APPENDIX D

Schism Model Results

Table of Contents

Figures

Table

ACRONYMS AND OTHER ABBREVIATIONS

°C	degrees Celsius
CCF	Clifton Court Forebay
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CMOP	Coastal Margin Observation and Prediction
D-1641	State Water Resources Control Board Water Rights Decision 1641
DCC	Delta Cross Channel
DCD	Delta Channel Depletion
DES	Department of Environmental Services
DETAW	Delta Evapotranspiration of Applied Water
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELCIRC	Eulerian–Lagrangian algorithm
ELM	Eulerian-Lagrangian method
km	kilometer
LSC2	localized sigma coordinates with shaved cells
LSZ	low salinity zone
m	meter
mS/cm	milliSiemens per centimeter
NOAA	National Oceanic and Atmospheric Administration
psu	practical salinity units
SCHISM	Semi-Implicit Cross-scale Hydroscience Integrated System Model
SELFE	semi-implicit Eulerian-Lagrangian finite-element
SMSCG	Suisun Marsh Salinity Control Gate
SMSCG	Suisun Marsh Salinity Control Gate
SWRCB	State Water Resources Control Board
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

SCHISM MODEL RESULTS

INTRODUCTION: STUDY OBJECTIVE

This appendix section summarizes 3-D hydrodynamics modeling and analysis performed by the Bay-Delta Office of the California Department of Water Resources (DWR) to investigate the Suisun Marsh Salinity Control Gate (SMSCG) reoperation and flow augmentation components of the ITP Proposed Project.

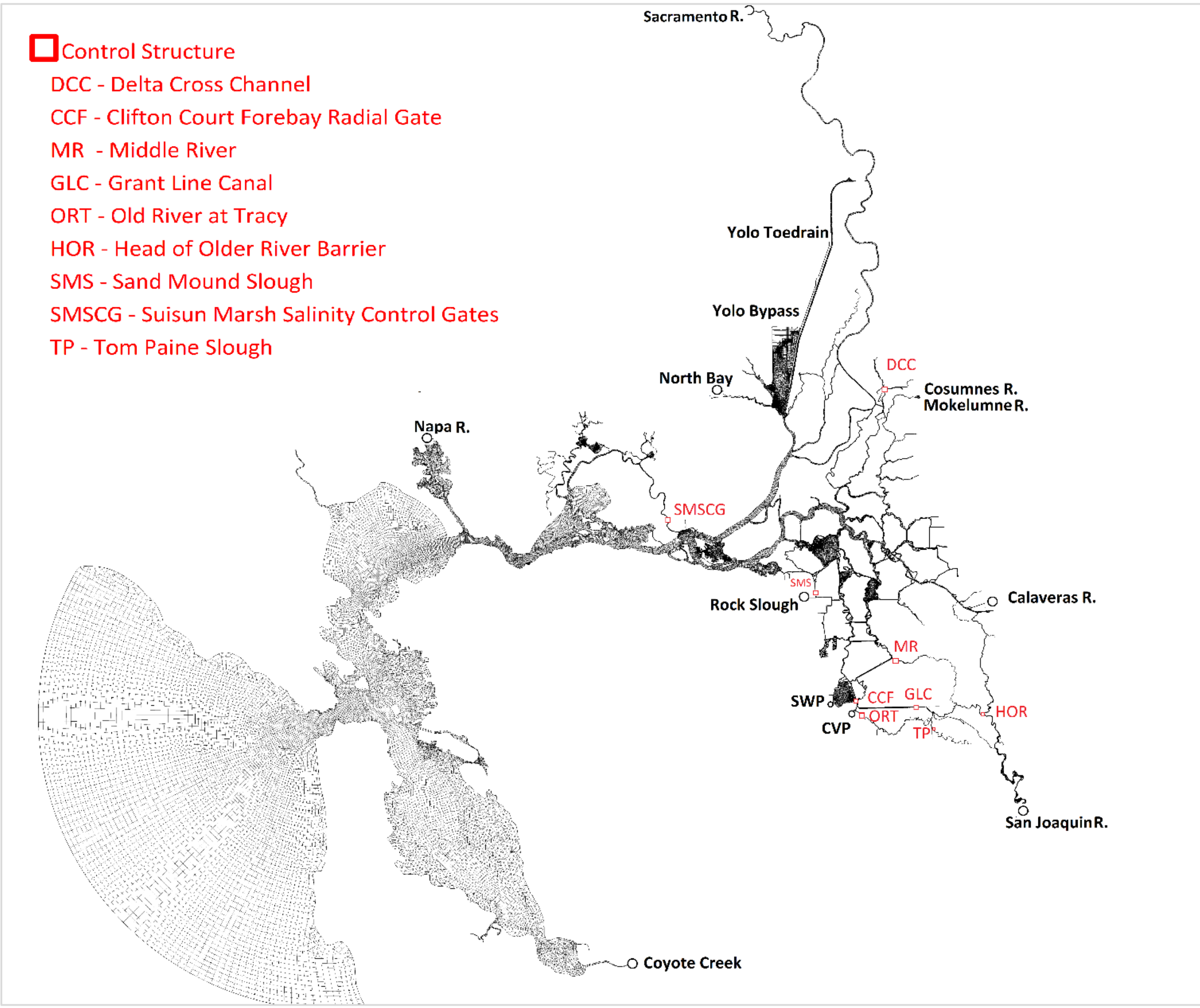
The focus of 3-D circulation modeling incorporated in the Incidental Take Permit (ITP) is to identify the habitat benefits of SMSCG operation and flow augmentation by mapping and computing low salinity zone and smelt habitat indices in various hydrologic and operational scenarios. Long-term water supply impacts of the proposed reoperation are incorporated in the CalSim and DSM2 modeling work described elsewhere.

SCHISM AND BAY-DELTA SCHISM BACKGROUND

The model used in this study is Bay-Delta SCHISM, which is based on the Semi-Implicit Cross-scale Hydroscience Integrated System Model (SCHISM, Zhang et al. 2016), which in turn is derived from the semi-implicit Eulerian-Lagrangian finite-element (SELFE) model (Zhang and Baptista 2008) SCHISM is an open-source community-supported modeling system, whose origins were to serve as a second-generation model (following ELCIRC, a Eulerian–Lagrangian algorithm used to solve shallow water equations) for use in the Columbia River estuary by the Center for Coastal Margin Observation and Prediction (CMOP). The model has subsequently been enhanced by the Virginia Institute of Marine Sciences and used in basins throughout the world in applications as diverse as reservoir temperature, estuarine transport of salinity, morphology, and near-coast tsunami response. The model has participated in numerous regional benchmark projects. A list of peer-review papers is maintained on the model website (http://ccrm.vims.edu/schismweb). The larger SCHISM suite includes modules for sediment transport, ecology/biology, wind-wave interaction, ice, oil spill, and marsh evolution.

The formulation of the core SCHISM hydrodynamic module is based on the 3-D hydrostatic Reynolds-averaged shallow water equations, including mass conservation, horizontal momentum conservation and salinity transport. The SCHISM hydrodynamic algorithm is based on mixed triangular-quadrangular unstructured grids in the horizontal and a flexible coordinate system in the vertical (localized sigma coordinates with shaved cells, or LSC2, Zhang et al. (2015)). The modeling system utilizes a semi-implicit finite-element/finite-volume method together with a Eulerian-Lagrangian method (ELM) for momentum advection to solve the Reynolds-averaged Navier-Stokes and transport equations at ocean to creek scales. It has both a hydrostatic and non-hydrostatic option, but as explained in MacWilliams et al. (2016) non-hydrostatic modeling is not feasible at field scale in the Bay-Delta because of the resolution required.

The DWR application of SCHISM to the Bay-Delta as well as a regional description of performance is described in Ateljevich et al (2014) and Ateljevich et al (2015). The mesh for the present model version 90e is shown in Figure 1 with model boundaries key hydraulic structures. The mesh contains 259,885 elements and 248,056 nodes, with length scales of the elements ranging from 1 kilometer (km) on the coast to 5m inland. The LSC2 vertical grid is terrain-conforming, but tapers in the number of vertical layers from 23 at the Farallon Islands to a single layer (2D horizontal) in the upstream reaches of the Sacramento River, Yolo Bypass and San Joaquin River. Near Suisun Bay and Marsh the mesh has 10-12 vertical layers, resulting in vertical resolution of 1m in the main ship channel and finer than 0.6 meter (m) in Suisun Bay and Montezuma Slough.



In addition, channel depletion sources from the Delta DCD model or similar methods are imposed throughout.

Figure 1: Bay-Delta SCHISM Mesh, Boundary Condition Location and Hydraulic Structure Locations

The Bay-Delta SCHISM model has been applied to study the performance of numerous operational and planning scenarios in the Bay-Delta, including the emergency Drought Barrier (MacWilliams 2016 and DWR efficacy report, in press), restoration of Franks Tract (Ateljevich, 2018), and hydrodynamic transit time through Clifton Court (Shu, 2018). The Franks Tract restoration study includes validation of performance in the western and middle Delta A Bay-only portion of SCHISM extended to Rio Vista is described and validated in Chao et al (2017a) for temperature as well as salinity and used to study a sea surface temperature anomaly in the Bay and near coast in Chao et al (2017b). The work of Cai

(2018) focused on the effects of submerged aquatic vegetation on flow physics and biogeochemistry in the Cache Complex.

Modeling assumptions and boundary conditions for the present study generally conform to the methods described by Ateljevich et al (2014). The mesh has been developed generally as part of the studies cited above and in response to improvements in bathymetry. For the present project, the mesh was modified to incorporate more marsh channels and marsh plains than previous versions of the Bay-Delta SCHISM mesh. Existing Montezuma Slough bathymetry was found to be insufficiently accurate for a focused study of the region and was resurveyed by the Bathymetry and Technical Support group at DWR. This work as well as single beam soundings upstream by UC Davis were incorporated into the latest (v4.1) modeling bathymetry map for modeling produced by DWR's Delta Modeling Section and were used in the current modeling; the production of the elevation model described by Wang (2018) and the elevations are available online in GeoTiff format in the Resources Agency Open Data Portal (DWR 2018).

The standard Bay-Delta SCHISM configuration incorporates approximations of numerous hydraulic structures in the Delta, including the Suisun Marsh Salinity Control Gate (SMSCG), Delta Cross Channel (DCC), and Clifton Court Forebay (CCF). All of which are modeled as radial gates using standard 1D approximations similar to those used in DSM2. No special configuration or recalibration was undertaken for the present work, but new periods of tidal operation were incorporated for SMSCG for some scenarios.

DWR consumptive use models do not account for evaporation and consumptive use in Suisun Marsh (including pond up of Duck Clubs and managed wetlands), and results in Grizzly Bay, the Marsh appear to be sensitive to this assumption. An estimate of evaporation from Suisun Bay and the marsh was included in the model, using a methodology similar to the Delta Evapotranspiration of Applied Water/Delta Channel Depletion (DETAW/DCD) land water balance technique (Liang, 2017) to arrive at an estimated peak total of 1,000-1,500 cubic feet per second (cfs) for July including bay evaporation in Grizzly and Honker Bay and evaporation on the marsh. Managed exports for duck clubs and wetlands were estimated by scaling volumes used by Research Management Associates for the Bay Delta Conservation Program Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) down by 60%, which gives good agreement at the one site in which short term monitoring and gate ratings were available at Roaring River intake. The assumption produces a peak pond-up flow in September that is similar to the peak evapotranspiration in June, consistent with the relatively constant rate of salinity intrusion across this transition.

SCENARIOS

DWR studied the proposed 60 days of additional tidal operation of the Suisun Marsh Salinity Control Gates in 2012 and 2017, two years representing different hydrologic, regulatory and antecedent salinity conditions. The scenarios are summarized in Table 1.

Table 1: Scenario Descriptions for SCHISM Modeling of ITP Proposed Operations for Suisun Marsh Habitat

Scenario Label	Year	SMSCG Gate operation	Flow
2012 Base	2012	Historical	Historical
2012 Gate (Jun)	2012	Historical + Tidal Op Jun 14, 60 days	Historical + Compensating
2012 Gate (Aug)	2012	Historical + Tidal Op Aug 14, 60 days	Historical + Compensating
2017 Base	2017	Historical	Historical
2017 Base No X2	2017	Historical	Base (modified historical)
2017 Gate (Sep)	2017	Historical + Tidal Op Sep 1, 60 days	Base (modified historical) + Compensating
2017 X2 80km	2017	Historical	Meet 80km X2 in Sep-Oct
2017 Gate (Sep) + X2 80km	2017	Historical + Tidal Op Sep 1, 60 days	Meet 80km-X2 in Sep-Oct + Compensating
2017 X2 74km	2017	Historical	Meet 74km X2 in Sep-Oct

Notes: km = kilometer
SMSCG = Suisun Marsh Salinity Control Gate
SCHISM = Semi-Implicit Cross-scale Hydroscience Integrated System Model
X2 = monthly averaged position of the 2.64 mS/cm isocontour of specific conductance at the surface (see caveats).

Two types of flow augmentation appear on this table. The term *X2 74km and X2 80km* refer to flow actions to provide habitat. The term *Compensating Flow* refers to additional flow used to maintain salinity at or below the level of the corresponding base case when the gate is tidally operated. Such compensating flow is required as the diversion of net flow to Montezuma Slough causes salinity on the main stem Sacramento and San Joaquin Rivers to increase. When the main action considered only includes tidal reoperation of the gate, the compensating flow is applied to maintain Jersey Point salinity. When the action includes both the X2 flow augmentation and the gate reoperation, the compensation maintains the X2 position.

Modified historical refers to historical inputs in which exports to achieve Fall X2 objectives have been eliminated. Operational constraints are instead provided by project capacity, State Water Resources Control Board (SWRCB) Water Rights Decision 1641 (D-1641) and upstream considerations such as reservoir drawdown. The reservoir drawdown in September was significant and to a certain extent releases were scheduled around X2, so increasing exports did not significantly change salinity conditions in September. In October, the modified historical scenario is significantly saltier. Finally, for the scenarios described as meeting X2 of 74km or 80km, Sacramento River flow was reduced to make this possible in September, ignoring some upstream constraints.

2012 was a year with Below Normal hydrological classification and is typical of an average operational situation in the Delta, with operations controlled by outflow in summer, D-1641 agricultural EC objectives in late summer through August 15 and informal guidance targets for the protection of mid-Delta water quality after August 15. In 2012, the historical hydrology was used unmodified as the base case.

The SMSCG was tidally operated historically starting October 15, 2012 and this historical operation is incorporated as part of the base case as well as the reoperation case. In the cases listed with additional August tidal gate operations in 2012, those operations begin on August 14, last 60 days, and transition immediately into the historical operation. Earlier gate operations were investigated on a screening basis, however, marsh salinity was not high enough in early-mid summer for tidal gate operations to have a large freshening effect.

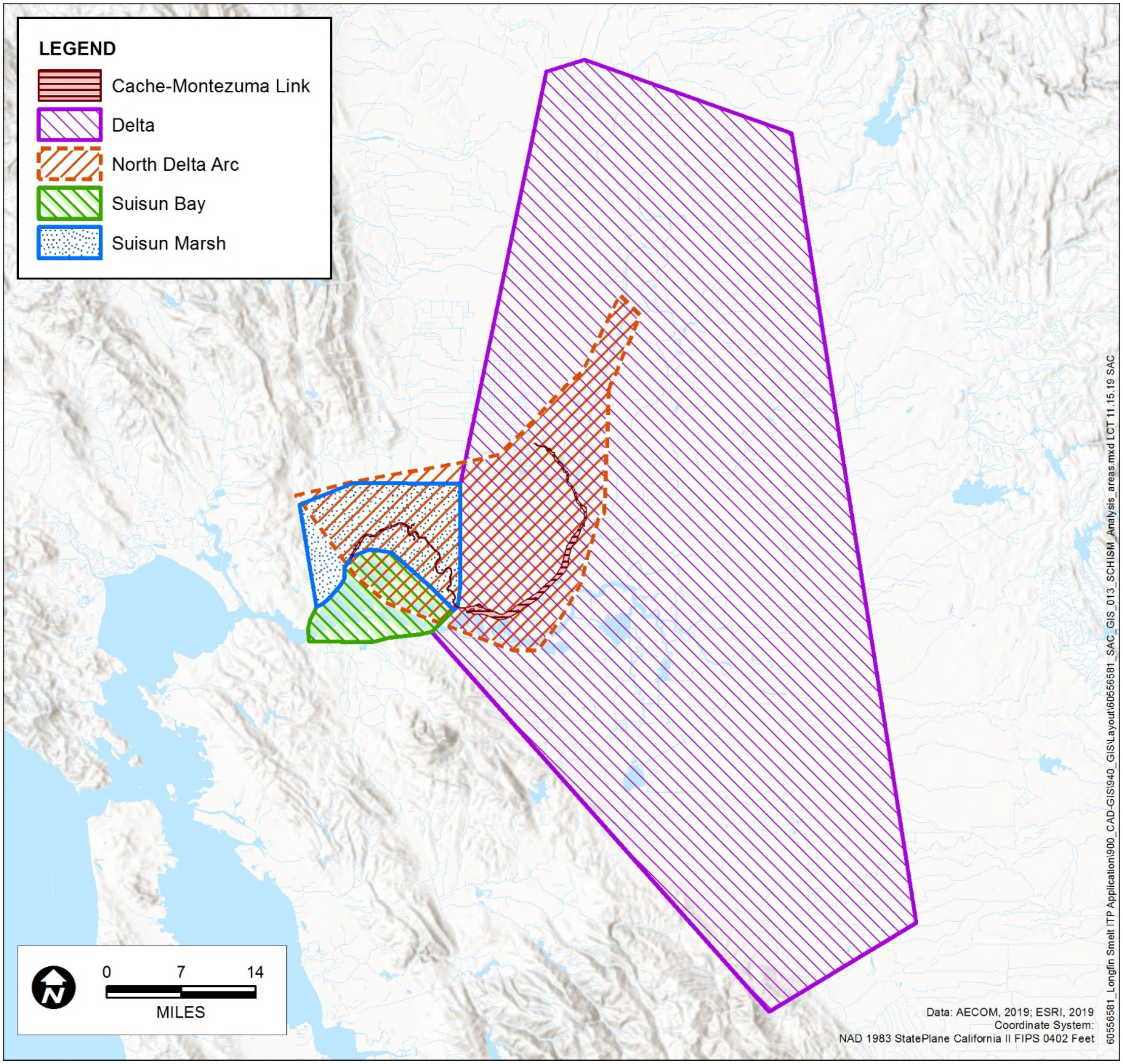
In contrast to 2012, 2017 was classified as a Wet year. Historical operations and water quality in the fall were controlled by a need to draw down upstream reservoirs and by a fall X2 objective that ranged between 74km and 79km based on coordination with U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW). Water quality in the Suisun Marsh and even in Suisun Bay was fresh historically through most of October. For ease of modeling the proposed project X2 target of 80km, the base case for 2017 was modeled by backing out the component of outflow that was used to achieve fall X2 requirements in 2017. Historical exports and inflows were modified for this scenario. The primary mechanism was increased exports, as close to project capacity as possible. Inflow reduction was also used in September to achieve 80km in cases where this was not possible with export increases alone.

In the cases listed with additional September tidal gate operations in 2017, those operations begin on September 1 and last 60 days, and transition immediately into the historical operation. Earlier gate operations were not considered as the marsh salinity was not high enough in early-mid summer for tidal gate operations to have a large freshening effect. In the 2017 cases listed with X2 flow, the historical exports and inflows were modified to maintain X2 conditions at 80 km in September and October.

Two metrics of habitat were produced in this study. The first identified the spatial area and acreage of habitat that met a low salinity zone (LSZ) threshold of 6psu (practical salinity units or psu, ubiquitous in modeling, are used throughout this text; they are essentially interchangeable with parts per thousand). The second combined this threshold with a target Secchi disk depth of 0.5m or less (higher turbidity) and water temperature of 25C or lower. These were aggregated within the zones shown in Figure 2. Temperature was interpolated from a network of DWR Department of Environmental Services (DES), National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS) stations. Secchi Depth was interpolated from the entire network of CDFW Summer Townet and Fall Midwater Trawl sites. The latter provided coverage in much of the North Delta Arc, but less so in the upper reaches of the Sacramento and San Joaquin Rivers (often excluded based on water temperatures).

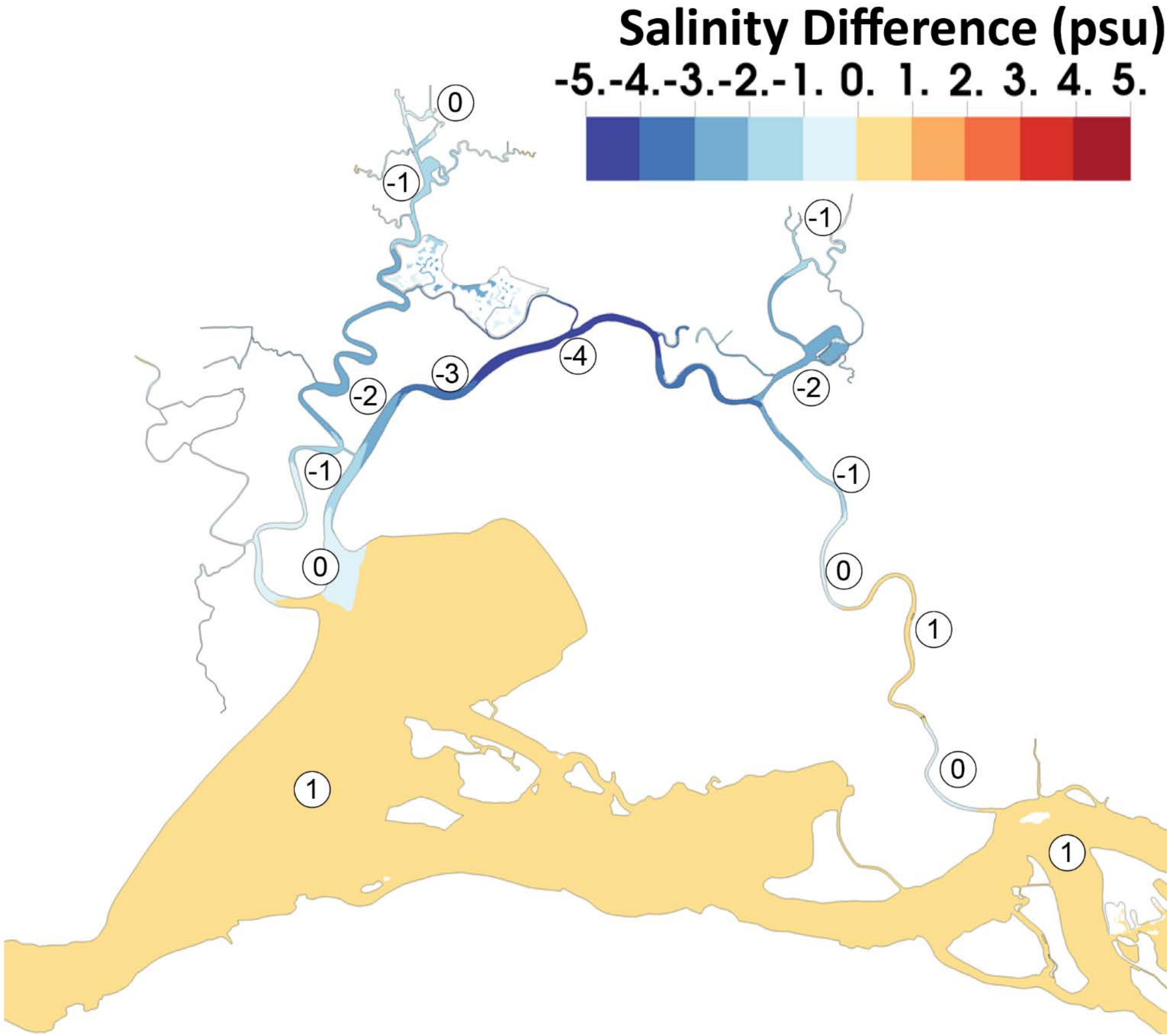
KEY RESULTS

The Suisun Marsh Salinity Control Structure is known to effectively freshen the marsh area. Figure 3 shows the change in salinity averaged over a fortnightly period in 2012 during operations. Tidal operation freshens the marsh with mild increases along the main stem of the estuary. Note that for 2012 approximately 550 cfs compensating flow has been applied (derived from DSM2 water cost studies), so that upstream at Jersey Point the salinity difference is zero – without this flow the increase in salinity on the main stem would be somewhat larger.



The category “All” represents the spatial union of areas in the legal Delta, Suisun Marsh and Suisun Bay.

Figure 2: Regions Used to Aggregate Low Salinity Zone and Habitat Suitability Indexes



The averaging period is August 29 – September 12, 2012.

Figure 3: Change in Fortnightly Salinity (in psu, equivalent to psu) in the Marsh Region Induced by Operating the Gates Tidally Starting August 14, 2012

Figure 6 and Figure 7 show time series of Low Salinity Zone and suitable habitat within zones under the gate actions in 2012. Figure 8 and Figure 9 show the same results for 2017. As demonstrated by these figures, SMSCG freshens the Suisun Marsh and has the potential to improve marsh habitat under some conditions. The potential increase in habitat from gate operations was most pronounced in the late August-September period in 2012 when external considerations such as the D-1641 agricultural standards do not incidentally freshen the marsh. Time continuity of habitat is also achievable for years such as 2012 if the gates are operated in August-September, bridging the period when LSZ habitat is protected by D-1641 objectives outside the marsh, with the period water quality is protected by standard tidal operation of the SMSCG radial gates typically starting mid-October. Such time continuity is evident in the LSZ acreage plot of Suisun Marsh in 2012. A sustained freshet peaking at a Net Delta

Outflow Index of 65,000 cfs coincides with the end of the habitat time series plot so the acreage at that time appears to represent habitat potential as represented by the model domain, slightly over 3,800 acres in the case of Suisun Marsh.

Similarly high flows predominated in 2017. Trivially, operation of the gate is not beneficial in the marsh under conditions that are already fresh, which continue to November. In fact, summer or fall tidal operation of the gate in very wet years such as 2017 improves water quality but does not create habitat as defined by the 6psu LSZ threshold. The tidal gate operation does, however, have a residual freshening effect in November that is visible in Figure 8. Additionally, during this November residual effect there seems to be a synergistic effect in the marsh between the 80km X2 flow augmentation and the tidal operation of the gate.

Fresh antecedent conditions would be expected in all Wet years through the August 15 end of the D-1641 agricultural objective. They would also hold under a Fall X2 requirement of 80km or better, or as a result of aggressive drawdown of reservoirs for flood control reasons that leads to high outflow. Low salinity does not otherwise seem to be a guaranteed consequence of a Wet year classification especially in drier fall months -- in some historical wetter years prior to the 2008/2009 biological opinions (e.g., 2000, which was regulated as Wet based on forecasts), fall salinity rose significantly enough that a gate action by itself might have been beneficial.

According to the modeling presented here, SMSCG tidal operation does not improve water quality over an appreciable acreage in Grizzly Bay during the operation period and in fact can rotate the salinity field in a way that slightly reduces LSZ habitat, as shown in Figure 3. The change is usually small (<1 psu) relative to the 6psu threshold for LSZ – for comparison, Beldons Landing salinity under these circumstances and averaging period decreases by 4.25psu from 7.29 to 3.04 psu.

The lack of LSZ habitat improvement in Grizzly Bay due to the gate action is visually important and represents a difference with prior results by AnchorQEA (2018) suggested freshening of 1-2psu over a substantial acreage in Grizzly Bay during a 2018 operational experiment. Field evidence on this point supports the position presented here, that Grizzly Bay is not freshened by tidal operation. Figure 4 shows the relationship between tidally averaged salinity at Collinsville and Grizzly Bay and, for comparison, at Hunter Cut. Points are colored by the gate operating regime. The colored dots represent 2008–2019 for Hunter Cut and the shorter 2016–2019 period of record for Grizzly Bay. The points have been filtered to eliminate periods of large flow transitions or Delta filling extremes (stage values far from 14-day average). The exception is the black dots, which represent the seven day transition (two before and five after) at the conclusion of the 2018 SMSCG field experiment. If Grizzly Bay were significantly freshened while Collinsville goes up as suggested by the AnchorQEA (2018) result, the scatter between Grizzly Bay and Collinsville when SMSCG is tidally operating, would shift compared to when SMSCG is open. Hunter Cut, which does exhibit this shift, is shown for contrast. Instead, Collinsville and Grizzly Bay seem to have the same relationship or only show minor differences regardless of the operating regime of the gate, suggesting that the SMSCG operation may have minimal effect on Grizzly Bay salinity conditions and that the salinity at Collinsville and Grizzly Bay would likely respond mostly to a common dynamic. In SCHISM results, this change is manifest as a mild increase in salinity at both locations when the SMSCG was tidally operating.

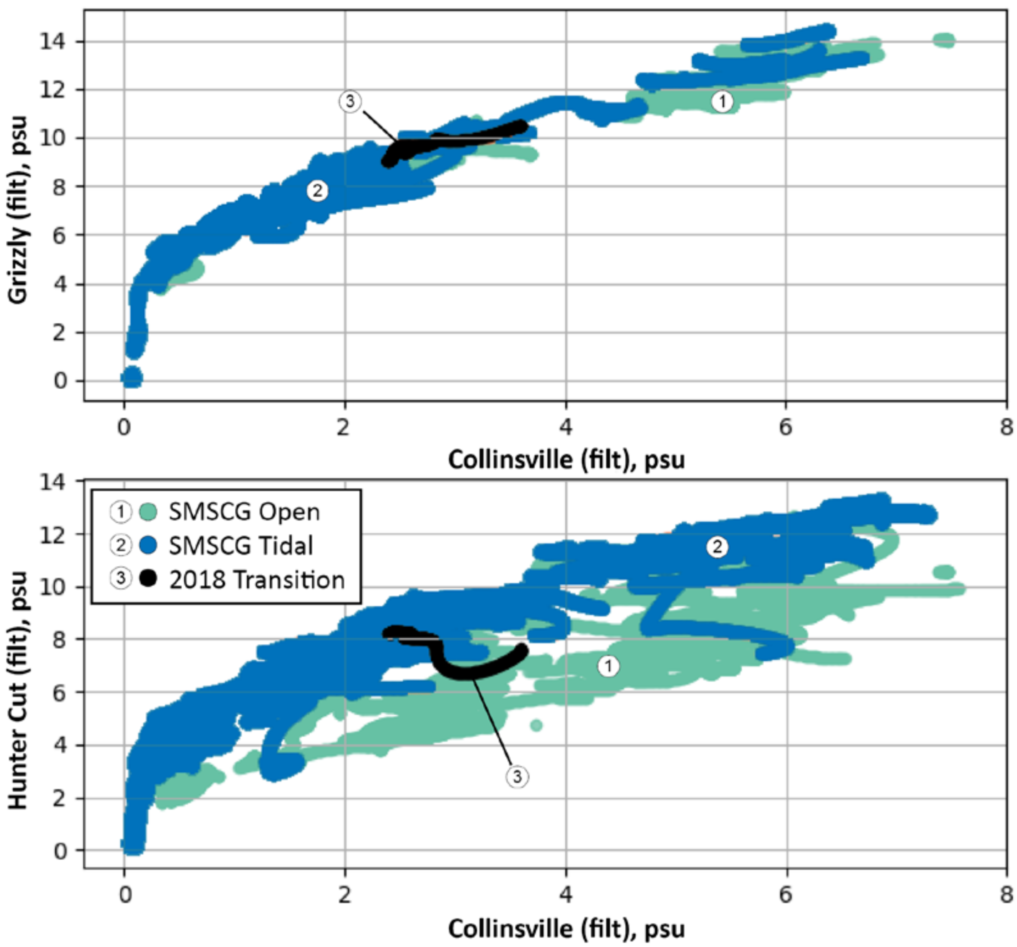
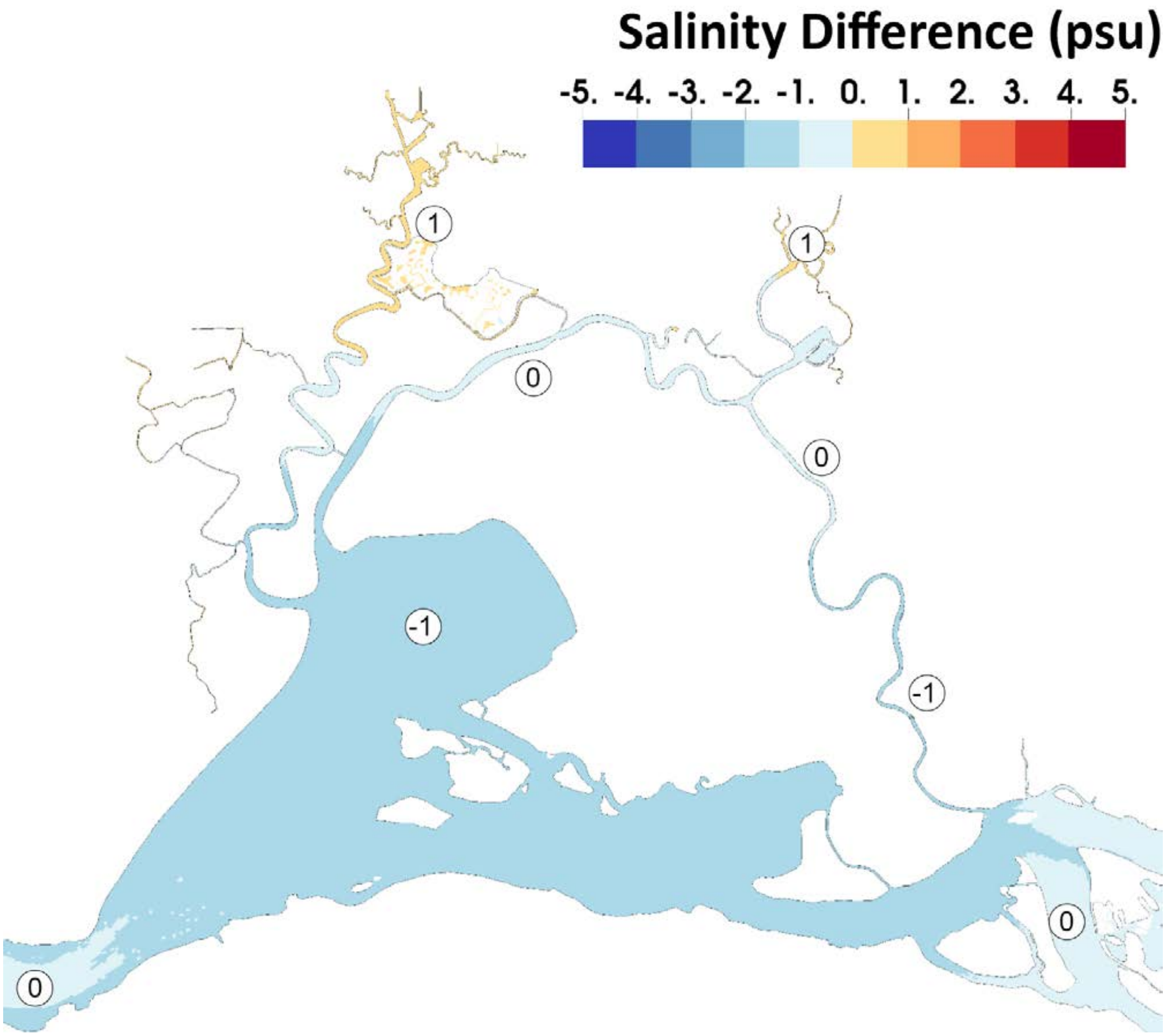


Figure 4: Comparison of Tidally Filtered Salinity at Collinsville (x-axis) Versus Grizzly Bay (CDEC GZB, top) and Hunter Cut (CDEC HUN, bottom)

Flow augmentation in fall 2017 targeting an X2 of 80km has little effect on LSZ of habitat in Grizzly Bay, particularly in October when it is very similar to the base condition. There is a decrease in LSZ habitat in parts of September, but this is because base September values are affected by reservoir drawdown so that X2 is lower in the base than in the action. The salinity change induced by this action relative to the No X2 case for that year is shown in Figure 5. Operating the gate tidally in addition to such a flow augmentation creates persistent habitat in November as noted above. The improved habitat conditions in November may be partly a result of the additional outflow needed to maintain the X2 at 80 km when gate is operating tidally. The gate action requires considerable compensating flow to maintain X2 at 80 km on the main stem, essentially supplementing the full 2,500 cfs net flow that is directed to Montezuma Slough with gate operations.

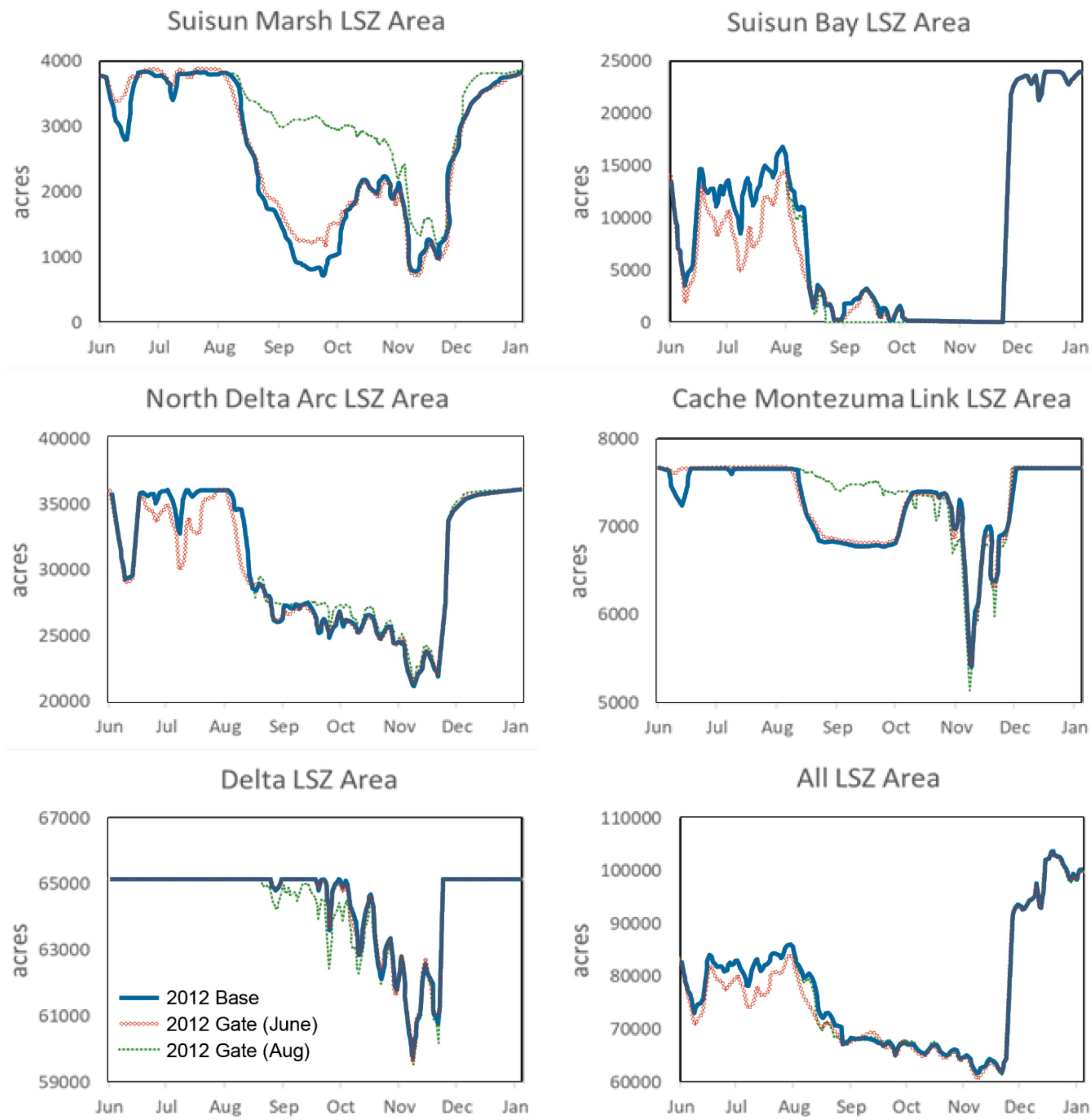
Flow augmentation in fall 2017 targeting a lower X2 value of 74km generates up to 11,000 acres of LSZ of habitat in Suisun Bay relative to the base case, with an improvement of 1000 acres or more persisting from October 9 to December 1.

When temperature (25 degrees Celsius [○C]) and Secchi Depth (0.5m) are considered in the three-variable habitat suitability index. The water clarity considerations (and to a lesser extent temperature) restrict candidate habitat considerably. This is particularly true when aggregated over large areas like the full statutory Delta, since water clarity or high temperatures excludes most of the interior Delta. Much of the remaining eligible habitat was in Suisun Bay and Marsh and the North Delta. However, one striking result in 2017 is that Suisun Bay LSZ habitat is greatly expanded but the three-variable habitat suitability index is not. This condition appears to be driven by water clarity, and a great deal more habitat would be available if the indexes were not binary (i.e., greater than >0.5 m Secchi not suitable versus <0.5 m suitable) and therefore brittle. In the present methodology, 6.1 psu is not habitat and 5.9 psu is.



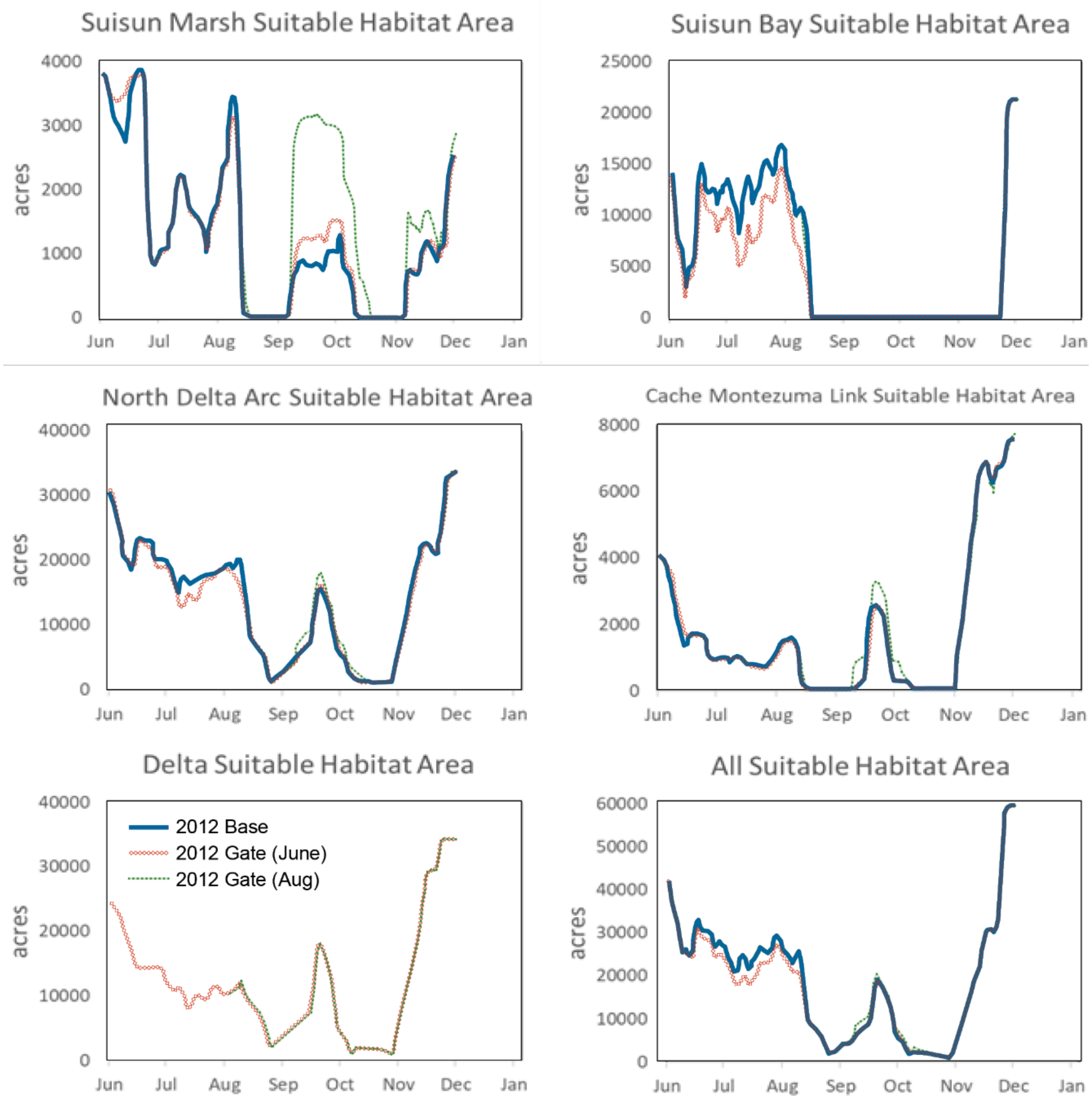
Averaging period was October 29 to November 12, 2017 (the largest effect happened slightly after the end of the action

Figure 5: Salinity Changed Induced by the 80km X2 Action in 2017 Relative to the No X2 Case Where the Historical 2017 fall X2 Action was Rolled Back to Conform to Other Regulatory Objectives and Obligations



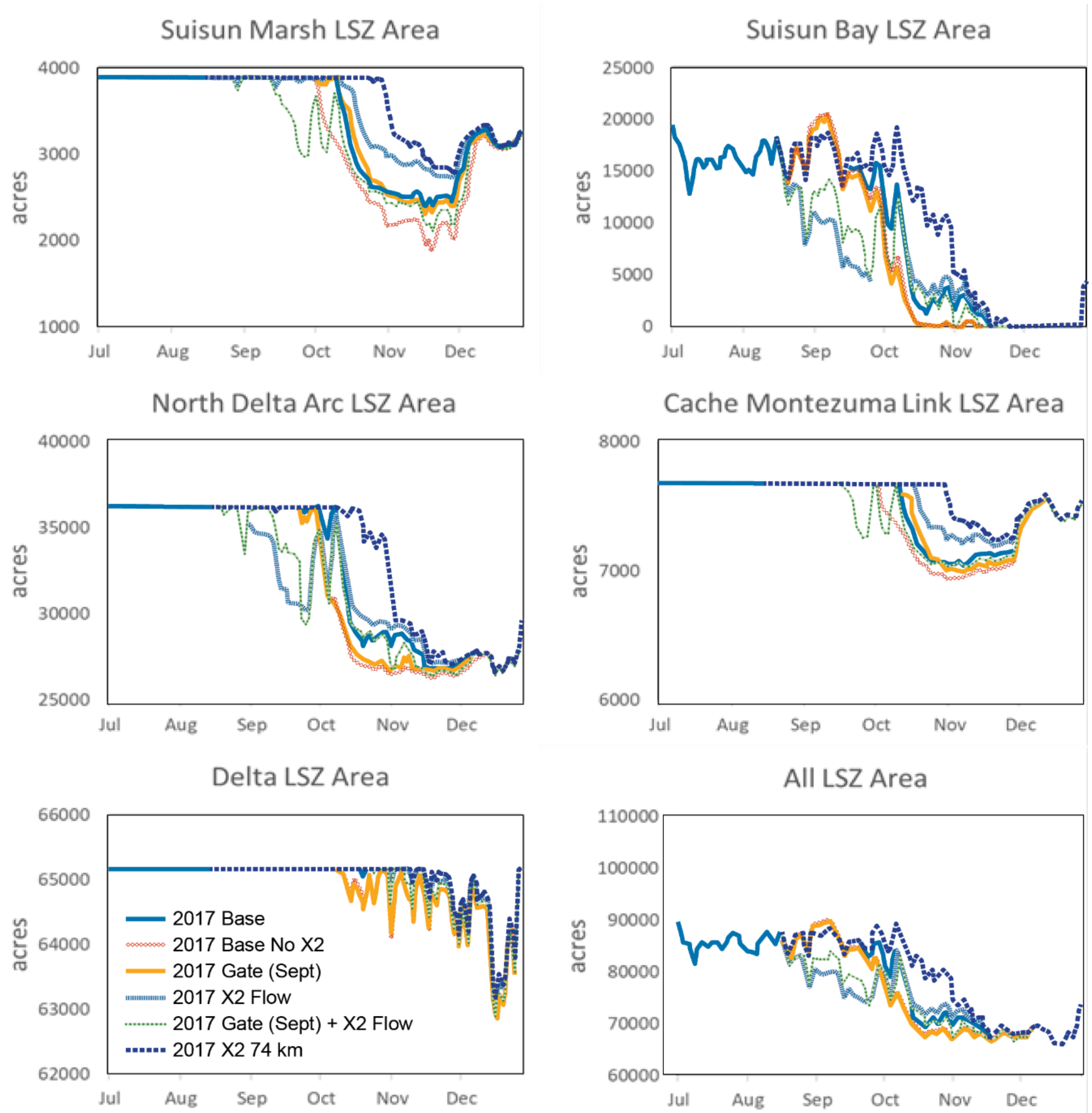
The base and two alternate gate timings are shown.

Figure 6: Low Salinity Zone Acreage in each of the Study Regions, Daily Averaged, for 2012



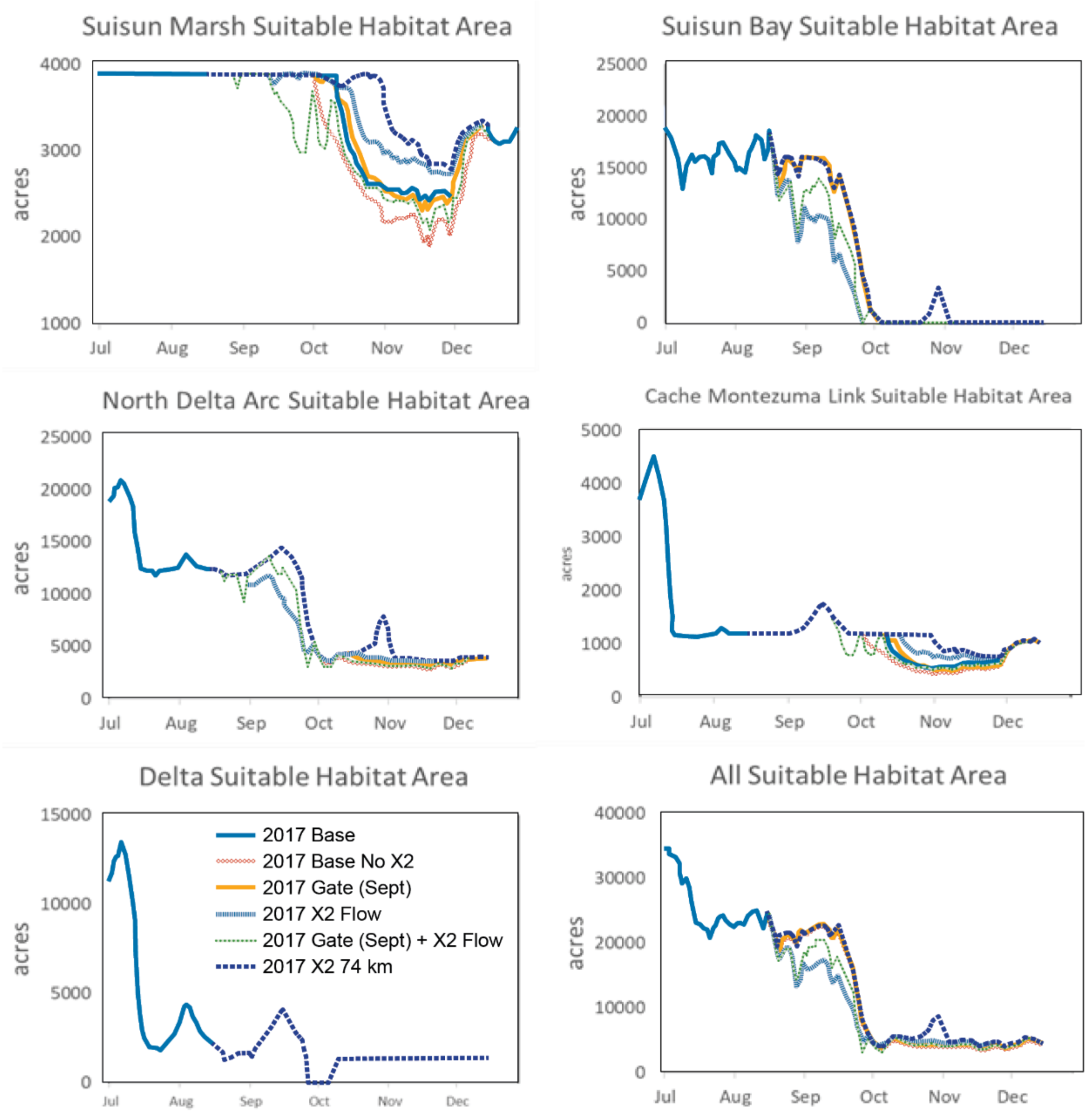
Areas are daily averaged.

Figure 7: Suitable Habitat Acreage within each of the Study Regions in 2012 using the Temperature, Seccchi Depth and Salinity Thresholds Described in the Text



The base, September gate operation, September-October 80 km X2, and both gate and 80 km X2 scenarios are shown.

Figure 8: Low Salinity Zone Acreage in each of the Study Regions, Daily Averaged, for 2017



Areas are daily averaged.

Figure 9: Suitable Habitat Acreage within each of the Study Regions in 2017 using the Temperature, Seccchi Depth and Salinity Thresholds Described in the Text

CONCLUSIONS

SMSCG tidal operation reliably freshens the marsh, but not Suisun Bay. The habitat benefits dependent on water clarity. Over a variety of year types, the most effective period for SMSCG tidal operations is after August 15 when mid-marsh salinity would otherwise rise steadily until any typical October action. When such SMSCG actions are followed by operations in October, considerable time continuity of the habitat can be achieved within the marsh. This seasonality is also largely predictable, which helps avoid thresholds which are hard to design in a way that they do not initiate the action too early.

Flow augmentation that maintains X2 at 80km appears to open up an additional 2,000–8,000 acres of LSZ habitat in Suisun Bay during the period of the action, as well as marsh habitat if the marsh is not so fresh as to render the action redundant. In 2017, this redundancy in the marsh was an issue through October. The flow and gate actions generated up to 500 acres (20%) extra LSZ habitat, but only as a residual improvement in November after the actions had already ended. Unlike the marsh, Suisun Bay LSZ habitat tends to respond to flow and gate interventions during higher flows.

One increment that may be of interest is the habitat difference between 74km and 80km X2. Comparison of the historical base run in 2017 (approximately 74km) and the 2017 X2 Flow run (80km) indicates that the LSZ habitat difference between these cases is approximately 5,000–6,000 acres (peaking at the end of September) in Suisun Bay. There is little change in the marsh because both X2 targets are sufficient to provide LSZ habitat there.

Even though there appears to be significant increase in low salinity habitat for some of the actions, the improvements in three-variable habitat index were muted, mainly due to the definition used for suitable water clarity. Tidal gate operations while holding 80km X2 requires an additional 2,500 cfs of additional flow beyond the 80km X2 action, which means that nearly all the flow diverted along Montezuma Slough must be compensated by releases or export reductions. It is not clear whether it is the flow or the gate operation provides the habitat benefit.

LIMITATIONS AND CAVEATS

Thresholds are sensitive: The threshold-based habitat metrics posed thus far are brittle for Suisun Marsh and Bay. 6psu is a common value for salinity in summer under the regulatory regime for many water types. A 0.1-0.4 psu variation would yield different significant area calculations. The same is true for the Secchi disk threshold of 0.5m, since at least in parts of 2012 and 2017 Suisun Bay hovered near this value. Although the study did not investigate either threshold in detail, it appears that values of 6.5 psu and 0.55m would more distinctly partition common operating regimes.

Turbidity is a sensitive component of habitat metric calculations limiting the habitat area severely in late summer and early fall outside of Suisun Marsh, Suisun Bay and parts of the North Delta. Temperature was less influential, except upstream on the San Joaquin River and in the South Delta where it excluded habitat.

Suisun Marsh Consumptive Use: Uncertainty over Suisun Marsh Consumptive Use was described in the modeling description. Work on marsh consumptive use is relatively recent. Progress has been made in estimating channel depletions and managed flows in the marsh in recent years. In the present study, uncertainty has been addressed with estimates that agree well with seasonality of flow and salinity measurements that are available and with reasonableness bounds imposed by evapotranspiration.

Definition of X2: Components of this study required that X2 be positioned at 80km. For these actions, the regulatory surrogate (2.64 milliSiemens per centimeter [mS/cm] surface EC) was used to position the salinity field, not the conceptual value of 2psu bottom salinity. The regulatory X2 represents the compliance method and has a higher outflow burden on the projects. The X2 surrogate used in compliance and the ecological literature is nearly always lower than conceptual X2 and therefore conservative. Stratification and shoal-channel differences do not completely explain the difference when X2 is near Collinsville. Figure 4 shows that salinity at Collinsville (81km) must be considerably fresher than 2psu for salinity at Grizzly Bay gage to fall below the 6 psu LSZ habitat threshold.

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