INTEGRATED REGIONAL WETLANDS MONITORING (IRWM) PILOT PROJECT

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This project is funded by the California Bay-Delta Authority Science Program

CALIFORNIA BAY-DELTA AUTHORITY

Physical Processes: Inundation, Datums, Salinity, Channel Geometry

S. W. Siegel[1], P.A.M. Bachand[1], J. Lowe[2], J. Kulpa[3], T. Carson[1], C. Toms[1], S. Avent[1], G. Appling[1]

[1]Wetlands and Water Resources, [2]Philip Williams and Associates, [3]Environmental Data Solutions

INTRODUCTION

How Physical Processes fit into IRWM

Physical processes are included in the IRWM Pilot Project for two primary reasons. First, the status of tidal marshes and the consequences of restoration and other activities are strongly reflected in hydraulic, topographic, and edaphic (soil) variables. These variables, in turn, exert a strong influence on and are modified by a variety of biological variables such as vegetation colonization. Thus, changes in marsh form, function, and extent are often reflected in the distribution of water and sediment. Second, interpretation of the distribution, abundance, and habits of living organisms that utilize tidal marshes generally requires knowledge of the spatial and temporal variations in physical parameters. Physical processes, in combination with landscape ecology processes, form the overarching conceptual model for IRWM; this model is presented on the adjacent poster, Introduction to IRWM Part 1: Overview and Conceptual Models and it describes inundation, the estuarine salinity gradient and sediment supply as the fundamental external processes that drive tidal marsh evolution and development and abiotic and biotic variability.

Standing 6'3" above the marsh plain just wasn't high enough; view from atop a data logger/telemetry station.

Poster Overview

This poster presents a calendar showing all the physical data being collected for the IRWM project and it uses a subset of these data to present preliminary results and analyses and early insights that will be expanded upon as the project progresses. We show surface water salinity data at all sites then a variety of results and analyses for one site, Brown's Island, located at the confluence of the Sacramento and San Joaquin rivers in the western Delta as it enters Suisun Bay.

Site	Location	Marsh Region	2003 Sep	2003 Oct	2003 Nov	2003 Dec	2004 Jan	2004 Feb	2004 Mar	2004 Apr	2004 May	2004 Jun	2004 Jul	2004 Aug	2004 Sep	2004 Oct	2004 Nov	2004 Dec
Water Level Sensors/Water Level, Conductivity, Suspended Sediment (at CTDS only)																		
Brown's Island	WL-1	marsh plain																
	WL-2	marsh plain																
	WL-3	marsh plain																
	WL-4	marsh plain																
	WL-5	channel																
	CTDS	inlet channel																
Bull Island	WL-1	marsh plain												*discontinued*				
	WL-2	marsh plain																
	WL-3	marsh plain																
	WL-4	channel																
	CTDS	inlet channel																
Coon Island	WL-1	marsh plain																
	WL-2	marsh plain																
	WL-3	marsh plain																
	WL-4	channel																
	CTDS	inlet channel																
Carl's Marsh	WL-1	marsh plain												*discontinued*				
	WL-2	marsh plain																
	WL-3	channel																
	CTDS	inlet channel																
Pond 2A	WL-1	marsh plain																
	WL-2	marsh plain																
	WL-3	marsh plain																
	WL-4	channel																
	CTDS	inlet channel																
Sherman Lake	WL-1	channel												*discontinued*				
	WL-2	marsh plain																
	WL-3	marsh plain												*discontinued*				
	WL-4	marsh plain																
	CTDS	inlet channel																
Porewater Salinity Readings																		
Brown's Island																		
Bull Island																		
Coon Island																		
Carl's Marsh																		
Pond 2A																		
Sherman Lake																		
Channel Cross-section Surveys																		
Brown's Island																		
Bull Island																		
Coon Island																		
Carl's Marsh																		
Pond 2A																		
Sherman Lake																		

Table 1. Data collection activities carried out by the Physical Processes Team. Shaded boxes indicate active data collection.

TIDAL INUNDATION, FREQUENCY, AND DURATION

Tidal inundation regime is defined as the frequency, duration and depth of water reaching the marsh plain of estuarine tidal marshes. The site-scale tidal inundation regime exerts significant control across the marsh plain in the chemical and physical properties of marsh soils with accompanying changes in the biological community. Inundation regimes can vary drastically over short distance within marshes that are relatively small in area. This variance is in large part controlled by the local tidal datum, marsh plain elevations, drainage characteristics, and vegetation.

We designed and implemented a large scale field data collection effort throughout all six IRWM sites in order to collect information on tidal inundation regimes at each site. This monitoring effort included water surface elevation (WSE) time series, logged at 12-minute intervals, at three to six locations within each marsh. One to four of the data collection stations are located on the marsh plain and two stations are located in each "main" tidal channel, at the inlet and headward ends. Figures 5 to 10 of the IRWM Introduction Part 2 Poster show sample locations. Associated with this monitoring effort, we performed first-order surveys of each data collection platform and marsh plain elevations, and channel cross sections.

We analyzed 80 days of data (2/28/04 through 5/19/04) collected from Brown's Island marsh plain stations 3 and 4 (Figure 8 on the Intro Part 1 poster). There is a 1.1 ft elevation difference between these two sites: WL-3 is 5.0 ft and WL-4 is 6.1 ft NAVD; local MHHW is 5.9 ft NAVD. We filtered the data to extract inundation frequency and duration at or above the marsh plain and inundation greater than 1 foot above the marsh plain. We also extracted duration between inundation events.

These data subsets were than analyzed to answer the following questions:

1) How often did the tide reach the marsh plain?
2) What was the duration for each period of inundation?
3) How often did the depth exceed 1.0 foot?
4) What was the duration of each period of inundation above 1.0 ft.?
5) What was duration between inundation events?

The analysis included looking at the statistics (minimum, mean, median and maximum) on a per-event basis and per-day basis (Table 2).

These results show that a relatively small change in local marsh plain elevation between two sites (1.1 ft) can have a dramatic effect on tidal datum inundation regimes. The maximum duration between inundation events (dry marsh plain) shows the most dramatic change between WL-3 and WL-4: 5.72 versus 66.32 days, respectively, during the data period evaluated. Figure 1 displays the duration of inundation at the Brown's Island CTDS, WL3 (the lowest elevation station), and WL4 (the highest elevation station).

Brown's Island Inundation Regime - Depth, Duration, and Frequency

		Period of Records				Per-Event Duration				Event Frequency		
Station	Event Type	From (date)	To (date)	Event (count)	Day (count)	min (day)	mean (day)	median (day)	max (day)	min (day^{-1})	mean (day^{-1})	max (day^{-1})
Lowest elevation marsh plain station (partial data set)												
BrI-WL-3	**Inundation**	2/29/04 6:24	5/19/04 4:12	102	79	0.02	0.14	0.15	0.26	0.00	1.24	2.00
BrI-WL-3	**depth>1.0ft**	3/1/04 9:36	5/19/04 2:36	31	78	0.01	0.08	0.07	0.16	0.00	0.40	1.00
BrI-WL-3	**dry**	2/28/04 10:36	5/19/04 23:36	103	80	0.24	0.63	0.45	5.72			
Highest elevation marsh plain station (partial data set)												
BrL-WL-4	**Inundation**	2/28/04 18:36	5/19/04 4:00	4	80	0.13	0.16	0.17	0.18	0.00	0.04	1.00
BrL-WL-4	**depth>1.0ft**	NA	NA	0								
BrL-WL-4	**dry**	2/28/04 18:36	5/19/04 4:00	5	80	0.81	15.93	0.86	66.32			

Notes:
1) BrI-WL-3 elevation is 5.0 ft NAVD, or - 0.9 ft relative to local MHHW
2) BrI-WL-4 elevation is 6.1 ft NAVD, or + 0.2 ft relative to local MHHW

Table 2. Tidal inundation depth, duration, and frequency statistics for marsh plain stations WL-3 and WL-4 at Brown's Island.

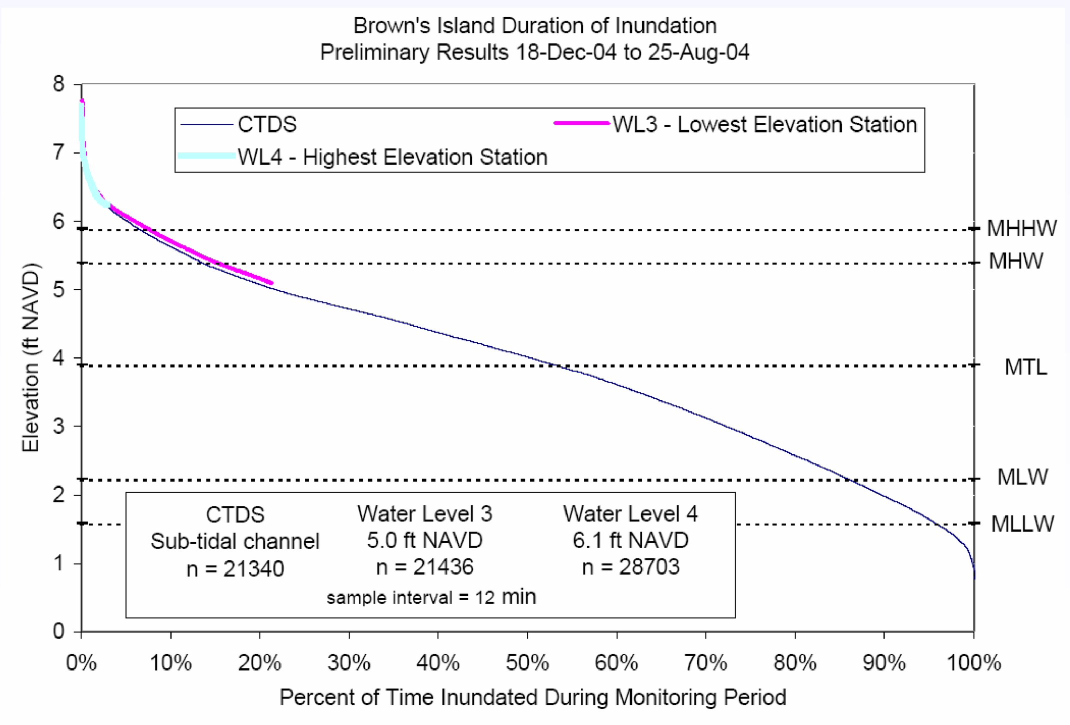


Figure 1. Percent time inundated vs. elevation, Brown's Island

TIDAL DATUMS

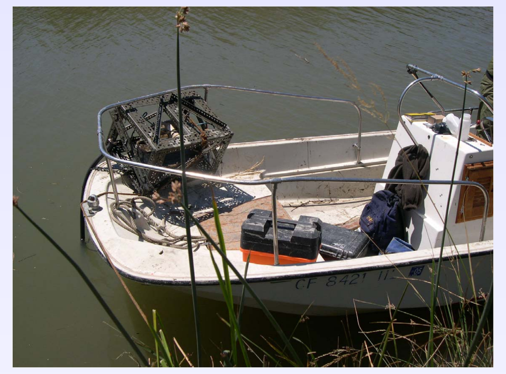
One of the most critical factors driving the IRWM conceptual model is the role of tidal inundation in the evolution of a marsh. One metric of inundation on the site scale, tidal datums, relates the tide heights to marsh plain elevations. Relative heights of tides and marsh plains are a critical ecological determinant. The San Francisco Estuary has mixed, semi-diurnal tides, meaning twice-daily tides with differing elevations for successive high and low tides. As a result, there are five tide levels of most interest to the IRWM team:

- Mean Higher High Water (MHHW) – the average elevation of all higher high tides
- Mean High Water (MHW) – the average elevation of all high tides
- Mean Tide Level (MTL) – the average elevation of all tides
- Mean Low Water (MLW) – the average elevation of all low tides
- Mean Lower Low Water (MLLW) – the average elevation of all lower low tides

Tidal datums were calculated using the method of corresponding tides described in Computational Techniques for Tidal Datums (NOAA, 2003). The reference station used in the calculations was the NOAA NOS Port Chicago station at Concord Naval Weapons Station (NOS 941-5144), approximately 8.8 km west of Brown's Island. The results of the tidal datum reckoning are displayed below in Table 3. Water level data for all six stations at Brown's Island (CTDS, one channel station, four marsh plain stations) is graphed in Figure 2 along with the tidal datums for the CTDS station.

Datum	Port Chicago (ft NAVD)	BrI CTDS channel at inlet (ft NAVD)	BrI CTDS channel at inlet # Tides	BrI WL-5 channel at head (ft NAVD)	BrI WL-5 channel at head # Tides
MHHW	6.01	5.87	136	5.96	127
MHW	5.51	5.38	272	5.49	253
MTL	3.68	3.89	21338	3.93	15718
MLW	1.84	2.22	271	2.16	253
MLLW	1.10	1.57	136	1.43	127
MLLW - MHHW range	4.91	4.30		4.59	

Table 3. Preliminary tidal datums at Brown's Island



Inlet channel CTDS monitoring station mooring: conductivity, temperature, depth, suspended sediment

Marsh plain water level monitoring station

Headward channel water level monitoring station

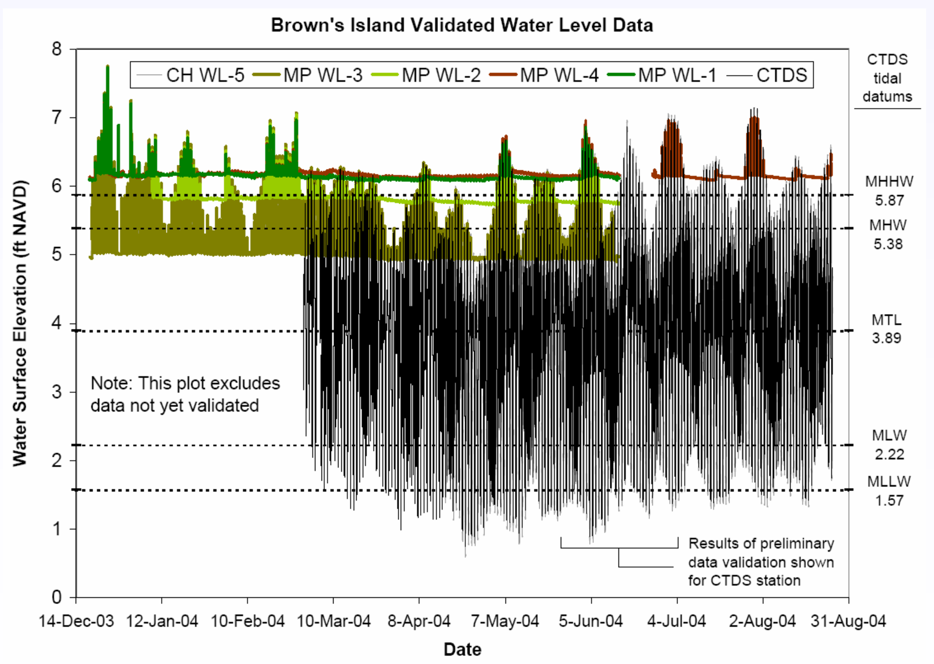


Figure 2. Water level time series data, all stations, Brown's Island

Taking a break from hydrographic surveying

CROSS-SECTION MORPHOLOGY

Brown's Island contains minimal tidal channel complexity. A single large channel dominates the interior of site with relatively few small channels extending into the marsh plain. Several large, linear channels extend around the exterior of the site. We surveyed four Brown's Island channel cross sections (Figure 3) along the length of the site's primary channel using hydrographic methods. Survey results indicate relatively unchanging channel geometry along the length of this channel. Channel cross section locations are shown in Figure 8 of the Introduction to IRWM Part 2: Site Selection poster.

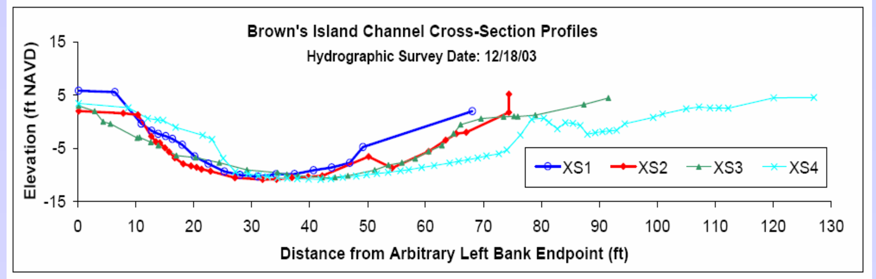


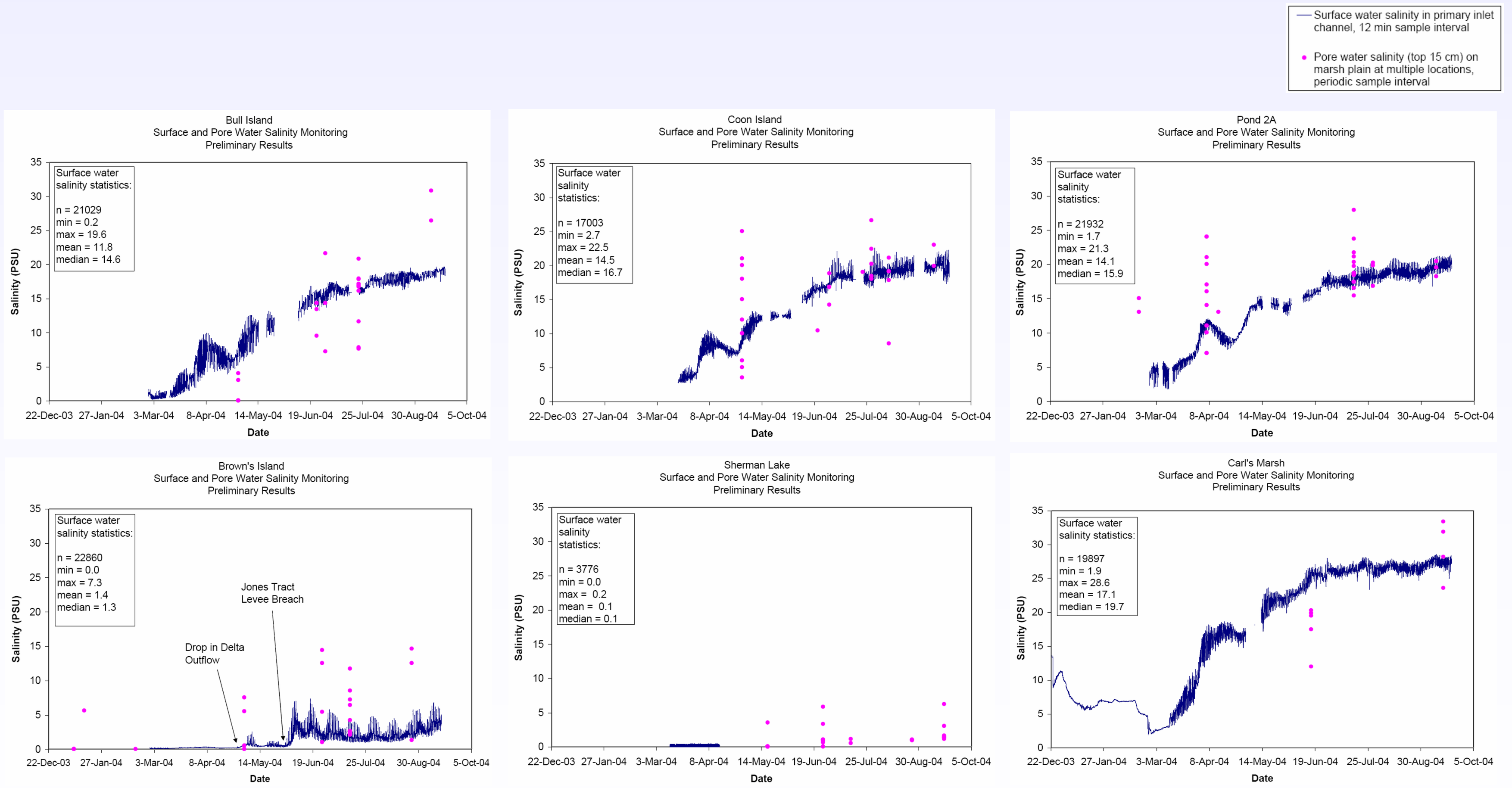
Figure 3. Channel Cross-Section Profiles at Brown's Island

SURFACE WATER AND MARSH PLAIN PORE WATER SALINITY

Salinity fundamentally influences tidal marsh structure, function, and process. It affects the distribution and abundance of marsh vegetation, influences ecological interactions, affects sedimentation, and affects site use by invertebrates, amphibians, reptiles, mammals, fish and birds. To characterize salinity dynamics at the six IRWM sites, continuous inlet channel surface water salinity monitoring and periodic marsh plain pore water salinity monitoring is being conducted. A Conductivity, Temperature, Depth, and Suspended Sediment (CTDS) station logs specific conductance (mS/cm) at 12-min intervals at an inlet channel. We convert specific conductance values to Practical Salinity Units (PSU) per USGS methodology. Each site has up to 12 shallow sub-surface piezometers (depth 15 cm) on the marsh plain from which pore water salinity is measured quarterly using a refractometer or handheld YSI conductivity meter. Piezometers locations were determined by vegetation class association, with three to four piezometers per vegetation class at each site.

Preliminary results of surface water salinity and marsh plain pore water salinity monitoring are shown below in Figures 4-9. The estuarine salinity gradient is evident across the six IRWM sites, with decreasing salinity values observed from the western-most site (Carl's Marsh) to the eastern sites (Brown's Island and Sherman Lake) in the west Delta. Initial pore water salinity values indicate a similar decrease in salinity values in comparing Carl's Marsh and the western Delta sites; though this decrease is not as apparent in pore water salinity observations at the Napa sites. A secondary estuarine salinity gradient is apparent along the Napa River, with decreasing salinities from Bull (northern), Coon Island (middle) and Pond2A (southern). The secondary gradient is more pronounced with late winter/early spring surface water salinity, a potentially significant factor affecting seed germination. Similarity in seasonal trend of increasing surface water PSU is apparent at the three Napa sites; once into the summer and fall period, when Napa River discharge is small relative to tidal action, all sites exhibit nearly identical values.

Brown's Island exhibited low salinity and low variability until the end of April, when salinity began exhibiting both higher values and greater variability. This shift tracks Delta outflow management changes. Brown's Island monitoring also indicates the influence of external factors, such as a notable spike in salinity following the failure of the Jones Tract levee on June 3rd. Continued monitoring of surface water and marsh plain pore water salinity over a longer duration which captures seasonal and annual variability will allow for greater ability to analyze salinity dynamics.



Figures 4 – 9. Surface Water and Marsh Plain Pore Water Salinity Graphs for all Six IRWM Study Sites