Action Specification Sheet:

Managed Wetlands Flooding and Draining in Suisun Marsh; Roaring River Distribution System

1 Short Description and Hypothesized Bottleneck

The intent of this action is to modify and coordinate the flooding and draining of managed wetlands in Suisun Marsh to produce a pulse of food for Delta Smelt and other species. The managed wetlands of Suisun Marsh have the potential to produce zooplankton, phytoplankton, and small invertebrates. The CSAMP Delta Smelt SDM TWG has identified lack of food as a key hypothesized bottleneck for Delta Smelt. This action would involve coordinating the voluntary participation of public lands and private duck clubs to flood and drain their wetlands in such a way to produce food for Delta Smelt. There are about 50 private duck clubs that have wetlands that drain to areas commonly used by Delta Smelt, and there are also some CDFW managed wetlands in this area.

In 2017 and 2018, DWR and the Delta Conservancy partnered to evaluate and map the water infrastructure of managed wetlands in Suisun Marsh. This assessment collected data on each managed wetland's floodable acres and the status of their flood and drain infrastructure (pipe and drain locations, diameter of pipes etc.). DWR has also partnered with San Francisco State University to evaluate the food web effects of draining water from managed wetlands into open water and channel habitats of the marsh where Delta Smelt may reside. The infrastructure assessment and initial field evaluations are critical first steps to planning a pilot food web action in Suisun Marsh using managed wetlands.

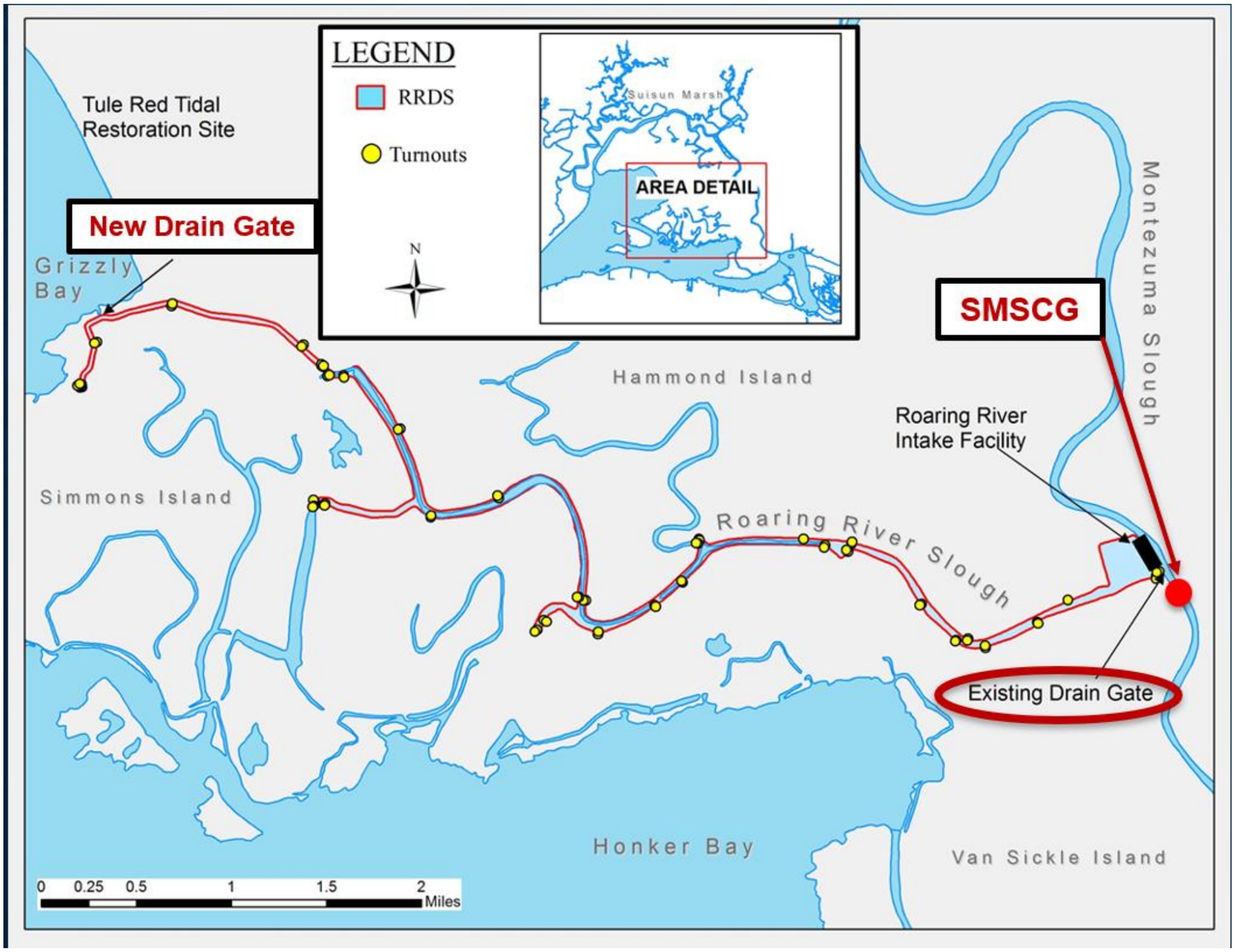
1.1 Roaring River Distribution System for food production

A component of the overall action to use managed wetlands to increase food in Suisun Marsh is coordinating wetland drain operations with the Roaring River Distribution System (RRDS). The Roaring River Intake Facility is a conveyance facility that takes water from Montezuma Slough across Grizzly Island to the other end (Figure 1). Managed wetlands take water from the Roaring River system because water from Montezuma Slough is fresher than water in Honker Bay or Grizzly Bay.

The RRDS would operate like a reservoir where water is brought in and retained in the system until food is produced and then food-rich water is drained out. Water could be drained through the existing drain gate into Montezuma Slough near the intake facility or into Grizzly Bay through a new gate installed in 2018.

The new gate on the western end of the system to allow draining into Grizzly Bay was completed by DWR and local partners in 2018 using funding from the Delta Smelt Resiliency Strategy. Starting in 2019, the RRDS became available to direct outflow from enriched wetlands into Grizzly Bay to enhance the smelt food web. The additional drain in the west will help convey water more quickly across the system from east to west, which will help meet duck club needs and will help foster relationships between duck clubs and DFW/DWR.

Figure 1. Map of Roaring River Distribution System

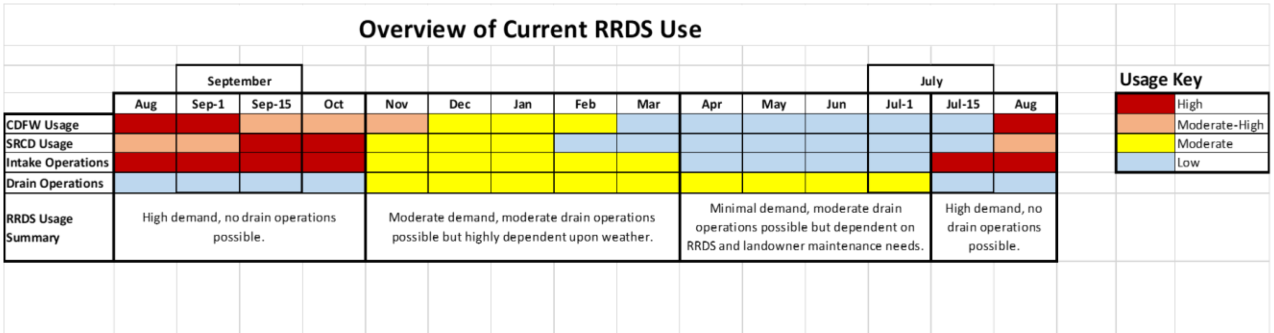


The timing of this action needs to consider two main factors: (1) when is it beneficial to produce food using the RRDS for Delta Smelt and (2) when is the RRDS available for use for food production purposes given that it is actively used to provide water to duck clubs at various times of the year.

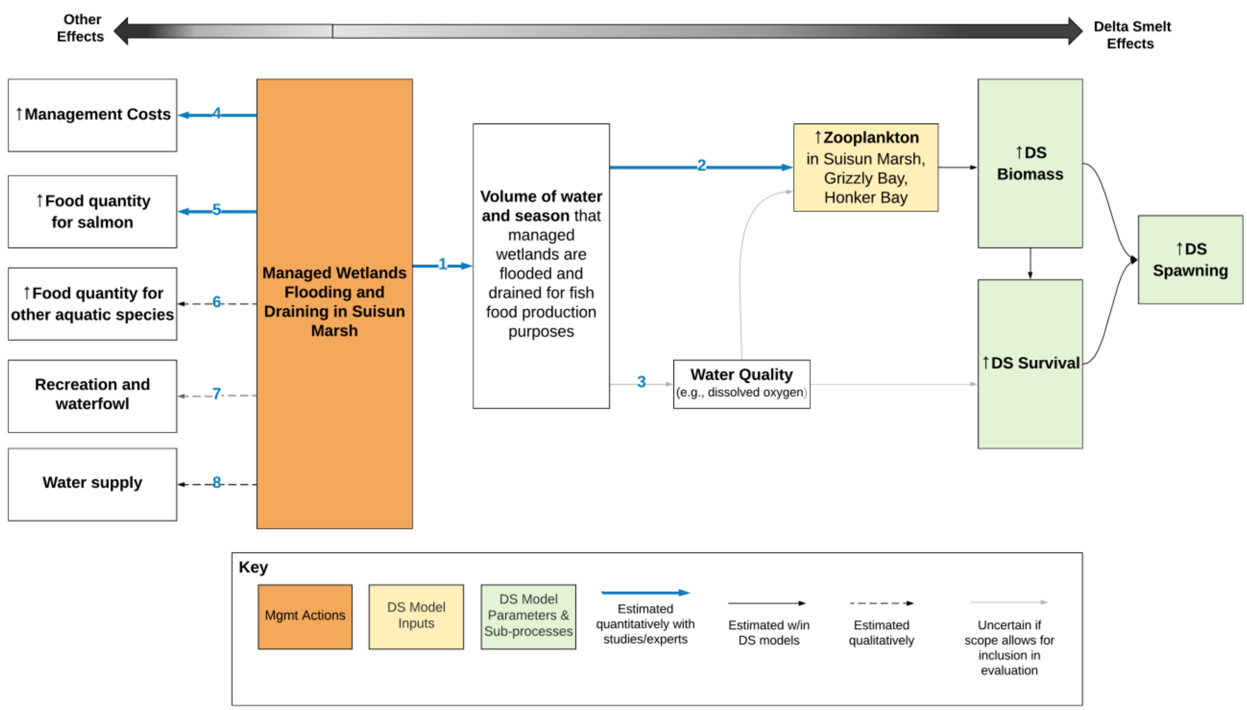
In 2019/2020, Rhiannon Klingonsmith (DWR) worked with CDFW and the Suisun Resource Conservation District (SRCD) to understand how private landowners in the area use the RRDS (SRCD represents all of the private landowners in Suisun Marsh). Their findings are summarized below and in the following table:

- Starting **August 1st** is the highest demand of water needs. This is fall flood up for waterfowl season, landowners flush salts out of their ponds and fill them up, and the intakes are bringing in water to freshen the system and meet demands. This peak usage period extends into October when waterfowl hunting season begins and more water is needed for supporting migrating waterfowl over the winter.
- From **Nov – Feb/March** water demand varies depending on the rain fall events. Generally little water is being used and managed wetlands have set intake gates to “circulation mode”
- **April – beginning of July** landowners are draining managed wetlands, not back into the system, but into nearby waterways and bays. During this time water levels can be lowered to help facilitate any repairs or projects along the system. Additionally, CDFW may pull water from RRDS to help support waterfowl brood ponds and provide wetlands for tule elk during the dry summer months.
- **August – October** is fall flood up and water is needed for landowners along the system again.

Figure 2. Overview of RRDS Use – Prepared by DWR in 2020 (Klingonsmith, 2021).



2 Influence Diagram



3 Action Evaluation

#	Effect Hypothesis	Effect Characterization within SDM Process
Delta Smelt		
1	**Volume of water and season that managed wetlands are flooded and drained for fish food production purposes.** This action relies on the voluntary participation of managed wetland owners. In addition, for this action to be possible on a managed wetland, the	Chappell et al. (2018) provides the best available information on which duck clubs have drainage infrastructure that is in optimal working order and could carry out this action – see Table 5 (pg. 14-15) in this study. This study also identifies which

	flooding and draining infrastructure needs to be in optimal working order, which includes managed wetlands flooding and draining within a 30-day period, reducing soil salinities through leaching cycles and irrigating desirable wetland plant communities, and improving water quality conditions to reduce low dissolved oxygen discharge events and decrease mosquito vector production for public health and safety (Chappell et al., 2018, pg. 5)	duck clubs could be in optimal working order if additional gravity drains are implemented. This information was used to specify multiple, potentially-feasible scales of the action (from 1,000 to 4,000 ac of managed wetlands) and multiple seasons when wetlands could be managed to produce food. The analysis assumes the water and infrastructure necessary to complete flood-drain cycles in up to 3 seasons per year.
2	**Volume of water & season → Zooplankton** Aha et al. (2021) find increased levels of zooplankton and higher juvenile salmon growth in managed wetlands compared to surrounding waters. See John Durand presentation here: https://mavensnotebook.com/2022/05/05/feature-wetland-responses-to-restoration-and-management/	Based on empirical monitoring data and expert judgment from Kyle Philips (Durand Lab, UC Davis). Data comes from 7 sites monitoring flood/drain operations in Mar-Apr. Effects for other time periods were based on expert judgment, since flooding/draining typically is not conducted in summer or fall. Results in this report represent model runs that assumed benefits to food in all three time periods. A description of the exercises and expert responses/assumptions are in Appendix 2 of this document. Tung et al. (2021) provides data to inform the quantification of this pathway (see pg. 27-28, 46-48).
3	**Volume of water & season → Water Quality (dissolved oxygen)** A key constraint of this action is meeting regulatory limits for low dissolved oxygen loading into the surrounding waters (there are new TMDL regulations for this).	This pathway was not captured in this SDM process. It is assumed that the implementation of this action will be managed in a way that meets dissolved oxygen regulations. This water quality issue is already managed in Suisun Marsh through staggering the flood and drain cycles of the ponds. There are water managers that ensure that all ponds are not draining at the same time and that dissolved oxygen regulations are being met (Klingonsmith, 2021).
Financial and water resources		
	Water cost	This pathway was not captured in this SDM process. Water supply impacts could be estimated in the future as specific implementation plans are formed for the action.

	Direct management costs	Estimate with available data & expert judgment from multiple sources. Final annualized cost estimates per ac included initial costs and annual operating costs and used an average of the upper and lower estimates. See Section 14 for details. **Final financial resource estimate: $580,007 per year 1,000 ac**

4 Location, intensity & timing

4.1 Current (background) operations

Normal operations of the managed wetlands in Suisun Marsh are to flood them in October, circulate the water on the site through the duck season, and then drain the wetlands in late January and early February. After draining, most duck clubs engage in a series of quick flooding and draining cycles to flush accumulated salts out of the wetlands (pers. comm, E. Loboschefsky, 2017).

The result of flooding these wetlands over the duck season is that they become large 'food engines' for zooplankton, phytoplankton, and small invertebrates. When the wetlands are drained in late January/early February, this food is exported into the receiving sloughs and channels around the marsh. It is also known that reduction in Dissolved Oxygen (DO) result from these draining as well as contaminants are discharged from the ponds and are currently regulated. The hypothesis is that this food then becomes available for Delta Smelt and longfin smelt to feed upon. Mid-winter is a period when Delta Smelt are present in the Suisun Marsh area because salinity levels are lower at this time (pers. comm, E. Loboschefsky, 2017). The flooding and draining of these wetlands is already coordinated at some level by the Suisun Resource Conservation District.

4.2 Modified operations scenarios for the SDM evaluation

The action proposed to be evaluated in the SDM process involves modifying/improving the coordination of flooding and draining operations in managed wetlands in a sequence that is hypothesized to be the best benefit to Delta Smelt. To specify versions of this action that will be evaluated in the SDM process, several options of location/intensity, seasonal timing, coordinated timing across wetlands, magnitudes of zooplankton peaks, and other factors were explored. Compass captured a range of estimates/scenarios for each factor and descriptions of the uncertainty and assumptions with each factor in the table below.

Table 1. Factors influencing potential food production from managed wetlands, ranges of estimates, and description of uncertainties/assumptions considered when constructing scenarios of this action to evaluate in Round 1 of the analysis.

Factor influencing food production from managed wetlands	Low estimate	Middle estimate	High estimate	Notes on uncertainty in assumption
# Acre-ft of additional wetlands participating in action	1,000 (~5%)	2,000 (~10%)	4,000 (~20%)	High estimate approximately corresponds to the total volume of privately-owned wetlands that could fully drain within 39 days, given current infrastructure (Chappell 2018). It is also roughly half of the 8,000 acres of wetlands on public land in Suisun Marsh. High uncertainty around potential participation of landowners.
# of flood and drain cycles per year for dedicated food production acres	1 Mar-Apr (current)	2 Mar-Apr; Jul-Aug	3 Mar-Apr; Jul-Aug; Sep-Oct	Relatively high uncertainty since there are limited or no existing data on zooplankton outcomes for flood/drain cycles outside of the Dec-Apr period. The number of possible flood cycles depends on site-specific infrastructure that may need upgrades for many wetlands. Kyle Phillips hypothesized that time between floods would need to be longer in cooler months to produce zooplankton blooms, and that flooding/draining managed wetlands every 4-6 months would provide sufficient rest periods for plant growth and seeding to occur that can stimulate zooplankton blooms." It is assumed that wetlands dedicated to food production could achieve one additional flood/drain cycle in the summer for the high estimate, relative to multi-use wetlands. Rosemary Hartman and Rhiannon Klingonsmith stated that multi-use wetlands would need to draw down water in the summer months for vegetation management that benefit duck hunting opportunities later in the year – but a second flood/drain cycle in Sep-Oct would be possible on these lands. Both types of wetlands would still need to provide sufficient rest time between floods to stimulate plant and zooplankton growth.
# of flood and drain cycles per year for multiple use acres	1 Mar-Apr (current)	2 Mar-Apr; Sep-Oct	2 Mar-Apr; Sep-Oct	
Seasonal timing of draining	Mar-Apr (current)	Mar-Apr; Sep-Oct	Mar-Apr; Jul-Aug; Sep-Oct	Timing reflects the following hypotheses: Mar-Apr – Increasing food in these months is intended to benefit larval Delta Smelt and corresponds to a period of relatively low suitable conditions for food in Suisun Marsh (Compass/TWG [2021] - the Dynamic Habitat Analysis Tool). It is assumed that wetlands for all uses could flood and drain during this period in minimum conflict with management for hunting opportunities (Rosemary Hartman and Rhiannon Klingonsmith, pers. comm.). Jul-Aug – Increasing food in these months is intended to provide additional resources to Delta

Factor influencing food production from managed wetlands	Low estimate	Middle estimate	High estimate	Notes on uncertainty in assumption
				Smelt during a period of thermal stress and improve survival. It is assumed that flooding/draining during this period would conflict with management goals for multi-use wetlands, so only food production wetlands could be used during this period. Sep-Oct – Increasing food in these months is intended to align food actions with Summer/Fall Habitat Actions that may increase the distribution of Delta Smelt in Suisun Marsh. Like Mar-Apr, this period also has relatively low suitable conditions for food in Suisun Marsh (Dynamic Habitat Analysis Tool). It is assumed that wetlands for all uses could flood and drain during this period in minimum conflict with management for hunting opportunities (Rosemary Hartman and Rhiannon Klingonsmith, pers. comm.).
Timing of draining (coordination among wetlands)	Spread draining evenly across focal months			Assume equal proportion of water is drained from wetlands for each focal month, such that peak zooplankton density is drained from each wetland. This also assumes a lower risk of DO stress, relative to all wetlands draining simultaneously.
Peak zooplankton density (inds/L) in flooded managed wetland under normal operations during first flood (Dec-Feb)	25.5	120.0	219.0	Relatively low uncertainty as these assumptions are based on monitoring data of zooplankton density in managed wetlands.
Peak zooplankton density (inds/L) in flooded managed wetland under altered operations (second flood up Jun-Oct)	70.0	155.0	230.0	Medium uncertainty, based on expert input from Kyle Phillips: "Zooplankton peak would occur 30-60 days after flood. Values are based on survey data from a single summer (July) flood cycle in Meins Landing. Hypothesis is summer peak in zooplankton would be higher than winter or spring peaks due to warmer temperatures."

The range of estimates for peak zooplankton density and potential number of flood/drain cycles was informed by expert judgment provided by Kyle Phillips (see Appendix 2, Section 2: "Zooplankton density outcomes from scenarios varying in managed wetland flood/drain operations").

The range of estimates for possible timing of draining and assumptions around coordinated timing of draining of wetlands was informed by expert interviews (pers. comm., E. Loboschefsky, 2017; R. Hartman, 2022; Klingonsmith, 2021).

4.3 Final operations scenario(s) to evaluate in the SDM process

Table 2. Managed wetland scenarios to evaluate that vary in seasonal timing (Spring, Summer, Fall) and proportion of additional wetlands participating in this action.

Scenario #	Name	Description
0	Baseline conditions	All wetlands flood up in Oct-Nov, drain first in Dec-Feb, then have secondary flood/drain cycle in Mar-May. Scenarios 2-6 are additive to baseline conditions.
1	Large increase in Spring	20% of wetland volume; 4K ac of managed wetlands 1 drain cycle in Mar-Apr (delay initial flood up and do first drain here) Middle (best) estimate of zooplankton density (apply Dec-Feb estimate)
2	Large increase in Summer	20% of wetland volume; 4K ac of managed wetlands 1 drain cycle in Jul-Aug Middle (best) estimate of zooplankton density
3	Large increase in Fall	20% of wetland volume; 4K ac of managed wetlands 1 drain cycle in Sep-Oct Middle (best) estimate of zooplankton density
4	Large increase in Spring, Summer, & Fall	20% of wetland volume; 4K ac of managed wetlands 3 drain cycles in Mar-Apr, Jul-Aug, and Sep-Oct Middle (best) estimate of zooplankton density
5	Medium increase in Spring, Summer, & Fall	10% of wetland volume; 2K ac of managed wetlands 3 drain cycles in Mar-Apr, Jul-Aug, and Sep-Oct Middle (best) estimate of zooplankton density
6	Small increase in Spring, Summer, & Fall	5% of wetland volume; 1K ac of managed wetlands 3 drain cycles in Mar-Apr, Jul-Aug, and Sep-Oct Middle (best) estimate of zooplankton density

Figure 3. Suisun Marsh Managed Wetlands (Klingonsmith 2021)

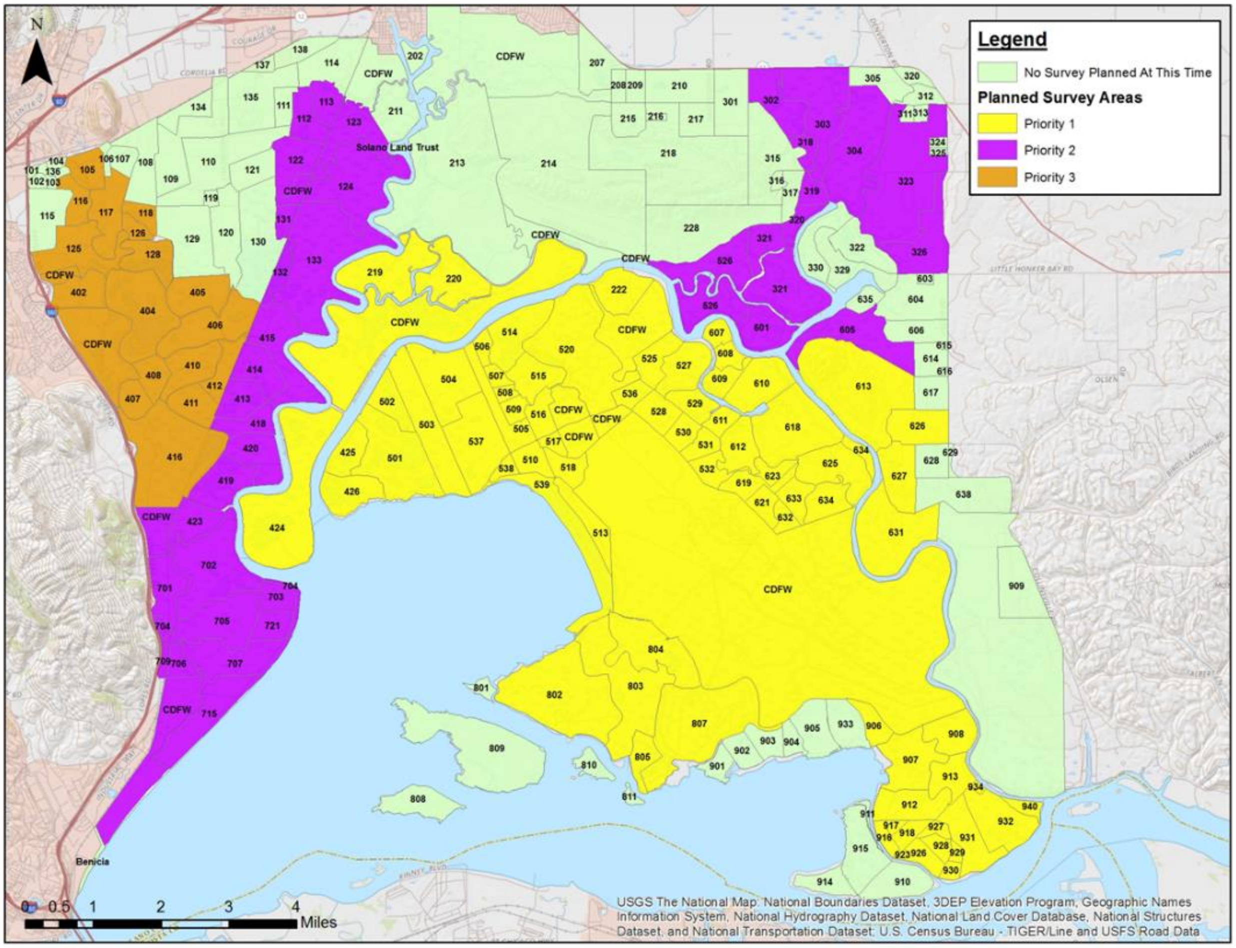
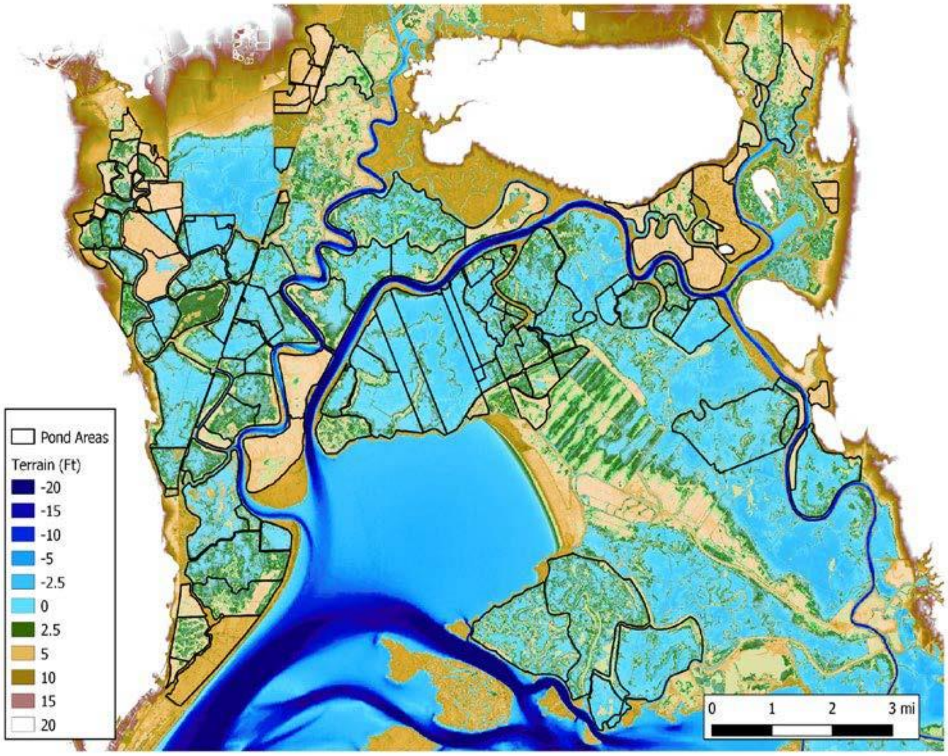


Figure 4. Final composite DEM used to develop storage elevation tables used in RAS model simulations in Chappell et al. (2018) (Klingonsmith 2021).



5 Evidence / Examples

5.1 Zooplankton Effects from November to June 2019 in Managed Wetland vs. Tidal Slough

Tung et al. (2021) assessed differences in water quality and plankton density between a managed wetland pond (Luco Pond) and a tidal slough (Luco Slough) in Suisun Marsh in Water Year 2019. Luco Pond is an approximately 580-acre managed wetland surrounded by tidal channels in the south and low-gradient uplands in the north. Luco Pond contains the historic upper reach of Luco Slough, which runs north-south about 1.6 km on the eastern side of the managed wetland. The pond's water depth from the surface to the sediment ranges from just a few cm, where pickleweed and brass buttons dominate the shallow zones, to approximately 1.5 m in the historic thalwegs, where emergent vegetation such as cattail, tules, and common reed dominates the fringe zones. The comparison site, Luco Slough, is a small, dendritic, shallow subtidal slough with a fringing marsh dominated by tules, cattails, and common reed.

The following is an excerpt from Tung et al. (2021) describing their zooplankton results (pg. 26): "Zooplankton densities in the pond spiked approximately one month after flood-up and persisted until spring (**Figure 3.21 - below**). Copepods were highly abundant in fall, with the omnivorous cyclopoid *Acanthocyclops* spp. being the dominant zooplankter (**Figures 3.21 and 3.22**). Copepods crashed in winter while cladocerans (mainly *Daphnia magna*) increased and became dominant through mid-spring. Copepods increased again in late April, but not at numbers comparable to the fall bloom. In the slough, zooplankton densities were low and changed little, with slightly more copepods than cladocerans." Tung et al. (2021) note further that in their 2019 sampling year, copepod densities were in the hundreds throughout the pond within two weeks of flood-up and were largely dominated by Acanthocyclops species.

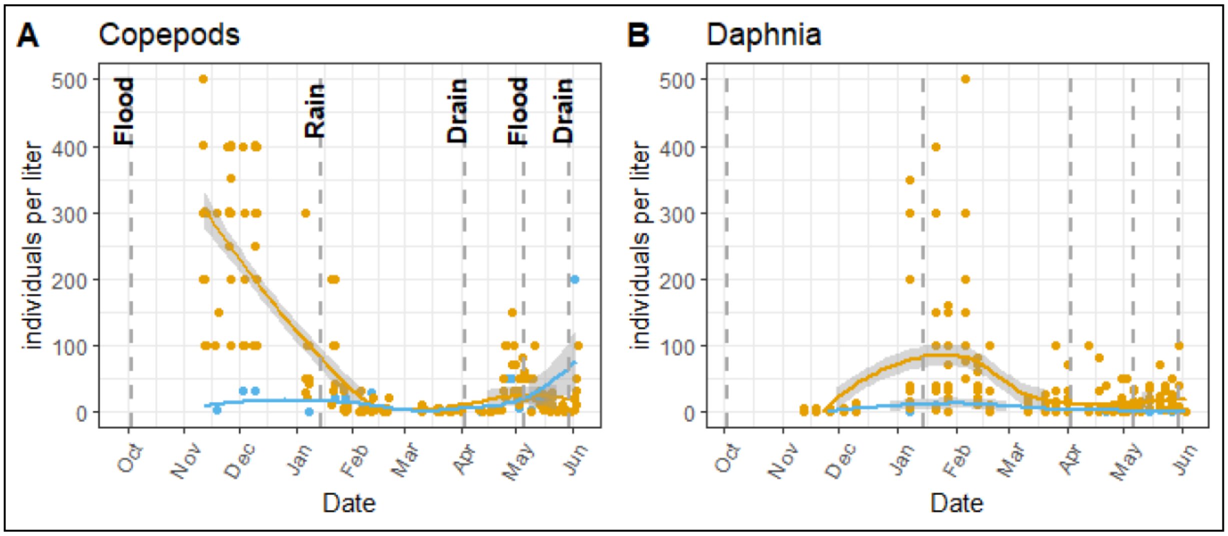


Figure 3.21. Preliminary Water Year 2019 rapidly assessed zooplankton estimations for Luco Pond. Data unavailable for October; data collection started in early November. Each point is one observation. Dotted vertical lines denote key periods in management (flood or drain) and high precipitation events (rain). Orange points denote pond sites; blue points denote slough values. **A)** Copepods. **B)** *Daphnia*.

5.2 Zooplankton Effects in Water Year 2019, 2020 and 2021 in Managed Wetlands vs. Tidal Sloughs

Tung et al. (2021) assessed differences in water quality and plankton density between multiple managed wetland ponds and a tidal sloughs in Suisun Marsh across Water Years 2019, 2020, and 2021. The figure below shows the ponds and water years included in the sampling. Each pond was paired with a nearby tidal slough reference site.

Figure 4.1. Ponds sampled in Suisun Marsh between Water Year 2019 and Water Year 2021 with sampling periods annotated ("WY" = water-year).

The figures below show zooplankton results from Tung et al. (2021, pg. 46-47).

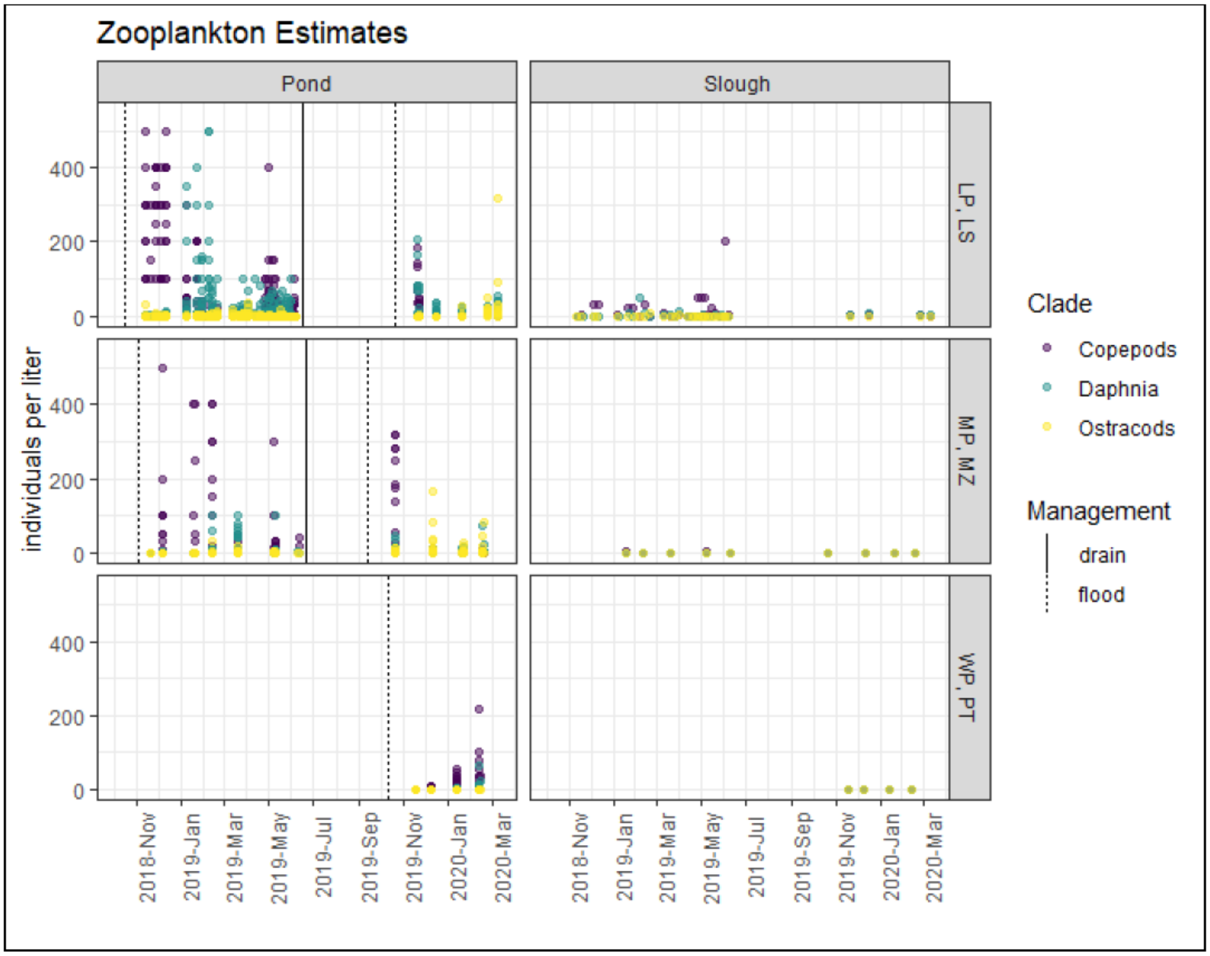


Figure 4.15. Rapid assessment zooplankton estimates for Luco Pond/Luco Slough (LP, LS), Meins Landing/Montezuma Slough (MP, MZ), and Wings Landing/Peytonia Slough (WP, PT). Dotted lines represent initial flood-up in ponds. Solid lines represent pond draining.

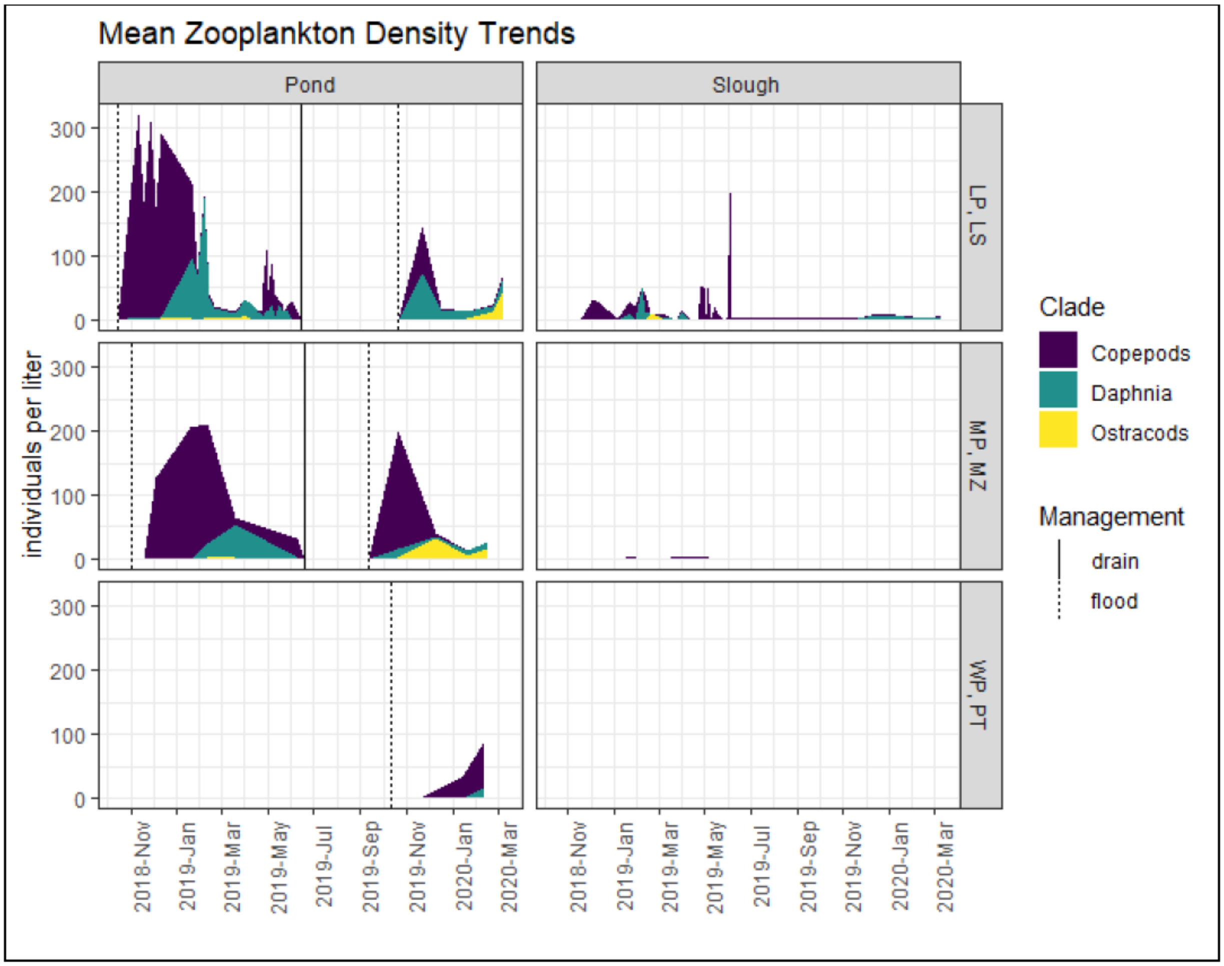


Figure 4.16. Rapid assessment mean estimates for Luco Pond/Luco Slough (LP, LS), Meins Landing/Montezuma Slough (MP, MZ), and Wings Landing/Peytonia Slough (WP, PT). Dotted lines represent initial flood-up in ponds. Solid lines represent pond draining.

5.3 Salmon benefits from Managed Wetlands Food Production

Aha et al. (2021) abstract excerpt: "To evaluate the potential of these ponds as a nursery habitat, juvenile Chinook salmon (~ 2.8 g, 63 mm FL) were reared in cages in four contrasting locations within Suisun Marsh, a large wetland in the San Francisco Estuary. The locations included a natural tidal slough, a leveed tidal slough, and the inlet and outlet of a tidally muted managed pond established for waterfowl hunting. Fish growth rates differed significantly among locations, with the fastest growth occurring near the outlet in the managed pond. High zooplankton biomass at the managed pond outlet was the best correlate of salmon growth. Water temperatures in the managed pond were also cooler and less variable compared to sloughs, reducing thermal stress. The stress of low dissolved oxygen concentrations within the managed pond was likely mediated by high concentrations of zooplankton and favorable temperatures. Our findings suggest that muted tidal habitats in the San Francisco Estuary and elsewhere could be managed to promote growth and survival of juvenile salmon and other native fishes."

6 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)
3.1	MgdWet spring, 4K ac	0.99	1.00	0%	17%
3.2	MgdWet summer, 4K ac	0.98	0.88	-1%	2%
3.3	MgdWet fall, 4K ac	0.98	0.86	0%	0%
3.4	MgdWet all seasons, 4K ac	0.98	1.03	0%	20%
3.5	MgdWet all seasons, 2K ac	0.98	0.99	0%	15%
3.6	MgdWet all seasons, 1K ac	0.99	0.95	0%	11%

- Multiple runs were used to explore population outcomes while varying the seasonal timing and spatial scale of the action (Action runs 3.1 – 3.6)
- **Action runs 3.4 – 3.6 – which included effects on food in all seasons at different spatial scales – were used as the "primary" model runs for Round 1 action and portfolio evaluation.**

7 Discussion and Next Steps

Regardless of the specific method, making incremental improvements in the food production of the wetlands for Delta Smelt would be dependent on the voluntary participation of the wetland owners. Providing incentives may be needed to achieve desired levels of participation. Incentives would likely need to be proportionate to the magnitude of change that is being requested from normal operations and/or how much this change is expected to impact the use of the wetland for waterfowl purposes (pers. comm, E. Loboschefsky, 2017).

Some possible barriers or impacts to changing normal flood and drain operations include:

- Some clubs are not able to open their flood gates after mid-February because of diversion restrictions for salmon. These clubs tend to drain in early February so that they can complete their salt leaching cycle. Higher salt concentrations in the wetland affects the growth of vegetation (duck food) for the next season. These clubs can still flood within these salmon diversion restriction windows, they just can not flood as fast (pers. comm, E. Loboschefsky, 2017).
- For the most part, most clubs fully drain their sites by late April/mid May and let the wetlands dry out so that they can do intensive vegetation management (mowing, cleaning out channels). Holding water on the wetlands for longer would delay when the site is sufficiently dry to allow for maintenance work (pers. comm, E. Loboschefsky, 2017).
- Mosquitos: Most of Suisun Marsh is subject to being treated for mosquitos if they hold water at the wrong time (need to talk to Mosquito Abatement Program for more information, e.g. what's the time period when mosquitoes are an issue and does the mosquito spray impact the food value of the water) (pers. comm, E. Loboschefsky, 2017).
- Discharge from the ponds is known to have increased biological oxygen demand and contaminants. Therefore, discharges are regulated to reduce the impacts of the contaminants and potential reduction in DO. Changing the operations would need to be sure that their permit still

covers the change and that cumulative effects are evaluated as permits are usually evaluated on a discharge by discharge basis with only some consideration of what the nearby dischargers would be doing.

Rhiannon Klingonsmith (DWR) provided an update to the CSAMP Delta Smelt TWG on where DWR is at with the implementation of this action on June 24, 2021. Key points from her presentation were:

- Compensation and incentivization would be required for this action if landowners are being asked to change their operations from what is optimal for their duck club purposes.
- Next steps for DWR are:
  - Evaluate properties that are best suited for the flood and drain export
  - Work with SRCD to connect with willing landowners
  - Conduct food resource availability studies in priority areas
  - Prepare an implementation plan for meeting this Delta Smelt Resiliency Strategy action.
- The main constraint for this action is lack of funding.

8 Relationships with other actions

Restored tidal wetlands and managed wetlands are both hypothesized to increase primary production and zooplankton. However, existing evidence and expert judgment suggests managed wetlands likely produce more zooplankton, relative to restored tidal wetlands, for several reasons that were discussed with Compass (John Durand and Kyle Phillips, UC Davis, online meeting with Compass, 2 May 2022).

- ***Water residence time:*** Managed wetlands are operated systematically to hold water on wetland floodplains for a few weeks to several months before being drained into surrounding water bodies. This increased residence time allows for plant decomposition, increases in algae and phytoplankton, and ultimately blooms of zooplankton. Conversely, restored tidal wetlands experience daily tidal patterns that do not allow for prolonged residence times that could produce blooms of zooplankton.
- ***Colonization of competitor species:*** Due to seasonal drying and operation of managed wetlands, these areas cannot be colonized by species that compete with Delta Smelt for zooplankton, compete with zooplankton for phytoplankton, or can depredate Delta Smelt directory. These species include invasive non-native clams and fish (e.g., Mississippi silversides). Conversely, restored tidal wetlands are open systems that can be colonized by these non-native clam and fish competitors (Williamshen et al. 2021). Since these species are efficient competitors that exhibit high feeding rates on primary production and zooplankton, Delta Smelt may only be able to access a portion of the total zooplankton being produced from restored tidal wetlands that are colonized by competitors.

9 Action Specification

- This action was initially identified in the 2016 Delta Smelt Resiliency Strategy and then further specified based on communications with DWR (E. Loboschefsky) during the Delta Smelt SDM Demo Project in 2017.

- Rhiannon Klingonsmith presented to the CSAMP Delta Smelt SDM TWG on June 24 and this action specification write-up was updated based on her presentation and the key documents that she provided (e.g., Chappell et al. (2018))

10 Key Contacts

- Rhiannon Klingonsmith, DWR - coordinating implementation with partners and stakeholders (main contact)

- Shaun Philippart, DWR, shaun.philippart@water.ca.gov - coordinating the monitoring and science around the action
- John Durand, Kyle Phillips (PhD student, U.C. Davis), and other Durand lab members (UC Davis; jdurand@ucdavis.edu): effects of wetlands on prey density.

11 References

Aha, N., P. Moyle, N. Fangue, A. Rypel, J. Durand. 2021. Managed Wetlands Can Benefit Juvenile Chinook Salmon in a Tidal Marsh. *Estuaries and Coasts.*

Chappell, S., J. Y. Takekawa, C. Tortosa, R. Eddings, G. Williams, S. Andrews, S. Burdick, and C. Feldheim. 2018. Suisun Marsh improvement assessment. Unpublished Report by the Suisun Resource Conservation District to the Sacramento-San Joaquin Delta Conservancy. 21pp.

Compass/TWG. 2021. The Dynamic Habitat Analysis Tool.

Klingonsmith, R. 2021. Suisun Marsh and the Delta Smelt Resiliency Strategy [PowerPoint slides]. California Department of Water Resources (DWR). Delivered to the CSAMP Delta Smelt SDM TWG on June 24, 2021.

Phillips, K. 2021. Expert judgment for zooplankton responses to flooding and draining operations of managed wetlands. Expert elicitation exercise and interview. September and December 2021.

Tung, A. Phillips, K. O'Rear, Teejay. Durand, J. 2021. Suisun Ponds Productivity Final Report – Draft. Prepared for California Department of Water Resources. UC Davis Center for Watershed Sciences. July 2021.

Williamshen, B.O., O'Rear, T.A., Riley, M.K., Moyle, P.B., Durand, J.R., 2021. Tidal restoration of a managed wetland in California favors non-native fishes. Restoration Ecology 29, e13392.

12 Appendix 1 – Meeting with Suisun Resource Conservation District (John Takekawa, Operations Manager, SRCD) – August 6, 2021

(1) Why was 30 days chosen as the threshold that managed wetlands would need to drain by to be considered in "optimal working order"?

- John stated that the 30 day threshold that was selected in his study was not rooted in any concrete science but rather, was a rule of thumb based on conventional best practices for achieving certain objectives/managing certain geographical features to most effectively manage Shore Bird habitats. These objectives/geographical features include;
    - **Providing landscaping opportunities.**
        - For proper landscape management, all water must be drained from the ponds.
        - This allows pond owners the ability to go in and manipulate the land as needed (i.e cutting, mowing, disking etc.)
    - **Average drainage time.**
        - There are roughly 50,000 acres of managed wetlands that exist in the Suisun Marsh. Drainage rate varies across all of these wetlands. Some wetlands are able to drain quickly (some as quickly as 5 days i.e. Laura Joyce Island) while others are drain-limited and require approximately 30 days to achieve full drainage.
    - **Salinity control (leaching).**
        - A time period of 30 days in necessary to have enough time to do any meaningful leaching. Any time period before 30 days allows for only one or two leach cycles which is insufficient to reduce salinity to desired levels.
        - Additionally, the first leach cycle does not typically count as a leach cycle because in this first drainage, only the water that has been sitting in the pond all winter is drained. It is only after the SECOND cycle that any meaningful leaching occurs. For this reason, the first drainage cycle is not considered a leach.
        - The first drainage cycle (in which last winter's water is drained) typically occurs during the month of February and takes approximately 30 days.
        - Come March, the first "official" leaching cycle takes place. Again, for all ponds in the estuary to fully drain their respective ponds, it will take approximately 30 days.
        - In April, plants begin to grow which limits the ability to flood and drain the ponds making the likelihood of salt leach during this time very minimal.
        - Beyond the aforementioned reasons for controlling salinity, effective salinity control aids to prevents the creation of salt flats which would eliminate native vegetation and allow colonization by pickleweed which is saline adapted. This can have broader negative consequences such as reducing habitat for waterfowl.
    - **Promoting the growth of high-density seed plants.**
        - It is known that in the hunting off-season, water must be cycled through the ponds to reduce salinity. This is done to promote the growth of high-density seed plants which are the preferred sources of food for Shore Birds (primary hunting targets).
        - High-density seed plants are known to prefer fresher water. For this reason, during the hunting off-season, fresh water must be cycled through the ponds to reduce the salinity that has accumulated during the winter months.

(2) Why is there a focus on draining to "1 ft below shoot level" in the SRCD report - is there some significance to that level of drainage, or was this just a way to standardize the analysis across the ponds?

- The SRDC report focuses on draining to 1ft below shoot level for two reasons.
  1. This depth is ideal for the duck species that are preferred by hunters (daffy duck).
     - When water levels are lower than this, ducks cannot reach the plant seeds that they depend on for sustenance.
  2. Depths that are lower than this damage levees.
     - When water levels get too low, gravity drainage is impossible. Thus, draining the water out of the ponds cannot be done. This has the potential to cause breaches to the levees. Repairing breaches tends to cost upwards of 1 million dollars. Given that ponds in the area are privately owned and that levee repairs must be paid for by individual land owners, landowners tend to keep water levels at depths that best prevent breaches.

(3) Did the SRCD study (or other study) give any sense of the extent to which managed wetland owners would be interested in flooding and draining their properties for the purposes of fish food production? Or whether they would be interested if financial incentives are provided?

- John opined that landowners would have an interest in altering their management practices in order to benefit the fish if and only if they were compensated.

(3b) What factors would increase or decrease willingness to participate by managed wetland owners?

- John guessed that $10.00 per acre would be a sufficient incentive to get landowners to start paying attention.

Caveat:

- However, it is his opinion that there have not been enough scientific studies conducted to fully understand what management practices should be recommended to landowners. "*Give 'em $10.00 but to do what?"*
- It is John's opinion that more studies are needed to fully understand what management practices would be best for achieving different aims with the wetlands (i.e food creation, soil salinity control). However, John notes that getting the funding to do these kinds of studies has been a real challenge in the past.

(4) Are you able to provide Table 5 on pg. 15 of the SRCD study (with the green, yellow, red shading) in a spreadsheet format? (I think this will be very helpful data for helping us to quantity the potential Delta Smelt benefits of this action)

- As of September 17, 2021 John is actively looking for this spreadsheet.

(5) Could you explain why these twenty wetlands are 'priorities' – what are the expected benefits of infrastructure improvements on these wetlands?

John did not answer this question in his interview.

13 Appendix 2 – Expert judgment for zooplankton responses to flooding and draining operations of managed wetlands

Kyle Phillips (PhD student, U.C. Davis) completed expert elicitation exercises and follow-up discussions with Compass between September and December 2021. The overall purpose of the exercises was to estimate effects of managed wetland operations on zooplankton density to inform management recommendations in the Suisun Marsh region.

Section 1: Timing and frequency of floods to produce peaks of zooplankton.

Instructions: Think about the following question: Assuming a managed wetland is flooded and no DO blowout occurs, how long after the flood will it take to reach the peak in zooplankton density in a managed pond in Suisun Marsh? Place your answers to this question in the table below in the green cells for copepods and daphnia, separately. Provide the lowest value it could realistically be, the highest value it could realistically be, and your best guess of months between flood and peak zooplankton density (you can put fractions of months). Your low and high estimates reflect that you are 80% confident it's between these values, and your best estimate is the value you think is most likely (e.g., the average).

Expert responses:

	Copepods			Daphnia			
	Low	High	Best	Low	High	Best	Evidence, hypotheses, assumptions, and other notes to describe responses
No. of months between fall (Oct) flood and peak in zoop density	1.76	3.08	2.42	2.36	3.86	3.11	Values are mean estimates and 80% CIs from 12 surveyed flood cycles (copepods) or 9 surveyed flood cycles (daphnia).
No. of months between spring/summer (e.g., May-Jul) flood and peak in zoop density	1	2	1.5	1.5	2.5	2	Values are based on survey data from a single summer (July) flood cycle in Meins Landing. The shorter time between flood and peak density, relative to fall floods, is hypothesized to be due to higher summer temperatures that increase rate of plant, phytoplankton, and subsequently zooplankton growth.

	Low	High	Best	Evidence, hypotheses, assumptions, and other notes to describe responses
How frequently can you flood and drain a wetland between March and September to produce a peak of zooplankton density?	every 1 mo	every 6 mo	every 4-5 mo	Low estimate assumes time from wetland being dry. High and best estimates provides sufficient rest period for plant growth and seeding to occur. It is hypothesized that time between floods would need to be longer in cooler months to account for slower plant growth. Drain and flood times are site-specific. Depends on the size of the wetland and size/number of water control structures on the wetlands. Meins Landing can take up to 3 weeks to flood/drain (big wetland, few water control structures). Others may take only a couple days to flood up.

Section 2: Zooplankton density outcomes from scenarios varying in managed wetland flood/drain operations.

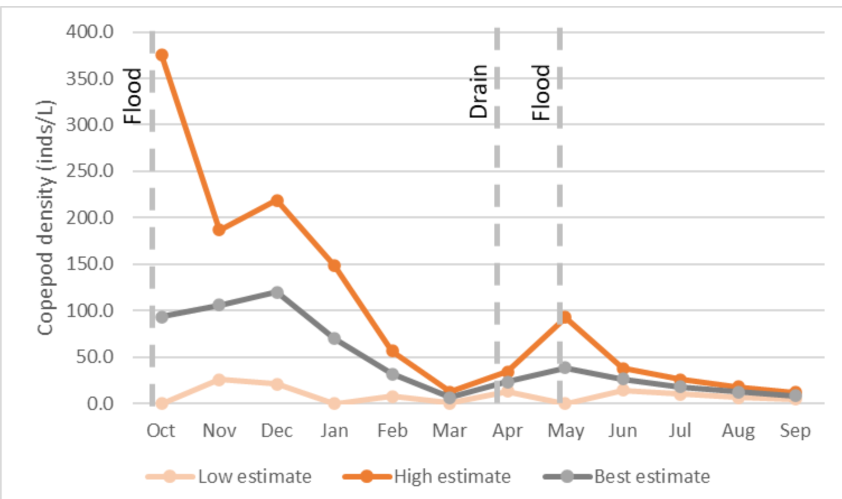
Instructions: Think about the following question: Assuming a set of managed wetland operations (a specific flood and drain schedule), assuming no DO blowout occurs, and assuming zooplankton density peaks at some point after flood up, what is the expected zooplankton density each month in a managed pond in Suisun Marsh? Place your answers to this question in the table below in the green cells. Provide the lowest value that density could realistically be, the highest value that density could realistically be, and your best guess of zooplankton density. Your low and high estimates reflect that you are 80% confident it's between these values, and your best estimate is the value you think is most likely (e.g., the average).

Expert responses:

Scenario 1: ALL Suisun Marsh - Normal operations (initial flood up in October, second flood in May)

Expert-provided assumptions:

- Estimates (mean, and 80% confidence intervals) assume flooding occurs sometime in fall (between late Sept, and early Dec) as is typical of wetland management in Suisun Marsh.
- No data available for July, August, Sept when ponds are typically dry. Estimates for those months were extrapolated, assuming the proportional decrease in zooplankton between May and June continues through summer months. Hypothesis that decreases would continue due to nutrient depletion and increased predation (higher fish densities within ponds).

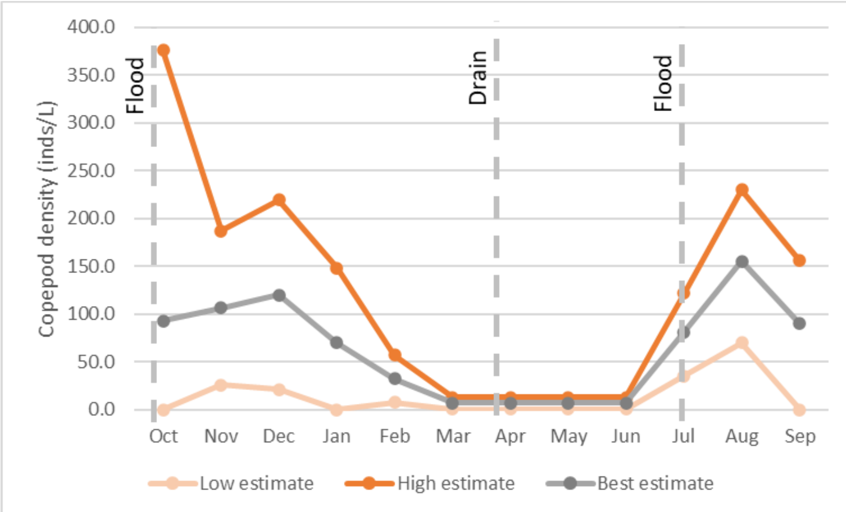


Scenario 2: ALL Suisun Marsh - Modified operations (initial flood up in October, second flood in July)

Expert-provided assumptions:

- Estimates (mean, and 80% confidence intervals) assume flooding occurs sometime in fall (between late Sept, and early Dec) as is typical of wetland management in Suisun Marsh.
- Drain in Mar/Apr. This is based on hypothesis that at least 4 months of drained conditions is a sufficient rest period for plant growth and seeding to occur that can stimulate zooplankton blooms.
- Assumes some low level of zooplankton density will persist through drained months, since wetlands are typically drained to roughly 3/4 of volume - but not completely drained.
- Zooplankton peak would occur 30-60 days after spring flood. Values are based on survey data from a single summer (July) flood cycle in Meins Landing. Hypothesis is summer peak in zooplankton would be higher than winter or spring peaks due to warmer temperatures.

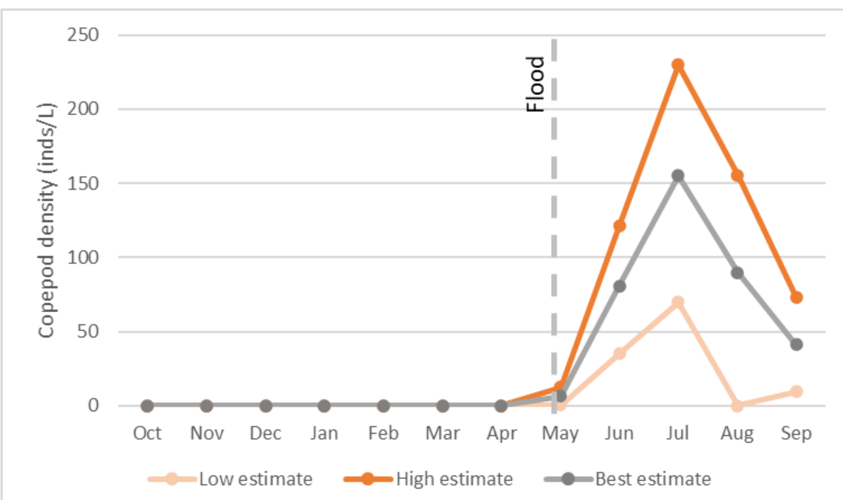
- Assumes same proportional decrease in zooplankton (following peak density) observed in Scenario 1.



Scenario 3: ALL Suisun Marsh - Modified operations (initial flood up in May)

Expert-provided assumptions:

- There is no existing data on zooplankton outcomes for this type of flood/drain cycle. Values from Scenario 2 (Jun-Sep) are assumed to be reasonable for this scenario. This set of draining operations may produce more plants, relative to Scenario 2, if it was last drained in October. This may cause greater increases in phytoplankton and zooplankton, but further research and monitoring would be needed.



14 Appendix 3 – Financial Resource Cost Calculations

The table below provides cost estimates and assumptions used for the action. It shows an example calculation for performing the action across 2,000 ac, which was applied to Portfolio 2c in the Round 1 evaluation. The orange cell indicates the annualized cost used for this action in that portfolio.

Managed Wetland Food Production
Portfolio(s) **2c**
Source: See table notes

Component		Notes	Quantity		Unit Cost		Frequency		Total	
Initial Costs										
	High	[a]	2,000	ac-ft @	$1,000	/acre-foot			2,000,000	
	Low	[b]	2,000	ac-ft @	$500	/acre-foot			1,000,000	
Annual Operating Costs										
High	Staff	[c]			$150,000	/year for	100%	of years	150,000	/yr
	O&M	[d]	2,000	ac-ft @	360	/ac-foot/year for	100%	of years	720,000	/yr
	Incentives	[e]	2,000	ac-ft @	$100	/ac-ft			200,000	/yr
	Subtotal								1,070,000	
Low	Staff	[f]			$150,000	/year for	100%	of years	150,000	/yr
	O&M	[g]	2,000	ac-ft @	$0	/ac-ft/year for	100%	of years	27	/yr
	Incentives	[h]	2,000	ac-ft @	$50	/ac			100,000	/yr
	Subtotal								250,027	
Undiscounted annual costs			20	years						
High									1,170,000	/yr
Average of high and low									760,013	/yr
Low									350,027	/yr

Notes

[a] Assumption for infrastructure improvement cost - loosely based on RRDS drain gate upgrade cost of 1,000,000

[b]

[c] Assume 1 FTE to co-ordinate =$100,000/year (Compass assumption)
Assume outreach costs =$25,000/year (Compass assumption)

[d] Incremental changes & maintenance

	Hamilton assumption: $15/af for 7,500 ac * 1 af/ac cycled 24 times =			2,700,000
[e]	Compass assumption			
[f]	Assume 1 FTE to co-ordinate	=$100,000/year (Compass assumption)		
	Assume outreach costs	=$25,000/year (Compass assumption)		
[g]	Incremental changes & maintenance	10%	of initial cost (Compass assumption)	
[h]	Compass assumption			

Possible Improvements

Get more input on upfront capital costs

Get O&M information from duck clubs (esp. for flushing flows in Jan-Feb period) - Suisun Marsh Conservation District is a possible contact