compass

Action Specification Sheet:
Suisun Marsh Salinity Control Gates

1 Short Description and Hypothesized Bottleneck

The Suisun Marsh Salinity Control Gates, which are normally operated from October to May, prevent saltwater from entering the marsh during high tide and open to allow freshwater into the marsh during low tide, thereby reducing marsh salinity. The action suggests that through off-season operation of these gates during dry summer months, habitat suitability can be improved for delta smelt such that they will make more use of this area.

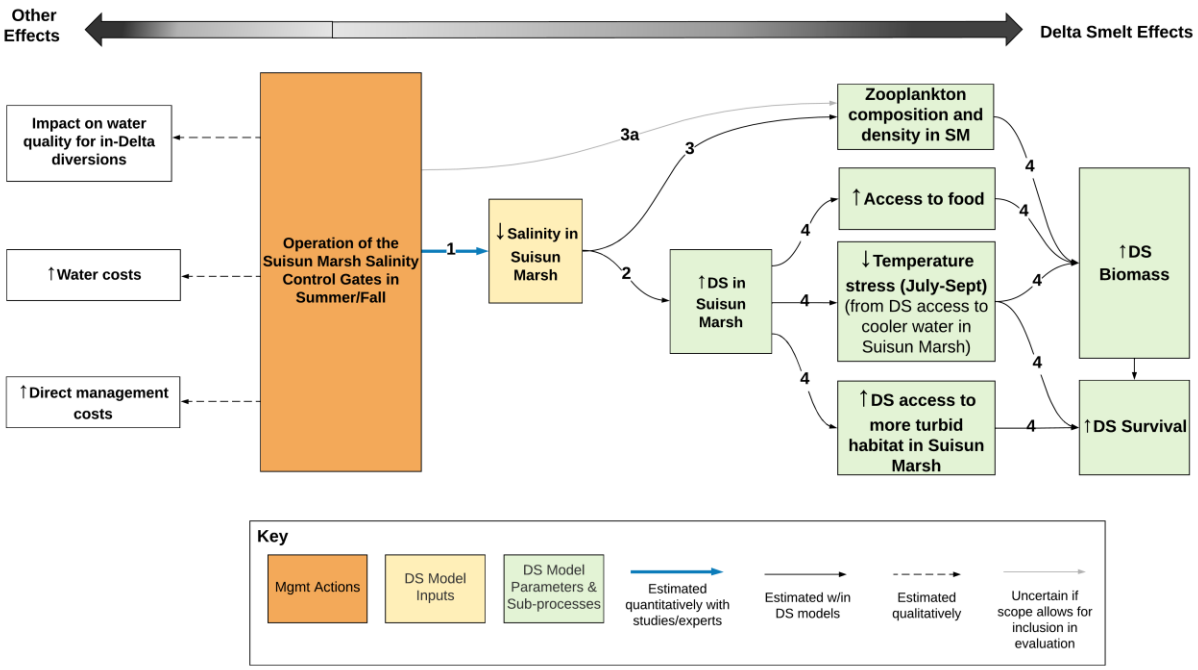
This action was analyzed as a Resiliency Strategy Action in the Compass Demo SDM project.

The 2019 update to the Resiliency Strategy says:

> With support from a coalition of agencies, water contractors, and local land managers, DWR completed a major SMSCG action in August 2018. The action included operation of the SMSCG for the entirety of August, during which the State Water Contractors (SWC) provided additional Delta outflow to maximize its efficacy. The action successfully improved habitat conditions during late summer 2018, as evidenced by better marsh water quality […] and apparent colonization by Delta Smelt shortly after the initiation of gate operations […].

In 2018 DWR issued a Suisun Marsh Salinity Gates Pilot Study (GEI 2018), followed by a Work Plan for Monitoring and Assessment of Suisun Marsh Salinity Control Gates Action, 2020-2021 (Hartman 2020). To support the adaptive management of the action, DWR is planning to monitor the change in water quality, phytoplankton, zooplankton, fishes, and clams resulting from the action. The monitoring plan will use data collected by the Interagency Ecological Program's (IEP) long-term monitoring programs when possible, supplemented with targeted sample collection where existing surveys lack spatial or temporal coverage. It will also be modeling the change in Delta Smelt habitat based on area of open water with appropriate temperature, salinity, and turbidity.

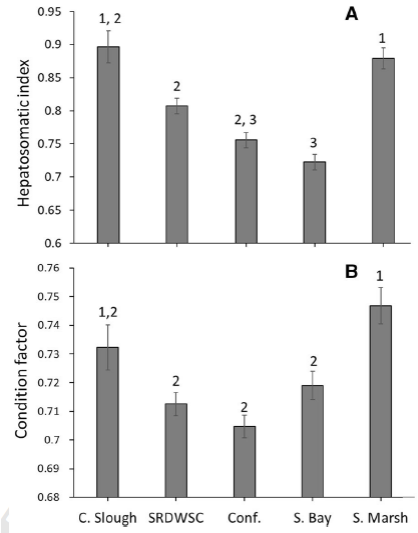
2 Influence Diagram



3 Action Evaluation

#	Effect Hypothesis	Estimation Method For Round 1 SDM Evaluation
Delta Smelt		
1	Operation of Gates in Summer / Fall → Salinity in Suisun Marsh RMA-USBR (2021) modeled SMSCG action in BN, AN, and wet years against a baseline scenario that includes Sept/Oct X2=80 in wet and AN years, and shows: • salinity at Belden's Landing is < 6 psu in the No Action scenario 89-100% of the time in June and July • SMSCG operation results in biggest improvement in salinity suitability in August and Sept. • In October, salinity is <6 psu at Belden's Landing for 65% to 78% of time in the no action scenario (see pg. 44)	**In Portfolio #1b, approximate ROD (2020) and ITP (2020) criteria by assuming (R. Hartman, pers. comm., Jan. 25, 2022; also see SMSCG Monitoring Plan for 2020 pg. 76-77 in pdf):** • <6 ppt or 10,000 µS/cm salinity in Suisun Marsh, June 1 to Oct. 31, in wet years (if beneficial) (ROD, 2020) • <4 ppt or 6800 µS/cm salinity in Suisun Marsh, June 1 to Oct. 31, in above normal and below normal years (ITP, 2020) • <4 ppt salinity in Suisun Marsh, June 1 to Oct. 31, in dry years following wet and above normal years (ITP, 2020) – the 100 TAF block of water in ITP will be used to support gates action in this year type. • <6 ppt salinity in Suisun Marsh, Aug. 1 to Sept. 30, in dry years following below normal years (ITP, 2020) – There is no 100 TAF in this year (because previous year was BN), hence the salinity criteria is higher. In drier years, the SMSCG often start operating early (in September as opposed to October) for the duck club purposes.

#	Effect Hypothesis	Estimation Method For Round 1 SDM Evaluation
		ROD (2020) and ITP (2020) include salinity criteria for Belden's Landing in Suisun Marsh, which is in the mid-point of Montezuma Slough. 6 ppt at Belden's Landing means that about half of SM < 6ppt and suitable for Delta Smelt. 4ppt at Belden's Landing means most of SM is <6 ppt. In our model years 1995-2015, this action is done in 8 of the 21 model years to meet ITP (2020) criteria and an additional 3 years with the ROD (2020) criteria: • 1996 (October) (Wet year) • 1997 (October) (Wet year) • 2000 (October) (Wet year) • 2001 (Dry year following wet year) • 2003 (AN year following dry year) • 2004 (BN year following AN year) • 2005 (BN year following a BN year) • 2007 (Dry year following a wet year) • 2010 (BN year following a dry year) • 2012 (BN year following a wet year) • 2013 (Dry year following a BN year) The ITP (2020) reserves 100 TAF for Delta Smelt in Wet and AN years and allows for deferral of this water to the next year, unless the next year is critical. CDFW/DWR would likely defer a portion of the 100TAF in W/AN years in case the next year is dry and they need this water for gate operations. The water cost of operating the gates in a dry year for 30 days is about 12-13 TAF (DWR, 2020).
2	**↓ Salinity in Suisun Marsh → ↑ DS in Suisun Marsh**	Compass and the TWG developed a method for changing distribution of Delta Smelt across subregions based on changes in salinity from management and historical patterns of distribution under similar salinity conditions. See Section 3.1 for more details. The Smith Distribution Sub-model for IBMR (Smith 2022) was also tested in initial model runs.
	DS in Suisun Marsh → ↑ DS condition indices (Hammock et al. 2022)	This pathway is not modeled directly. Would be good to think through the extent to which the IBMR does or does not capture this benefit of DS being in SM compared to other strata. IBMR predicts biomass as a function of zooplankton, turbidity, and temperature, which vary as

#	Effect Hypothesis	Estimation Method For Round 1 SDM Evaluation
		monthly averages over the 13 IBMR strata and 20 model years.  **Fig. 4** Mean (± SE) HSI (**A**) and CF (**B**) by region, averaged across all seasons. For HSI, sample sizes for each region were 126, 533, 461, 293, and 215, left to right. For CF, sample sizes for each region were 130, 577, 520, 304, and 218, left to right. Note that only 5 of the 126 fish collected from the Cache Slough Complex were from the fall, the season with the lowest mean HSI (Fig. 3). Differing numbers above the bars denote significant differences based on Tukey HSD tests
3	↓ Salinity in Suisun Marsh → changes to zooplankton	Effects of subregion-specific salinity on taxa-specific food density were estimated from the Bashevkin salinity-food model, fit to historical data (CRM 2022c). A similar version of this model was recently published (Bashevkin et al. 2023).
3a	Changes in flow → changes to zooplankton	**This pathway won't be modeled. It is an area of active discussion/research**. The DCG has considered evaluating this pathway in their work and found no available models/methods to estimate this effect for this action.
4	↑ DS in Suisun Marsh & changes to zooplankton → DS growth and survival	Captured within IBMR (Smith 2022)
	↓ Salinity in Suisun Marsh → ↑ Brazilian Water Weed (it can only survive in water with less than 5ppt salt content) (Borgnis and Boyer, 2015)	**This pathway won't be modeled. It is an area of active discussion/research.** DWR is doing annual mapping of SAV in Suisun Marsh and will adapt Gate operations as necessary if summer/fall operation is increasing SAV (R. Hartman, pers. comm., Jan. 25, 2022)**.**
	↓ Salinity in Suisun Marsh → possible effects to water temperature?	RMA-USBR (2021) found negligible changes to water temperature with operation of the SMSCG in the Summer/Fall.
Resources Required (water, money, other)		

#	Effect Hypothesis	Estimation Method For Round 1 SDM Evaluation
	Water Cost	Water cost estimates available through the DCG SFHA modeling. DWR (2020) did modeling runs with DSM2 to estimate the water cost – they did multiple scenarios with operating the gates for 30 days in a dry year and the water cost was between 12 to 13 TAF for operating the gates biweekly from Aug. 3, 2020 to Sept. 23, 2020. The daily extra flow needed was between 117 and 127 cfs. In this modeling, exports were used to absorb the water cost of the SMSCG action. For WY 2022, DCG did additional estimation of water costs and found (Contact Rosemary Hartman, DWR, for documentation): • SMSCG action targeting 4ppt in Suisun Marsh for a Below Normal year = 69 TAF • SMSCG action targeting 6 ppt in Suisun Marsh for a BN year = 63 TAF

3.1 Effect pathway #2: distribution of Delta Smelt

Compass developed a method for changing distribution of Delta Smelt across subregions based on changes in salinity from management and historical patterns of distribution under similar salinity conditions. Specifically, performed the following steps to specify new distributions for the SMSCG action in management months.

1) We took the salinity value (PSU) for each month that received management in the SMSCG action (e.g., October 1996).
2) We searched for the salinity value from baseline IBMR inputs (i.e., historical conditions) in the management month across all model years. For example, we searched all salinity values in October from 1995 to 2014.
3) For the month-year when salinity was closest to the new salinity under management conditions, we extracted the % Delta Smelt distribution in Suisun Marsh and used this value as the new distribution in the management month-year.
4) We adjusted % distribution in all other subregions using the historical distributions from the management month-year and adjusting them proportionally to account for the change in distribution in Suisun Marsh, so that distributions would sum to 1.

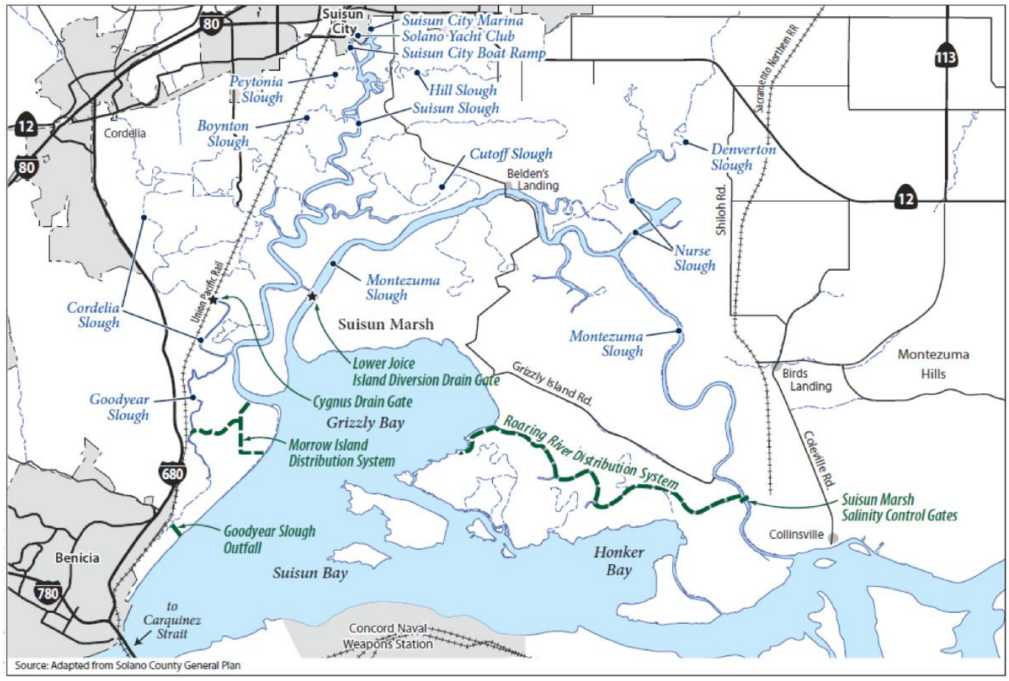
The method was reviewed, discussed, and modified to the version presented above during the 4 Nov 2022 TWG meeting. Conceptually, this method also aligns with the one used to predict new Delta Smelt distributions from changing X2 location (CRM 2022a).

Table 1: Example for changing distribution in October 1996 due to a simulated reduction in salinity to 6 PSU from the SMSCG action.

Subregion	Distribution (baseline, Oct 1996)	Distribution in SM in Oct with closest historical salinity (Oct 2002, 6.1 PSU) to mgmt conditions (6 PSU)	New distribution (mgmt)
Yolo Bypass	0%		0%

Upper Sacramento	0%		0%
South Delta	0%		0%
East Delta	0%		0%
Lower Sacramento	30%		28%
Lower San Joaquin	0%		0%
Confluence	17%		16%
South Suisun East	30%		28%
North Suisun East	8%		8%
Suisun Marsh	8%	14%	14%
South Suisun West	0%		0%
North Suisun West	7%		7%

4 Location(s)



5 Timing / Lifestage / Triggering Conditions

Summer months; up to 60 additional days between June 1 – October 31, depending on year type.

5.1 Table 9a from ITP

The table below shows the regulatory requirements for the Summer Fall Habitat Action in the ITP (2020).

Table 2: Table 9a from ITP (2020)

Month	Water Year Type (SVI)				
	Wet	Above-normal	Below-normal	Dry	Critical
June	Additional 100 TAF Delta outflow, June through October**	Criteria: Operate SMSCG for 60 days*	Criteria: Operate SMSCG for 60 days*	Criteria: In dry years following below-normal years operate SMSCG for 30 days*	No action
July		Additional 100 TAF Delta outflow, June through October**			

August			
September	Criteria: 30-day average X2 ≤ 80km	Criteria: 30-day average X2 ≤ 80km	Criteria: In dry years following wet or above-normal water years operate SMSCG for 60 days* ***
October			
*** Water necessary to implement SMSCG operations may be provided through export curtailments supported by the SWP Contractors through a commitment pursuant to Voluntary Agreements or as early implementation of such agreements.**			
**** If approved by CDFW the Additional 100 TAF may be deferred and redeployed to supplement Delta outflow the following water year during the March – October timeframe, unless the following water year is critical (see Condition of Approval 8.19). This use of the redeployed water is not intended to serve as a criteria.**			
***** CDFW anticipates deferring a portion of the 100 TAF received from an above normal or wet year when the following year is dry to facilitate SMSCG operation for 60 days in the absence of other available water.**			

6 Intensity Required

*[Describe the **extent** (or scale) to which the action needs to be applied to get the intended benefit – this could involve specifying multiple scales of interest]*

Hartman (2020), pg. 84 describes the following SMSCG action for the ITP:

> In Above Normal and Below Normal water years (SVI), ITP (2020) requires operation of the SMSCG for up to **60 days** between June 1 to Oct. 31 to maximize the number of days that the three-day average salinity at Beldon's landing in Suisun Marsh is less than 4ppt.
>
> In Dry water years (SVI) following above normal and wet years, ITP (2020) requires operation of the SMSCG for up to **30 days** between June 1 to Oct. 31 to maximize the number of days that the three-day average salinity at Beldon's landing in Suisun Marsh is less than 4ppt except. For Dry years following Below Normal years, a target three-day average salinity of 6ppt is used.
>
> This action is not done in wet years, critical years, or dry years following dry or critical years.

7 Evidence / Examples

[Provide evidence and examples that are relevant to specifying and evaluating the action]

RMA (2021) documents modeling of the SMSCG Summer/Fall Action – example modeling outputs are in the figures below and more can be found at the following website: [RMA Shiny Demo (rmanet.app).]

Figure 1: Changes in salinity (psu) with SMSCG operation in September of 1979 (Below Normal water year)

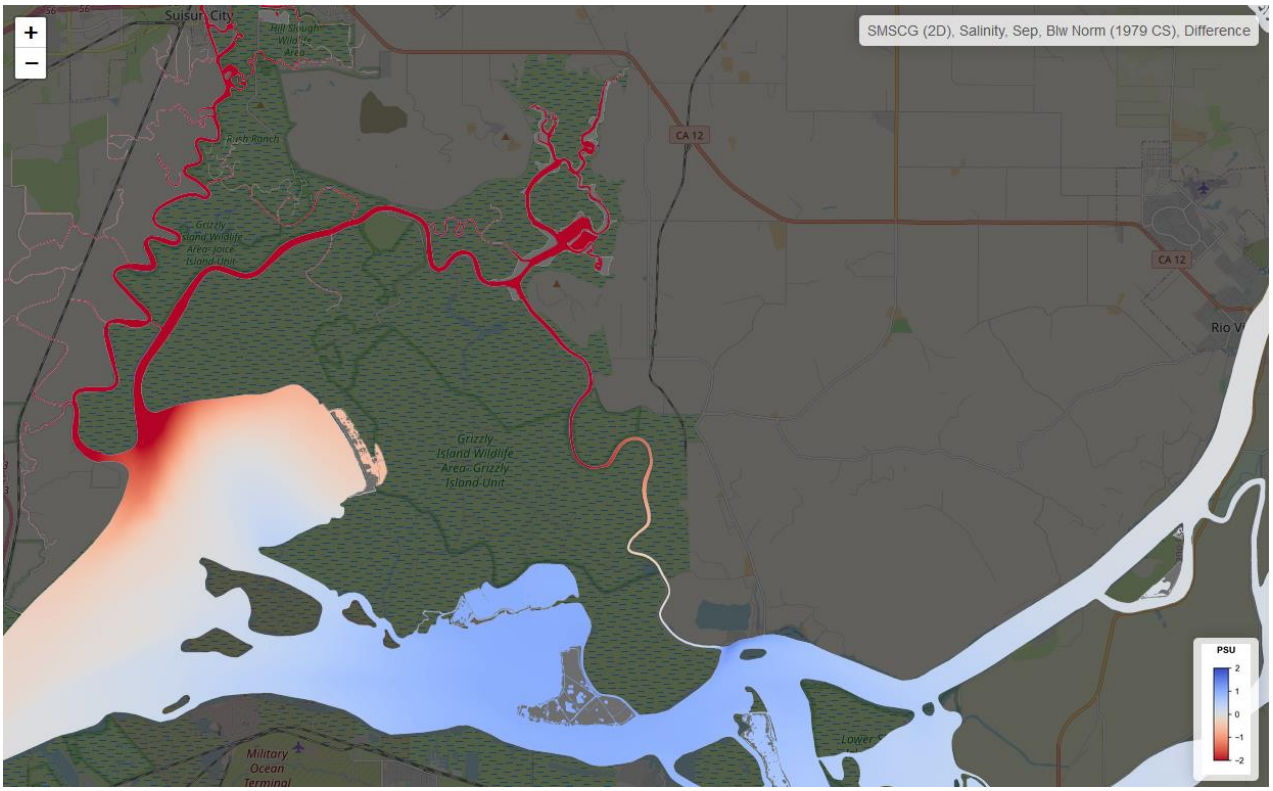


Figure 2: Changes in salinity (psu) with SMSCG operation in September of 1940 (Above Normal water year)

8 Delta Smelt Model Results

The table below shows predicted population outcomes across the 20-year model timeframe for several versions of the action that were tested with the IBMR and LF models.

		Population Growth Rate		% Change in Population Growth Rate from Baseline	
		IBMR	LF	IBMR	LF
Action run ID	Scenario name	Average lambda (1995-2014)	Average lambda (1995-2014)	% change in average lambda (1995-2014)	% change in average lambda (1995-2014)
5.1	SMSCG SumFall sal	0.98		0%	-
5.2	SMSCG SumFall sal, dist, sal-food med (Bashevkin)	0.99	0.86	0%	0%
5.3	SMSCG SumFall sal, dist, sal-food low (Bashevkin)	0.98		0%	-
5.4	SMSCG SumFall sal, dist, sal-food high (Bashevkin)	1.01		3%	-

- Multiple runs were used to explore population outcomes when only including the salinity effect of SMSCG (run 5.1), including the salinity effect and median food effect (5.2), and including the salinity effect and lower and upper 95% credible intervals of the food effect (5.3 and 5.4).
- **Action run 5.2 – which included effects on salinity, distribution, and the median effect on food – was used for Round 1 portfolio evaluation and sensitivity analyses.**

9 Key Contacts

- Rosemary Hartman, DWR – Principal Investigator for SMSCG action at DWR, Department of Water Resources Division of Environmental Services

10 References

Bashevkin, S.M., Burdi, C.E., Hartman, R., Barros, A., 2023. Long-term trends in seasonality and abundance of three key zooplankters in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science 21. https://doi.org/10.15447/sfews.2023v21iss3art1

Beakes, M. P., Graham, C., Conrad, J. L., White, J. R., Koohafkan, M., Durand, J., & Sommer, T. Large-scale flow management action drives estuarine ecological response. *North American Journal of Fisheries Management*, 41:64-77.

Borgnis E, Boyer KE. 2015. Salinity tolerance and competition drive distributions of native and invasive submerged aquatic vegetation in the Upper San Francisco Estuary. Estuaries and Coasts.1-11. 10.1007/s12237-015-0033-5.

Compass Resource Management (CRM), 2022a. Methods for predicting changes in Delta Smelt distribution across subregions due to X2 management actions (Technical Note). Prepared for CSAMP Delta Smelt SDM Technical Working Group (TWG). 3 Oct 2022.

Compass Resource Management (CRM), 2022c. Methods for predicting changes in zooplankton density due to salinity changes from management actions (Technical Note). Prepared for CSAMP Delta Smelt SDM Technical Working Group (TWG). 1 Nov 2022.

DWR, 2020. SMSCG Summer Operation Water Cost Analysis for March 2020 DCO Study. Provided to Compass by Rosemary Hartman (DWR).

Hammock, B.G. Rosemary Hartman. Randy A. Dahlgren. Catherine Johnston. Tomofumi Kurobe. Peggy W. Lehman. Levi S. Lewis. Erwin Van Nieuwenhuyse. Wilson F. Ramirez-Duarte. Andrew A. Schultz. Swee J. 2022. Patterns and predictors of condition indices in a critically endangered fish. *Hydrobiologia,* 849, 675-695.

Hartman, R. (2020). Draft Work Plan for Monitoring and Assessment of Suisun Marsh Salinity Control Gates Action, 2020-2021. June 1, 2020.

RMA 2021. Numerical Modeling in Support of Reclamation Delta Smelt Summer/Fall Habitat Analysis. Technical Memorandum, May 14, 2021. Prepared for: United States Bureau of Reclamation. Prepared by: Resource Management Associates. RMA Shiny Demo (rmanet.app)

Smith, W.E., 2022. A Delta Smelt Individual-Based Life Cycle Model in the R statistical environment (Technical Note). Prepared for CSAMP Delta Smelt SDM Technical Working Group (TWG). 15 Jul 2022.