Modeling tidal marsh sediment accumulation and accretion

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Introduction

Important terminology:

- **Sediment**: inorganic/mineral particles
- **Accumulation**: used to refer to a mass accumulation rate [mass/area-time]
- **Accretion**: vertical growth above a defined horizon [length/time]
  - Accretion can be calculated by dividing total mass accumulation by bulk density

Most common methods of determining sediment accumulation rate:

- Constant
- Function of elevation
- Function of SSC
- Function of settling velocity
- Function of distance from sediment source
- Deposition-Erosion

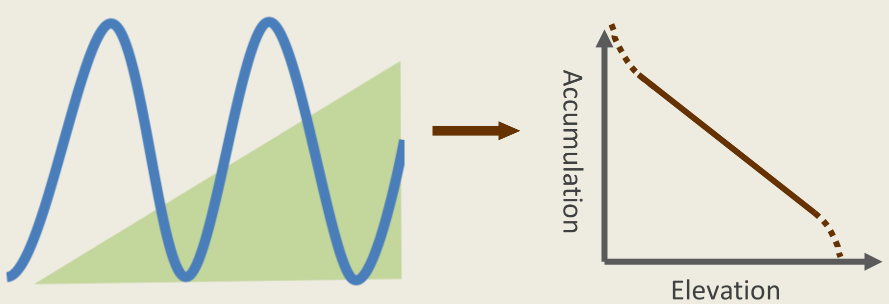
(Or some combination thereof!)

Constant deposition rate

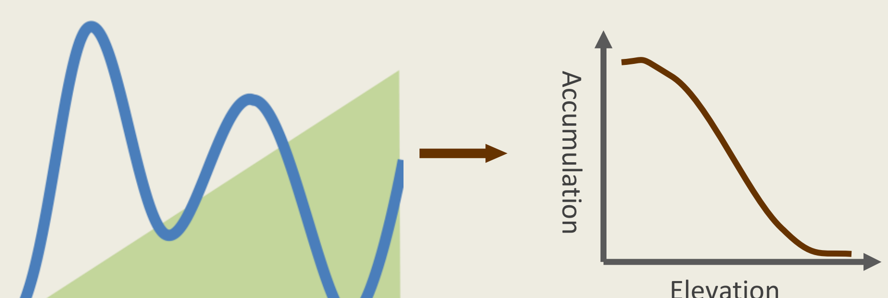
- Useful for landscape scale models or where elevation data is not robust
- Typically based on field measurements

Function of elevation

Elevation is a proxy for inundation time

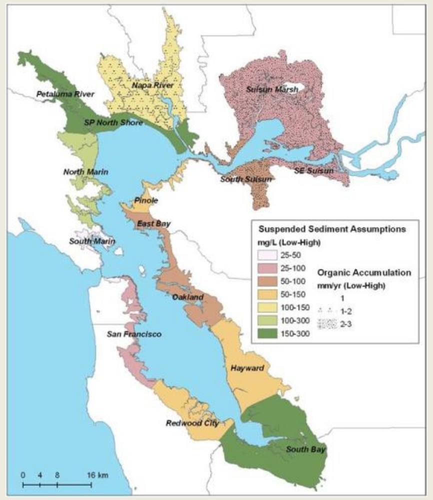


Sinusoidal tides lead to a nearly linear relationship between elevation and accumulation after French (1993). The numerical solution for the relationship is actually for the interval [0 1].

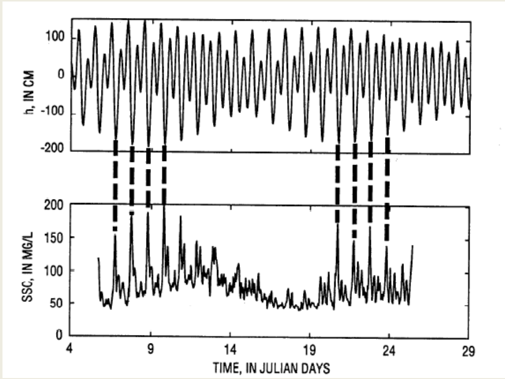


Mixed tides lead to a anon-linear relationship between elevation and accumulation, though it is quasi-linear between MSL and MHW.

Function of SSC



SSC can vary spatially and temporally (over many time scales)

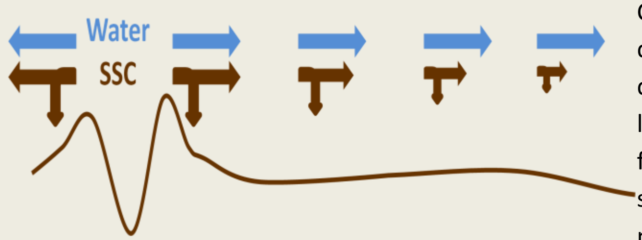


Left: Map of SSC zones used by PRBO for Climate Change Scenarios for Tidal Marsh Habitats (www.prbo.org). Right: Water surface elevation and SSC near the Dumbarton Bridge from Schoellhamer (1996).

Function of settling velocity

- Constant
- Stokes
- Floc settling velocity, ex . (Krone, 1987)

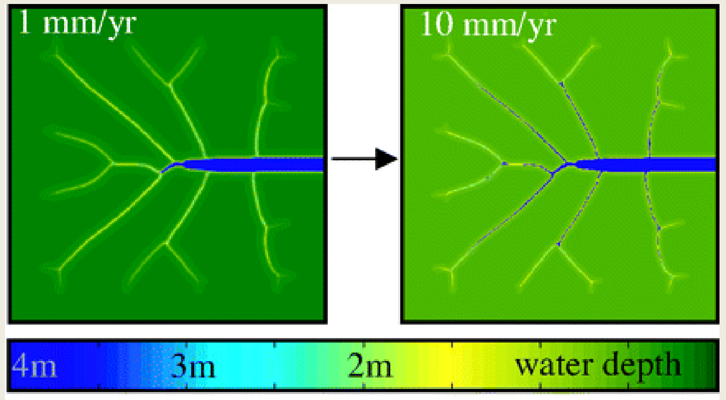
Function of distance from sediment source



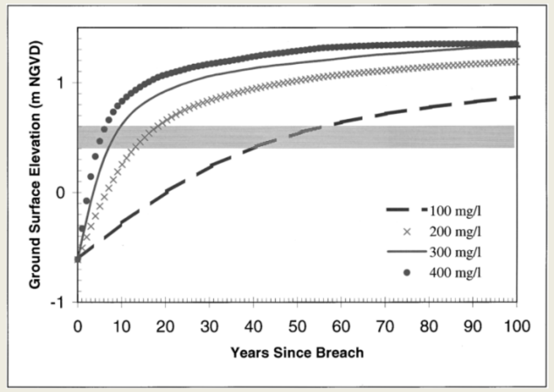
Concentration (and deposition) decrease with increasing distance from a sediment source like a tidal creek as a function of flow depth, flow velocity and settling velocity (Swanson in prep).

Erosion

Requires a full hydrodynamic model of flow across the marsh surface coupled with a geomorphic model of marsh topography, e.g. Kirwan and Murray (2002). This particular result is for a vegetated marsh surface with 1 and 10 mm/yr SLR:

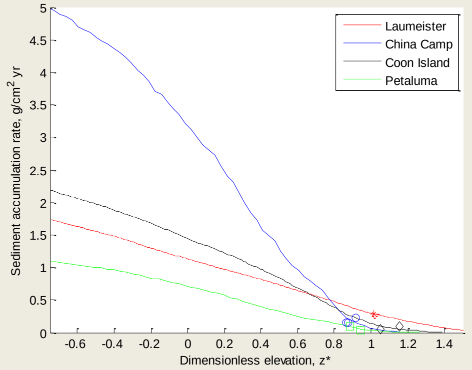


A few combined models



The results of the "Krone Model" presented by Williams and Orr (2002). This model typically assumes sinusoidal tidal inundation, constant concentration and uses the Krone (1987) formulation for settling velocity. Accretion is linear with elevation and the marsh surface approaches maximum elevation asymptotically.

Sediment accumulation curves developed for the WARMER model from time-series of water surface elevation and SSC. A constant effective settling velocity is calculated to fit measured sediment accumulation rates from dated sediment cores. Sediment cores are typically located in the high marsh so the lower half of the curve is not well defined by data. Calculated accumulation rates at low elevations can be very large because the high SSC is associated with high bed shear stress at low tide (Schoellhamer, 1996).



What we still need (my personal wish list)

SSC data in or near marshes
Spatially robust sediment accumulation rates
Predictions of future trends in SSC
Site-specific inundation records
In-situ measurements of floc properties in or near marshes

References

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