Peat accretion rates, carbon storage, and sustainability of marshes in the Sacramento-San Joaquin Delta, California.

Judy Z. Drexler[1]
Christian S. de Fontaine[1]
Thomas A. Brown[2]

[1]USGS CA Water Science Center, Sacramento, CA
[2]Lawrence Livermore National Laboratory, Center for Accelerator Mass Spectrometry, Livermore, CA

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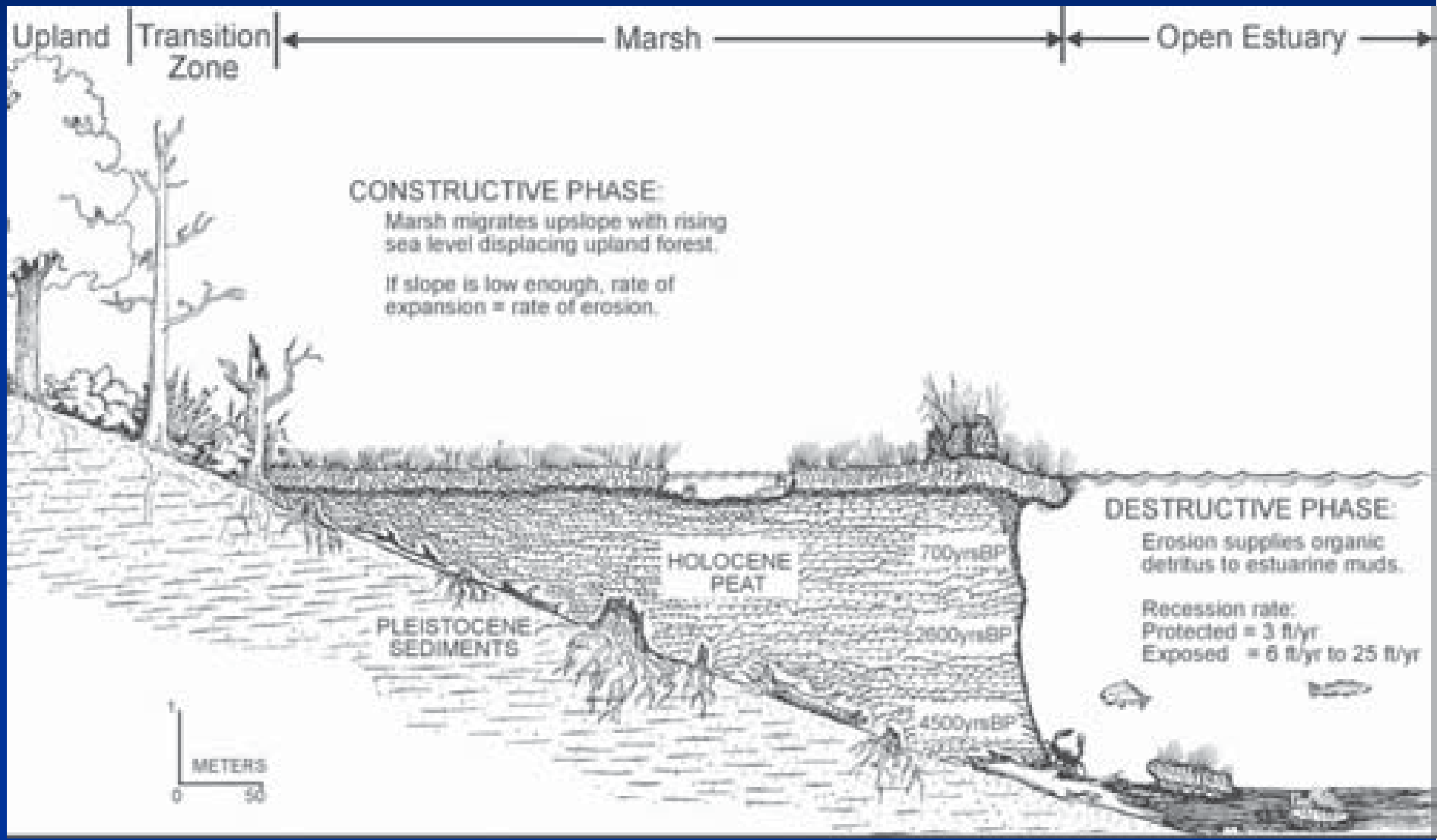
science for a changing world

How do marshes maintain their elevation within the tidal frame?



Marsh elevation in the tidal frame =
(vertical peat accretion + neotectonic uplift)
-
(scour + eustatic sea-level rise +
neotectonic subsidence + land-surface
subsidence from human activities)

REPEAT Project Goals

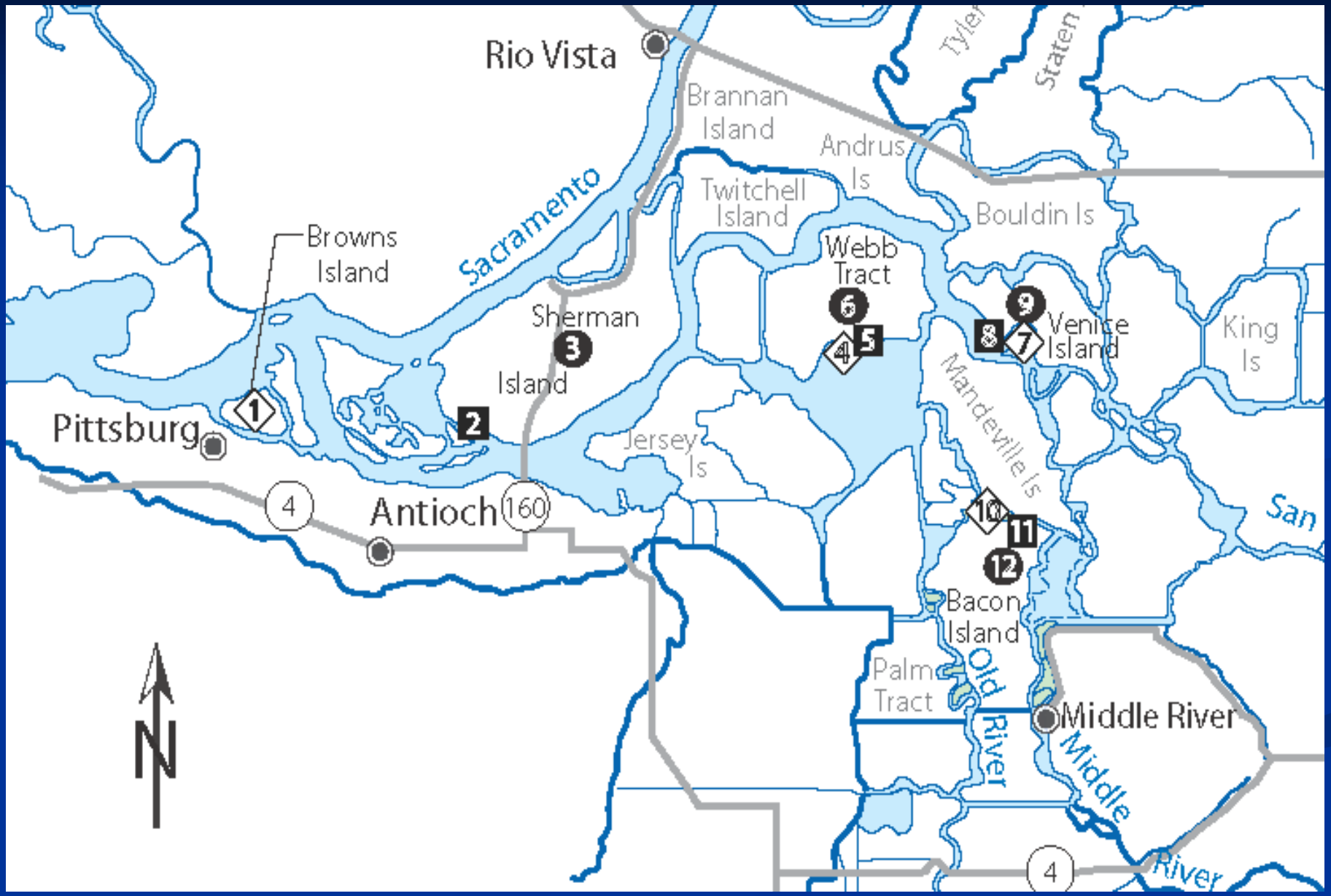
To determine the following through studying the peat archive in the Delta:

1. When peat started forming in the Delta
2. Rates of peat accretion throughout the ~7000-yr history of the Delta
3. Key environmental controls over peat accretion processes
4. Impacts of drainage for agriculture on the remaining peat resource
5. History of heavy metal contaminants in the Delta
6. Future rates of peat accretion in the Delta through predictive modeling

Methods

1. Sites
   - 4 paired study sites within the central and western Delta
   - transect approach – salinity, geomorphology
2. Field Work
   - Peat coring with Livingstone corer
   - 2 cores /farmed island; 1 core/marsh island
   - RTK GPS elevation survey
3. Laboratory Analyses of Peat:
   - BD, % OM, % OC, major and trace elements,
   - ^{14}C of macrofossils

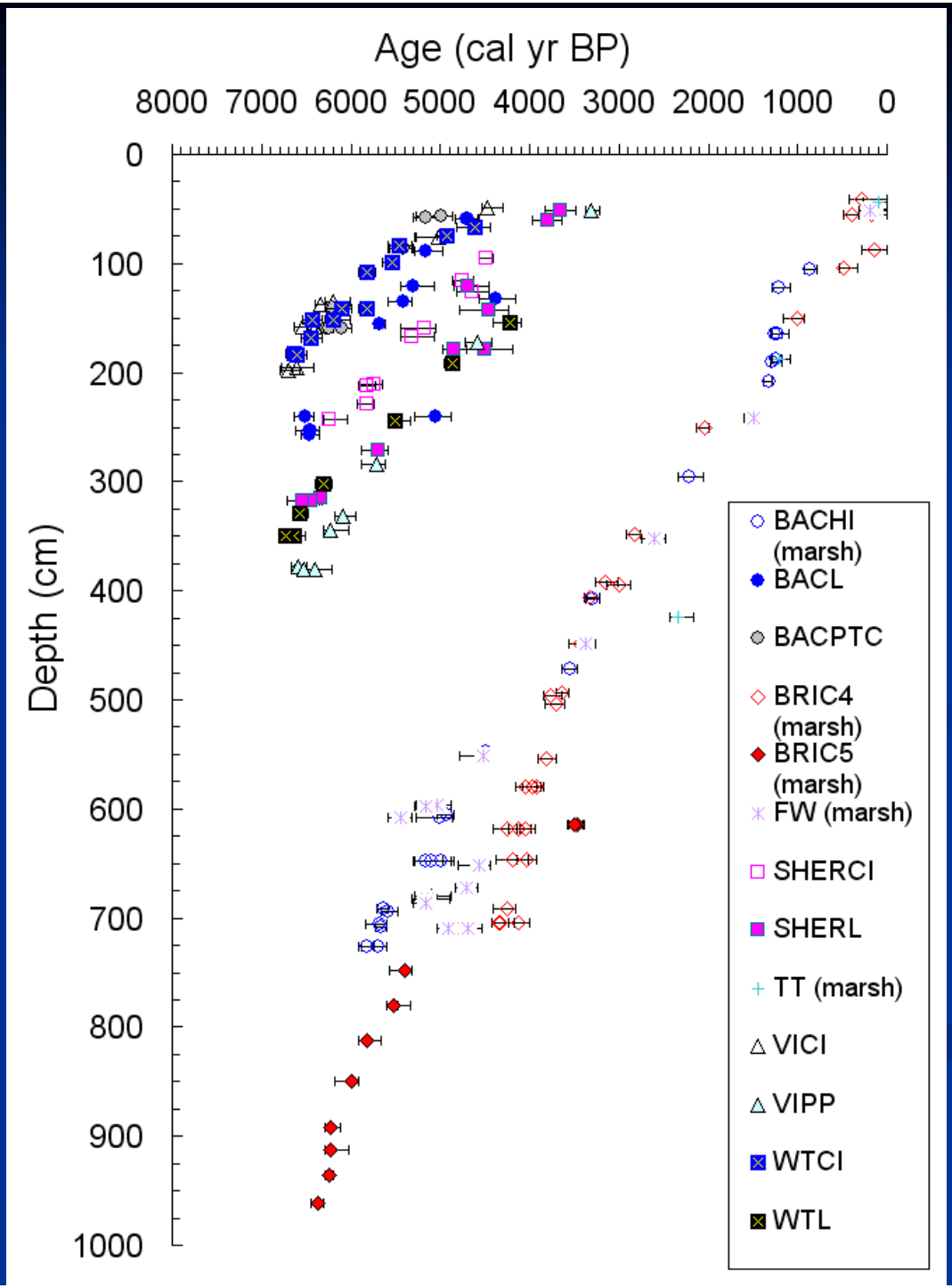
Study Sites


Rio Vista
Brannan Island
Andrus Is
Tyler
Staten
Twitchell Island
Bouldin Is
Sacramento
Browns Island
Webb Tract
Sherman Island
Venice Island
King Is
Mandeville Is
Pittsburg
Jersey Is
Antioch
San
Bacon Island
Palm Tract
Old River
Middle River
Middle River
N

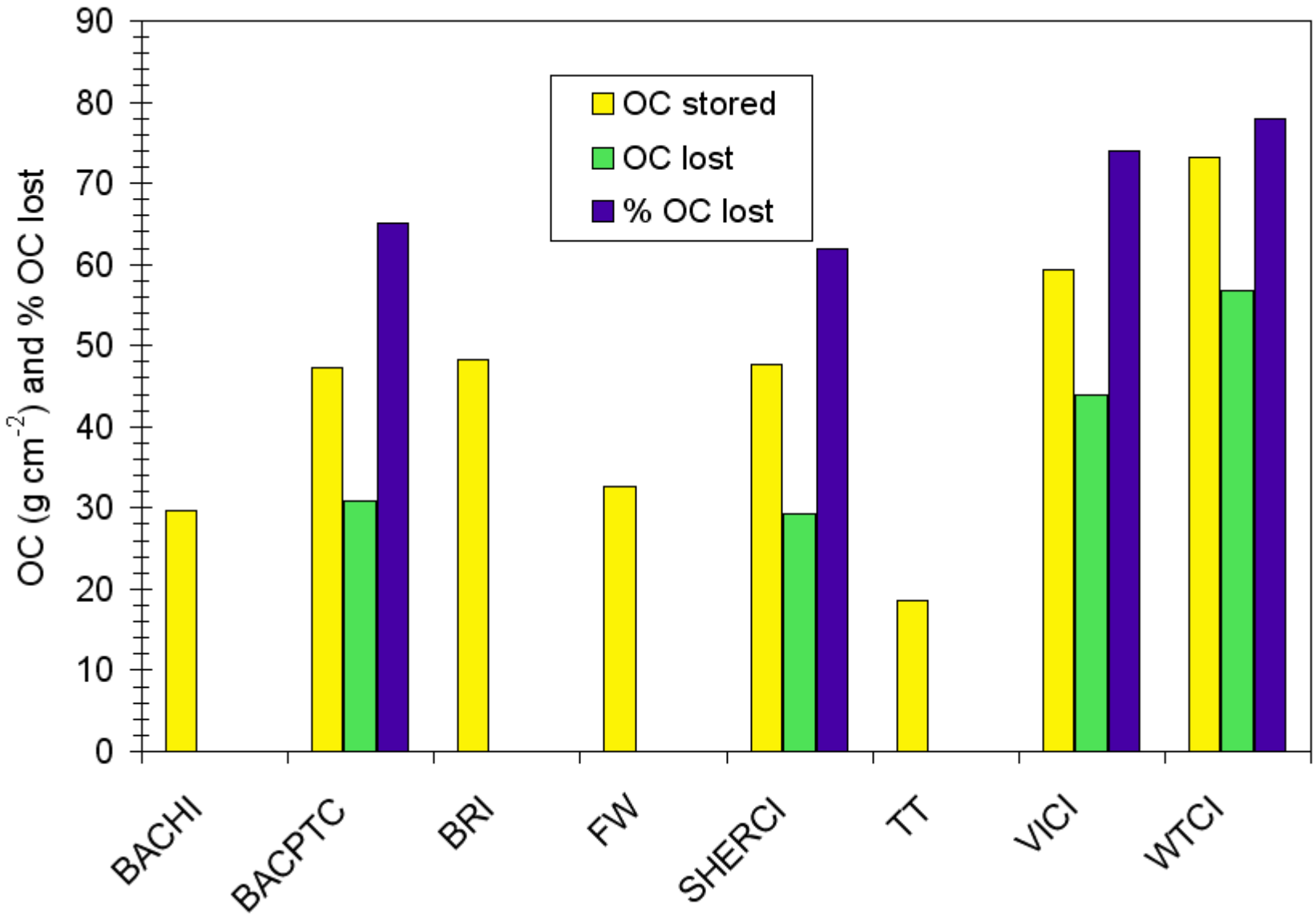
Webb Tract and Franks Wetland

Oldest basal peats date to ~6700 cal yrs BP

(Deltas formed around the world between 6000-7000 yrs ago.)



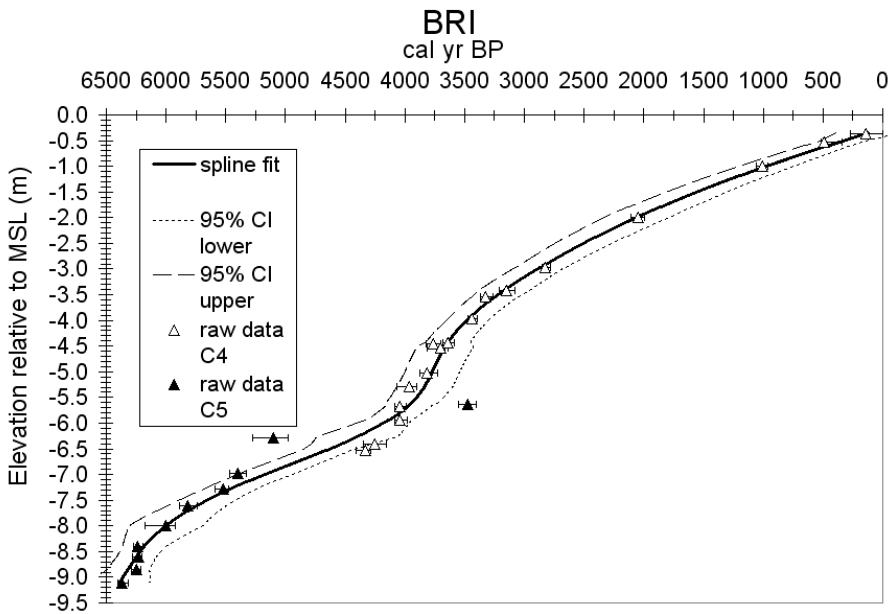
Total carbon storage and loss in the Delta

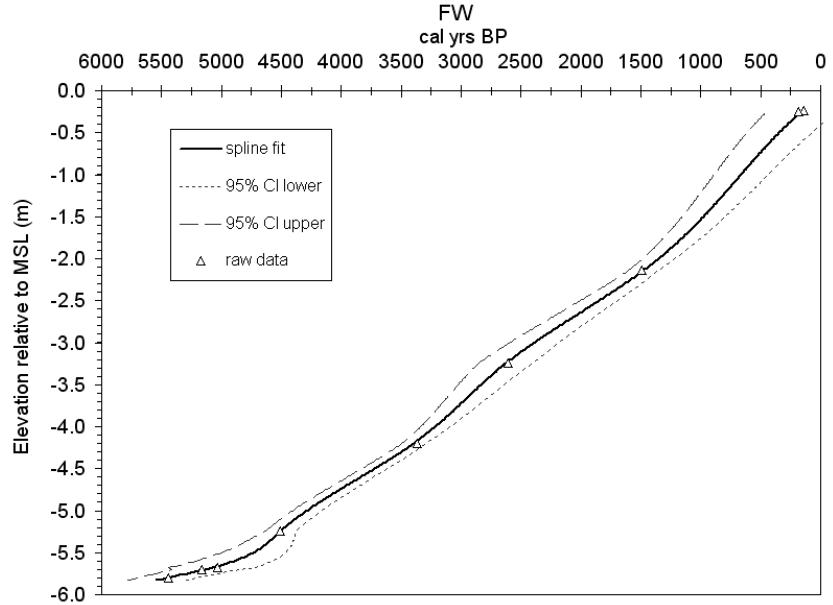


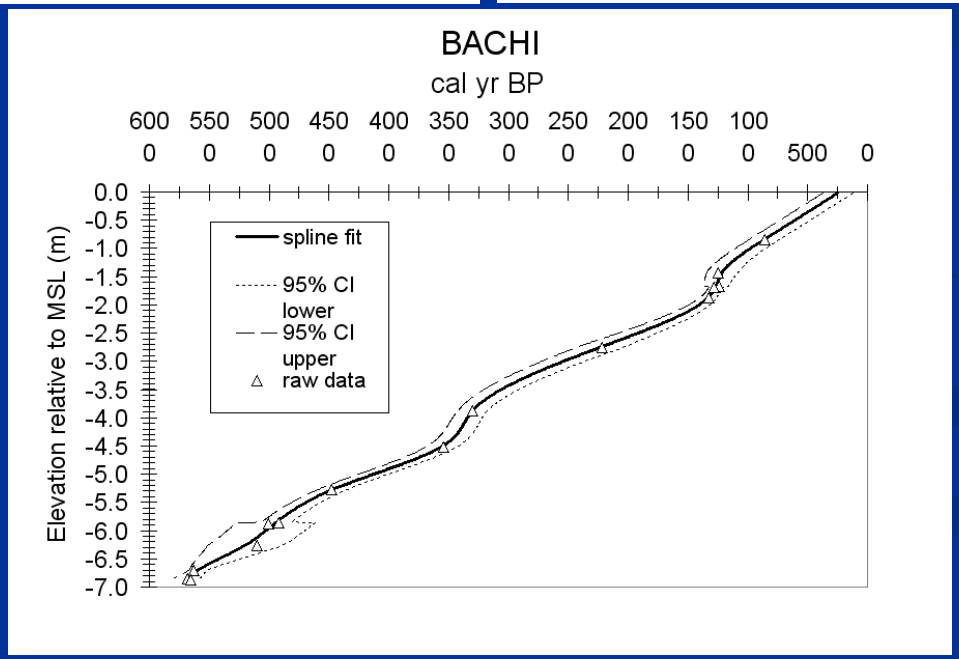
REPEAT Age-depth (spline fit) models
(based on Heegaard et al. 2005)

- Uses a mixed effect regression model that incorporates both within object and between object error in ^{14}C dating
- Uses loess smoothing procedure to produce age-depth curve
- Applied to 3 of the 4 marsh sites that had enough ^{14}C data

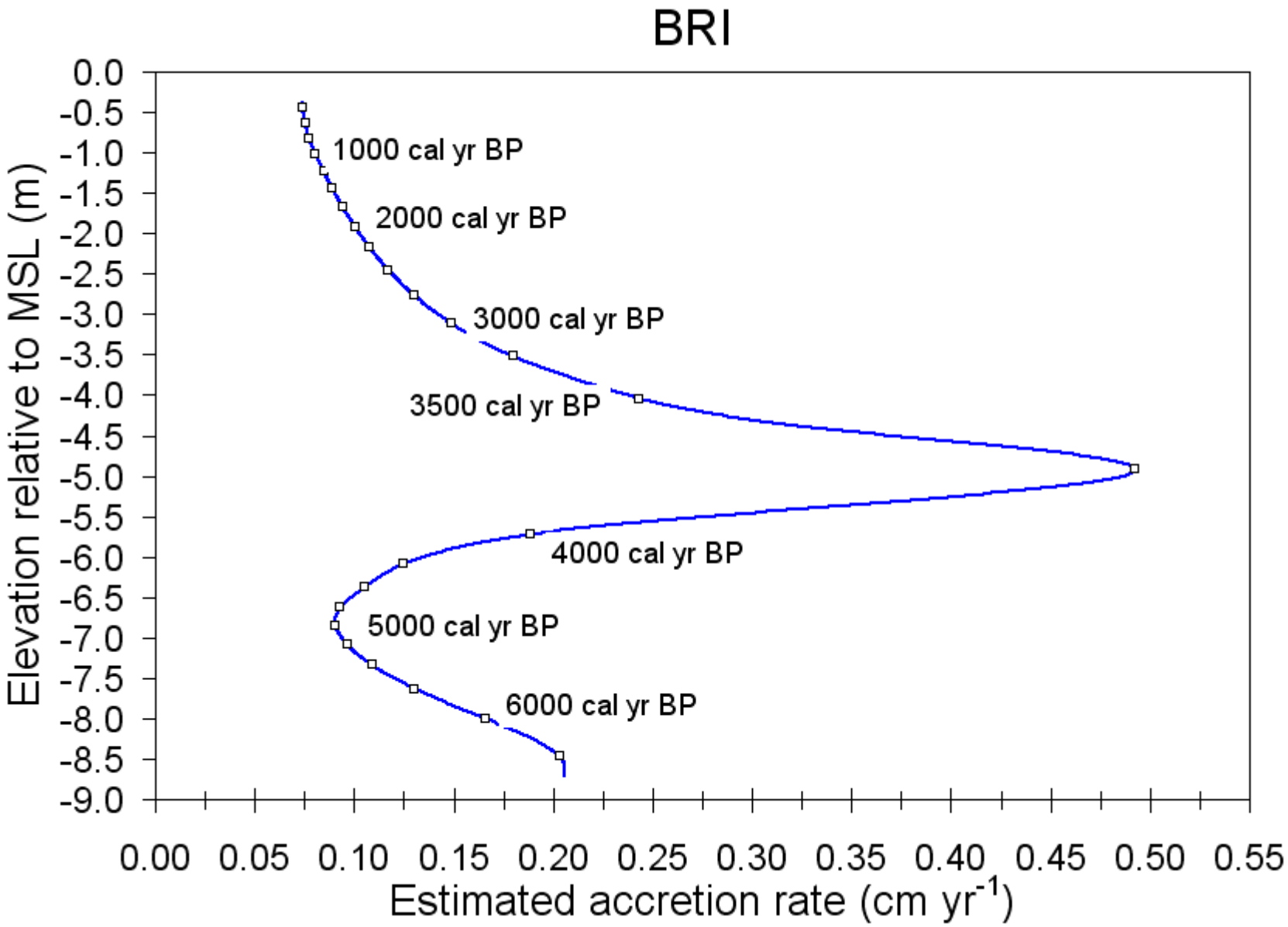
Spline fit models



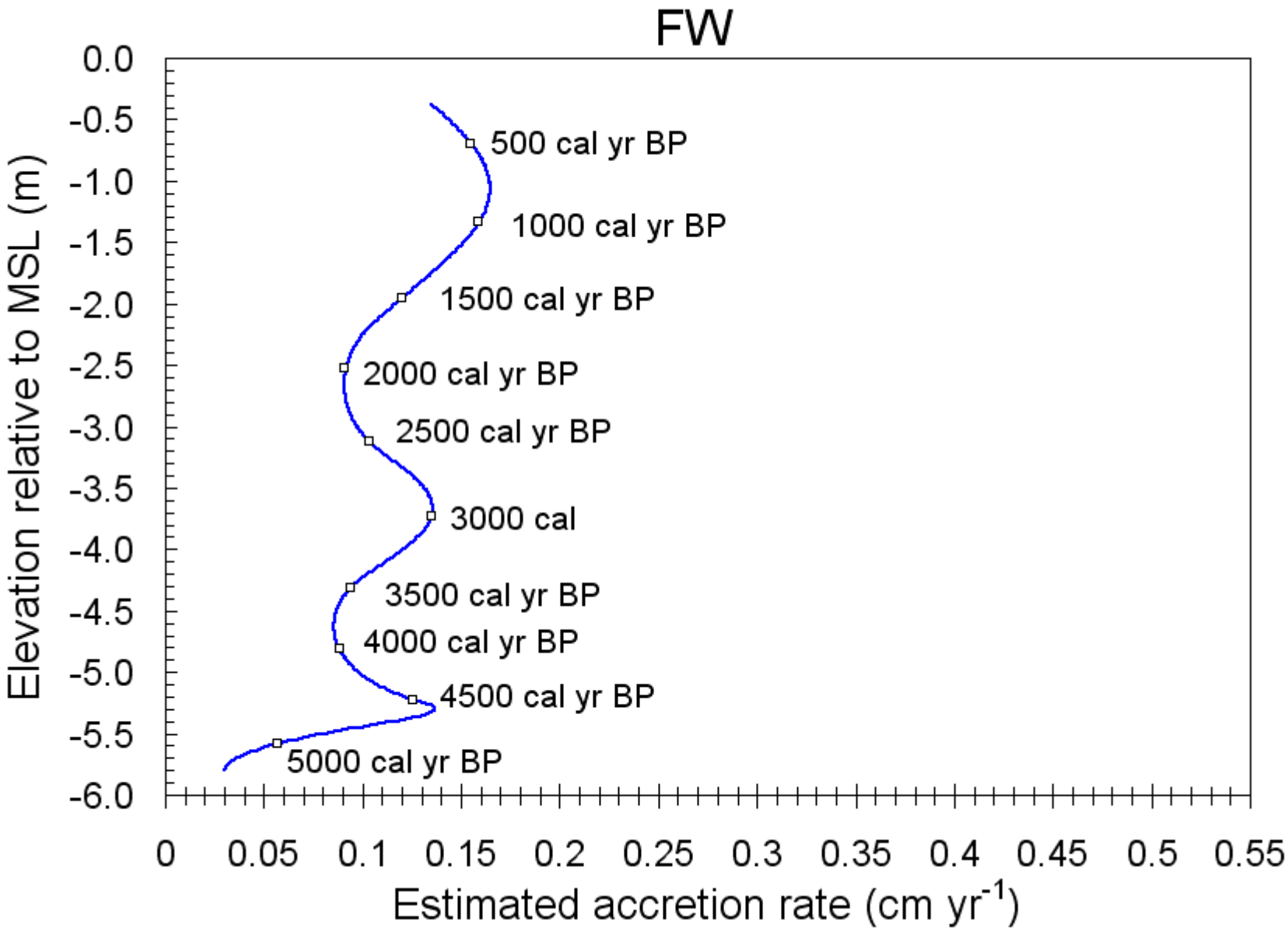




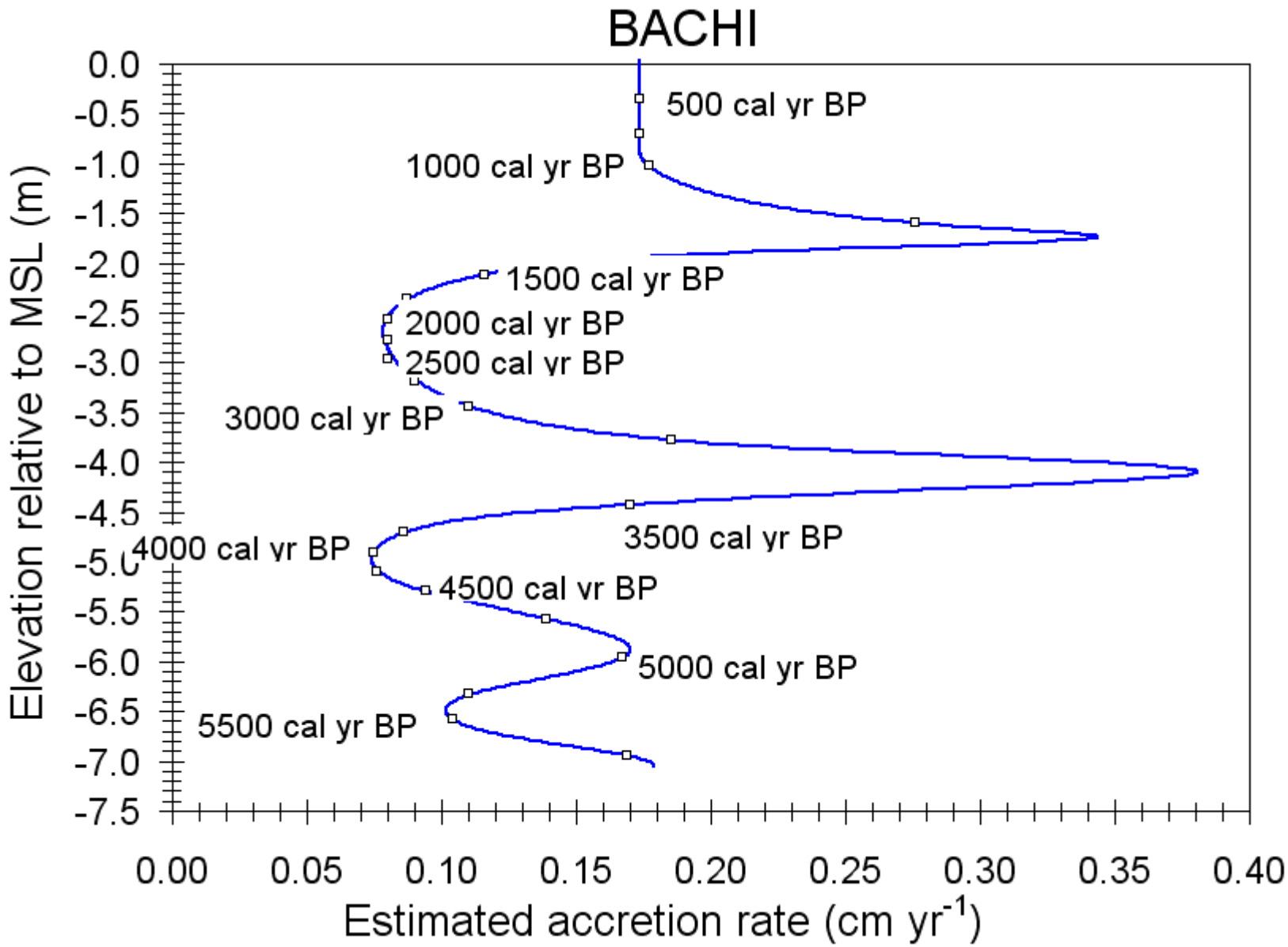
Estimated accretion: Browns Island



Estimated accretion: Franks Wetland



Estimated accretion: Bacon Channel Island



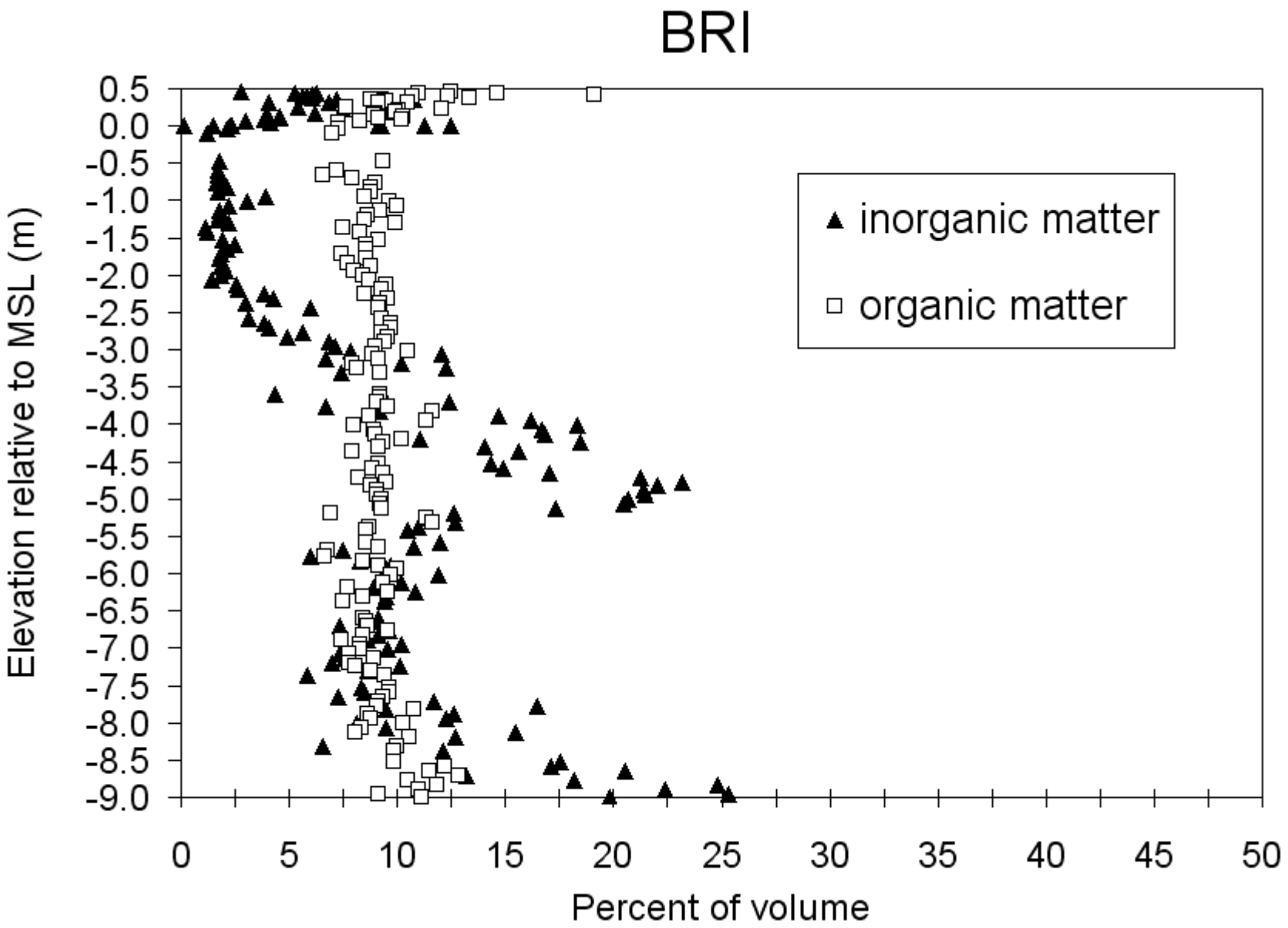
What % of soil volume is taken up by organic (OM_v) vs. inorganic matter (IM_v)?

% OM_v = (Bulk density * % OM))/1.1
where 1.1 = particle density of pure OM

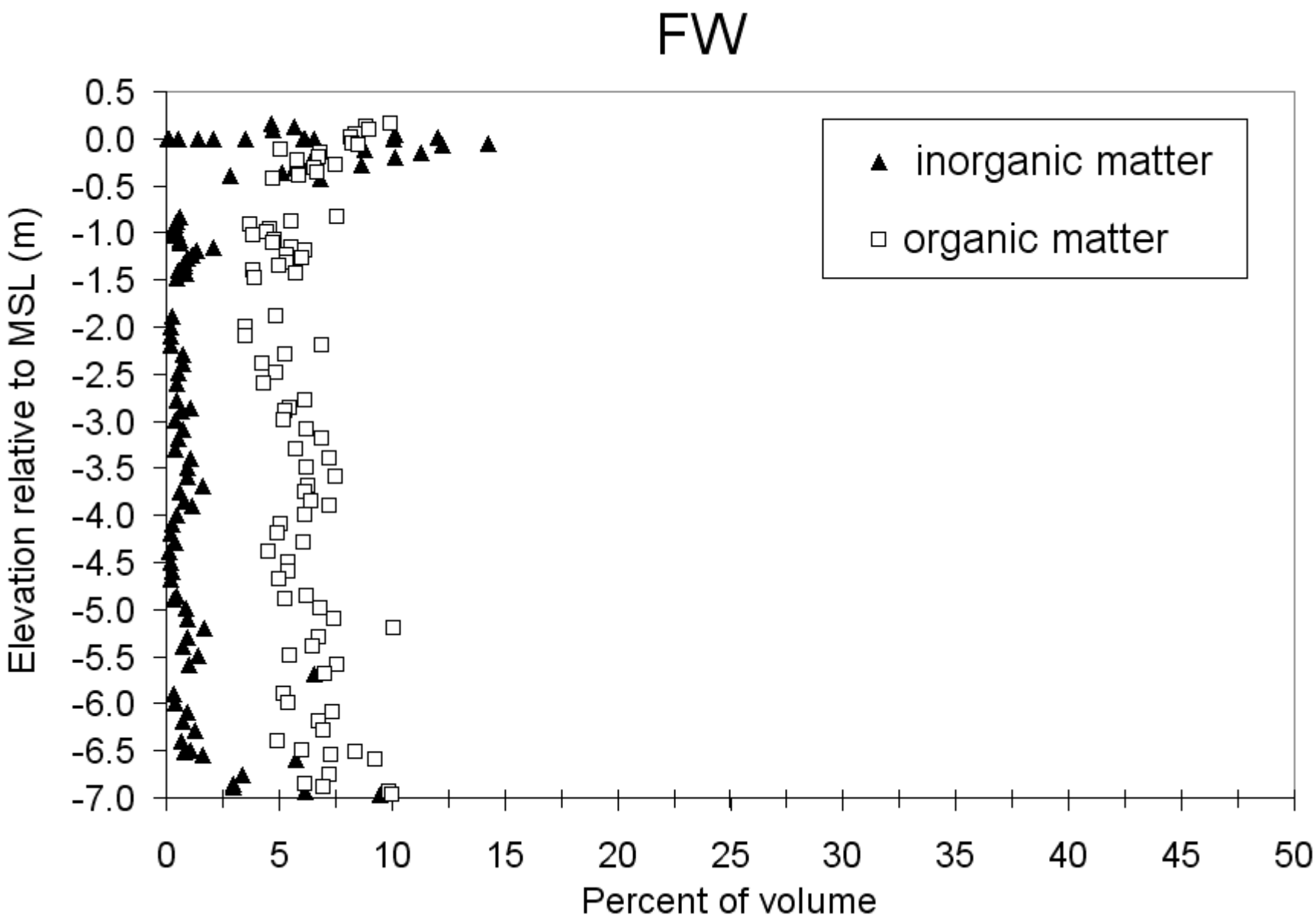
% IM_v= (Bulk density * % IM)/2.6
where 2.6 = particle density of pure IM

(constants from Delaune et al. 1983)

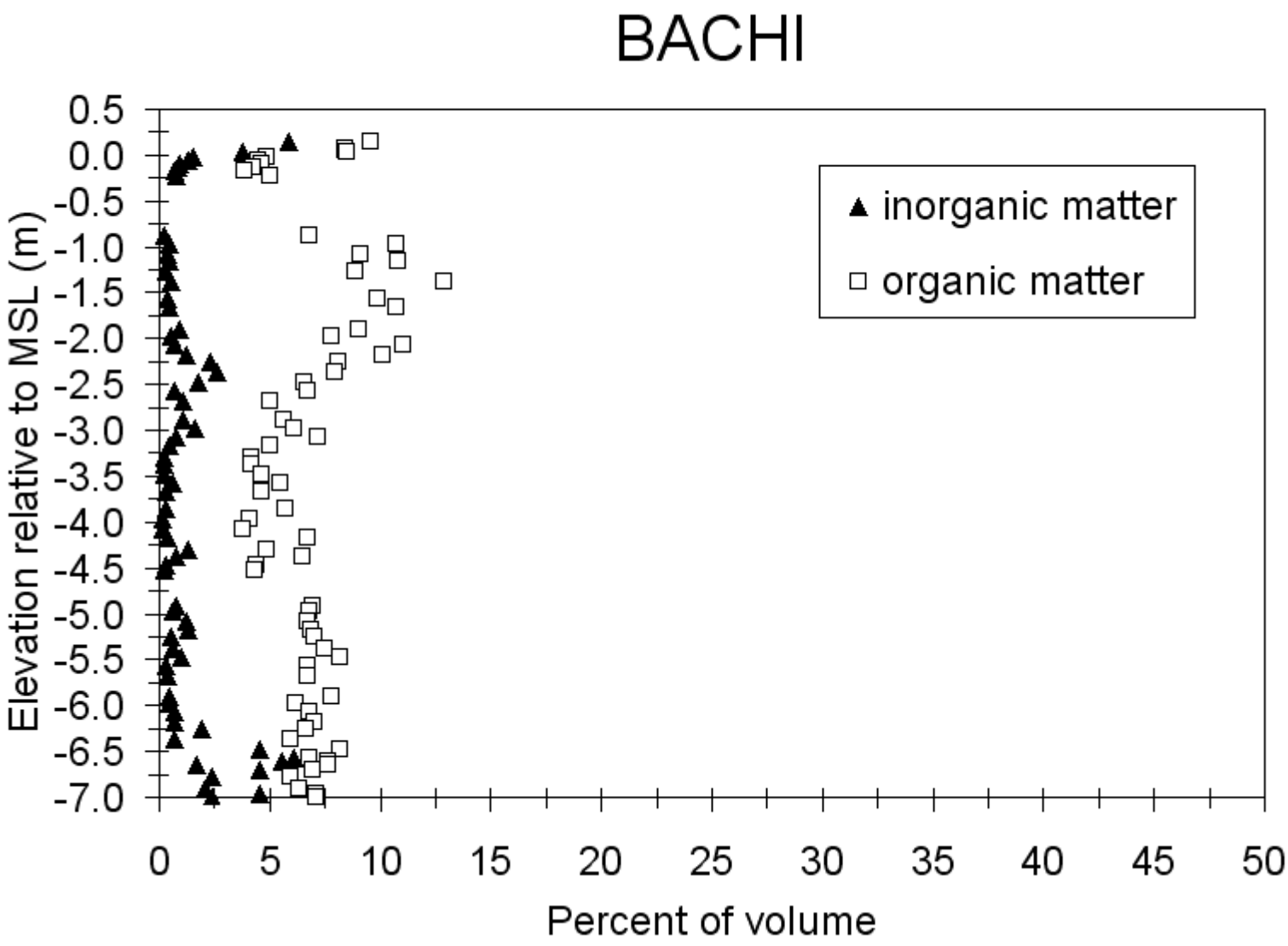
Contribution to soil volume: Browns Island



Contribution to soil volume: Franks Wetland



Contribution to soil volume: Bacon Channel Island



Contribution to soil volume: Tip of Mandeville Tip

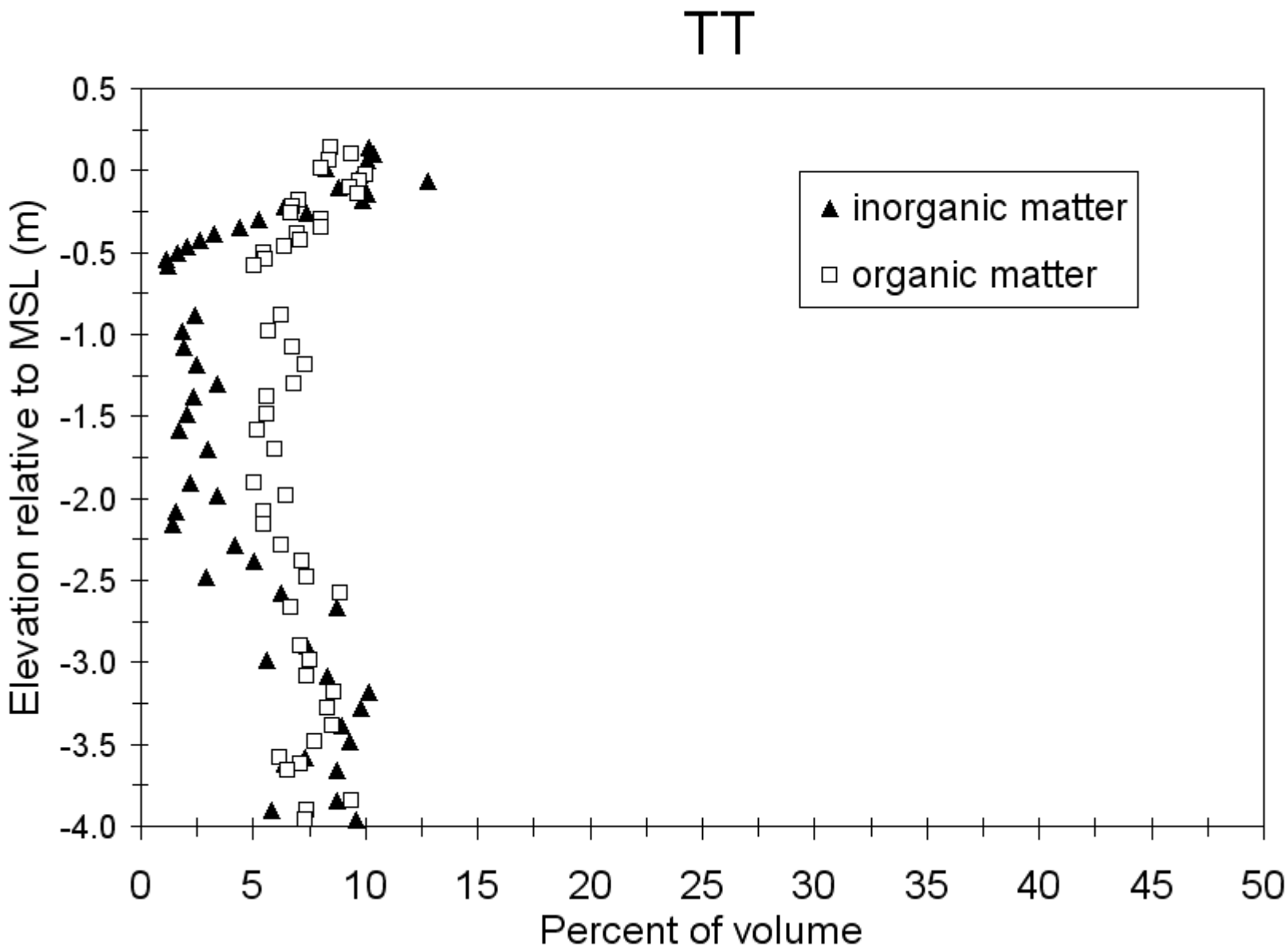


Table 1. Estimated vertical accretion rates for marshes vs. 20th century global rate of sea-level rise and IPCC predictions for 2090-2100 rate of sea-level rise (cm yr^{-1}).

Site	Estimated range, mean (sd) of median calibrated ages	20th century global estimate (Church and White 2006)	IPCC predicted central estimate and range for 2090-2100 (Meehl et al. 2007)
BRI	(0.07 – 0.49), 0.18 (0.11)	0.17 +/ 0.03	0.38 (0.15 – 0.97)
BACHI	(0.07 – 0.38), 0.16 (0.07)	0.17 +/ 0.03	0.38 (0.15 – 0.97)
FW&	(0.03 – 0.16), 0.12 (0.03)	0.17 +/ 0.03	0.38 (0.15 – 0.97)
TT (linear estimates)	Only 2 estimates: 0.13 for 97-1214 & 0.21 for 1214 - 2338 cal yr BP	0.17 +/ 0.03	0.38 (0.15 – 0.97)

Remaining uncertainties:

- Neotectonics (0.2 – 0.6 mm yr^{-1}; Weber-Band 1998)
- Reduced sediment supply in rivers

Conclusions

- Estimated accretion rates range between 0.03-0.50 cm yr^{-1} (for median ^{14}C dates) for the past 6000 years in the Delta.
- Accretion rates have varied through time; some variability is associated with major changes in climate.
- The relative contribution of IM_v to soil volume varies more than the OM_v.
- The volume of sediment incorporated into peat is greater at marshes situated in high energy environments.
- All marshes seem to be currently keeping pace with sea-level rise.
- Although much uncertainty exists, remaining Delta marshes may not be sustainable under the IPCC sea-level rise predictions for 2090-2010.
- Such assessments need to be redone using sea-level rise and sediment supply predictions specific to the San Francisco Bay Estuary.

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