

Linking sediment flux to marshes with dynamics in Bay shallows

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BDSC 2016

Motivation

Marshes and other shallow water habitats are particularly threatened by sea-level rise.

Import of sediment from adjacent waters helps marshes maintain elevation as sea level rises.

Predictions of the fate of marshes as sea level rises vary widely with assumed sediment concentration.

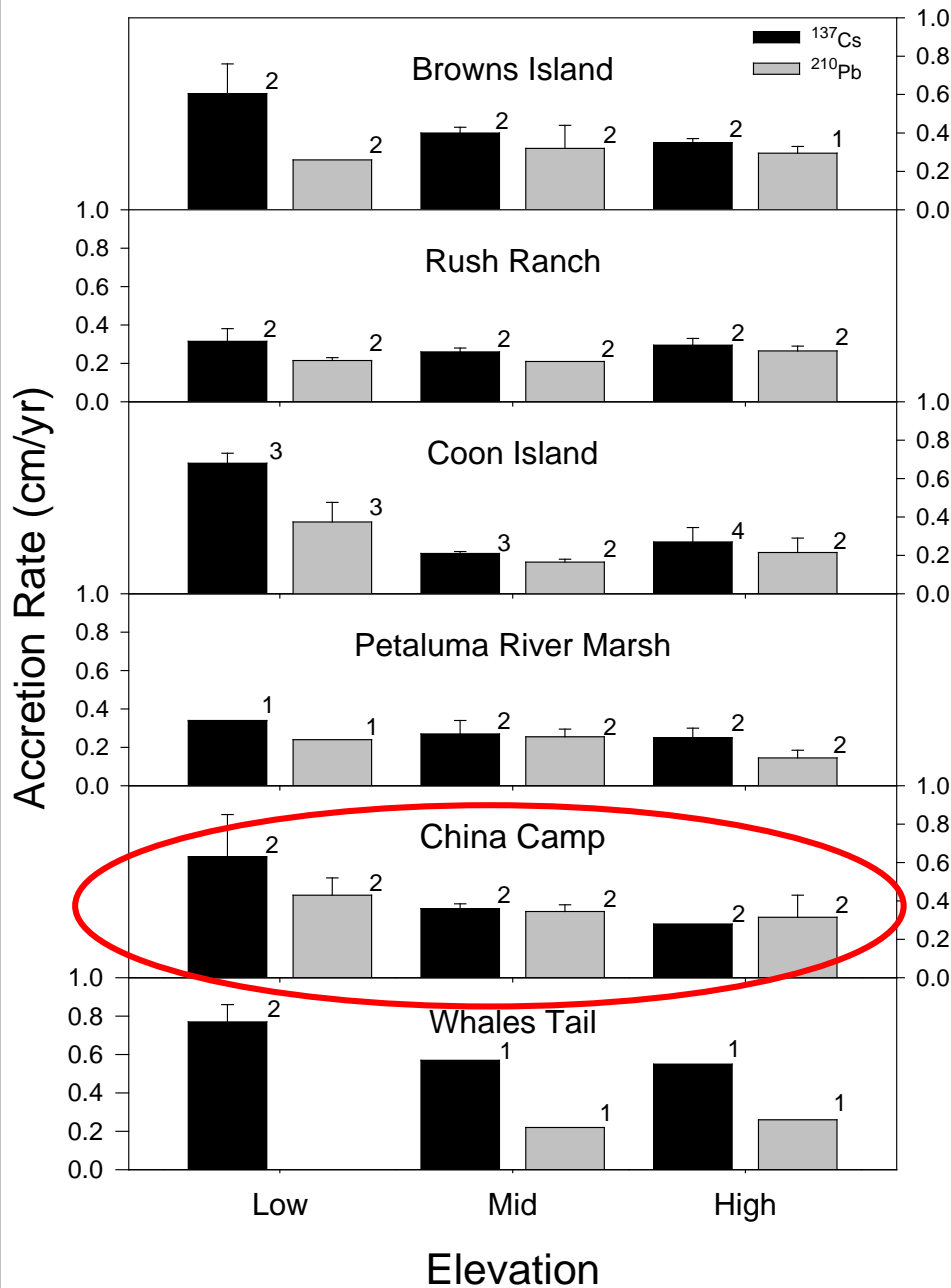
Objective: link observations of sediment dynamics in Bay shallows to import/export to a tidal marsh.



- San Francisco Bay tide range is about 2 m.
- Salt marsh is relatively high in the tidal frame.
- The longest inundation periods are during the highest ('King') tides of the year.



Hypothesis: King tides are important times for sediment delivery.



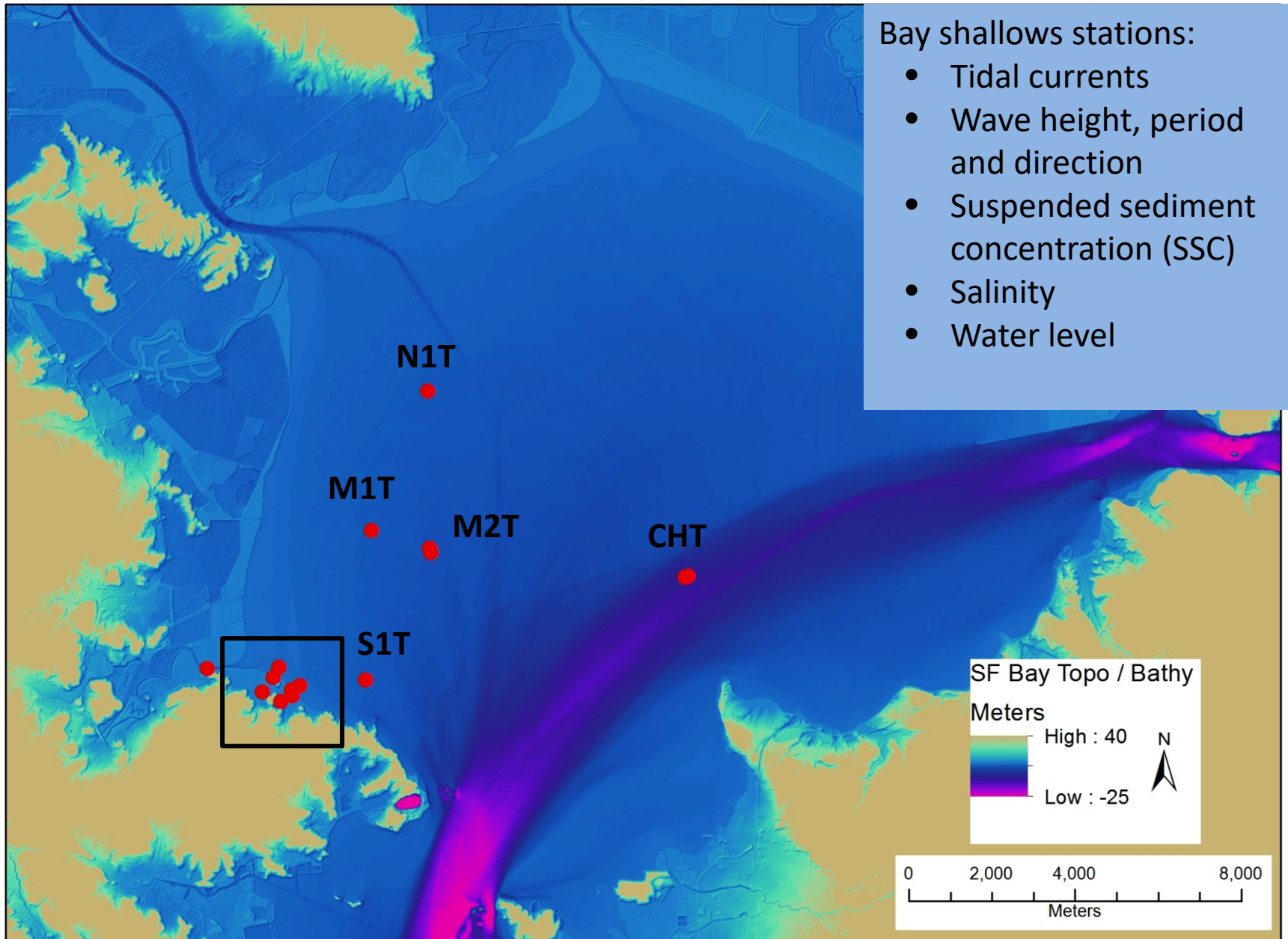
Study site: China Camp marsh in San Pablo Bay

Long-term accretion rates in natural SF Bay marshes are more than adequate to keep up with current sea-level rise.

> 3 mm/yr in China Camp

(Callaway et al., 2012)

Study design: Winter 2013/14, winter 2014/15, summer 2016



S1T ↗
-1 m MLLW

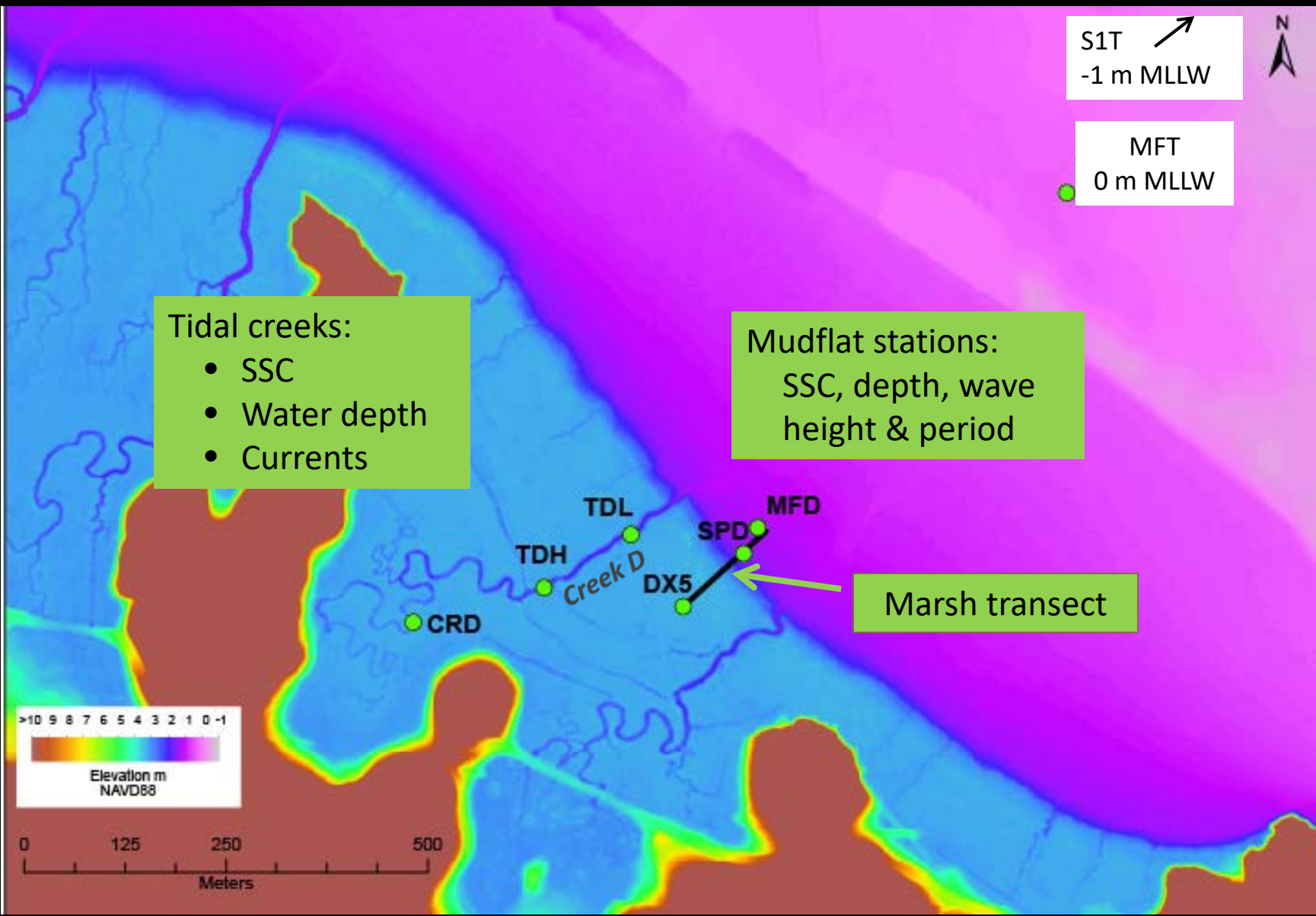
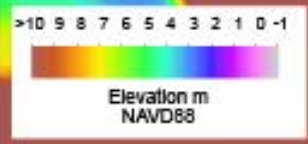


MFT
● 0 m MLLW

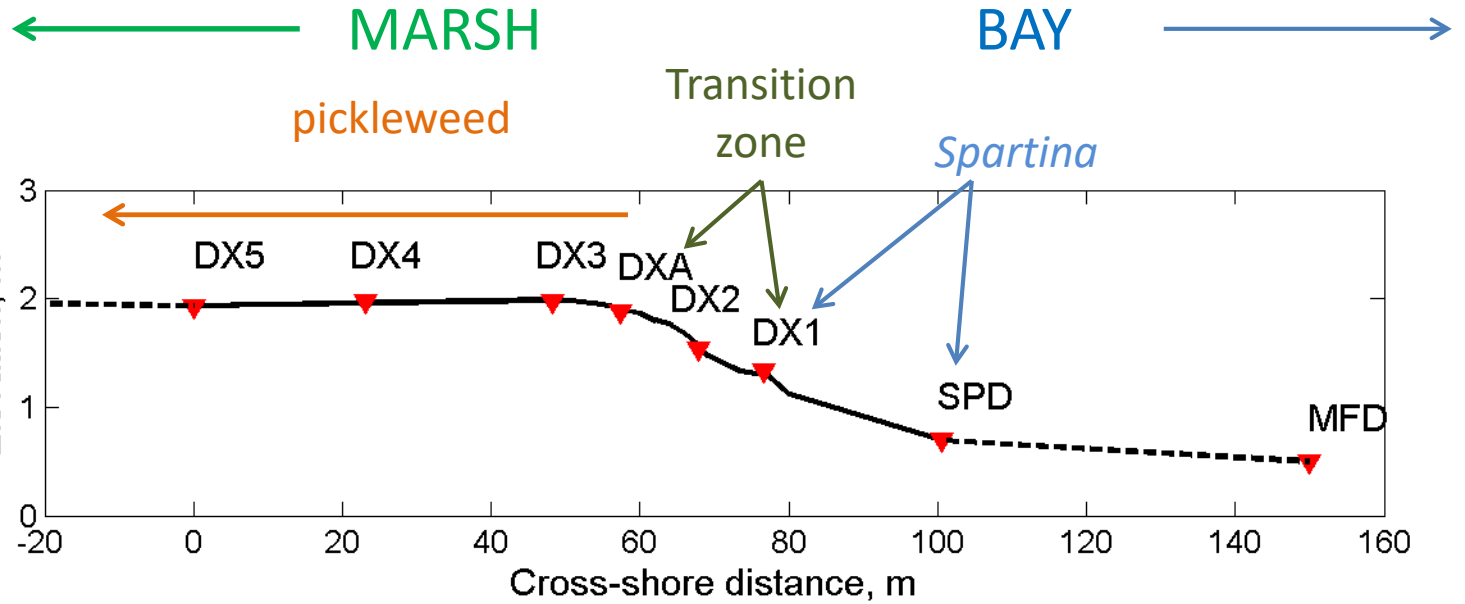
Tidal creeks:
• SSC
• Water depth
• Currents

Mudflat stations:
SSC, depth, wave
height & period

Marsh transect



Winter 2014/15 and summer 2016



- Turbidity
- Water level
- Wave height



1. Sediment flux

Very high velocities on ebb King tides.

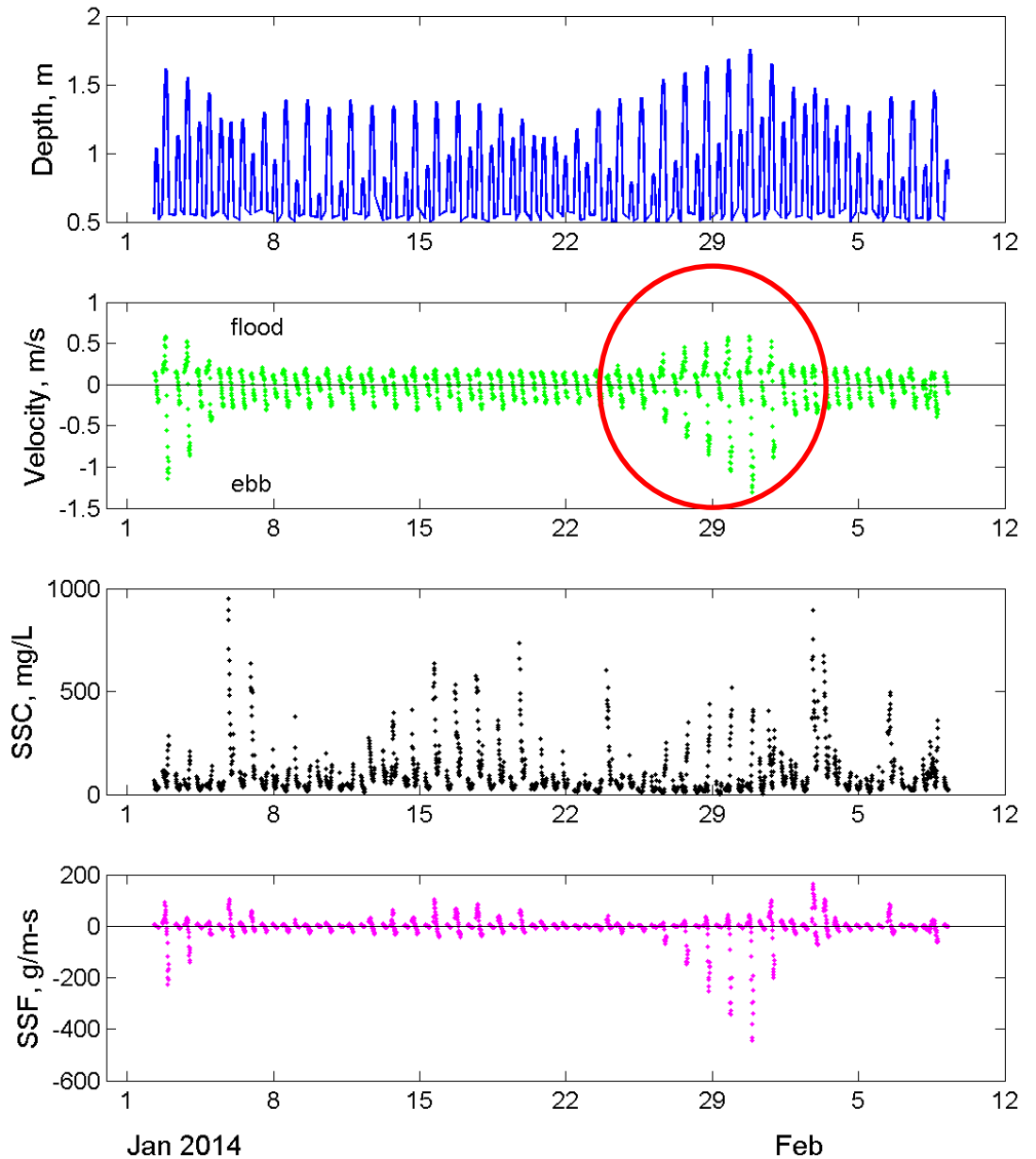
$$SSF = uhc$$

u : velocity

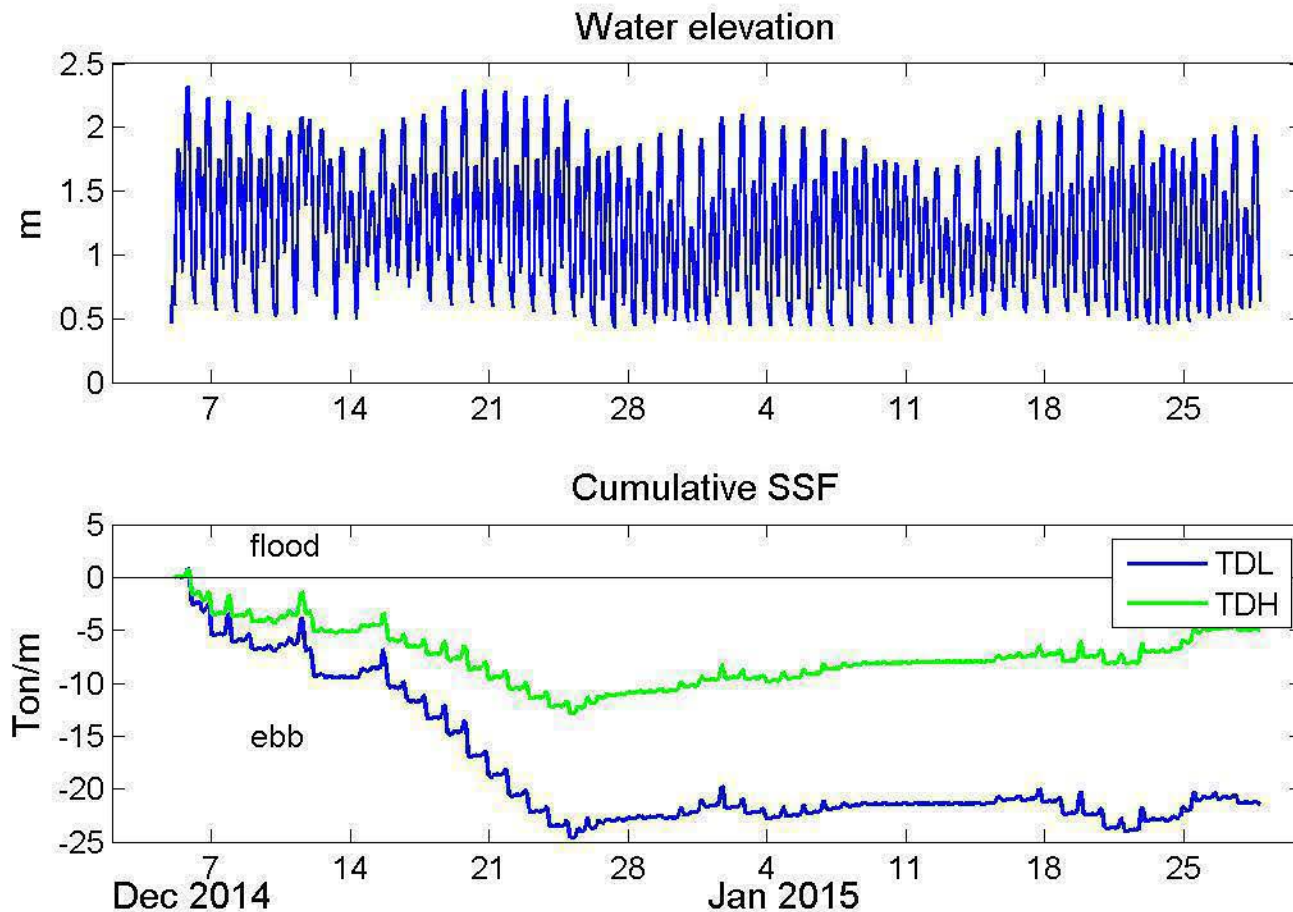
h : depth

c : SSC

Lower Creek station: Winter 2014/15



Cumulative sediment flux in winter 2014/15



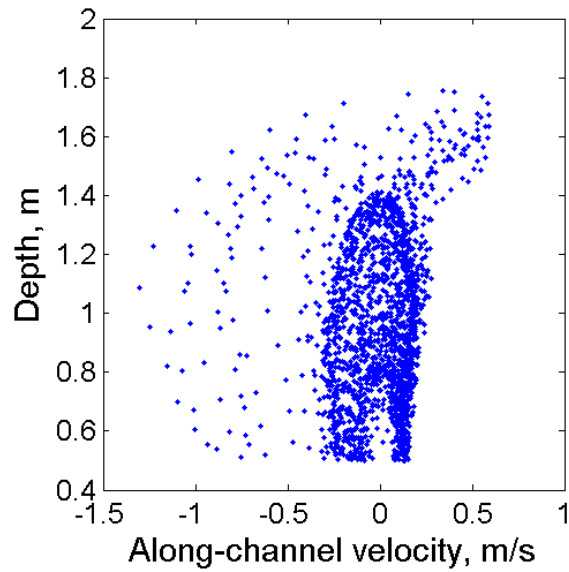
- Bayward flux during King tides: > 15 tons/m in 4 days
- More export lower in Creek.
- Import also observed, especially during storms.

Sediment export of very similar magnitude was measured during large spring tides in winter 2013/14 and summer 2016.

In summer, export during ebbs was comparable to winter, but import on floods was slightly greater, due to regular afternoon wind waves.



Tidal creek instrumentation



Greater current speed
during King tides,
especially ebbs

Suggests scour within creeks rather than erosion of marsh plain

2. Spatial patterns in SSC

SSC in Bay shallows is an indicator of sediment available to be delivered to the marsh.

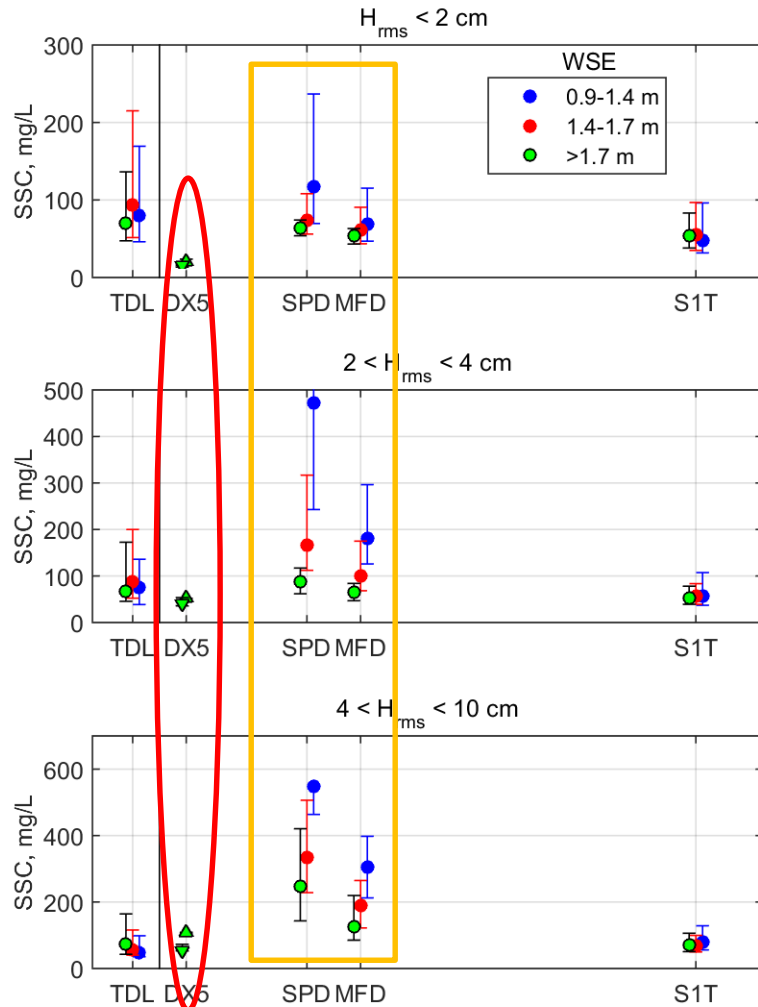
How spatially variable is SSC across the shallows?

SSC over the marsh plain is an indicator of the amount of sediment delivered to the marsh.

How is SSC within the marsh related to SSC at the marsh edge?



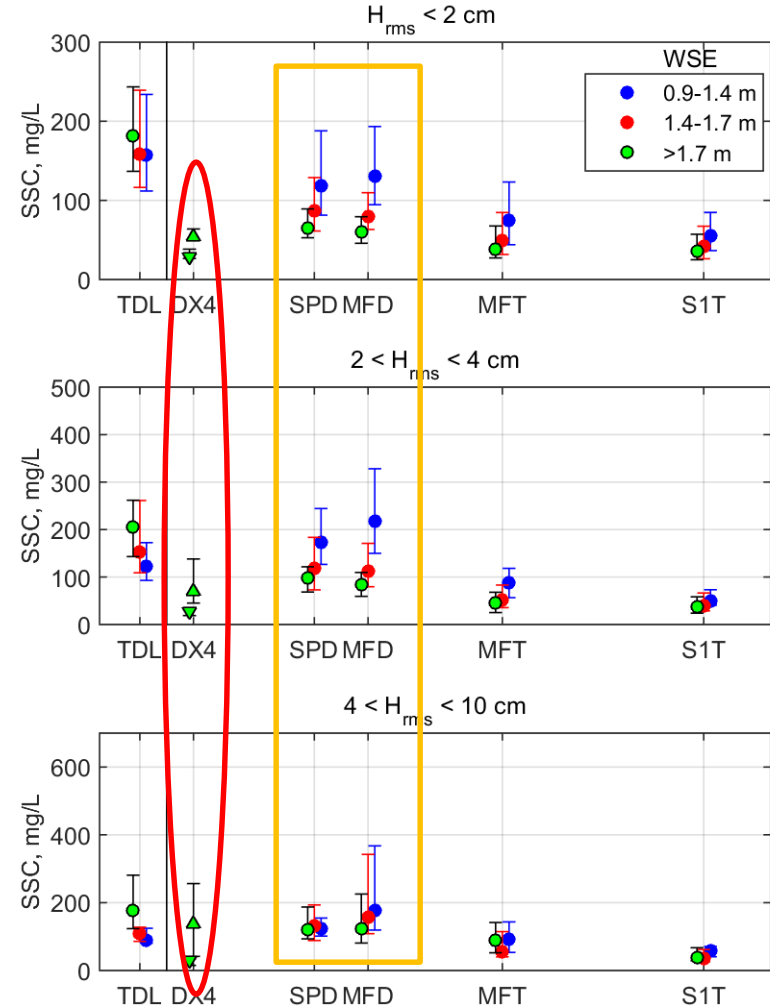
Winter 2014/15



MARSH

BAY

Summer 2016



MARSH

BAY

- SSC lower at high than low tide
- SSC greatest at marsh edge
- SSC within marsh greater in summer than in winter data set.

Why is SSC greatest at the marsh edge?

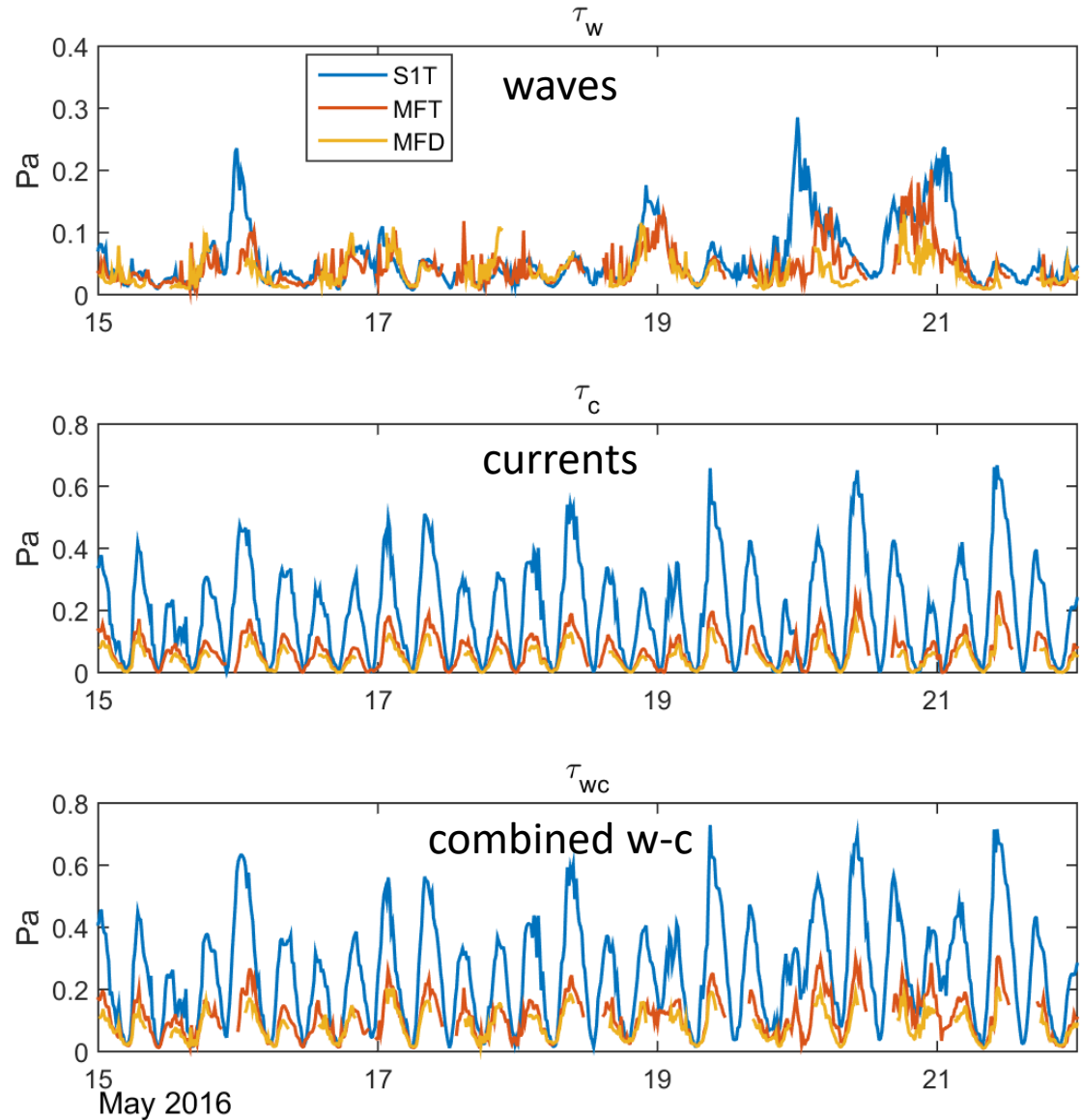
Why is SSC greater over the marsh and in the tidal creek during summer than winter?

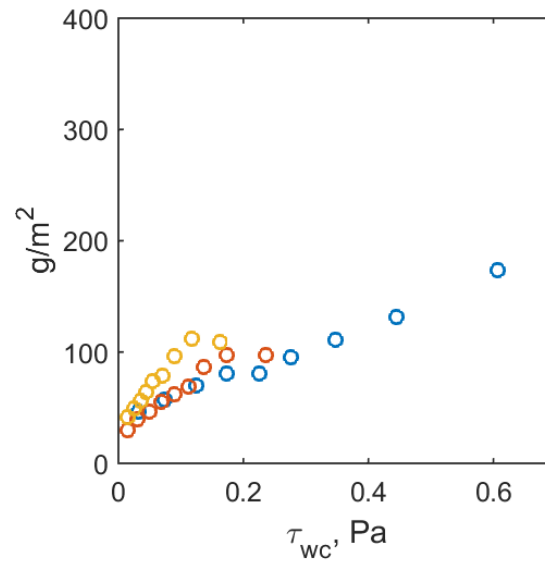
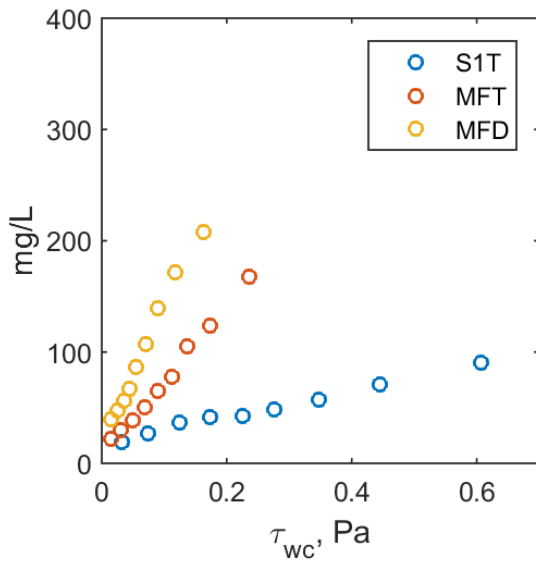
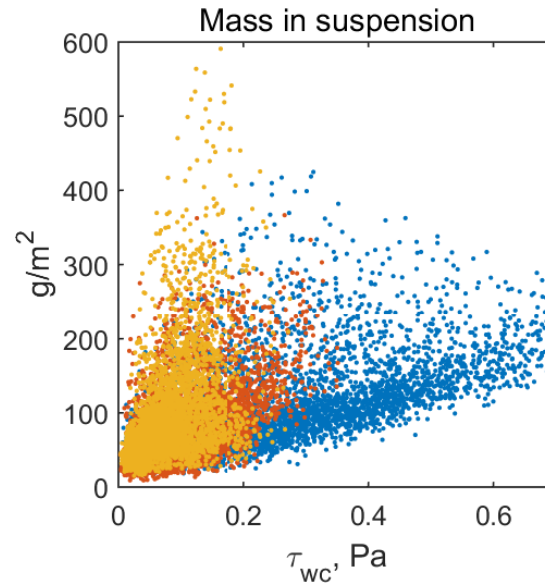
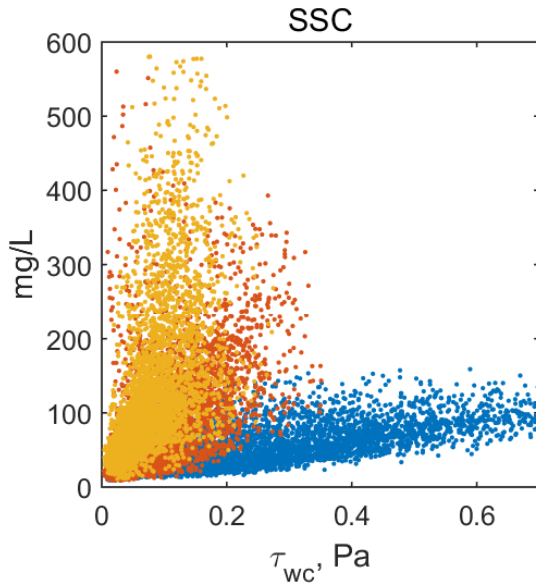


Bed shear stress: summer 2016

Does SSC increase towards shore because waves impact the bed more?

No. While relative importance of waves increases towards shore, total bed shear stress decreases.



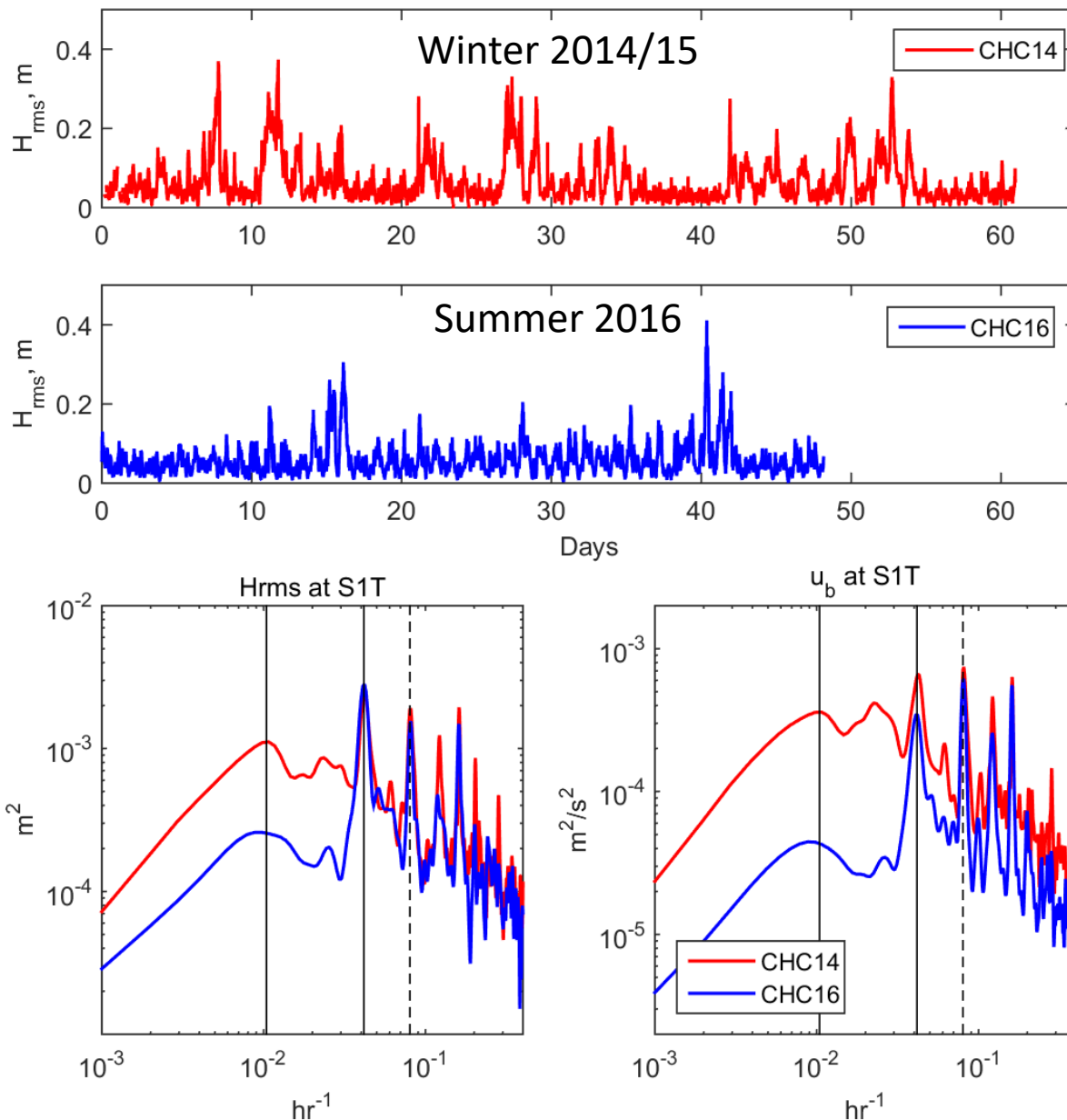


Does SSC increase towards shore because of decreasing depth?

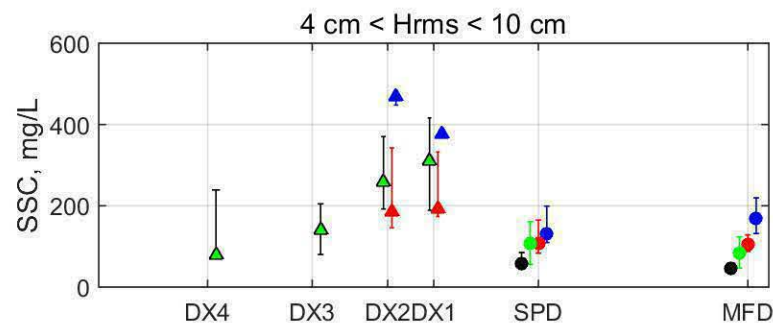
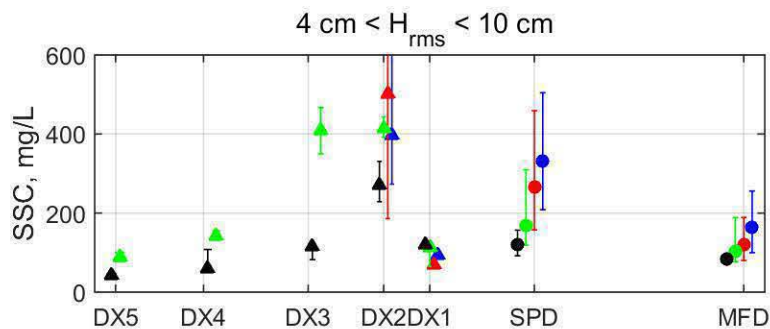
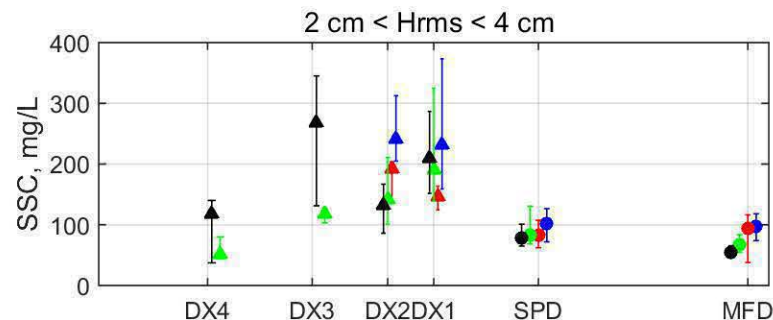
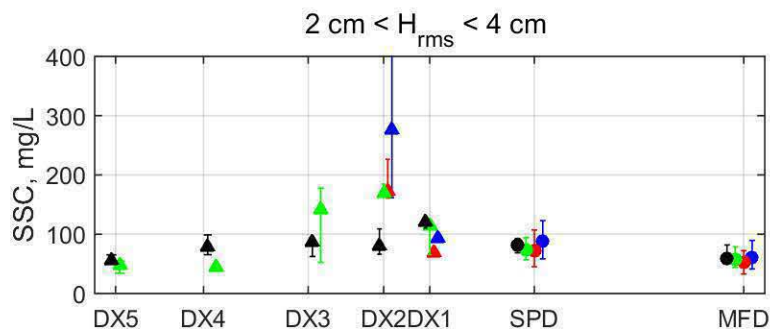
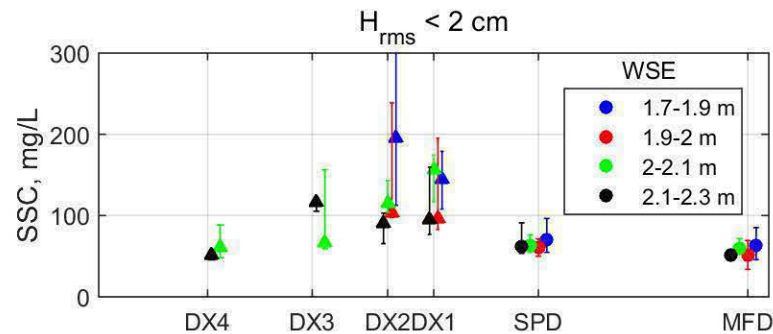
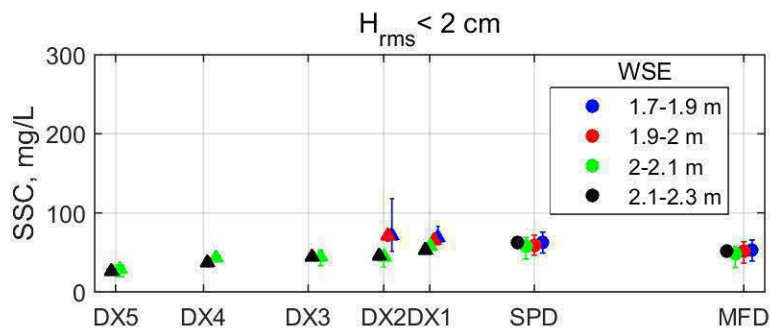
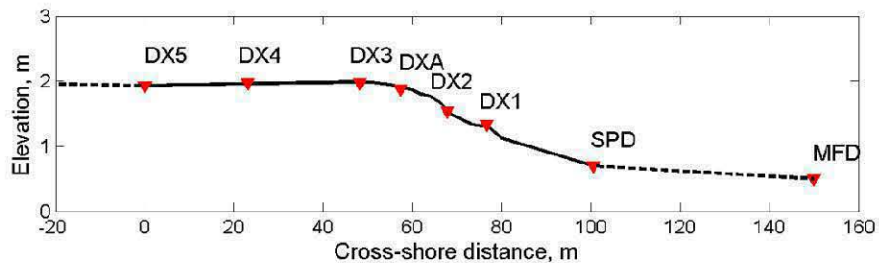
Yes. Equivalent erosion of sediment in lower water depth results in greater SSC adjacent to marsh.

Can greater SSC over marsh during summer be attributed to a difference in wave energy?

Daily wave energy at very similar, event-scale energy greater in winter.



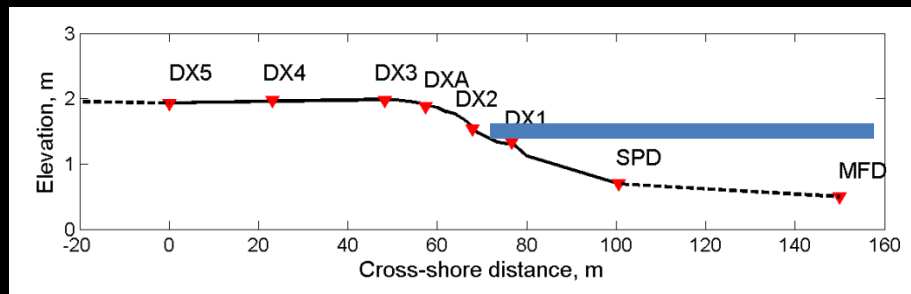
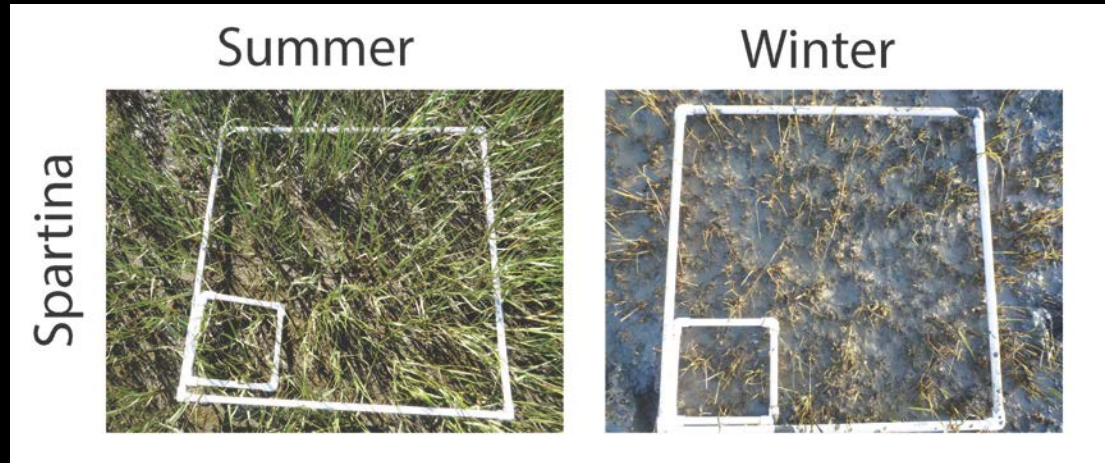
SSC along marsh transect:



Winter 2014/15

Summer 2016

- Maximum SSC occurs within the *Spartina* and transition zone.
- This effect is much more pronounced in summer than winter.
- Vegetation measurements show that *Spartina* is taller and more dense in summer than winter



- The *Spartina* zone is inundated during lower high tides, which do not reach the marsh plain.

We hypothesize that the dense summer *Spartina* traps sediment during lower high tides, which is easily resuspended during the following flood tide.

Conclusions

Recommendations for timing of sediment placement for marsh nourishment:

- Avoid energetic spring tides
- Moderate tides during windy periods are best
- Actively growing *Spartina* fringe may enhance sediment trapping.

Spatial patterns in SSC (relevant to sediment supply to marshes):

- SSC increases towards the marsh edge, and much of the increase can be accounted for by decreasing depth.
- SSC continues to increase through the *Spartina* and transition zone, especially when vegetation is thriving.

Questions?



SSC at the marsh edge

- In subtidal shallows, both tidal currents and wind waves mobilize sediment.
- Adjacent to the marsh edge, waves are much more important.
- SSC in subtidal shallows not necessarily representative of marsh edge.

