United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Regional Office
2800 Cottage Way
Sacramento, CA 95825-1898

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MAR 13 2020

Memorandum

To: Regional Director
U.S. Fish and Wildlife Service, Interior Region 10

From: Ernest A. Conant
Regional Director , Acting for

Subject: Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP), Additional Real-Time Old and Middle River (OMR) Flow Restrictions for Delta Smelt Larval and Juvenile Entrainment for 2019

The October 2019 Proposed Action for the LTO calls for Reclamation and DWR to manage exports to limit entrainment to be protective of larval and juvenile delta smelt on or after March 15 of each year, if QWEST is negative, and larval or juvenile delta smelt are within the entrainment zone of the pumps based on real-time sampling of spawning adults or young of year life stages. The 2019 Fish and Wildlife Service Biological Opinion permits incidental take through entrainment during March-June, under the ecological conditions of OMR flows managed at no more negative than -5000 cfs on a 14-day moving average or at the flow determined through use of Service-approved life cycle models to limit recruitment to stable levels. Reasonable and Prudent Measure 1, Term and Condition 6 requires Reclamation and DWR to use Service life cycle models or other Service-approved models when available for the purposes of estimating proportion of the population affected by entrainment.

Reclamation coordinated with the Service on the Life Cycle Model entrainment module and proposes to operationalize results through the management of OMR reverse flows. When the secchi depth in the south Delta is less than 1 meter, as determined by the weekly assessments based on Enhanced Delta Smelt Monitoring (EDSM) and other available data, Reclamation will operate to OMR no more negative than -3,500 cfs. When the secchi depth in the south Delta is greater than 1 meter, Reclamation and DWR will operate to OMR no more negative than -5,000 cfs. Reclamation and DWR shall prepare weekly assessments and coordinate with the Service through the smelt monitoring team. The assessments may consider real-time monitoring for the spatial distribution of Delta Smelt, hydrodynamic models, forecasts of entrainment, and other information to propose an alternative OMR between -3,500 and -5,000 cfs or more negative OMR during storm-related events. Reclamation and DWR shall finalize weekly assessments at the Water Operations Management Team (WOMT). If, after WOMT, Service representatives on

WOMT find the assessments are not technically sufficient, are not consistent with the analyzed effects of the Proposed Action and Incidental Take Statements, and/or do not consider a reasonable operation allowable under the Proposed Action, the Service may elevate the assessment to the Regional Directors of the Service and Reclamation.

I appreciate your ongoing efforts and those of your staff to coordinate on the operation of the CVP and SWP. Please let me know if you have concerns with this approach for water year 2020 and beyond, unless and until superseded by an updated memorandum. We look forward to working with you on potential improvements and refinements over the next year.

Attachment

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DSM TN 47. Predictions of Delta Smelt entrainment mortality for conservation planning

William Smith, 2 March 2020

The objective of this exercise was to predict proportional entrainment mortality of Delta Smelt as a function of Old and Middle River flow and South Delta Secchi depth.

Methods

Monte Carlo simulations were used to predict expected values of proportional entrainment mortality u_{s} for early and late postlarval lifestages *s* (PL1 and PL2) of Delta Smelt, given a set of Old and Middle River flow (OMR) and South Delta Secchi depth (Secchi) conditions and Delta Smelt population dynamics parameters from the fitted Life Cycle Model with Entrainment (LCME, Smith et al. 2019). In each iteration of the Monte Carlo simulation, random values of parameters γ, β, σ_{F} and σ_{M}, defined below, were drawn from their joint posterior distribution estimated during fitting of the LCME. This process was iterated 40,000 times, and the distribution of u_{s} calculated from these random values for a given set of OMR and Secchi values represented both parameter and process uncertainty. Representation of critical uncertainties facilitated a probabilistic approach to risk assessment.

u_{s} was calculated from instantaneous rates of entrainment mortality F and natural mortality M

$$u_{\mathrm{s}} = \frac{F_{\mathrm{s}} * (1 - e^{-(F_{\mathrm{s}} + M_{\mathrm{s}})})}{(F_{\mathrm{s}} + M_{\mathrm{s}})}.$$

Expected values of F depended on environmental conditions and regression parameters γ, and expected values of M depended on expected mean weight W_{s}, environmental conditions (mean June-August *Outflow*), and regression parameters β. In order to account for uncertainty in F and M, stochastic F and M were simulated from lognormal distributions

$$F_{\mathrm{s}} \sim \mathrm{Lognormal}\left(\left(\gamma_{0,\mathrm{s}} + \gamma_{1,\mathrm{s}} * OMR + \gamma_{2,\mathrm{s}} * Secchi + \gamma_{3,\mathrm{s}} * OMR * Secchi\right), \sigma_{\mathrm{F}}\right),$$

$$M_{\mathrm{PL1}} \sim \mathrm{Lognormal}\left(\left(\beta_0 + \beta_1 * W_{\mathrm{PL1}}\right), \sigma_{\mathrm{M}}\right), \text{ and}$$

$$M_{\mathrm{PL2}} \sim \mathrm{Lognormal}\left(\left(\beta_0 + \beta_1 * W_{\mathrm{PL2}} + \beta_3 * Outflow\right), \sigma_{\mathrm{M}}\right).$$

where the parameters σ_{F} and σ_{M} were the standard deviation parameters describing process variation.

As the value $(\beta_0 + \beta_1 * W_{\mathrm{PL1}})$ did not vary, expected values of M_{PL1} were calculated from an intercept-only model, while expected values of M_{PL2} were calculated as a function of 2002-2015 mean June-August outflow. Sensitivity analysis using the 2002-2015 minimum June-August outflow indicated that values of u_{s} were insensitive to this choice. As M_{PL2} represented a 2-3 month mortality value, while F_{PL2} (and therefore u_{PL2}) represented a single month at the beginning of the period beginning in June and ending in August, M_{PL2} was divided by three when calculating u_{PL2}.

Both OMR and Secchi disk depths in the south Delta affect entrainment predictions in LCME. Therefore, two sets of simulations were performed. One set a fixed value for Secchi depth and allowed OMR to vary across a wide range of values, and the second set fixed OMR at -6,500ft^3 and allowed Secchi to vary across a wide range of values. A target was defined at u = 0.10, and predictions were compared to this value. A precautionary approach was used to define risk tolerance, where risk was the probability that the target was exceeded. A risk tolerance of 25% (risk of exceeding target = 25%) was defined, so the upper quantiles of the posterior distributions of predicted u (25% of posterior density > reported value) were reported. This means that there is a 25% chance the target is exceeded at the OMR and Secchi conditions specified or a 100% minus 25% = 75% chance a target would not be exceeded under the specified conditions.

Results

Delta Smelt Life Cycle Model results are presented in Table 1 and Figure 1 to provide context for the mortality predictions generated in this Technical Note. During the period of highest entrainment mortality, 1999-2003, estimates of proportional entrainment mortality (posterior means) across early and late post-larval life stages (April-June) ranged 0.08-0.18 (8% to 18%) per year. In subsequent years 2004-2015, proportional entrainment mortality declined substantially, ranging 0.001-0.03 (0.1% to 3% per year). Most of the cumulative April-June entrainment mortality appeared to occur in April-May when fish are smaller on average. Average April-May and June OMR reached minimal (most negative) values during the same 1999-2003 period that entrainment mortality peaked, but average OMR was generally higher (less negative) subsequent to 2005. South Delta Secchi depths increased over the 1995-2015 time period (Fig. 2).

At the lowest levels of Secchi depth, which represent the most turbid water conditions (Fig. 2; 61cm) observed during 2007-2015, the upper quartile of cumulative April-June proportional entrainment mortality was predicted to increase from 0.05 to 0.10 (5% to 10%) over an OMR range of approximately -2,450 to -5,500ft^3 (Table 2; Fig. 3). In contrast, at the median 2007-2015 Secchi depth (99cm), the same change in the upper quartile of proportional entrainment mortality occurred over an OMR range of approximately -5,600 to -9,250ft^3. Using a negative OMR assumption of -6,500ft^3 (i.e., lower than the 2007-2015 minimum of -4,664ft^3; Fig. 4) the upper quartile of cumulative April-June proportional entrainment mortality increased from 0.05 to 0.10 (5% to 10%) at Secchi depths near the 2007-2015 median (Table 3).

Discussion

Target values of proportional entrainment mortality *u* representing a sustainable level of entrainment mortality cannot be defined given current Delta Smelt population dynamics. Defining a sustainable level of entrainment would require excess production of delta smelt. Collection of datasets used to fit the Delta Smelt Life Cycle Model only began in 1995, after the Delta Smelt was listed as a threatened species, in decline, and no longer generated excess production. The delta smelt population has declined for several reasons; thus, even if it were possible to achieve entrainment mortality of 0, it would not likely result in population growth.

Flexibility in managing entrainment risk

The value *u* represents the combination of two competing source of mortality. Importantly, as natural mortality increases, the same number of entrained individuals results in increasingly greater entrainment mortality. A dynamic strategy to evaluating future entrainment risk could include some consideration of natural mortality. In years when high natural mortality rates are expected, target *u* will occur at slightly less negative OMR, while in years when low natural mortality is expected, target *u* will occur at slightly more negative OMR. Unfortunately, the current configuration of the Delta Smelt Life Cycle Model does not include covariates for early post-larval natural mortality, which could be used to identify high and low mortality conditions.

The Life Cycle Model does include June-August outflow as a covariate for late post-larval natural mortality, but most natural mortality is expected to occur after entrainment (June) during this seasonal period (June-August). Historically, only a small fraction of the total cumulative entrainment mortality has occurred in June, and predicted June *u* was not sensitive to the value of natural mortality. In other words, consideration of late post-larval (summer) natural mortality is unlikely to lead to greater flexibility in defining conservation thresholds for OMR management, while identification of early post-larval natural mortality covariates could leverage greater flexibility.

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Literature Cited

Smith, W.E., Polanksy, L.P., and Nobriga, M.N. 2019. Disentangling trends in entrainment and natural mortality an endangered estuarine fish using a stage-structured population model. Final report submitted to California Department of Water Resources under the Delta Smelt Life Cycle Model grant.

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Table 1. Posterior summaries of proportional entrainment mortality estimated for Delta Smelt post-larvae during years 1995-2015. Median posterior values are listed, and 95% credible intervals are shown in parentheses. Early post-larvae represents the April-May time period, late post-larvae represents the June time period, and all post-larvae represents the cumulative April-June total.

Year	Early post-larvae	Late post-larvae	All post-larvae
1995	0.0032 (0.0005-0.0192)	0.0002 ($4.1e^{-5}$ -0.0007)	0.0032 (0.0006-0.0185)
1996	0.0404 (0.0117-0.1332)	0.0029 (0.001-0.0086)	0.0327 (0.0106-0.104)
1997	0.0508 (0.0146-0.1564)	0.004 (0.0016-0.0098)	0.0372 (0.0126-0.1098)
1998	0.0022 (0.0003-0.0155)	0.0005 (0.0001-0.0035)	0.0025 (0.0004-0.0149)
1999	0.1343 (0.0417-0.4016)	0.0214 (0.0091-0.0501)	0.1304 (0.0475-0.3605)
2000	0.1444 (0.0435-0.4412)	0.0074 (0.0028-0.0192)	0.1091 (0.0368-0.3327)
2001	0.0884 (0.0285-0.2595)	0.0106 (0.0037-0.0304)	0.0812 (0.0298-0.2245)
2002	0.2488 (0.0867-0.6352)	0.0075 (0.0028-0.0201)	0.1838 (0.0676-0.491)
2003	0.1655 (0.0517-0.4782)	0.0108 (0.0039-0.0302)	0.1235 (0.0434-0.3557)
2004	0.0406 (0.0096-0.1451)	0.006 (0.0025-0.0145)	0.0296 (0.0093-0.0945)
2005	0.0091 (0.0024-0.0328)	0.0012 (0.0004-0.0038)	0.0072 (0.0024-0.0235)
2006	0.0024 (0.0004-0.0145)	0.0002 ($3.7e^{-5}$ -0.0007)	0.0013 (0.0003-0.007)
2007	0.0129 (0.003-0.0486)	0.0025 (0.001-0.0064)	0.0093 (0.0031-0.0304)
2008	0.0186 (0.0045-0.0696)	0.0016 (0.0005-0.0045)	0.0128 (0.0038-0.0448)
2009	0.0074 (0.0021-0.0256)	0.001 (0.0004-0.0026)	0.0046 (0.0017-0.0136)
2010	0.0038 (0.0008-0.0163)	0.0001 ($2.3e^{-5}$ -0.0004)	0.0026 (0.0006-0.0109)
2011	0.0076 (0.0011-0.0505)	0.0002 (0.0001-0.0009)	0.007 (0.0012-0.0454)
2012	0.0301 (0.0087-0.099)	0.0013 (0.0005-0.0033)	0.0185 (0.0063-0.0585)
2013	0.0209 (0.0063-0.0655)	0.0002 (0.0001-0.0007)	0.0132 (0.0041-0.0419)
2014	0.0061 (0.0013-0.0264)	0.000041 ($1.0e^{-5}$ -0.0002)	0.0041 (0.0009-0.0173)
2015	0.0266 (0.0069-0.0979)	0.0001 ($3.7e^{-5}$ -0.0006)	0.015 (0.004-0.0566)

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Table 2. Upper quantiles of predicted entrainment mortality (1/4 of predictions above reported value, ¾ of predictions below) at the minimum and median levels of Secchi depth observed during April-June during 2007-2015, over a range of Old and Middle River flow (OMR). Entrainment mortality for two life stages (PL1, PL2; early and late post-larval) and the combination of both life stages are presented.

Legend
A = proportion F >=0.1
B = proportion F between 0.05 and 0.1
C = proportion F <=0.05

OMR	Early post-larvae (Low secchi = 61 cm)	Late post-larval (Low secchi = 61 cm)	All post-larvae (Low secchi = 61 cm)	Early post-larvae (Median secchi = 99 cm)	Late post-larvae (Median secchi = 99 cm)	All post-larvae (Median secchi = 99 cm)
-10,237	0.351^{A}	0.008^{C}	0.253^{A}	0.170^{A}	0.003^{C}	0.117^{A}
-9,899	0.332^{A}	0.008^{C}	0.238^{A}	0.158^{A}	0.003^{C}	0.110^{A}
-9,560	0.314^{A}	0.007^{C}	0.225^{A}	0.150^{A}	0.003^{C}	0.105^{A}
-9,221	0.295^{A}	0.006^{C}	0.210^{A}	0.141^{A}	0.003^{C}	0.098^{A}
-8,883	0.280^{A}	0.006^{C}	0.199^{A}	0.132^{A}	0.003^{C}	0.098^{B}
-8,544	0.263^{A}	0.005^{C}	0.185^{A}	0.124^{A}	0.002^{C}	0.086^{B}
-8,206	0.243^{A}	0.005^{C}	0.171^{A}	0.116^{A}	0.002^{C}	0.081^{B}
-7,867	0.224^{A}	0.005^{C}	0.157^{A}	0.111^{A}	0.002^{C}	0.076^{B}
-7,529	0.215^{A}	0.004^{C}	0.150^{A}	0.104^{A}	0.002^{C}	0.072^{B}
-7,190	0.201^{A}	0.004^{C}	0.140^{A}	0.097^{B}	0.002^{C}	0.067^{B}
-6,852	0.185^{A}	0.004^{C}	0.128^{A}	0.092^{B}	0.002^{C}	0.064^{B}
-6,513	0.174^{A}	0.003^{C}	0.121^{A}	0.086^{B}	0.002^{C}	0.059^{B}
-6,174	0.161^{A}	0.003^{C}	0.113^{A}	0.081^{B}	0.002^{C}	0.056^{B}
-5,836	0.150^{A}	0.003^{C}	0.103^{A}	0.076^{B}	0.001^{C}	0.052^{C}
-5,497	0.138^{A}	0.003^{C}	0.097^{B}	0.071^{B}	0.001^{C}	0.049^{C}
-5,159	0.131^{A}	0.003^{C}	0.091^{B}	0.068^{B}	0.001^{C}	0.046^{C}
-4,820	0.122^{A}	0.002^{C}	0.085^{B}	0.064^{B}	0.001^{C}	0.044^{C}
-4,482	0.113^{A}	0.002^{C}	0.078^{B}	0.060^{B}	0.001^{C}	0.041^{C}
-4,143	0.105^{A}	0.002^{C}	0.072^{B}	0.057^{B}	0.001^{C}	0.039^{C}
-3,805	0.099^{A}	0.002^{C}	0.068^{B}	0.053^{C}	0.001^{C}	0.036^{C}
-3,466	0.092^{B}	0.002^{C}	0.063^{B}	0.050^{C}	0.001^{C}	0.035^{C}
-3,128	0.085^{B}	0.002^{C}	0.059^{B}	0.048^{C}	0.001^{C}	0.033^{C}
-2,789	0.078^{B}	0.002^{C}	0.054^{B}	0.045^{C}	0.001^{C}	0.031^{C}
-2,450	0.073^{B}	0.001^{C}	0.051^{C}	0.042^{C}	0.001^{C}	0.029^{C}
-2,112	0.068^{B}	0.001^{C}	0.047^{C}	0.040^{C}	0.001^{C}	0.027^{C}
-1,773	0.065^{B}	0.001^{C}	0.044^{C}	0.037^{C}	0.001^{C}	0.026^{C}
-1,435	0.059^{B}	0.001^{C}	0.040^{C}	0.036^{C}	0.001^{C}	0.025^{C}
-1,096	0.055^{B}	0.001^{C}	0.038^{C}	0.034^{C}	0.001^{C}	0.023^{C}
-758	0.051^{C}	0.001^{C}	0.035^{C}	0.032^{C}	0.001^{C}	0.022^{C}
-419	0.048^{C}	0.001^{C}	0.033^{C}	0.031^{C}	0.001^{C}	0.021^{C}
-81	0.044^{C}	0.001^{C}	0.031^{C}	0.029^{C}	0.001^{C}	0.020^{C}
258	0.042^{C}	0.001^{C}	0.029^{C}	0.027^{C}	0.001^{C}	0.019^{C}
596	0.039^{C}	0.001^{C}	0.026^{C}	0.026^{C}	0.000^{C}	0.018^{C}
935	0.036^{C}	0.001^{C}	0.025^{C}	0.025^{C}	0.000^{C}	0.017^{C}
1,274	0.034^{C}	0.001^{C}	0.023^{C}	0.023^{C}	0.000^{C}	0.016^{C}
1,612	0.032^{C}	0.001^{C}	0.022^{C}	0.022^{C}	0.000^{C}	0.015^{C}
1,951	0.030^{C}	0.001^{C}	0.020^{C}	0.021^{C}	0.000^{C}	0.014^{C}
2,289	0.027^{C}	0.001^{C}	0.019^{C}	0.020^{C}	0.000^{C}	0.014^{C}
2,628	0.026^{C}	0.000^{C}	0.017^{C}	0.019^{C}	0.000^{C}	0.013^{C}
2,966	0.024^{C}	0.000^{C}	0.017^{C}	0.018^{C}	0.000^{C}	0.013^{C}
3,305	0.022^{C}	0.000^{C}	0.015^{C}	0.017^{C}	0.000^{C}	0.012^{C}
3,643	0.021^{C}	0.000^{C}	0.014^{C}	0.017^{C}	0.000^{C}	0.011^{C}
3,982	0.020^{C}	0.000^{C}	0.014^{C}	0.016^{C}	0.000^{C}	0.011^{C}

OMR	Early post-larvae (Low secchi = 61 cm)	Late post-larval (Low secchi = 61 cm)	All post-larvae (Low secchi = 61 cm)	Early post-larvae (Median secchi = 99 cm)	Late post-larvae (Median secchi = 99 cm)	All post-larvae (Median secchi = 99 cm)
4,321	0.018^{C}	0.000^{C}	0.012^{C}	0.015^{C}	0.000^{C}	0.010^{C}
4,659	0.017^{C}	0.000^{C}	0.012^{C}	0.014^{C}	0.000^{C}	0.010^{C}
4,998	0.016^{C}	0.000^{C}	0.011^{C}	0.014^{C}	0.000^{C}	0.009^{C}
5,336	0.015^{C}	0.000^{C}	0.010^{C}	0.013^{C}	0.000^{C}	0.009^{C}
5,675	0.014^{C}	0.000^{C}	0.009^{C}	0.013^{C}	0.000^{C}	0.009^{C}
6,013	0.013^{C}	0.000^{C}	0.009^{C}	0.012^{C}	0.000^{C}	0.008^{C}
6,352	0.012^{C}	0.000^{C}	0.008^{C}	0.012^{C}	0.000^{C}	0.008^{C}

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Table 3. Upper quantiles of predicted entrainment mortality (1/4 of predictions above reported value, ¾ of predictions below) at a low level of Old and Middle River flow (OMR), over a range of secchi depth. Entrainment mortality for two life stages (PL1, PL2; early and late post-larval) and the combination of both life stages are presented.

Legend
A = proportion F >=0.1
B = proportion F between 0.05 and 0.1
C = proportion F <=0.05

South Delta Secchi	Early post-larvae (OMR = -6500ft^3)	Late post-larvae (OMR = -6500ft^3)	All post-larvae (OMR = -6500ft^3)
35.9	0.885^A	0.069^C	0.775^A
37.9	0.869^A	0.063^C	0.752^A
39.8	0.851^A	0.055^C	0.723^A
41.7	0.833^A	0.048^C	0.700^A
43.6	0.813^A	0.043^C	0.675^A
45.5	0.786^A	0.038^C	0.644^A
47.5	0.755^A	0.034^C	0.610^A
49.4	0.731^A	0.030^C	0.584^A
51.3	0.697^A	0.027^C	0.547^A
53.2	0.664^A	0.024^C	0.521^A
55.1	0.633^A	0.021^C	0.487^A
57.1	0.597^A	0.019^C	0.452^A
59.0	0.563^A	0.017^C	0.423^A
60.9	0.526^A	0.015^C	0.393^A
62.8	0.493^A	0.013^C	0.361^A
64.7	0.455^A	0.012^C	0.334^A
66.7	0.421^A	0.011^C	0.308^A
68.6	0.387^A	0.009^C	0.281^A
70.5	0.358^A	0.008^C	0.260^A
72.4	0.329^A	0.008^C	0.236^A
74.3	0.303^A	0.007^C	0.215^A
76.3	0.276^A	0.006^C	0.195^A
78.2	0.251^A	0.005^C	0.176^A
80.1	0.227^A	0.005^C	0.160^A
82.0	0.207^A	0.004^C	0.145^A
83.9	0.191^A	0.004^C	0.133^A
85.9	0.170^A	0.003^C	0.119^A
87.8	0.156^A	0.003^C	0.108^A
89.7	0.142^A	0.003^C	0.098^A
91.6	0.127^A	0.002^C	0.088^B
93.5	0.115^A	0.002^C	0.079^B
95.5	0.105^A	0.002^C	0.073^B
97.4	0.094^B	0.002^C	0.065^B
99.3	0.085^B	0.002^C	0.059^B
101.2	0.078^B	0.001^C	0.053^B
103.1	0.070^B	0.001^C	0.048^C
105.1	0.062^B	0.001^C	0.043^C
107.0	0.057^B	0.001^C	0.039^C
108.9	0.051^C	0.001^C	0.035^C
110.8	0.047^C	0.001^C	0.032^C

South Delta Secchi	Early post-larvae (OMR = -6500ft^3)	Late post-larvae (OMR = -6500ft^3)	All post-larvae (OMR = -6500ft^3)
112.7	0.041^C	0.001^C	0.029^C
114.7	0.038^C	0.001^C	0.026^C
116.6	0.035^C	0.001^C	0.024^C
118.5	0.031^C	0.001^C	0.021^C
120.4	0.028^C	0.001^C	0.019^C
122.3	0.025^C	0.000^C	0.017^C
124.3	0.023^C	0.000^C	0.015^C
126.2	0.020^C	0.000^C	0.014^C
128.1	0.019^C	0.000^C	0.013^C
130.0	0.017^C	0.000^C	0.012^C

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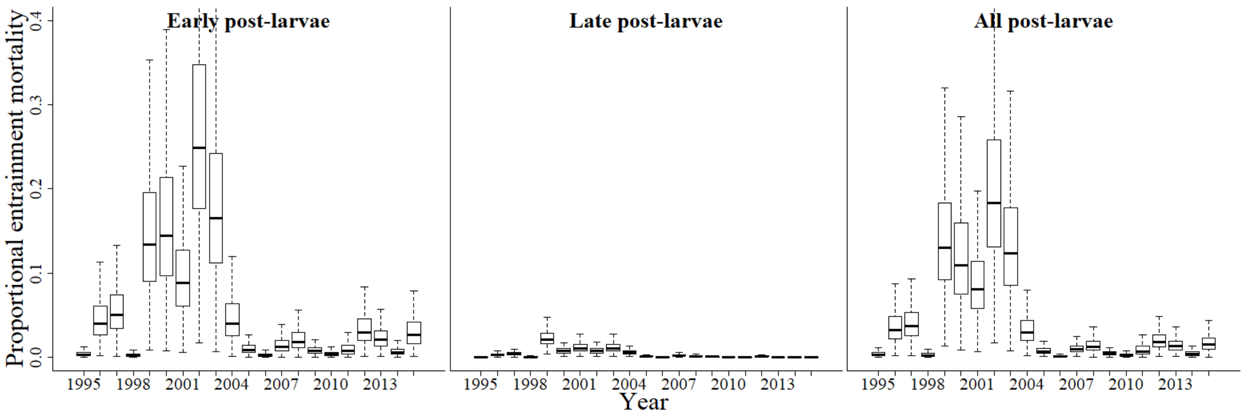

Figure 1. Time series of post-larval proportional entrainment posterior distributions from the fitted Delta Smelt Life Cycle Model. Early post-larvae represents the April-May time period, late post-larvae represents the June time period, and all post-larvae represents the cumulative April-June total.

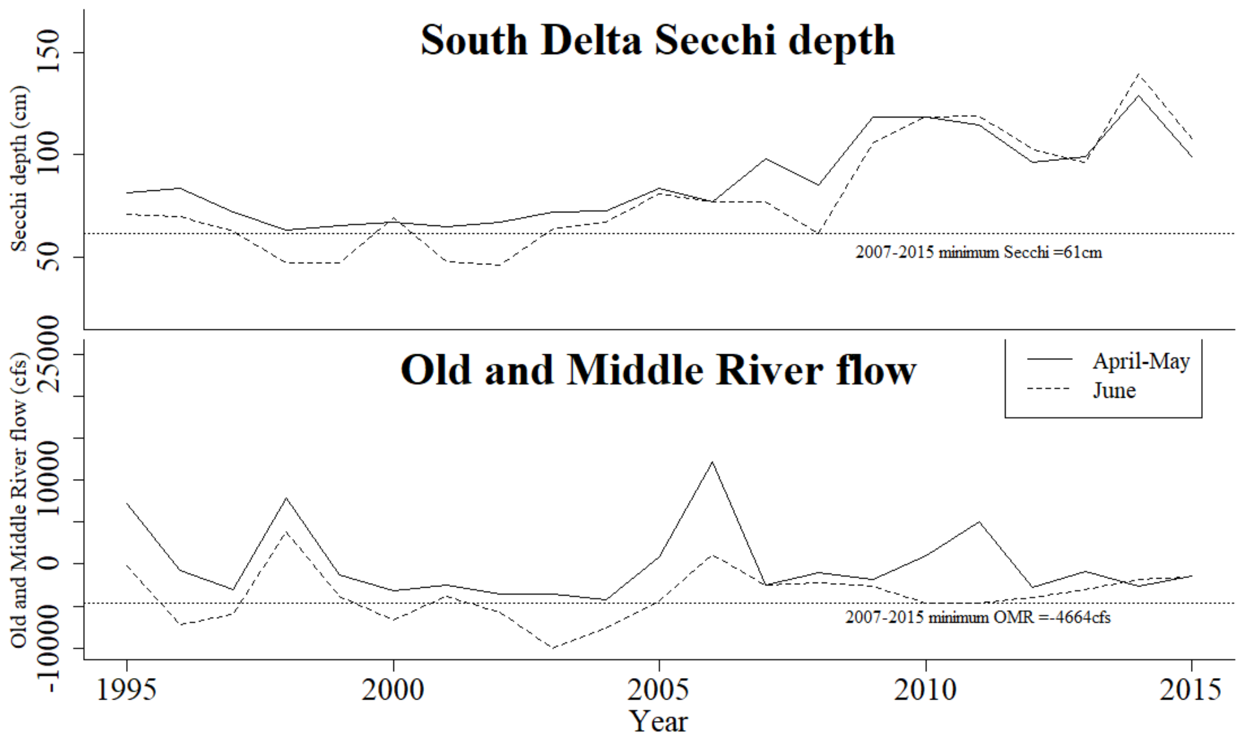

Figure 2. Time series of post-larval entrainment variables used to fit the Delta Smelt Life Cycle Model with Entrainment.

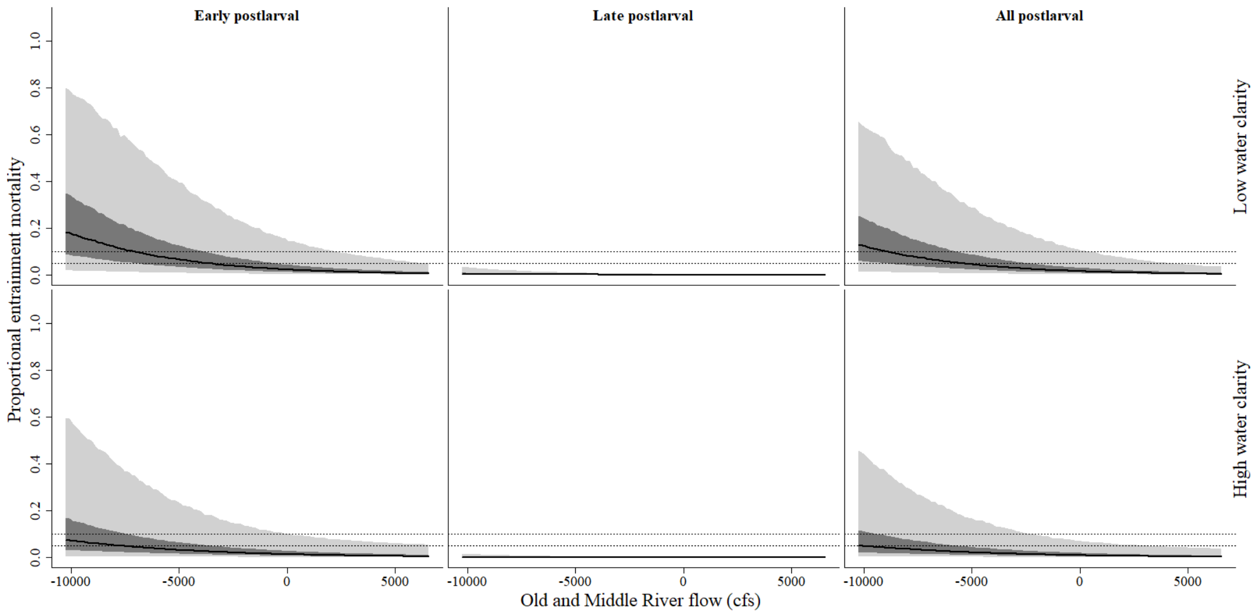

Figure 3. Predicted proportional entrainment mortality at the minimum (upper panels) and median (lower panels) levels of secchi depth observed during April-June during 2007-2015. Dotted reference lines show mortality values of 0.10 and 0.05. The solid black line indicates the medians of predicted proportional entrainment mortality, the dark gray bands indicate the interquartile ranges of proportional entrainment mortality, and the light gray bands indicate the 95% credible intervals. The upper edge of the gray bands correspond to the upper quantile of predicted proportional entrainment mortality that were used to define the limit of exceedance probability.

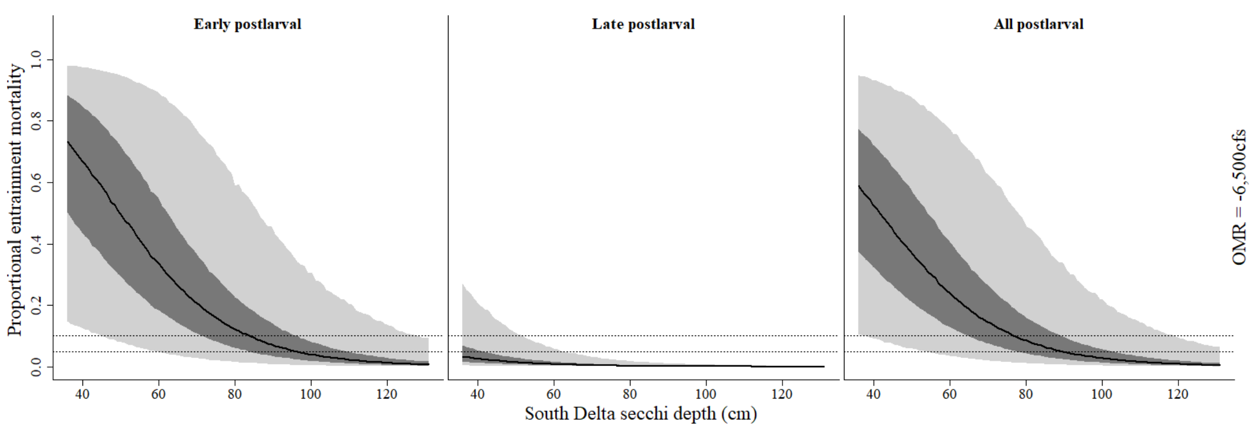

Figure 4. Predicted proportional entrainment mortality at a low level of OMR, across a range of South Delta Secchi depths. Dotted reference lines show mortality values of 0.10 and 0.05. The solid black line indicates the medians of predicted proportional entrainment mortality, the dark gray bands indicate the interquartile ranges of proportional entrainment mortality, and the light gray bands indicate the 95% credible intervals.