

Appendix AB-I, Old and Middle River Flow Management

Attachment I.4 Longfin Smelt Salvage-OMR Relationship

I.4.1 Model Overview

The Longfin smelt salvage-OMR relationship is a model of salvage at South Delta facilities as a function of flow based on historical salvage data. The results are a quantitative analysis of loss differences between operating scenarios (including the Proposed Action). The method uses data from 1993-2005, reflective of historically high periods of juvenile salvage at the CVP and SWP collection facilities and OMR flows. This period represents conditions prior to the 2009 and 2019 Biological Opinions and 2009/2020 Incidental Take Permits, which imposed greater restrictions on south Delta exports to limit entrainment of state- and federally listed fish.

I.4.2 Model Development

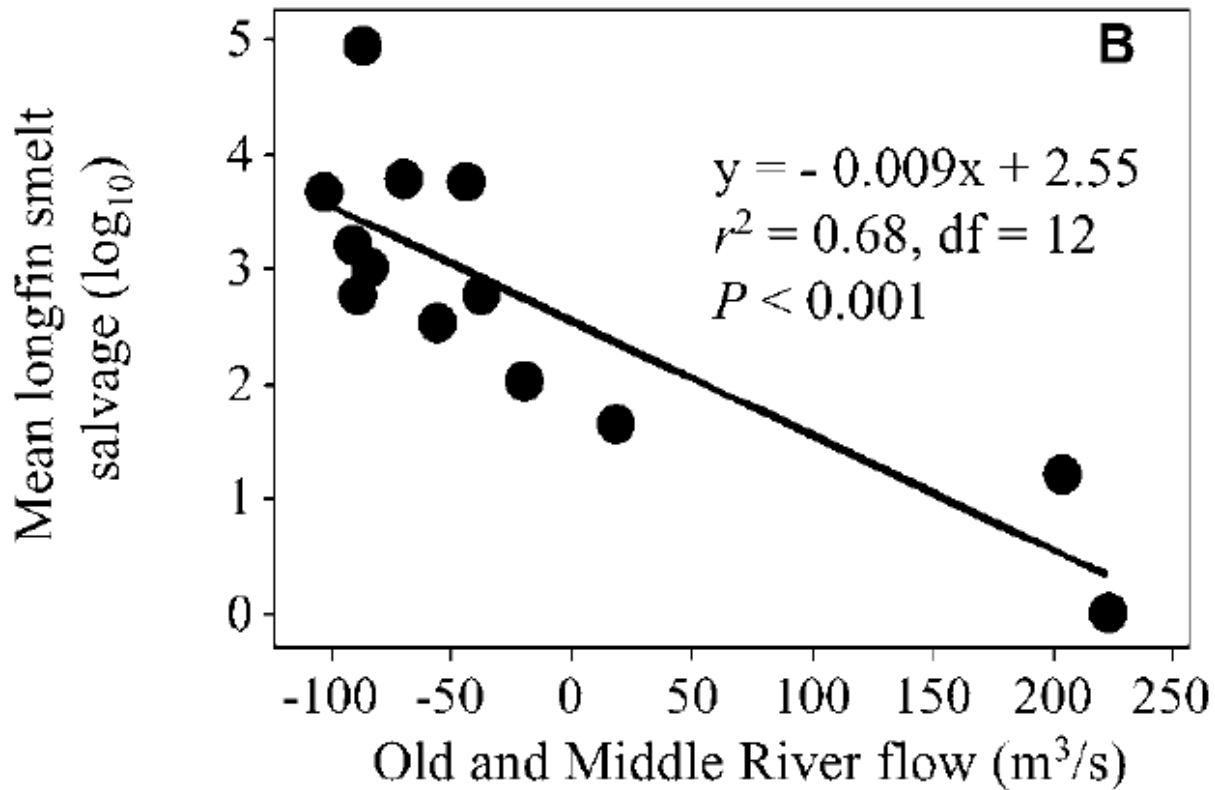
I.4.2.1 Methods

Grimaldo et al. (2009:Figure 7B) found a significant relationship between juvenile Longfin Smelt salvage in April and May as a function of cumulative mean April–May Old and Middle River flows. In order to assess potential differences in salvage between the modeled 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 when using CalSim 3-derived estimates of Old and Middle River flows as input for the modeled scenarios.

Longfin Smelt salvage data for April and May 1993–2005 were obtained from the California Department of Fish and Wildlife salvage monitoring website.¹ 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. 2012). Following Grimaldo et al. (2009), $\log_{10}(\text{total salvage})$ 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 I.4-1):

¹ <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).

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



Source: Grimaldo et al. 2009.

Figure I.4-1. Regression of April–May Longfin Smelt Salvage as a Function of Old and Middle River Flow

For the comparison of the modeled scenarios, CalSim 3 data outputs were used to calculate mean April–May Old and Middle River flows for each year of the 1922–2021 simulation. The salvage–Old and Middle River flow regression calculated as above was used to estimate salvage for the modeled scenarios. The log-transformed salvage estimates were back-transformed to a linear scale for comparison of the modeled scenarios. 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 prediction limits giving negative estimates of salvage were converted to zero before statistical summary. Statistical analyses were conducted with R statistical software (R Core Team 2023).

I.4.2.2 Assumptions / Uncertainty

This analysis is meant as a tool to compare potential longfin smelt salvage across different operation scenarios based on OMR flows and is not a predictive tool.

The historical salvage records used to develop this model were from 1993-2005, prior to the USFWS 2008 and 2009 Biological Opinions (BiOp). The USFWS 2008 BiOp included measures implemented specific to entrainment of Delta smelt, and management actions for listed fish protections, such as the “First Flush” action. While this action was meant for Delta smelt, longfin smelt likely benefited as well. The Old and Middle River Flow Management was developed from the 2009 BiOp to reduce vulnerability of listed fish within the lower Sacramento and San Joaquin rivers to entrainment into the Delta fish collection facilities. Analysis of historically more recent (2009 – 2020) Smelt Larval Survey (SLS) data showed proportional entrainment was unlikely to have exceeded 3% of the population likely due to OMR management strategies (USFWS 2022).

This model only has a single covariate and therefore implicitly assumes constant population size across time. More complex models analyzing entrainment in other listed species such as Delta smelt have incorporated water clarity/turbidity (Smith et al. 2021) and behavior (Korman et al. 2021) that are likely to interact with OMR flows to reduce or increase entrainment. The model does not account for the geographical shift in distribution of juvenile longfin smelt during wet years further seaward away from the South Delta, which would decrease risk of entrainment. While OMR flow may be a large factor in the entrainment of longfin smelt, recent studies have also indicated that the proportion of the longfin smelt population entrained into the facilities in a given year are relatively low under the 2009 and 2019 BiOp conditions (Kimmerer and Gross 2022, Gross et al. 2022).

I.4.2.3 Code and Data Repository

OMR Data: Old Middle River flow data are available online at:
<https://data.cnra.ca.gov/dataset/dayflow>

Salvage data are available at online at: Salvage inputs: Salvage data available online at
http://www.cbr.washington.edu/sacramento/data/query_loss_detail.html

Model predictions are available from Reclamation upon request.

I.4.3 Results

Mean longfin smelt salvage by water year type for each alternative is present in Table I.4-1 and Table I.4-2.

Tables include results from Explanatory 1 (EXP1), Explanatory 3 (EXP3), No Action Alternative (NAA), Alternative 2 with TUCPs (Alt2wTUCPwoVA), Alternative 2 without TUCPs (Alt2woTUCPwoVA), Alternative 2 with Delta VA (Alt2woTUCPDeltaVA), and Alternative 2 with systemwide VAs (Alt2woTUCPAllVA).

Another set of tables includes results from No Action Alternative (NAA), Alternative 1 (Alt1), Alternative 2 with TUCPs (Alt2wTUCPwoVA), Alternative 2 without TUCPs (Alt2woTUCPwoVA), Alternative 2 with Delta VA (Alt2woTUCPDeltaVA), and Alternative 2 with systemwide VAs (Alt2woTUCPAllVA), Alternative 3 (Alt3), Alternative 4 (Alt4).

During the **wet year type**, mean salvage was highest for Alternative 1 (4032) which was a 197% increase compared to the NAA, followed by Alt2TUCPwoVA (3712, 173% increase), Alt2woTUCPwoVA (3706, 173% increase), Alt4 (3508, 158% increase), Alt2woTUCPDeltaVA (2764, 103% increase) and Alt2woTUCPAllVA (2697, 98% increase). Mean salvage was lowest for Alternative 3 (109) which was a 92% decrease compared to the NAA.

During the **above normal year type**, mean salvage was highest for Alternative 1 (5280) which was a 295% increase compared to the NAA, followed by Alt4 (3813, 185% increase), Alt2woTUCPwoVA (3757, 181% increase), Alt2wTUCPwoVA (3754, 181% increase), Alt2woTUCPDeltaVA (1829, 37% increase) and Alt2woTUCPAllVA (1779, 33% increase). Mean salvage was lowest for Alternative 3 (265) which was a 80% decrease compared to the NAA.

During the **below normal year type**, mean salvage was highest for Alternative 1 (3388) which was a 134% increase compared to the NAA, followed by Alt4 (2700, 86% increase), Alt2woTUCPwoVA (2647, 82% increase), Alt2wTUCPwoVA (2537, 75% increase), Alt2woTUCPDeltaVA (1901, 31% increase) and Alt2woTUCPAllVA (1763, 22% increase). Mean salvage was lowest for Alternative 3 (395) which was a 73% decrease compared to the NAA.

During the **dry year type**, mean salvage was highest for Alternative 1 (2390) which was a 63% increase compared to the NAA, followed by Alt4 (2124, 45% increase), Alt2woTUCPwoVA (2091, 43% increase), Alt2wTUCPwoVA (2090, 43% increase), Alt2woTUCPDeltaVA (1578, 8% increase) and Alt2woTUCPAllVA (1403, 4% decrease). Mean salvage was lowest for Alternative 3 (449) which was a 69% decrease compared to the NAA.

During the **critical year type**, mean salvage was highest for Alternative 1 (1226) which was a 35% increase compared to the NAA, followed by Alt4 (1114, 23% increase), Alt2woTUCPDeltaVA (1170, 29% increase), Alt2wTUCPwoVA (1168, 29% increase), Alt2woTUCPAllVA (1126, 24% increase) and Alt2woTUCPAllVA (1110, 23% decrease). Mean salvage was lowest for Alternative 3 (477) which was a 47% decrease compared to the NAA.

For Alt 1, Alt2wTUCPwoVA, Alt2woTUCPwoVA, Alt2woTUCPDeltaVA, Alt2woTUCPAllVA, Alt 4, mean OMR values across April – May were most negative for Above Normal, followed by Below Normal, then Wet, Dry, Critical (Table I.4-3). For Alt 3 mean OMR values decreased as the water year type became drier.

Generally, salvage was higher for the alternatives with more negative mean April-May OMR values. Across all water year types, Alt 3 had the lowest salvage and either positive (during Wet and Above Normal WYT) or the least negative mean April-May OMR values (during Below Normal, Dry and Critical WYT) which resulted in the fewest fish being salvaged. Alt 1 had the most negative mean OMR values across all WYT and the highest predicted salvage. For the phases of Alt 2, Alt2woTUCPDeltaVA and Alt2woTUCPAllVA, had less predicted salvage than Alt2wTUCP and Alt2woTUCPwoVA because of the less negative mean April-May OMR values across all WYT except for the Critical WYT (Figure I.4-2). For phases Alt2woTUCPDeltaVA and Alt2woTUCPAllVA, mean predicted salvage was highest during Wet years even though mean April-May OMR was most negative for the Above Normal WYT (Table I.4-2 and Table I.4-3). However, OMR flow was more variable and median OMR flow was more negative in Wet years (Figure I.4-2) which explains why salvage was higher during the Wet WYT.

I.4.4 Tables

Table I.4-1. April – May predicted Longfin Smelt salvage by water year type (WYT) for modeled scenarios. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	28	37	1359	3712	3706	2764	2697
Above Normal	89	117	1335	3754	3757	1829	1779
Below Normal	152	172	1451	2537	2647	1901	1763
Dry	218	247	1464	2090	2091	1578	1403
Critical	304	286	905	1168	1110	1170	1126

Table I.4-2. April – May predicted Longfin Smelt salvage by water year type (WYT) for modeled scenarios. Values are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	1359	4,032 (197%)	3,712 (173%)	3,706 (173%)	2,764 (103%)	2,697 (98%)	109 (-92%)	3,508 (158%)
Above Normal	1335	5,280 (295%)	3,754 (181%)	3,757 (181%)	1,829 (37%)	1,779 (33%)	265 (-80%)	3,813 (185%)
Below Normal	1451	3,388 (134%)	2,537 (75%)	2,647 (82%)	1,901 (31%)	1,763 (22%)	395 (-73%)	2,700 (86%)
Dry	1464	2,390 (63%)	2,090 (43%)	2,091 (43%)	1,578 (8%)	1,403 (-4%)	449 (-69%)	2,124 (45%)
Critical	905	1,226 (35%)	1,168 (29%)	1,110 (23%)	1,170 (29%)	1,126 (24%)	477 (-47%)	1,114 (23%)

Table I.4-3. Mean April-May OMR flows.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	-1500	-2895	-2835	-2843	-2323	-2284	3367	-2793
Above Normal	-1992	-4028	-3585	-3584	-2527	-2467	702	-3601
Below Normal	-2133	-3423	-3133	-3083	-2488	-2355	-98	-3167
Dry	-2151	-2737	-2522	-2507	-2114	-1946	-410	-2536
Critical	-1401	-1729	-1541	-1697	-1689	-1648	-478	-1526

I.4.5 Figures

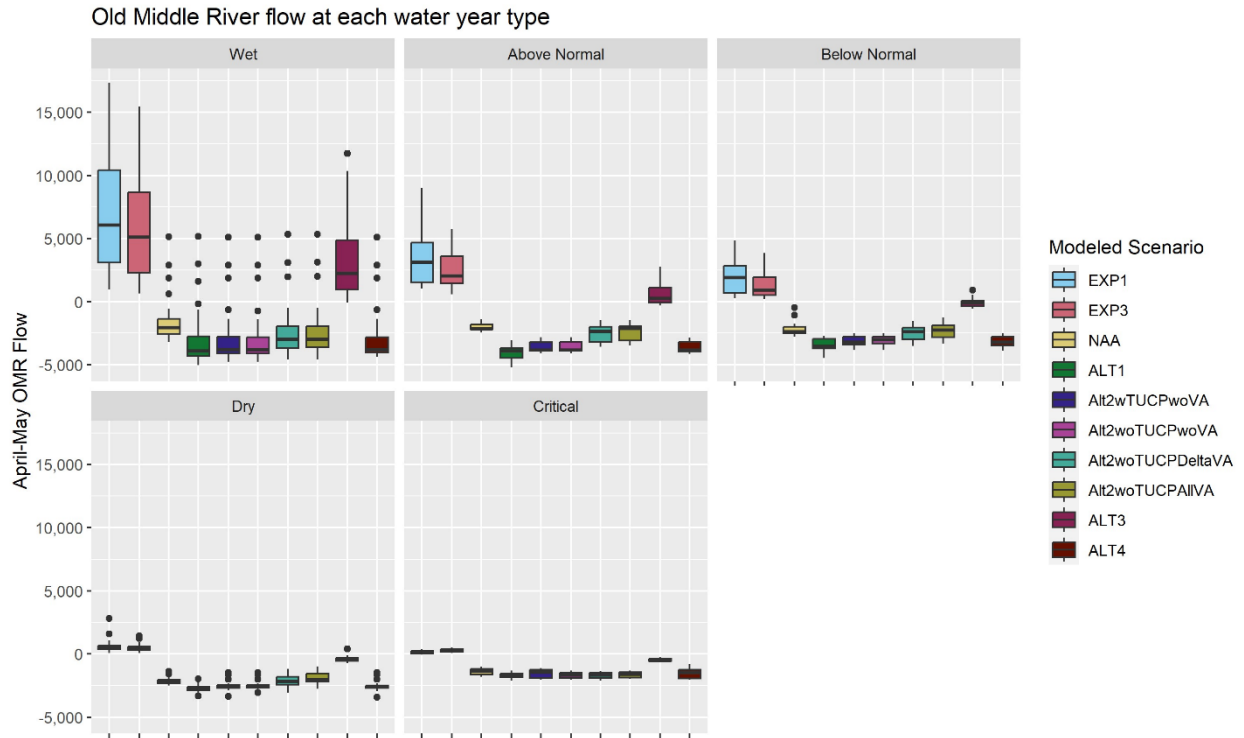


Figure I.4-2. monthly Old and Middle River flows by water year type for all scenarios. Note the y-axis scale is fixed.

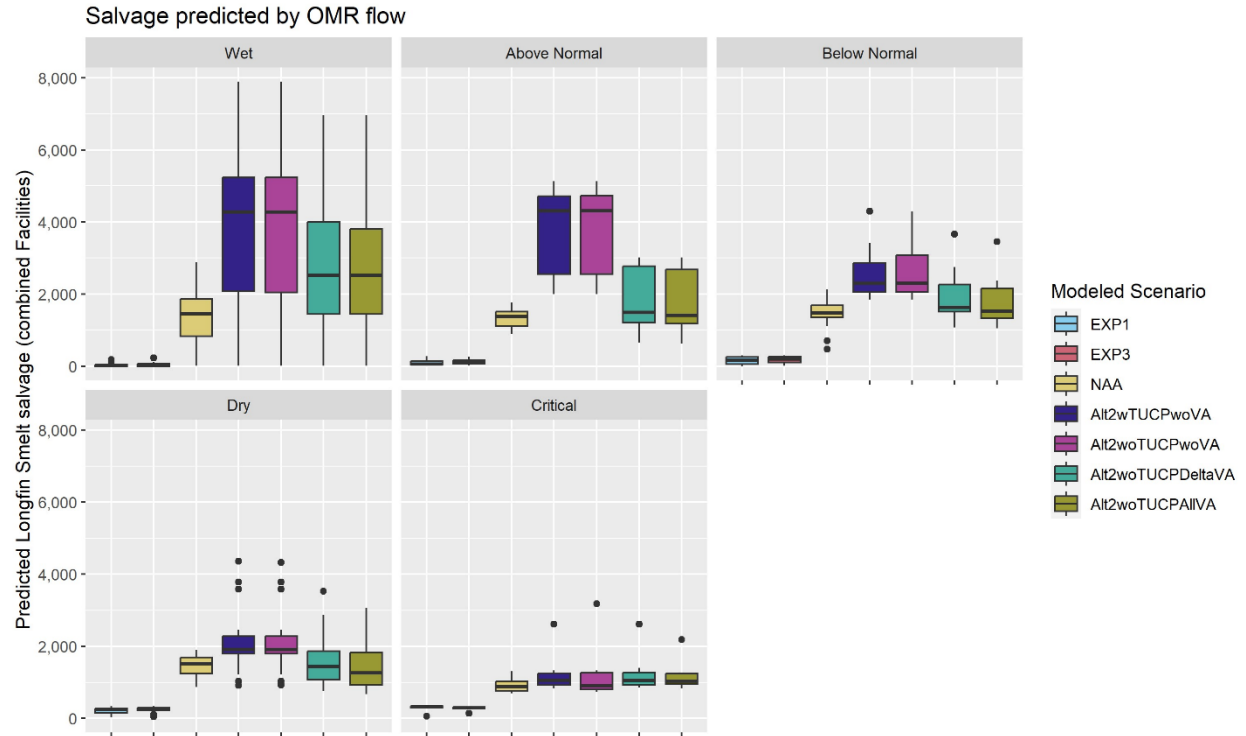


Figure I.4-3. Total salvage at USBR and CDWR facilities, predicted from Old and Middle River flows. Figure displays data given in Table I.4-1.

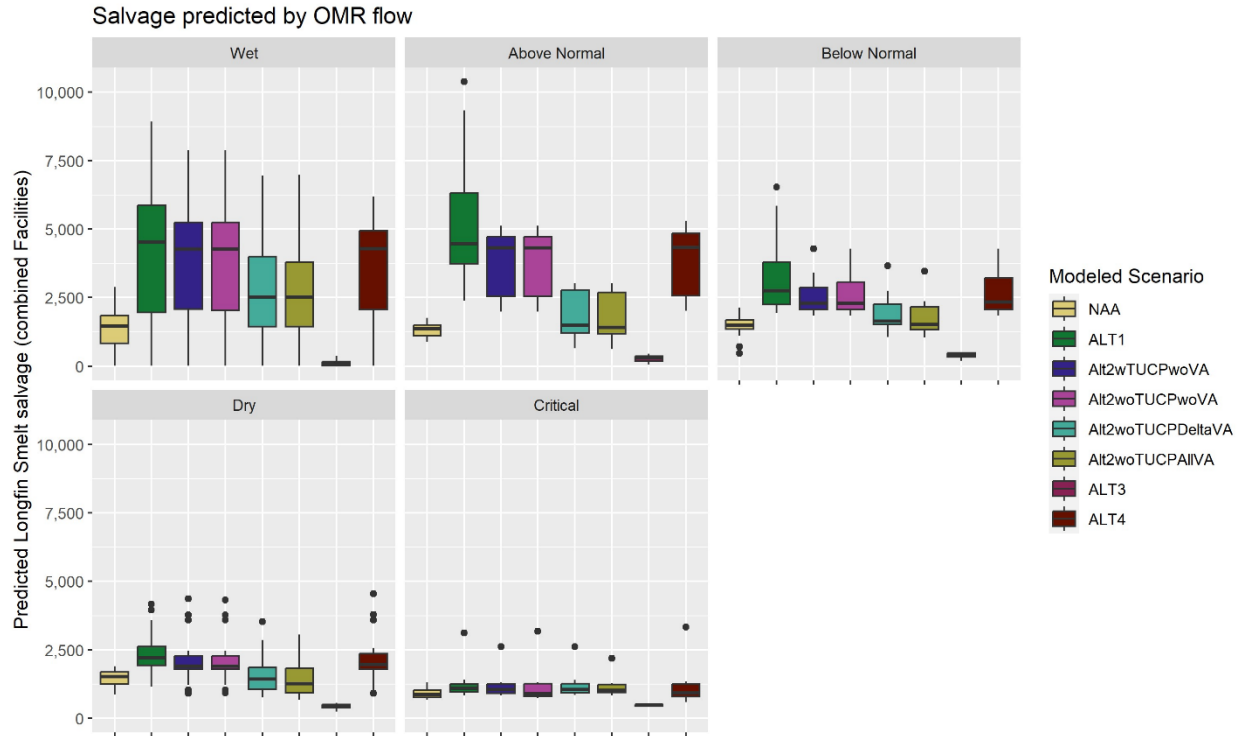


Figure I.4-4. Total salvage at USBR and CDWR facilities, predicted from Old and Middle River flows. Figure displays data given in Table I.4-2.

I.4.6 References

Grimaldo, L., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. Moyle, P. Smith, and B. Herbold. 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.

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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.

Smith, Peter. U.S. Geological Survey. 2012—Spreadsheet with Old and Middle River daily flows for WY 1979-2012, sent to Lenny Grimaldo, U.S. Bureau of Reclamation, Sacramento, CA.