**Appendix B**

# Black John Marsh

## Introduction

Black John Marsh (hereafter Black John) is located in Sonoma County at the confluence of Black John Slough, Rush Creek and the Petaluma River. It is owned and managed by the California Department of Fish and Game. It is influenced by both tidal flow and freshwater input from the Petaluma River. Black John is part of the Petaluma Marsh complex, which is the largest marsh complex in California that has never been diked or drained. The land surrounding the marsh is used almost exclusively for agriculture and light grazing. In 2003, the California State Coastal Conservancy funded the acquisition and restoration of a 632 acre parcel just west of Black John, increasing the future potential size of the marsh. Black John is home to several endangered species and species of concern such as California black rail (*Laterallus jamaicensis coturniculus*).

This study focused on 30.9 ha portion of Black John. Elevation and vegetation surveys were conducted in 2010 using an RTK GPS. To monitor tidal inundation and salinity, two water level loggers were deployed in 2009.

## Results

### *Elevation surveys*

A total of 213 elevation measurements were taken at Black John (Fig. B-1). The elevation range was 1.18 - 1.97 m with a mean of 1.75 m (NAVD88). Half (50%) of the survey points were within 1.70 - 1.80 m, with a 0.1 m range (Fig. B-2). Over half (67%) of the survey points were located at elevations above mean high water (MHW). A 3-m resolution elevation model was developed in

ArcGIS 9.3 (ESRI, Redlands, CA), using the Kriging method (Fig. B-3). This baseline elevation model was used as the initial elevation in the WARMER sea-level rise (SLR) model.

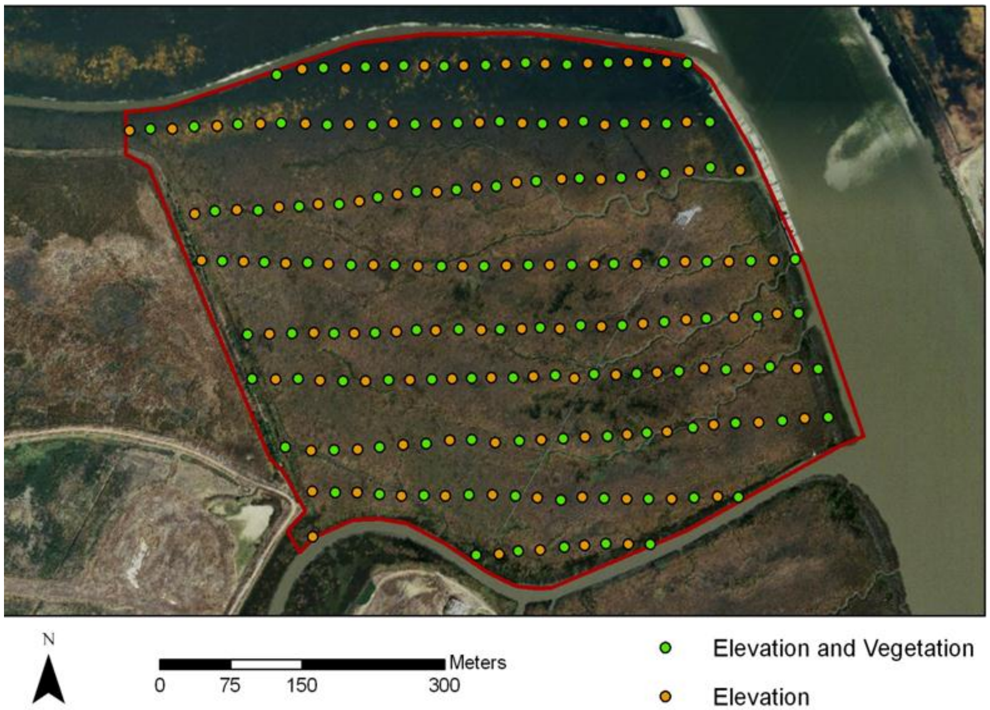


**Figure B-1.** Elevation and vegetation survey points collected at Black John in 2010.

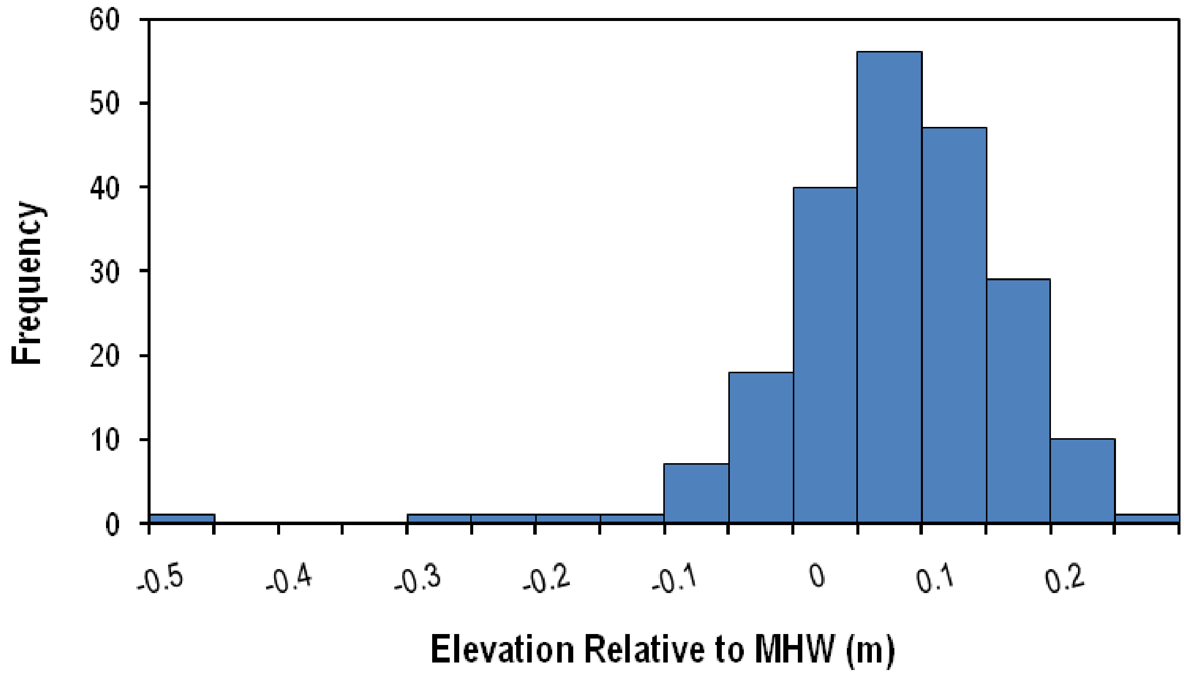


**Figure B-2.** Distribution of elevation relative to local mean high water (MHW) at Black John.

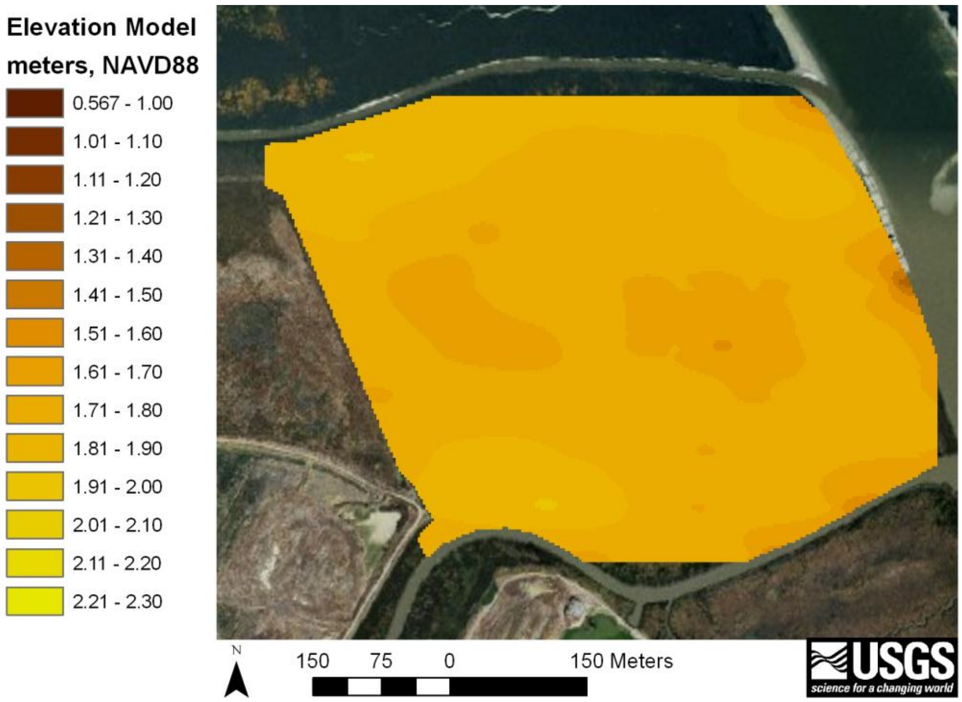


**Figure B-3.** Elevation model (3-m resolution), developed from ground RTK GPS elevation data. Parameters were optimized to produce minimal root-mean-square error.

### *Vegetation surveys*

Vegetation surveys were conducted concurrently with elevation surveys in June 2010. A total of 108 locations (Fig. B-1) were measured for vegetation composition, height (cm), and percent cover (Table B-1). We did not distinguish between *Spartina spp*. or *Scirpus spp.* in the survey. Vegetation in marshes is sensitive to soil salinity, inundation patterns and disturbance. Therefore, a stratification of vegetation species relative to MHW (Fig. B-4) was observed within this low slope marsh.

**Table B-1.** Mean marsh elevation, avg. and max height (cm), percent cover with standard deviations (SD), and presence by species at Black John.

| Species | Elevation (MHW, m) | Elevation SD (MHW, m) | Avg. Height (cm) | Avg. Height SD (cm) | Max Height (cm) | Max Height SD (cm) | % Cover | % Cover SD | n | % Presence |
|---|---|---|---|---|---|---|---|---|---|---|
| *Salicornia pacifica* | 0.02 | 0.12 | 37.59 | 11.65 | 51.46 | 14.62 | 73.22 | 30.60 | 282 | 91.56 |
| *Spartina spp.* | -0.29 | 0.03 | 47.50 | 3.54 | 50.00 | 7.07 | 13.00 | 16.97 | 2 | 0.65 |
| *Scirpus spp.* | 0.02 | 0.10 | 64.66 | 17.01 | 82.18 | 23.42 | 13.10 | 15.46 | 125 | 40.58 |
| *Grindelia stricta* | 0.09 | 0.13 | 68.09 | 21.71 | 83.26 | 28.38 | 41.05 | 25.88 | 58 | 18.83 |
| *Jaumea carnosa* | 0.13 | - | 15.00 | - | 20.00 | - | 25.00 | - | 1 | 0.32 |
| *Frankenia salina* | 0.16 | 0.31 | 27.58 | 8.81 | 35.00 | 11.48 | 45.42 | 38.82 | 12 | 3.90 |
| *Distichlis spicata* | 0.13 | 0.24 | 25.83 | 9.17 | 33.47 | 9.07 | 38.36 | 28.66 | 66 | 21.43 |
| *Lepidium latifolium* | 0.38 | 0.34 | 92.00 | 21.63 | 113.38 | 19.60 | 35.75 | 27.76 | 8 | 2.60 |
| *Atriplex triangularis* | 0.01 | 0.05 | 13.33 | 7.64 | 15.00 | 13.23 | 8.67 | 7.09 | 3 | 0.97 |
| *Baccharis pilurais* | 0.19 | 0.34 | 60.00 | 22.32 | 91.67 | 33.02 | 28.22 | 28.85 | 27 | 8.77 |

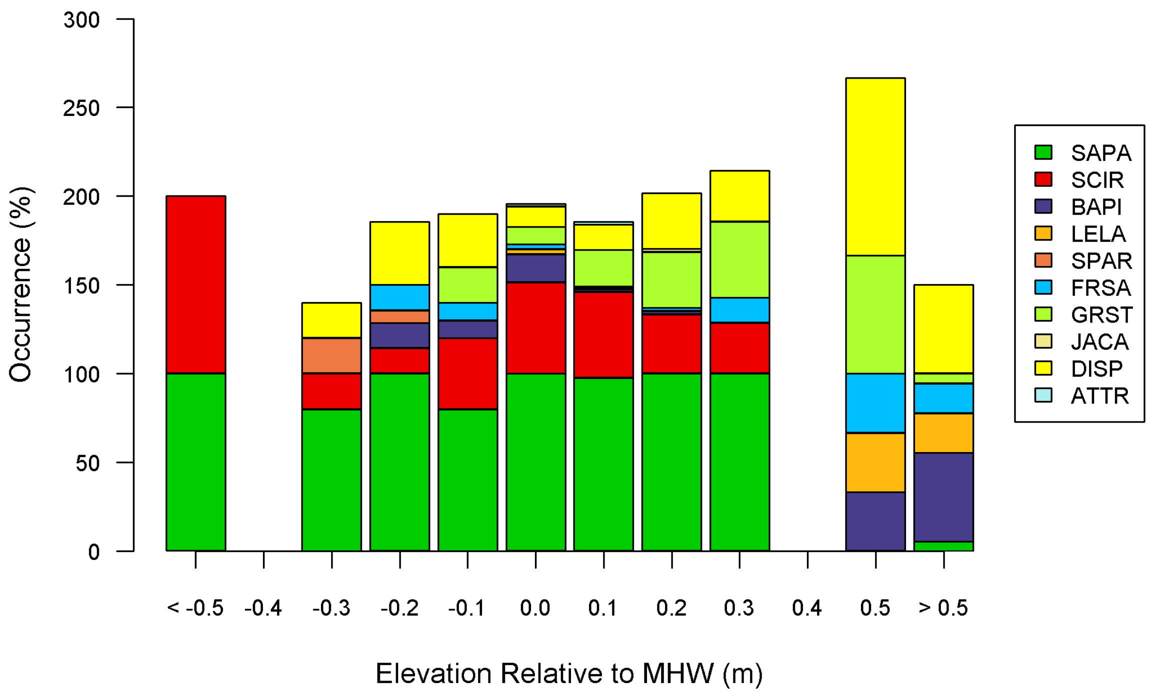


**Figure B-4.** Stratification of vegetation species was observed relative to MHW. Species codes: SAPA = *Sarcocornia pacifica;* SCIR = *Scirpus spp.;* BAPI = *Baccharis pilurais*; LELA: = *Lepidium latifolium*; SPAR = *Spartina spp;* FRSA = Frankenia salina; GRST = *Grindelia stricta;* JACA = *Jaumea carnosa*; DISP = *Distichlis spicata;* ATTR = Atriplex triangularis

***Water level monitoring***

Site-specific water level was measured from December 2009 – May 2010. Water level was measured using two data loggers deployed at the mouth of a second order channel and in the marsh interior. We found mean high water (MHW) was 1.73 m, and mean higher high water (MHHW) was 1.91 m for the site (NAVD88). The salt marsh platform (defined as mean marsh elevation) was inundated most often in January 2010 and February 2010 (Fig. B-5). Those months recorded above average water levels due to several record breaking storms that brought low air pressure and substantial rainfall, resulting in higher than predicted tides. The cumulative rainfall in

January 2010 was above average throughout the San Francisco bay area and daily rainfall records where broken in some locations (NOAA). This resulted in longer inundation periods of the marsh platform. Mean salinity during 2010 at Black John was 15.3 (SD = 6.6) PSS.

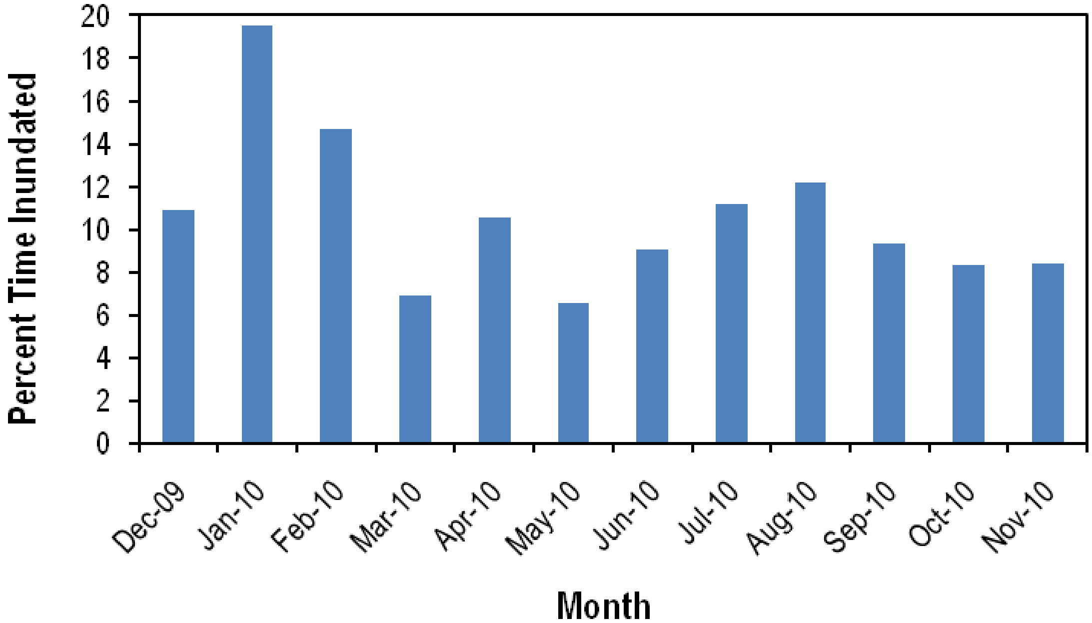


**Figure B-5.** Percent of time Black John was inundated monthly, based on the mean elevation of the marsh platform.

***Marsh elevation modeling***

The WARMER scenario indicated that Black John will not keep pace with sea level rise (SLR) through this century. WARMER results showed a gradual reduction in elevation relative to MHW over time, with a more dramatic decline after 2060 (Fig B-6). By 2080 the marsh is projected to be below mean sea level and functionally a mudflat (Fig. B-7).

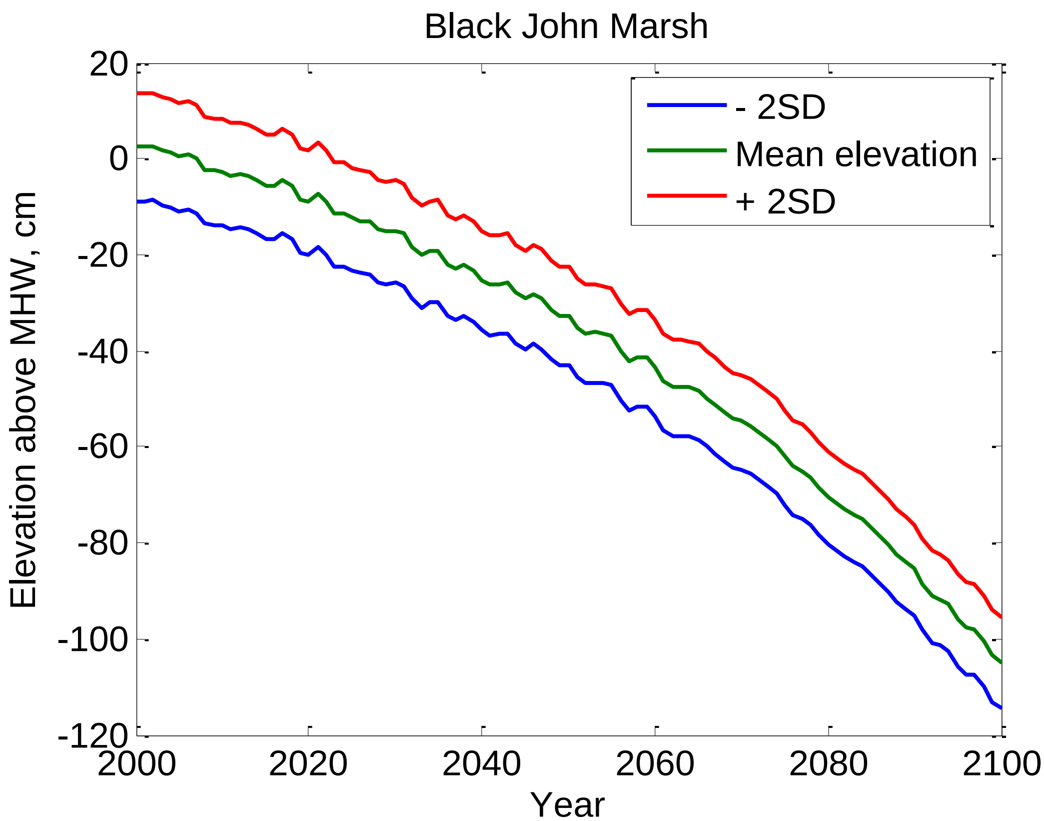


**Figure B-6.** WARMER scenarios for Black John marsh elevation change. Elevation above MHW is plotted versus model year with two standard deviations (SD).

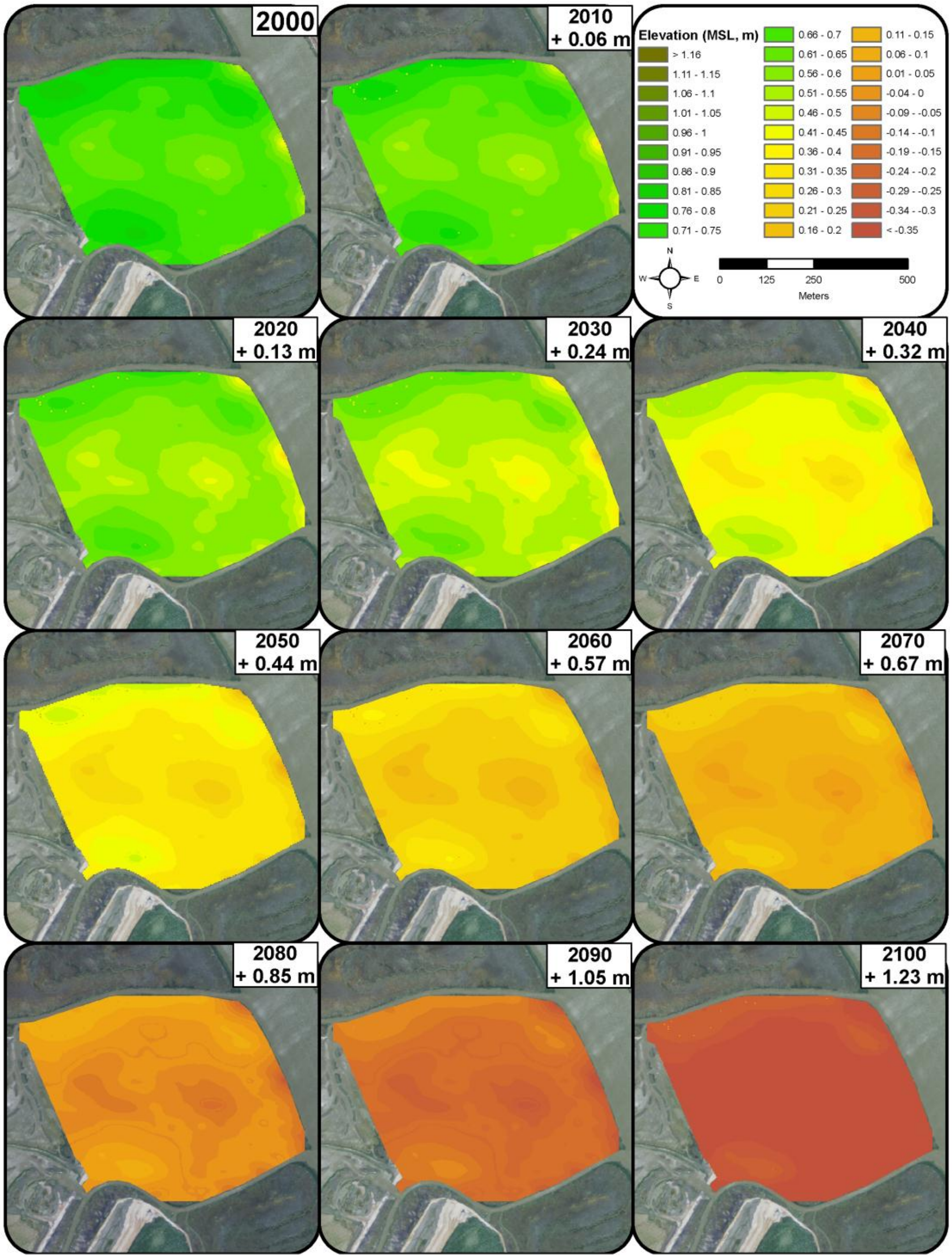


**Figure B-7.** WARMER results for Black John. WARMER accounts for changes in relative sea level, subsidence, inorganic sediment accumulation, above/below ground organic matter productivity, compaction, and decay. Non-linear sea-level rise projections for California were used (Cayan *et al.* 2009).

Elevation relative to the local tidal datum can be tied to vegetation observations (see methods). Vegetation data were categorized as mudflat, low, mid, high marsh, or upland transition plant communities (Table 4) and used to interpret the WARMER SLR results (Figs. B-8 – B-9). Upland transition (> 1.0 m MSL), is characterized by coyote bush (*Baccharis pilularis*). High marsh (0.7 – 1.0 m MSL), is characterized by *Frankenia salina* and *Jaumea carnosa*, while mid marsh (0.45 – 0.7 m MSL), is dominated by *Sarcocornia pacifica.* Low marsh (0.2 – 0.45 m MSL), is characterized by *Spartina spp.* or *Scirpus spp.* in brackish areas. Mudflat habitat (< 0.2 m MSL), is unvegetated or sparsely covered with *Spartina spp.* Currently, Black John is a mixture of mid and high marsh vegetation. All high marsh vegetation is projected to disappear by 2040 (+ 0.24 m SLR). The largest change is projected to occur around 2040 (+ 0.32 m SLR) at which time the majority of the marsh will transition to low marsh, a habitat zone which currently represents negligible area at Black John. A transition to complete mudflat was projected by 2080 (+ 0.85 m SLR).

The WARMER model parameters for Black John were extrapolated using sediment core data from Petaluma Marsh; thus, predictions should be interpreted with caution as local sedimentation processes may be different between these marshes. In addition, quality control issues with the Petaluma sediment cores resulted in the removal of data that indicated high sedimentation rates. The Petaluma River is a major source of sediment to San Francisco Bay, therefore it is likely that the current inputs to WARMER are underestimating accretion potential at Black John. To improve results, local site-specific sediment core data should be collected, along with suspended sediment concentration data to characterize sediment deposition potential.

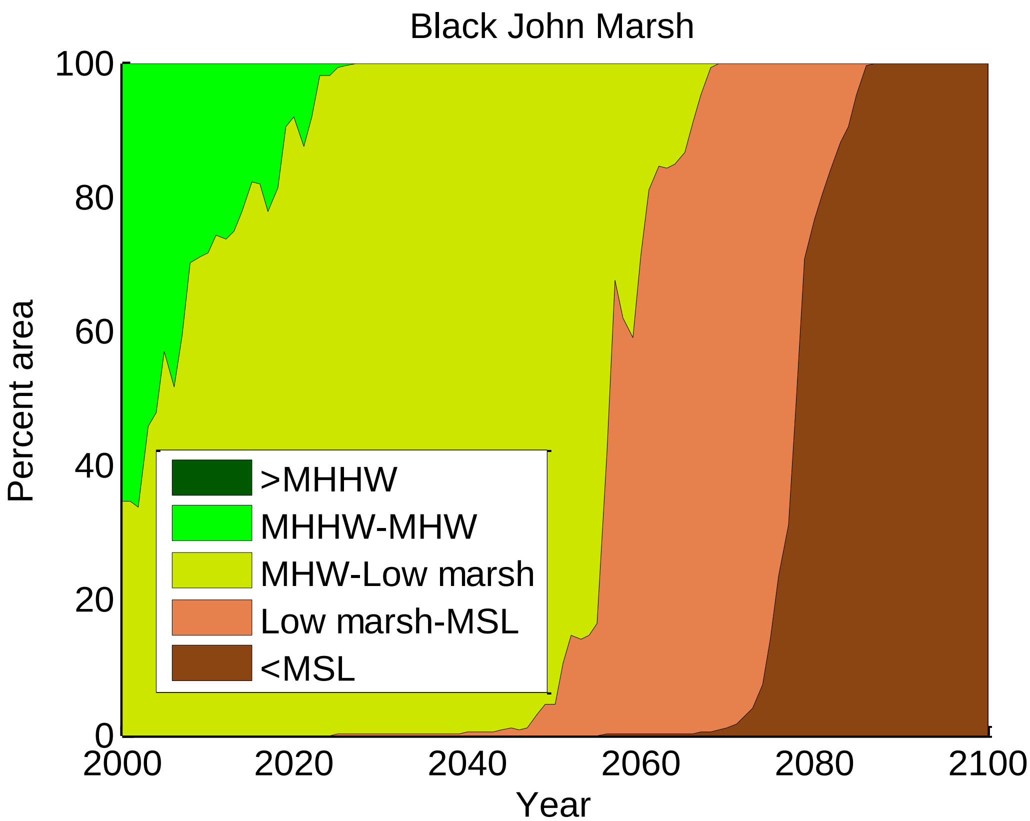


**Figure B-8.** Area of Black John within a given tidal range for the duration of the simulation period.

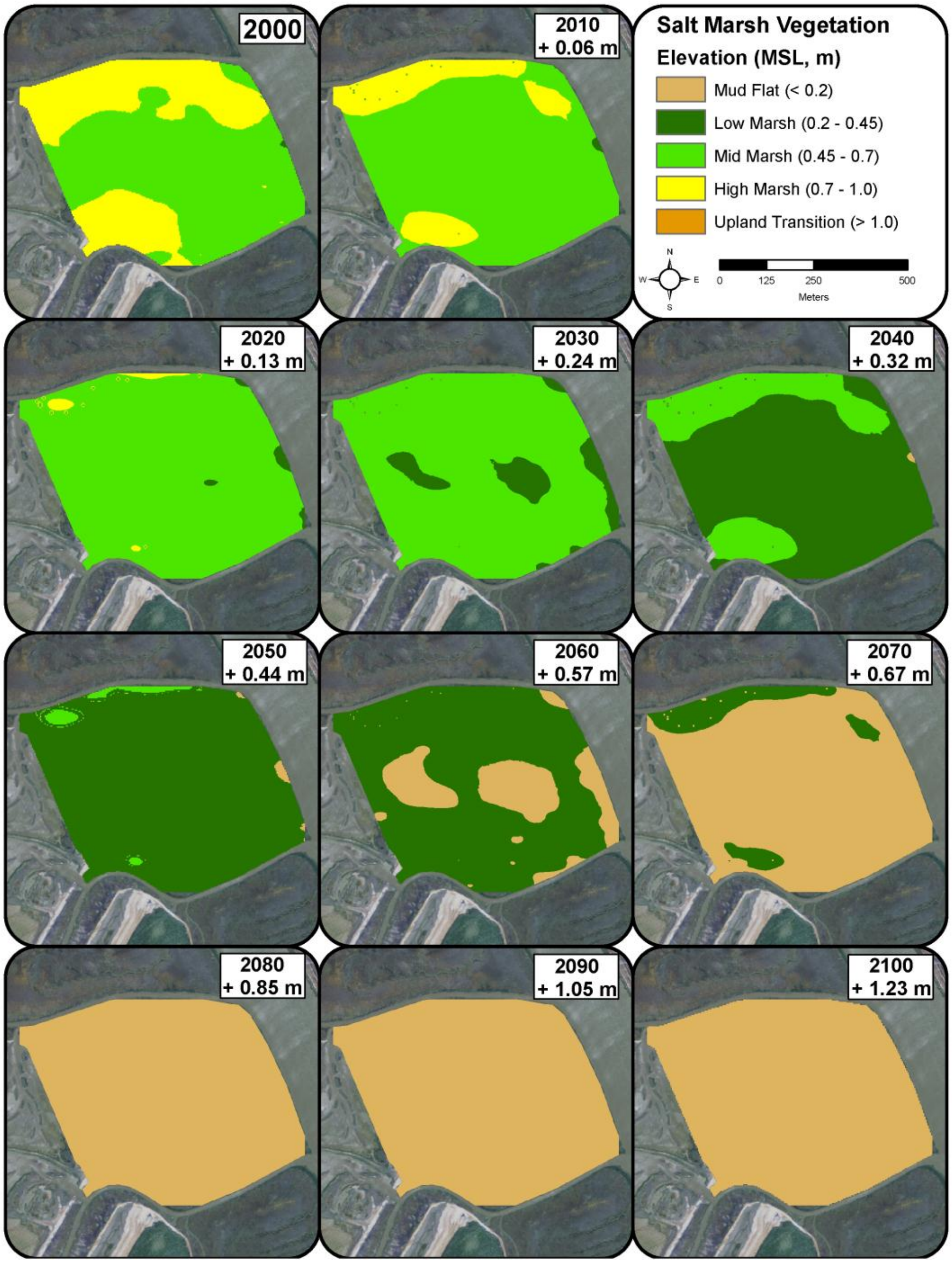


**Figure B-9.** Black John WARMER results in terms of plant communities: mudflat, low, mid, or high marsh, or upland transition.