently residing in the Delta, downstream of Knights Landing. No yearling spring-run Chinook Salmon have been caught in 2014 monitoring, however, yearling spring-run observations are expected to be rare because of their relatively large size and strong swimming ability (associated with gear avoidance), and relatively low densities relative to YOY. The majority of YOY, yearling, and surrogate (hatchery late-fall) spring-run are currently rearing in the Delta, and additional downstream movement will be expected, concurrent with the flow pulse, for all juvenile stages still residing upstream of the Delta in the main stem Sacramento River.

Effects of Proposed Action on Spring-run Chinook Salmon

Reclamation and DWR are currently operating consistent with RPA actions in the NMFS BiOp (NMFS 2009). Action IV.2.3 is in place January 1 through June 15 to reduce the vulnerability of emigrating salmonids to entrainment into the central and south Delta and loss at the facilities. During February, this RPA primarily protects winter-run and spring-run Chinook Salmon and steelhead. Reclamation and DWR propose to modify this action to allow for a 14 day running average OMR flow of no more negative than -5,500 cfs (Table 1) while natural and abandoned flow allow for outflow of 7,100 cfs of greater from the storms of February 6-9. If density triggers as described in Action IV.2.3 are exceeded, negative OMR flows will be reduced consistent with the NMFS BiOp (NMFS 2009).

Due to changes in Delta conditions (i.e., flows, temperatures, and turbidity) during the storm, changes in migratory behavior of juveniles will increase risks of entrainment into the central and south Delta and loss at the CVP/SWP fish collection facilities regardless of the Proposed Action. Additionally, since the majority of the yearling and YOY spring-run Chinook Salmon are currently rearing in the Delta, the Proposed Action is likely to increase entrainment risk for the proportion of the population currently within the central and south Delta.

Hydrodynamic modeling of the Proposed Action’s management for OMR flows (allowing more rapid transition to more negative OMR values for 5 days and subsequently operating to daily 14-day average OMR values that are more negative than -5,000 cfs) did not predict differences in average daily velocities or average daily proportion positive flows in channels measured across the North Delta, Central Delta, South Delta and San Joaquin regions (Tables 3-4). Average daily flows during the modeled 5-day period at OMR values of -6,250 cfs were significantly more negative between the baseline and Proposed Action models at channel nodes in the central and south Delta, particularly along the Old and Middle river corridor (Table 3). Average daily flow during the modeled 12-day period at OMR values of -5,000 cfs were not greater than 51cfs in these same channels through the central and south Delta (Table 4).

Changes in the daily average flow at node 49 (Jersey Point on San Joaquin) and Node 50 (Sherman Island on San Joaquin) are approximately 1,100 cfs more negative for the Proposed Action than the baseline modeling, although following return to OMR values of -5,000 cfs daily flow differences are less than -350 cfs (Tables 6-7). These patterns and magnitudes are similar at other nodes in the Old and Middle river corridors. Three Mile Slough (node 310) had a daily average flow that was approximately 250 cfs more negative under the Proposed Action than baseline scenario, indicating river flows were moving through the slough from the Sacramento River to the San Joaquin River. Likewise, flows in Columbia and Turner cuts were predicted to be more negative by up to several hundred cfs during the 5-day period of OMR flows at -6,250 cfs. Although no differences in average daily velocities are observable to the hundredths of a foot per second in the modeling, the changes in flows indicates some potential change in the maximum and minimum velocities during a 24 hour period (Table 7).

The Proposed Action is expected to cause hydrodynamic changes that enhance the risk of entrainment of juveniles into the central and south Delta and may cause greater loss at the CVP/SWP fish collection facilities (Table 9) during the 5 days of more negative OMR flows and possibly to a lesser extent, over the extended period of the Proposed Action, which incorporates the 14-day averaging period. The distributions of spring-run Chinook Salmon are likely to change after February 16 and may affect the risks of entrainment into the south and central Delta and loss at the facilities. There is moderate certainty in our understanding of how hydrodynamic affects juvenile spring-run Chinook behavior and distribution. The current methods of race assignment used in the monitoring of Chinook Salmon, length-at-date size chart and genetic run assignment, are less reliable for spring-run than for winter-run Chinook Salmon, and as such, monitoring of spring-run Chinook salmon-sized fish to minimize operational impacts will be more difficult than for winter-run Chinook salmon.

Summary of Effects on Spring-run Chinook Salmon

Spring-run Chinook Salmon will be present in the Delta during the Proposed Action (Table 9). Due to the low production of natural origin spring-run, the population entering the Delta is very low. Implementation of the NMFS Biological Opinion (NMFS 2009), reasonable and prudent alternative Action IV.2.3 for OMR flow management is using the minimum default density trigger (2.5 fish/TAF) for older juvenile Chinook salmon (based on a calculation using the winter-run Chinook salmon juvenile production estimate), which includes sizes of yearling spring-run Chinook salmon as well as winter-run and late fall-run sized fish too. Maintaining a short cumulative period of OMR flows more negative than -5,000 cfs increases risks of entrainment into the central and south Delta and loss at the CVP/SWP fish collection facilities since current environmental conditions and the species' periodicity are optimal for smolt migration and continued rearing of juvenile spring-run Chinook Salmon in the Delta. Due to insensitive analytical tools, uncertainty concerning realized flows, and actual juvenile distributions the increase in vulnerability is difficult to quantify.

Despite the increased risk of south and Central Delta entrainment, the rapid transitioning and limited duration of greater negative OMR flows and consequential exceedance of 14-day average OMR thresholds do not have an effect on the species' critical habitat.

Biological Review of Green Sturgeon

Table 10. Predicted Distribution of Green Sturgeon During the Proposed Action Period and Potential Effects Based on the Most Recent Monitoring Data. Prediction of distribution are through February 16 and based on monitoring data through February 6.

Green sturgeon	Life Stage Affected?	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Egg	This life stage is not present in the Delta.			
Juvenile (<3 year old)	Juvenile green sturgeon are distributed through the Delta.			
Delta	Yes	May Enhance	No Change	Low
Subadults	This life stage is not present in the Delta.			
Adults	Adult green sturgeon may be entering the Delta and previous year's spawners may still be exiting the Delta			
Delta	Yes	No Change	No Change	High

Updated Status of Green Sturgeon

Juvenile and adult green sturgeon will be present in the San Joaquin and Sacramento rivers and Delta during the Proposed Action. These life stages will continue to be dispersed through the fresh and brackish portions of the region, which is the same distribution recently described in the Biological Review prepared for the February-March Temporary Urgency Change Petition (Reclamation 2015). These distributions normally expose green sturgeon to a broad spectrum of tidally-dominated flow conditions, and they freely move throughout the Delta to find suitable conditions for their needs. There has been no additional detection of green sturgeon in river, Delta, Bay, or salvage monitoring since this most recent status of the species (Reclamation 2015). A review of CVP/SWP fish collection facilities salvage counts from 1995 to 2009 observed less than 1% (n=5) of the total green sturgeon observed during February.

Effect of Proposed Action on Green Sturgeon

Hydrodynamic modeling of the Proposed Action's management for OMR flows (allowing more rapid transition to more negative OMR values for 5 days and subsequently operating to daily 14-day average OMR values that are more negative than -5,000 cfs) did not predict differences in average daily velocities or average daily proportion positive flows in channels measured across the North Delta, Central Delta, South Delta and San Joaquin regions (Tables 3-4). Average daily flows during the modeled 5-day period at OMR values of -6,250 cfs were significantly more negative between the baseline and Proposed Action models at channel nodes in the central and south Delta, particularly along the Old and Middle river corridor (Table 3). Average daily flow during the modeled 12-day period at OMR values of -5,000 cfs were not greater than 51cfs in these same channels through the central and south Delta (Table 4).

Changes in the daily average flow at node 49 (Jersey Point on San Joaquin) and Node 50 (Sherman Island on San Joaquin) are approximately 1,100 cfs more negative for the Proposed Action than the baseline modeling, although following return to OMR values of -5,000 cfs daily flow differences are less than -350 cfs (Tables 6-7). These patterns and magnitudes are similar at other nodes in the Old and Middle river corridors. Three Mile Slough (node 310) had a daily average flow that was approximately 250 cfs more negative under the Proposed Action than baseline scenario, indicating river flows were moving through the slough from the Sacramento River to the San Joaquin River. Likewise, flows in Columbia and Turner cuts were predicted to be more negative by up to several hundred cfs during the 5-day period of OMR flows at -6,250 cfs. Although no differences in average daily velocities are observable to the hundredths of a foot per second in the modeling, the changes in flows indicates some potential change in the maximum and minimum velocities during a 24 hour period (Table 7). Thus, the Proposed Action is expected to cause hydrodynamic changes that may enhance the risk of entrainment of these fish into the central and south Delta and may cause greater loss at the CVP/SWP fish collection facilities (Table 10) during the 5 days of OMR flows at -6,250 cfs, but not over the extended period of the Proposed Action OMR levels, which incorporates the 14-day averaging period. There is low certainty in our understanding of how hydrodynamics affects green sturgeon behavior and distribution.

Summary of Effects on Green Sturgeon

Green sturgeon will be present in the Delta during the Proposed Action. There is limited information about the spawning adult green sturgeon population, but it is estimated to be small. The small population size limits the productivity of the population, although more Brood Year (BY) 2014 larvae were observed than the long-term average. Also, more BY 2014 juveniles were observed during fall 2014 than recently seen in previous years of observations at Sacramento River fish monitoring sites (*i.e.*, Red Bluff Diversion Dam, Glenn-Colusa Irrigation District rotary screw traps). As previously mentioned, entrainment risk is low during February (1%) relative to the total entrainment during the other months. However, no empirical estimates of the juvenile population (0-3 years) in the Delta are available nor is there information about their rearing and distribution patterns within the Delta.

While the increased risk of south and Central Delta is greater, the rapid transitioning and limited duration of greater negative OMR flows and consequential exceedance of 14-day average OMR thresholds result in daily OMR flows within a range potentially observed under RPA implementation (NMFS 2009). Thus, the Proposed Action is unlikely to have an effect on green sturgeon critical habitat.

Biological Review of Central Valley Steelhead

Table 11. Predicted Distribution of Central Valley Steelhead During the Proposed Action Period and Potential Effects Based on the Most Recently Available Monitoring Data. Prediction of distribution are through February 16 and based on monitoring data through February 8.

Steelhead	Life Stage Affected?	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Egg	This life stage is not present in the Delta			
Wild Sacramento smolts				
50-70% upstream of the Delta in the Sacramento River and tributaries	No	No Change	No Change	High
30-50% in the Delta	Yes	Increased	Increased	Moderate
<5% past Chipps	No	No Change	No Change	High
Wild San Joaquin smolts				
>80% upstream in the San Joaquin River and tributaries	No	No Change	No Change	High
<20% Delta	Yes	Increased	Increased	Moderate
<5% past Chipps	No	No Change	No Change	High
Hatchery Sacramento smolts	Coleman and Feather Hatchery smolts released prior to February 6			
40-60% upstream of the Delta in the Sacramento River	No	No Change	No Change	High
40-60% in the Delta	Yes	Increased	Increased	High
Adults	Yes	Not Affected	Minimal	Moderate

Updated Status of Central Valley Steelhead

Juvenile and adult Central Valley steelhead trout will be present in the San Joaquin and Sacramento rivers and within the Delta during the Proposed Action. The distributions of these life stages are broad and will be primarily found upstream of the Delta in river migratory, spawning, and natal rearing habitats. A significant proportion of Sacramento origin and a smaller proportion of San Joaquin River origin wild juveniles are predicted to be in the Delta during the week of February 9-16, 2015 in response to downstream emigration into the Delta with winter precipitation events. Prior to February 8, there have been no additional detections of steelhead at the Tisdale Weir or Knights Landing rotary screw traps or in Delta beach seine and trawl fish monitoring since the review of the status of the species for the February-March TUCP (Reclamation 2015). Hatchery steelhead have been salvaged in the past two weeks, suggesting hatchery smolts are distributed throughout the south Delta. A total of 121 hatchery steelhead are estimated to have been lost at the CVP/SWP fish collection facilities between January 23 and 31, 2015.

Effect of Proposed Action on Central Valley Steelhead

Reclamation and DWR are currently operating consistent with RPA actions in the NMFS BiOp (NMFS 2009). Action IV.2.3 is in place January 1 through June 15 to reduce the vulnerability of emigrating salmonids to entrainment into the central and south Delta and loss at the facilities. During February, this RPA primarily protects winter-run and spring-run Chinook salmon and steelhead. Reclamation and DWR propose to modify this action to allow for a 14 day running average OMR flow of no more negative than -5,500 cfs (Table 1) while natural and abandoned flow allow for outflow of 7,100 cfs of greater from the storms of February 6-9. If density triggers as described in Action IV.2.3 are exceeded, negative OMR flows will be reduced consistent with the NMFS BiOp (NMFS 2009).

Due to changes in Delta conditions (*i.e*., flows, temperatures, and turbidity) during the early February storm event, increases in the presence of steelhead smolts in the Delta and migratory behavior of steelhead juveniles suggests an increased risk of entrainment into the south and central Delta and an increased risk of loss at the CVP/SWP fish collection facilities.

Hydrodynamic modeling of the Proposed Action's management for OMR flows (allowing more rapid transition to more negative OMR values for 5 days and subsequently operating to daily 14-day average OMR values that are more negative than -5,000 cfs) did not predict differences in average daily velocities or average daily proportion positive flows in channels measured across the North Delta, Central Delta, South Delta and San Joaquin regions (Tables 3-4). Average daily flows during the modeled 5-day period at OMR values of -6,250 cfs were significantly more negative between the baseline and Proposed Action models at channel nodes in the central and south Delta, particularly along the Old and Middle river corridor (Table 3). Average daily flow during the modeled 12-day period at OMR values of -5,000 cfs were not greater than 51cfs in these same channels through the central and south Delta (Table 4).

Changes in the daily average flow at node 49 (Jersey Point on San Joaquin) and Node 50 (Sherman Island on San Joaquin) are approximately 1,100 cfs more negative for the Proposed Action than the baseline modeling, although following return to OMR values of -5,000 cfs daily flow differences are less than -350 cfs (Tables 6-7). These patterns and magnitudes are similar at other nodes in the Old and Middle river corridors. Three Mile Slough (node 310) had a daily average flow that was approximately 250 cfs more negative under the Proposed Action than baseline scenario, indicating river flows were moving through the slough from the Sacramento River to the San Joaquin River. Likewise, flows in Columbia and Turner cuts were predicted to be more negative by up to several hundred cfs during the 5-day period of OMR flows at -6,250 cfs. Although no differences in average daily velocities are observable to the hundredths of a foot per second in the modeling, the changes in flows indicates some potential change in the maximum and minimum velocities during a 24 hour period (Table 7).

The Proposed Action is expected to cause hydrodynamic changes that enhance the risk of entrainment of juvenile steelhead into the central and south Delta and may cause greater loss at the CVP/SWP fish collection facilities (Table 11) during the 5 days of more negative OMR flows and possible to a lesser extent, over the extended period of the Proposed Action which incorporates the 14-day averaging period. The distributions of steelhead smolts and adults are likely to change after February 16 and may affect the risks of entrainment into the south and central Delta and loss at the facilities. Adult steelhead may still be migrating through the Delta to spawn and kelts are likely to be outmigrating through the Delta. The described hydrodynamic changes may to a lesser extent change adult steelhead migration behavior and patterns. There is low certainty in our understanding of how hydrodynamic affects steelhead behavior and distribution.

Summary of Effects on Central Valley Steelhead

Steelhead will be present in the Delta during the Proposed Action (Table 11). There is limited information about the adult steelhead population, but it is estimated to be small. This limits the productivity of the population. The drought conditions may have impacted summer freshwater conditions and reduced habitat for Brood Year (BY) 2013 and 2014 juveniles. A majority of juvenile steelhead remain in natal tributary habitats, but current storm conditions will increase the proportion of these fish migrating through the Delta. Maintaining a short cumulative period of OMR flows more negative than -5,000 cfs increases risks of entrainment into the south and central Delta and loss at the facilities since current environmental conditions and timing is optimal for migration of wild and hatchery juveniles. Due to insensitive analytical tools, uncertainty concerning realized flows, and actual juvenile distributions the increase in vulnerability is difficult to quantify.

The hydrodynamic changes associated with rapid transitioning and limited duration of greater negative OMR flows and consequential exceedance of 14-day average OMR are not likely to result in changes to the primary constituent elements of freshwater migratory corridors, rearing habitats, and estuarine areas beyond those analyzed in the NMFS BiOp (NMFS 2009). Thus, the likely Proposed Action conditions are unlikely to further impair functioning of habitats designated as Central Valley steelhead critical habitat.

Biological Review of Delta Smelt

Table 22. Current Estimates of Delta Smelt Distribution Based on Available Survey Data through February 9, 2015 and Potential Effects During the Proposed Action Period. UNK= Unknown distribution at time of review.

Delta Smelt (Pre-Storm Distribution)	Life stage Affected	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Eggs	Attached to substrate with very low risk of entrainment			
Larvae	Based on recent adult maturation stage and larval fish surveys, spawning has only just begun; few if any eggs are likely to have hatched. Assumption is eggs are distributed roughly where adults have been detected			
20% Cache Slough / Liberty Island	Not applicable	Not applicable	Not applicable	Not applicable
South Delta (% unknown; assumed low – no salvage since January 7)	Not applicable	Not applicable	Not applicable	Not applicable
20% Lower Sacramento	Not applicable	Not applicable	Not applicable	Not applicable
20% Lower San Joaquin (high catches this week at Jersey Point)	Not applicable	Not applicable	Not applicable	Not applicable
40% downstream of Confluence	Not applicable	Not applicable	Not applicable	Not applicable
Juvenile	It is too early in the year for juvenile Age-0 delta smelt			
Adults	Distribution based on January 2015 SKT surveys			
20% Cache Slough / Liberty Island	No	Not affected	Not affected	High
South Delta (% unknown; assumed low – no salvage since January 7)	Yes	Increased	Increased	High
20% Lower Sacramento	Possibly	Increased	Increased	Low
20% Lower San Joaquin (high catches this week at Jersey Point)	Yes	Increased	Increased	High
40% downstream of Confluence	Possibly	Increased	Increased	Low[†]

[†] Fate depends on whether any of these fish move into the San Joaquin River.

Updated Status of Delta Smelt

The results of the 2014 Fall Midwater Trawls (FMWT) indicated that Delta Smelt adults were in poor condition and at record low population densities throughout the Delta at the start of winter.

These results and a detailed account of the spatial distribution of the adult population were described in the Biological Review of the Feb-Mar 2015 TUCP (Reclamation 2015). Indications are that the proportion of the population in the Cache Slough / Liberty Island complex is low relative to prior years. The estimated cumulative seasonal total for adult Delta Smelt salvage is 56; no salvage has been reported since January 7. Daily "early-warning" sampling that resumed during the week of February 2nd at Jersey and Prisoners Point in anticipation of the current hydro-meteorological conditions recorded a spike in catch of 14 adults at Jersey Point on February 6, with gametes expressed from 2 mature individuals and 18 adults on February 8th, but no smelt have been caught at Prisoners Point in the past week (http://www.fws.gov/sfbaydelta/documents/DS_early_warning_spreadsheets/usfws_delta_smelt_daily_monitoring_data.pdf). These observations, combined with warming water conditions (12°C temperatures at a 3-station average reported by the Smelt Working Group on February 2nd, 2015) suggest Delta Smelt spawning is imminent or may have already commenced. Distribution of Delta Smelt can change rapidly and indicators of distribution should be evaluated as frequently as data allow during and following storms. No Delta Smelt larvae have been observed in the Smelt Larva Survey (SLS) #2 or 3 (in samples processed to date). This is not surprising given that the Delta is only starting to warm to spawning temperatures.

Effect of Proposed Action on Delta Smelt

The following discussion is based on DSM-2 PTM modeling. When reviewing this section, it is important to remember that adult Delta Smelt do not behave as neutrally-buoyant particles so a literal translation of results into changes in entrainment or entrainment risk is not advisable. In particular, the model predictions of westward advection are not relevant. It is the changes in central/south Delta hydrodynamics that are of interest because these flow conditions may affect tide-surfing fishes seeking turbid fresh water. To estimate the effect of the proposed 5-day increase in OMR on Delta Smelt, a particle tracking model of the Proposed Action was compared to one of baseline hydrological conditions, assuming an equally distributed population between injection points (Figure 15). The first scenario represents a baseline with constant OMR values of -5,000 cfs, while the proposed action includes a five-day period with OMR values of -6,250 cfs. Other input values remained constant and reflected the best information available to DWR modelers when models were run on February 6, 2015, but it should be noted that particles were injected on February 1st, with 5-8 days of innocuous conditions. The modeled conditions of the proposed increase in OMR resulted in small to slight changes in the final fate of particles (as of February 28) compared to baseline conditions. Under either set of modeled conditions, only particles originating from the San Joaquin River east of Franks Tract (injection node 815 at Prisoners Point) arrived at the state and federal pumping facilities by February 28 (Figure 16). Of these particles, 20% were predicted to be entrained at the pumping facilities as of February 28 under the Proposed Action, compared to 16% under baseline; 20% compared to 18% moved south past Holland Tract toward the export facilities (Figures 21-22), 65% compared to 71% ended up in Frank's Tract (Figures 19-20), It is impossible to quantify whether the differences between baseline conditions and the Proposed Action are biologically significant to the Delta Smelt populations without knowledge of the size of the population.

Modeling outputs suggest that effects from this proposed action on outflow are negligible through the end of February (Table 12), but there are differences in south Delta hydrodynamics that coupled with possible dispersion of turbidity could entice up to 20% of Delta Smelt to spawn in the San Joaquin River. Fish behavior and movement of adults will determine actual effects.

The proposed action in the presence of warming water conditions above 12°C may cause a greater proportion of fish than estimated to move into the central and south Delta.

Summary of Effects on Delta Smelt

The small numbers of Delta Smelt adults found so far in field surveys seems to indicate that the WY 2014 drought had a significant impact on the population. Like many other species in the Delta, the Delta Smelt population is expected to have low recruitment again this year due to effects of the continuing drought. Model results indicate that the Proposed Action may marginally increase entrainment risk for Delta Smelt moving around in the San Joaquin River above baseline conditions. The proposed action is unlikely to negatively affect Delta Smelt spawning and recruitment across the entire population as indicated by particle tracking modeling of baseline and the more negative proposed OMR flows anticipated under the Proposed Action. The spawning status and spatial distribution of delta smelt should continue to be evaluated as frequently as data allow to assess changes in the risk of entrainment of adults and (in the coming weeks) larvae. Delta Smelt have spawned in the San Joaquin River, which may increase the effects of more negative OMR flows on these adults and subsequent larvae, if turbidity spreads into the south Delta. Delta Smelt that moved into the zones of entrainment in early January and may be moving in response to this storm will be difficult to assess until the second Spring Kodiak Trawl survey becomes available.

No action under RPA action 2 (adults) or 3 (larvae and juveniles) has reduced OMR below -5000 for calendar year 2015. However, as early warning monitoring has found ripe individuals and temperatures in the Delta are consistent with spawning, the Smelt Working Group will be monitoring both adults and larva pursuant to the RPA. If the entrainment risk to either of these life stages necessitates a reduction in the negative OMR flows, the action proposed by Reclamation and DWR will off-ramp. The Biological Opinion (p 280) states that the RPA is designed to increase the suitability of spawning habitat for Delta Smelt by decreasing the amount of Delta habitat affected by export pumping during the spawning period. The proposed modification to the RPA has the potential to reduce the available suitable spawning habitat.

Ongoing IEP monitoring, Early Warning Monitoring, and Fish Salvage operations, will continue to inform the RTDOT, WOMT, SWG, DCT and other groups who will be providing input to Reclamation on a near real-time basis.

Biological Review of Longfin Smelt

Table 33. Current Distribution of Longfin Smelt During the Proposed Action Period and Potential Effects Based on the Most Recently Available Survey Data through February 8.

Longfin Smelt	Life stage Affected	Change in Risk of SD/CD Entrainment	Change in Risk of Facility Loss	Certainty
Eggs	Attached to substrate with very low risk of entrainment			
Larvae	Distribution based on Smelt Larva Survey #3			
~2% South Delta	Yes	Increased	Increased	High
~3% San Joaquin River	Yes	Increased	Increased	Moderate
~35% Sacramento River	Possibly	Increased	Increased	Low
~60% Confluence and Suisun	No	Not Affected	Not Affected	High
Juvenile	Juvenile Longfin (>20mm) have not yet been detected this year			
Adults	Distribution based on January 2015 Bay Study and SKT surveys			
0% South Delta	Yes	Increased	Increased	High
<5% San Joaquin River	Yes	Increased	Increased	Moderate
<15% Sacramento River	No	Not Affected	Not Affected	Low
80% Confluence and Suisun	No	Not Affected	Not Affected	High

Updated Status of Longfin Smelt

The results from the December 2014 Bay Study trawls indicate that Longfin Smelt continued to occur at relatively low population densities throughout the estuary at the start of winter. In Bay Study trawls conducted during the week of January 5-9, 2015, the majority of adult Longfin Smelt were detected in Suisun Bay, the Confluence area, and the lower Sacramento River, with overall catches remaining low. In Spring Kodiak Trawl #1, conducted during the week of January 12, 2015, adult Longfin Smelt were detected only in areas downstream of the confluence. The reduced catches in these surveys relative to recent years indicates that the spawning stock of Longfin Smelt in 2015 is at low abundance. As of February 6, 2015, no Longfin Smelt salvage has been detected at either the CVP or SWP fish facilities.

The presence of larvae in the most recent Smelt Larva surveys indicate that Longfin Smelt began spawning well over a month ago (approximately 4 week incubation duration) in the lower San Joaquin River and elsewhere in the Estuary. The third Smelt Larva Survey, from the week of February 2, 2015, found larval Longfin Smelt at multiple locations in the central and south Delta including stations 915 (n=1) and 914 (n=2) in Old and Middle Rivers, respectively, and station 901 in Frank’s Tract (n=2). Additional larvae were detected in the San Joaquin River at Jersey Point (n=2) and station 812 (n=3). While larvae in these southern areas will be at substantial risk of entrainment during operations (either baseline or proposed), the larvae in the south Delta represent only 5% of the total larval catch in SLS #3 (n=207).

It is not known how much additional spawning of Longfin Smelt will occur. The historical presence of recently-hatched larvae in sampling during March and April, indicates that spawning typically continues through February and into March (CDFG 2009). It is possible that Longfin Smelt distributed downstream of the confluence may yet make spawning forays into the central and south Delta, which would put them at increased risk of entrainment, though these risks are inherently unquantifiable at this time due to the unprecedented circumstances of continued drought conditions.

Effect of Proposed Action on Longfin Smelt

To estimate the effect of the proposed 5 day increase in more negative Old and Middle River (OMR) flows on Longfin Smelt, particle tracking models were run using hydrology from the proposed action and also baseline conditions, assuming an equally distributed population between injection points (Figure 15). The modeled conditions of the proposed rapid transition to OMR flows of -6250 cfs and modified 14-day averaging period calculation resulted in small changes in the fate of particles (at the end of the modeling period) compared to baseline conditions. Under either set of modeled conditions, only particles originating from the San Joaquin River east of Franks Tract (injection node 815 at Prisoners Point) arrived at the state and federal pumping facilities by February 28 (Figure 16). Of these particles, 20% were entrained at the pumping facilities as of February 28 under the proposed increase in OMR, compared to 16% under baseline; 20% compared to 18% fluxed south past Holland Tract toward the export facilities (Figures 21 & 22) and 71 % compared to 65% ended up in Frank's Tract or farther south (Figures 19 & 20). Of the particles injected at other stations in the Delta under the proposed action, the percentage that moved past Chipps Island by February 28 was 88% for those seeded in the Sacramento River (Station 707) at Three-mile Slough above Decker Island, and 69% for those seeded in the San Joaquin River (Station 809) at Jersey Point (Figure 17-18), compared to 89% and 73% under baseline conditions. It is impossible to quantify whether the differences between baseline conditions and the proposed action are biologically significant to the Longfin Smelt populations without knowledge of the size of the population.

Modeling outputs indicate that the proposed action will have a negligible impact on outflow through the end of February (Table 1), and outflow is one of the best predictors of Longfin Smelt year class strength. However, given the results of the PTM model, it is likely that Longfin Smelt larva and perhaps some adults near and upstream of Prisoner's Point will have an increased risk of entrainment into the South Delta as part of the proposed action. Longfin Smelt located in the south Delta, near Frank's Tract and within Old and Middle Rivers will likely be at high risk of entrainment under both baseline conditions and the proposed action.

Summary of Effects on Longfin Smelt

Like other species, Longfin Smelt is likely to have reduced recruitment this year due to effects of the continuing drought. Low spawning rates so far this year seem to indicate that this is already occurring. The proposed action is unlikely to substantially negatively affect Longfin Smelt spawning and recruitment across the population in any measureable manner, as recent surveys indicate that the majorities of both adult and larval Longfin Smelt are distributed outside the zone of influence of the export facilities. Adult Longfin Smelt in the San Joaquin River are unlikely to be affected by the Proposed Action. Larval Longfin Smelt in the San Joaquin River are at an elevated risk of entrainment into the south Delta under the Proposed Action scenario. Longfin Smelt in the South Delta are already present, thus they are at a high risk of entrainment under both baseline and Proposed Action scenarios.

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