Sediment flux between San Francisco Bay shallows and marshes

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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.

The details of how and when sediment is supplied to marshes are not well understood.

Treatment of sediment supply in many models is simplistic, and sediment export is not accounted for.

Goals

Measure sediment export and import to a natural marsh during winter, spanning the King tides.

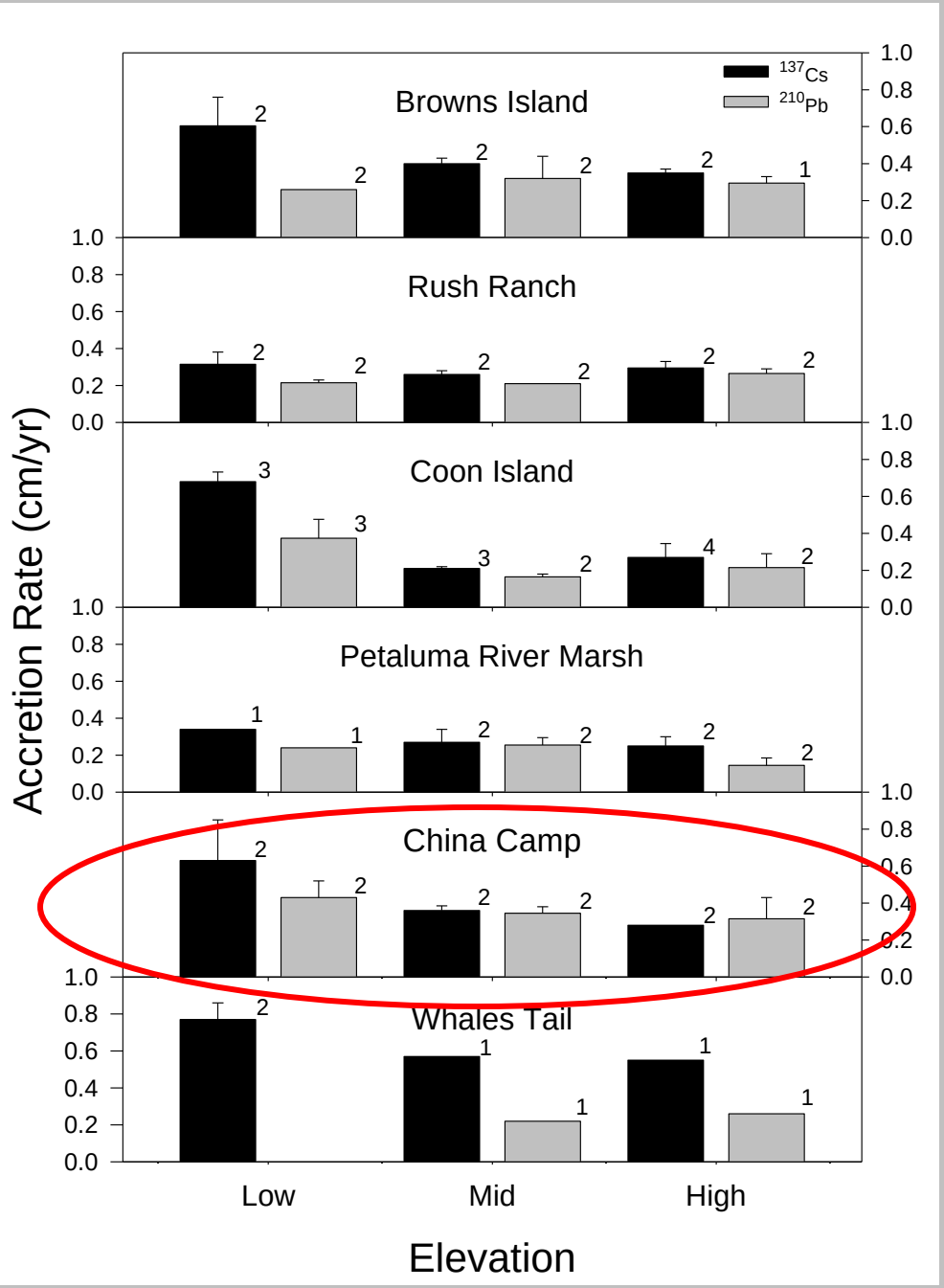
Link?

Observe suspended sediment dynamics in adjacent Bay shallows.

Study site

China Camp marsh, San Pablo Bay

Collaboration with NERR
Mud on the Move project



Accretion in natural SF Bay marshes is more than adequate to keep up with current sea-level rise

- Consistent rates of accretion in mid and high marsh: ~0.3 cm/yr
- 37 dated cores using both ^{137}Cs and ^{210}Pb

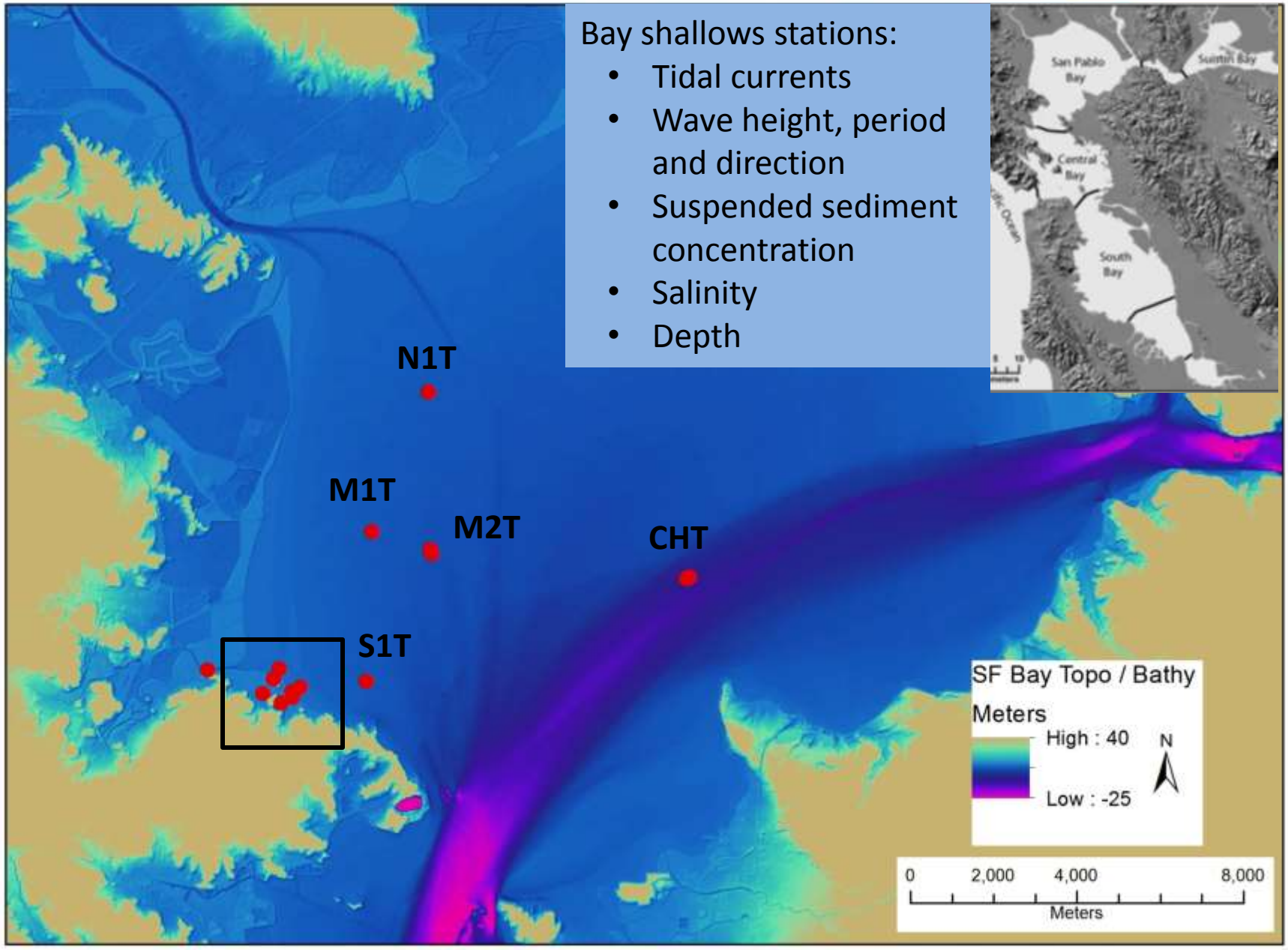
(Callaway et al., 2012)

During King tides the marsh is inundated, which is a rare occurrence.

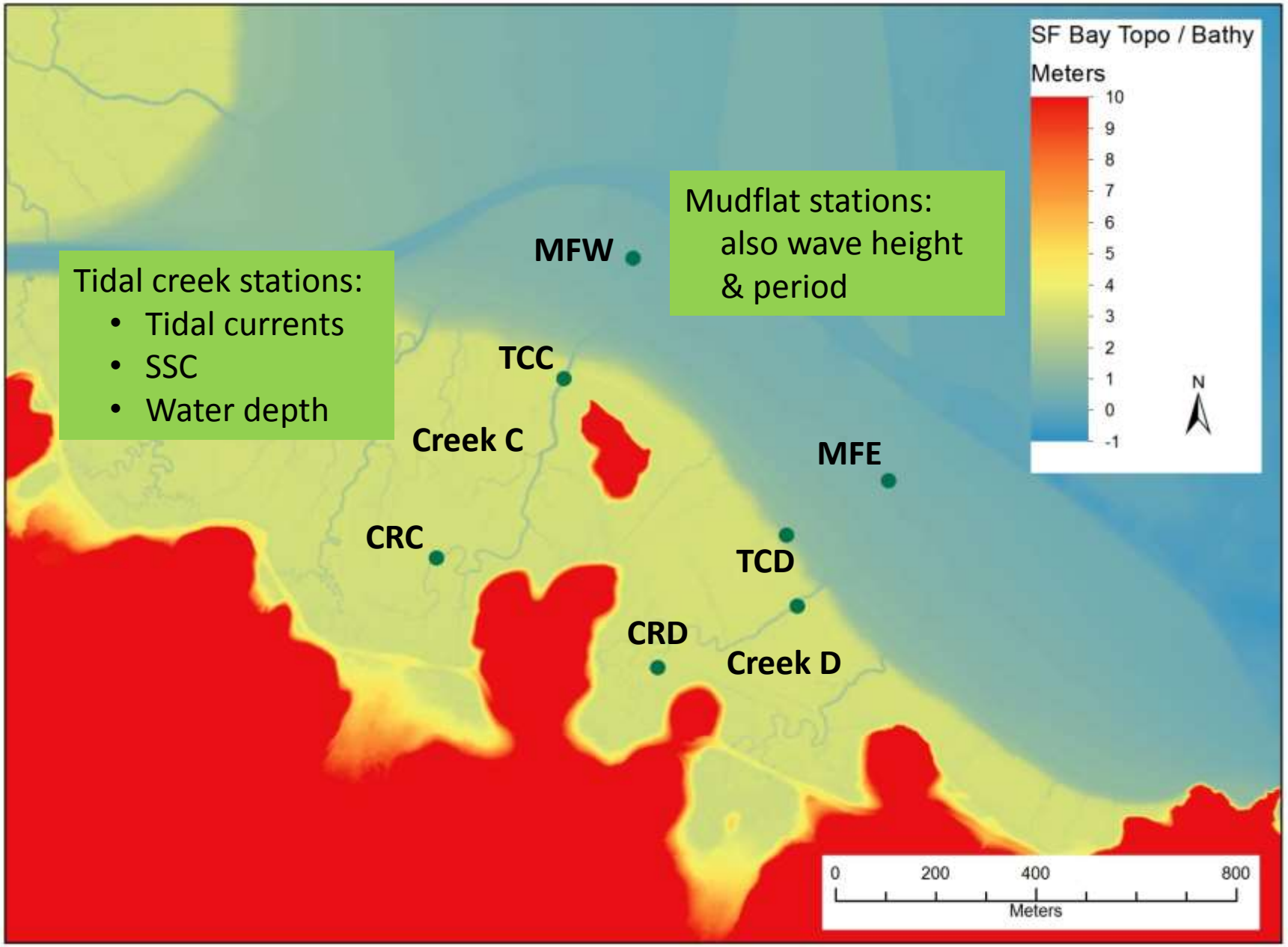
Hypothesis: King tides are important times for sediment delivery.

China Camp marsh during King tides

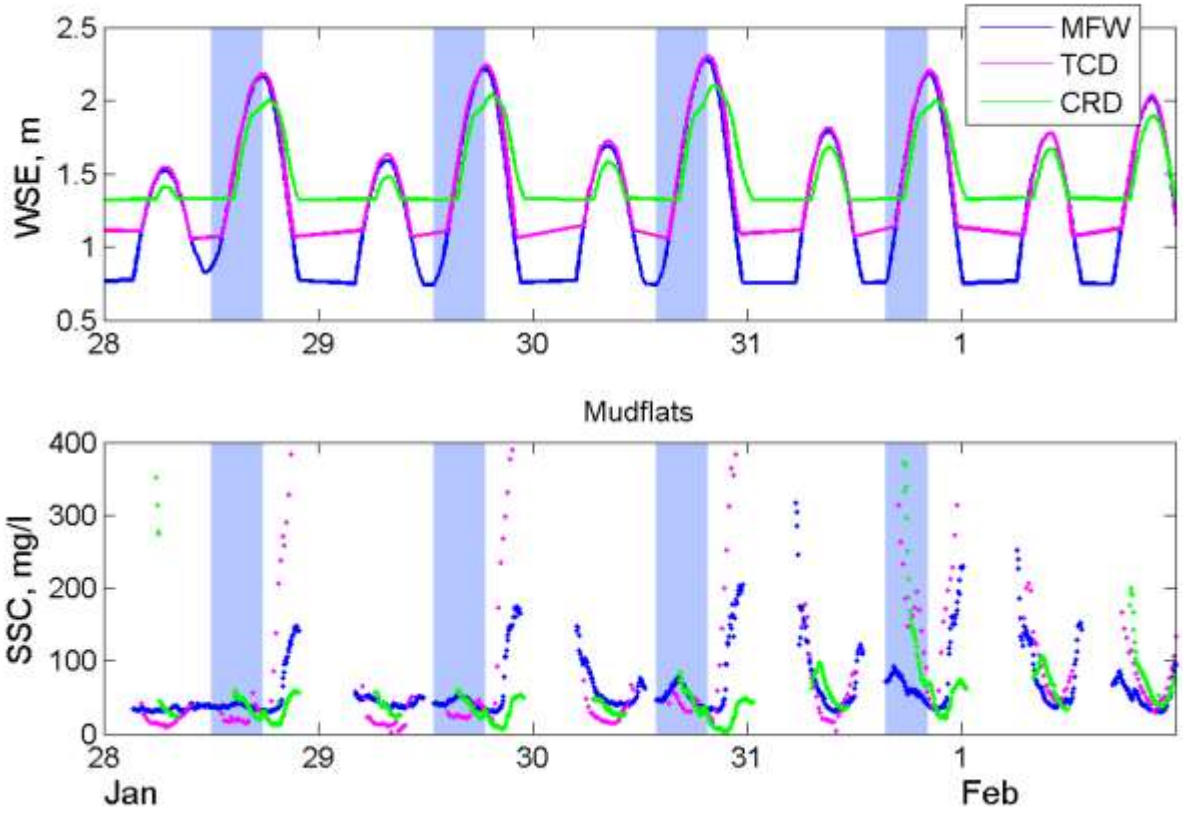
Dec 2013 to Feb 2014 deployment



Instrumented two creeks within China Camp marsh



Spatial variability in SSC



Blue = flood tide

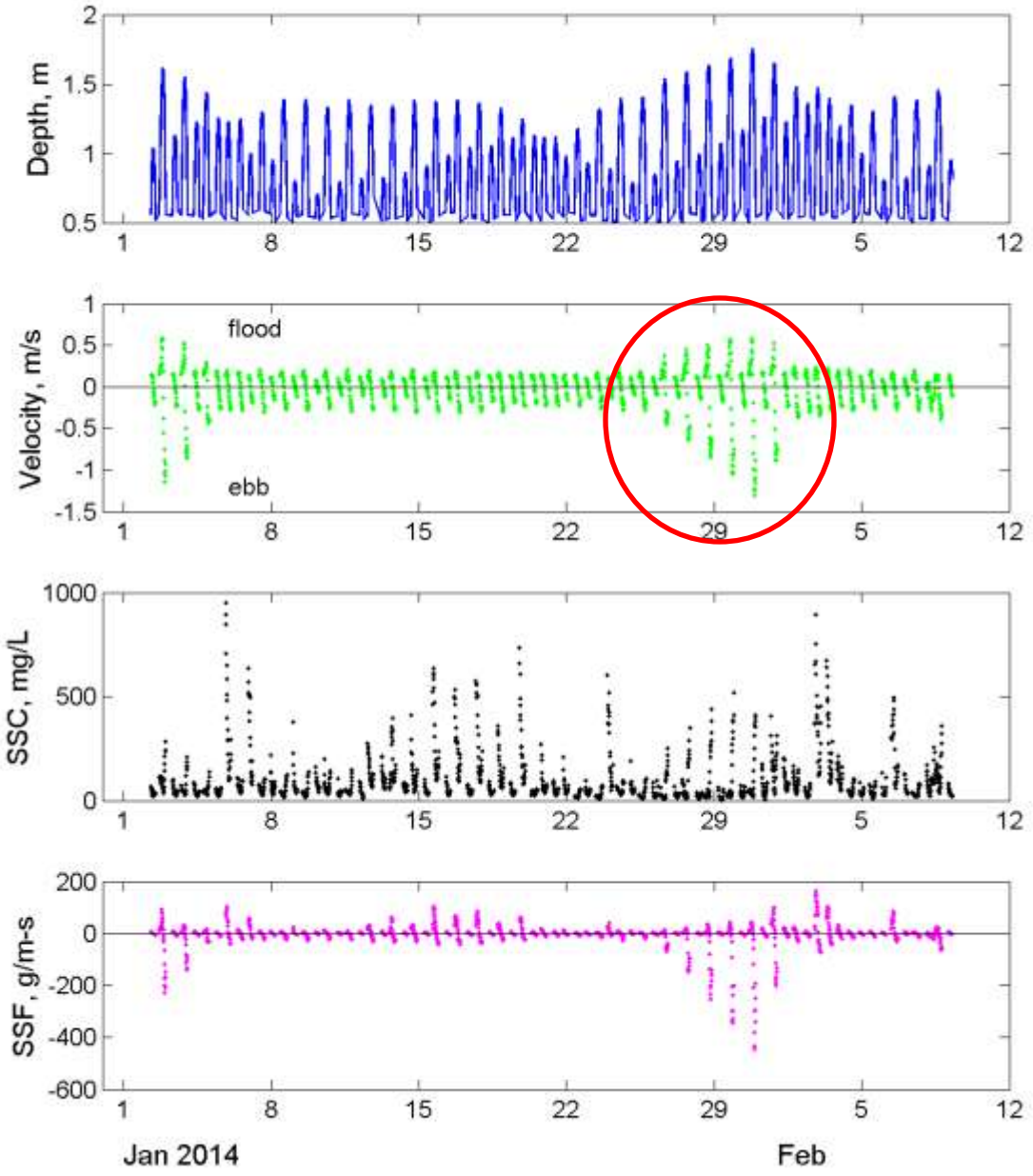
- Highest concentrations at lower tidal creek station
- Highest concentrations everywhere at low tide
- Lowest concentrations at high slack

Lower Creek D station: TCD

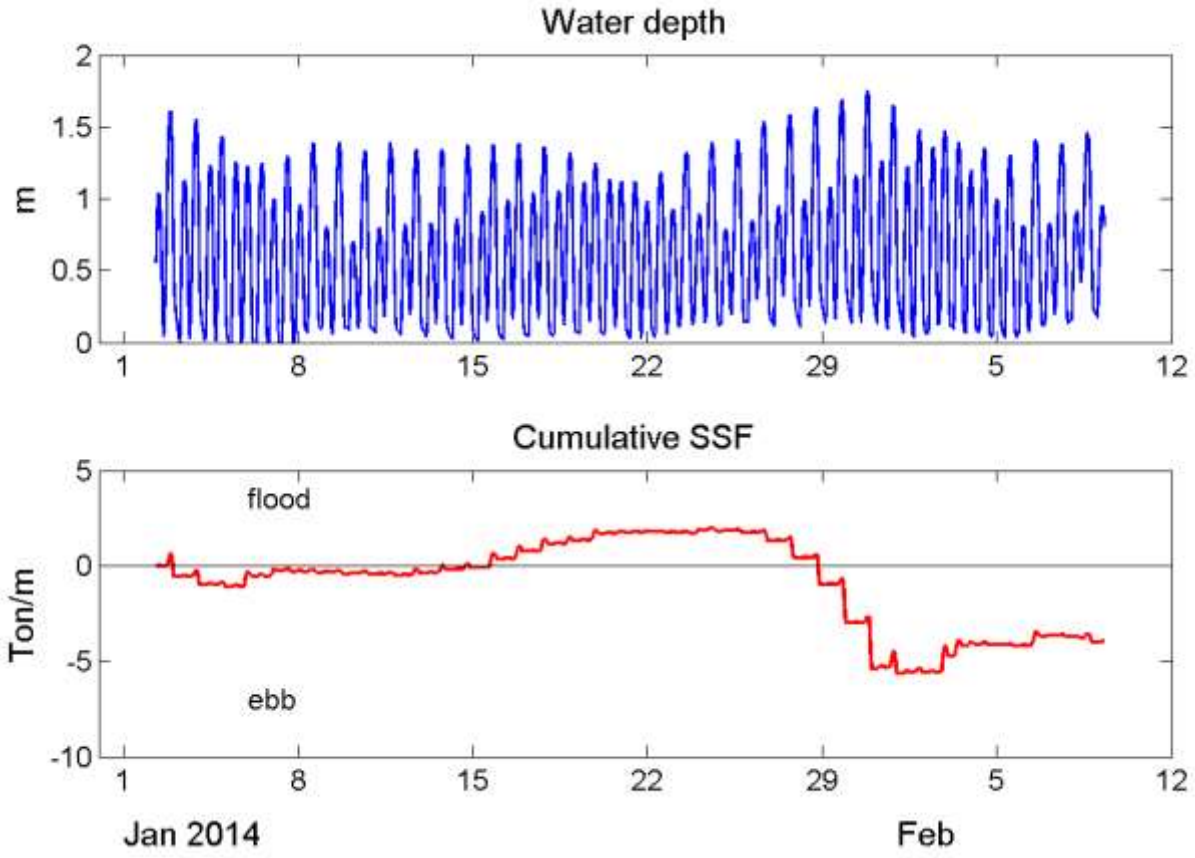
Very high velocities on ebb King tides.

SSF = *uhc*

u: velocity
h: depth
c: SSC



Cumulative suspended-sediment flux in

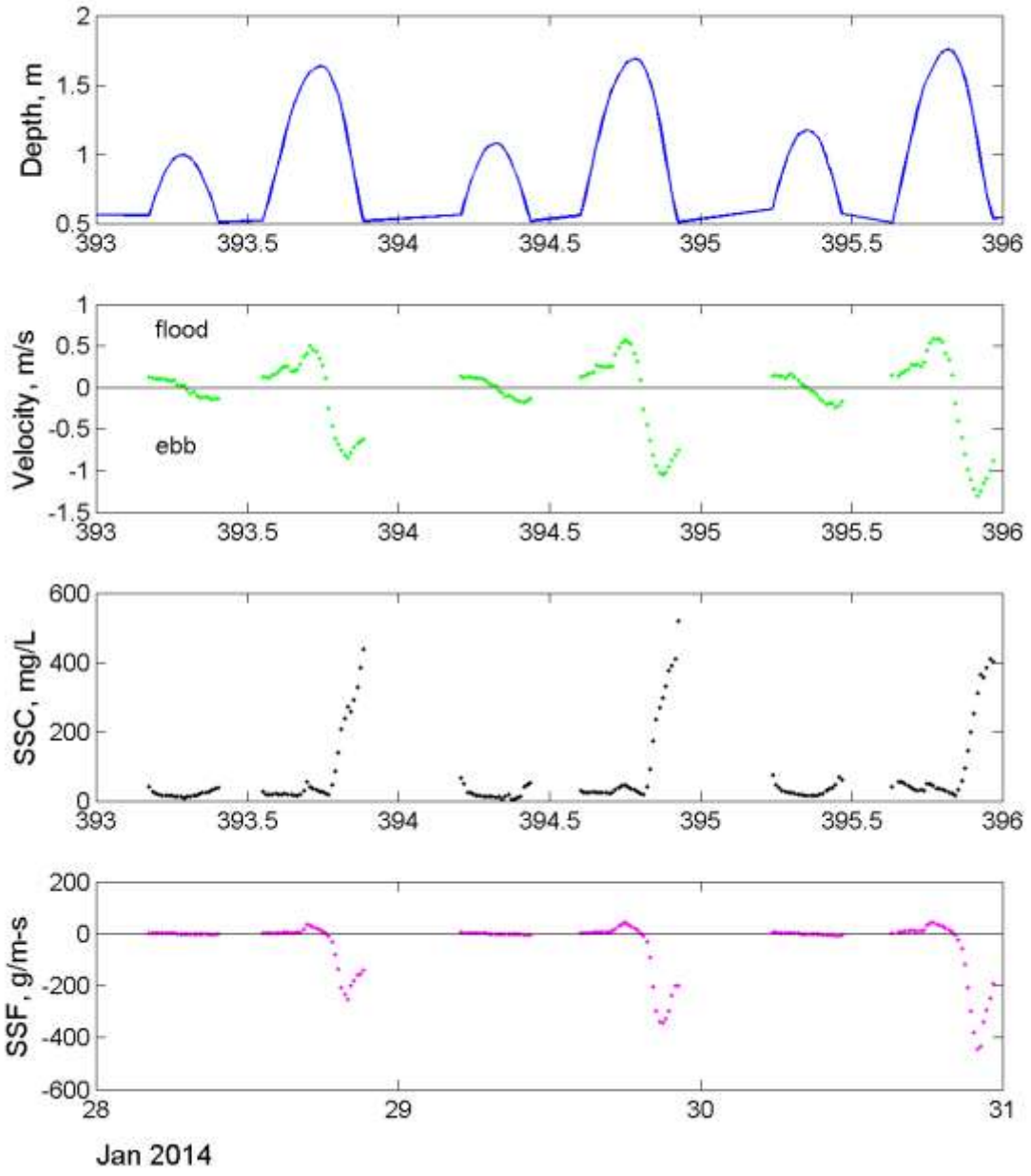


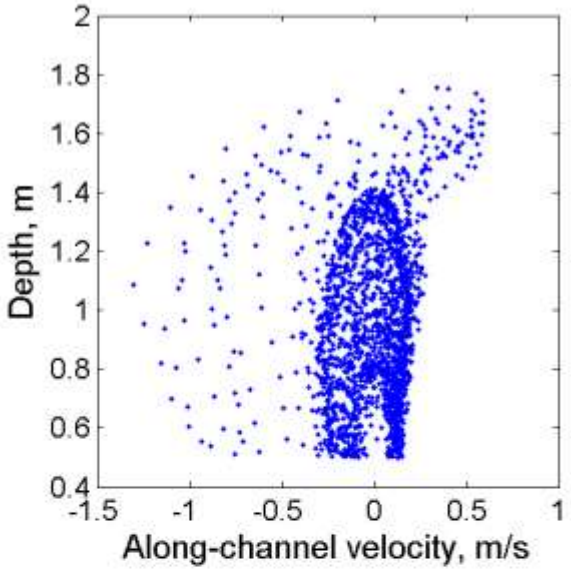
During January King tides, 8 tons of sediment export per meter of creek width. Creek 3.2 m wide.

10 tons of sediment export from Creek C.

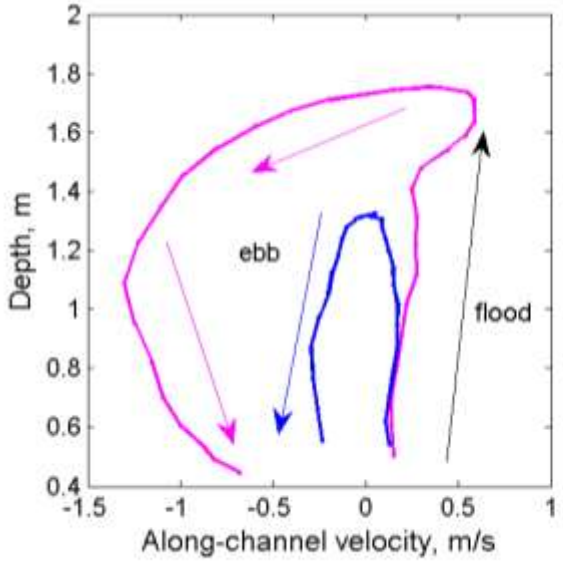
Spring ‘King’ tides, Creek D

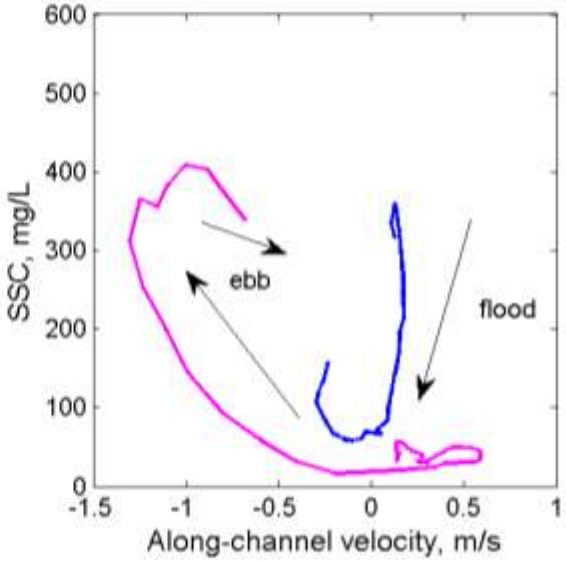
Strong bayward velocities correlated with high suspended sediment concentration.





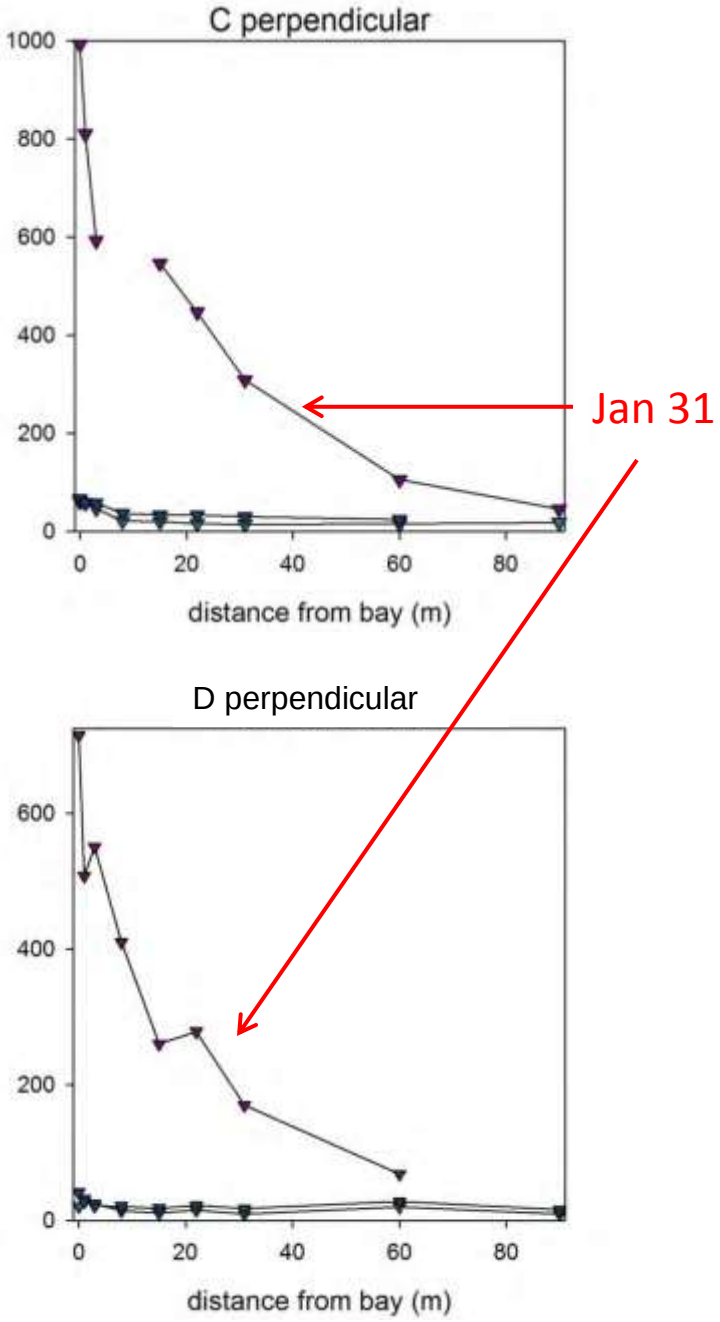
- Highest SSC at low slack
- Greater current speed during King tides
- Resuspension within creeks





Typical

King



Another pathway?

SSC measured over the marsh suggests that significant amounts of sediment may be delivered to across the marsh edge.

Water balance indicates net supply across marsh-Bay interface

During neap tides, flow in and out of marsh channels over tidal cycle about equal (difference < 8%).

During King tides, discharge 18% (average) greater than inflow.

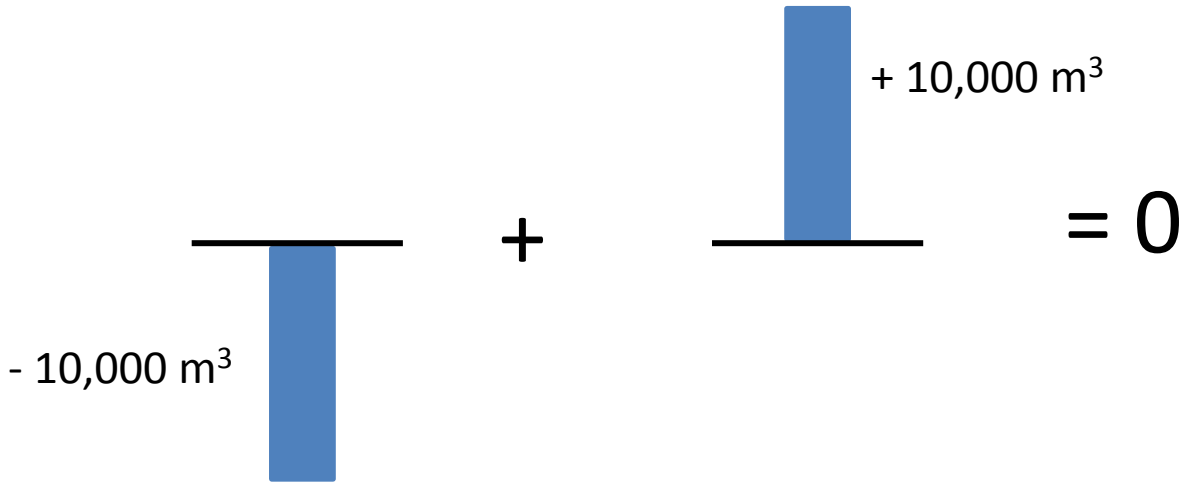
However, simple estimates indicate that this source would not completely offset the net sediment discharge through the creeks.

Example:
Jan 30, Creek D

Tidal Creek
(measured)

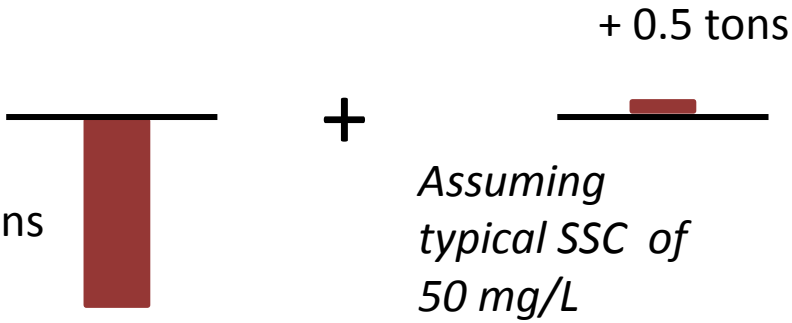
Marsh edge
(inferred)

Water



= 0

Sediment



Assuming typical SSC of 50 mg/L

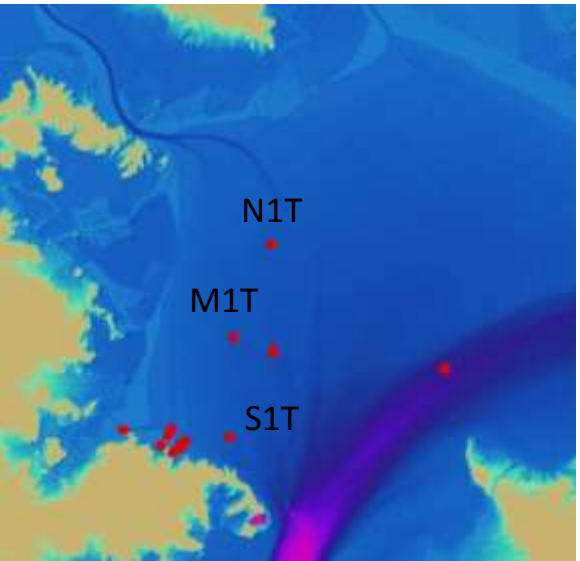
= **9 tons**

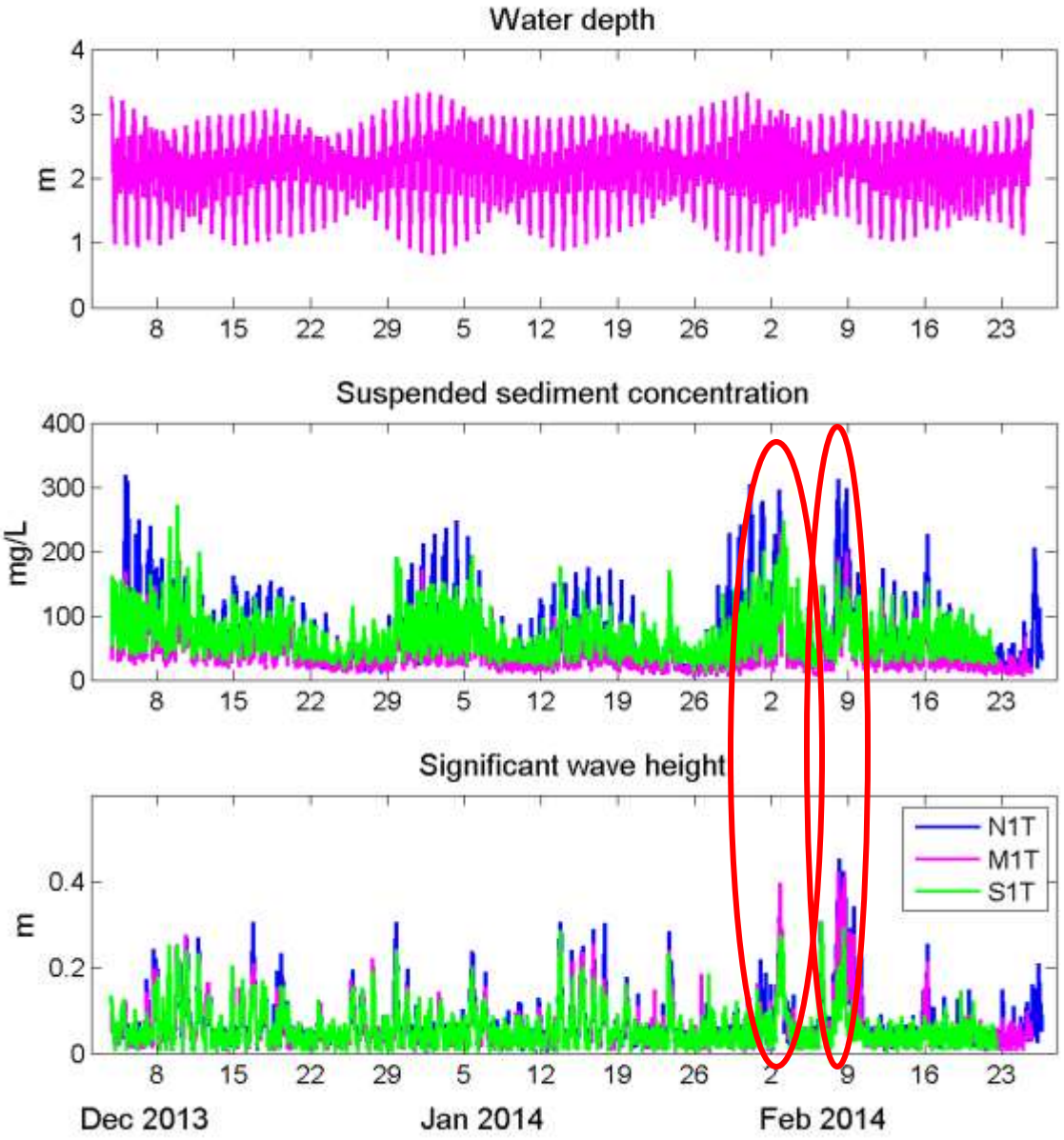
To balance sediment flux would require SSC of 900 mg/L throughout flood tide, which is very unlikely.

What about supply at other times?

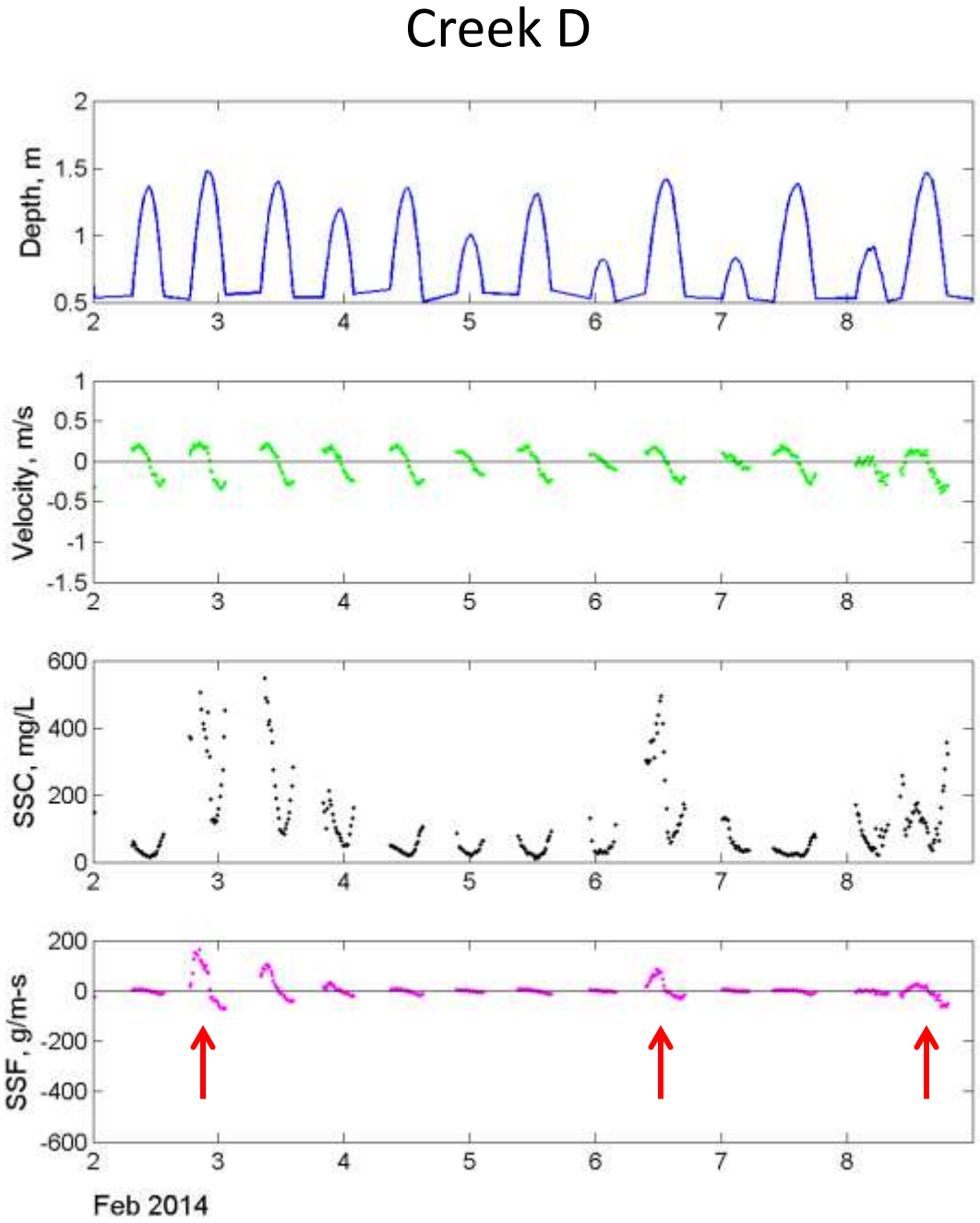
In Bay shallows, both tidal currents and waves resuspend sediment.

Few storms during 2013/14 drought

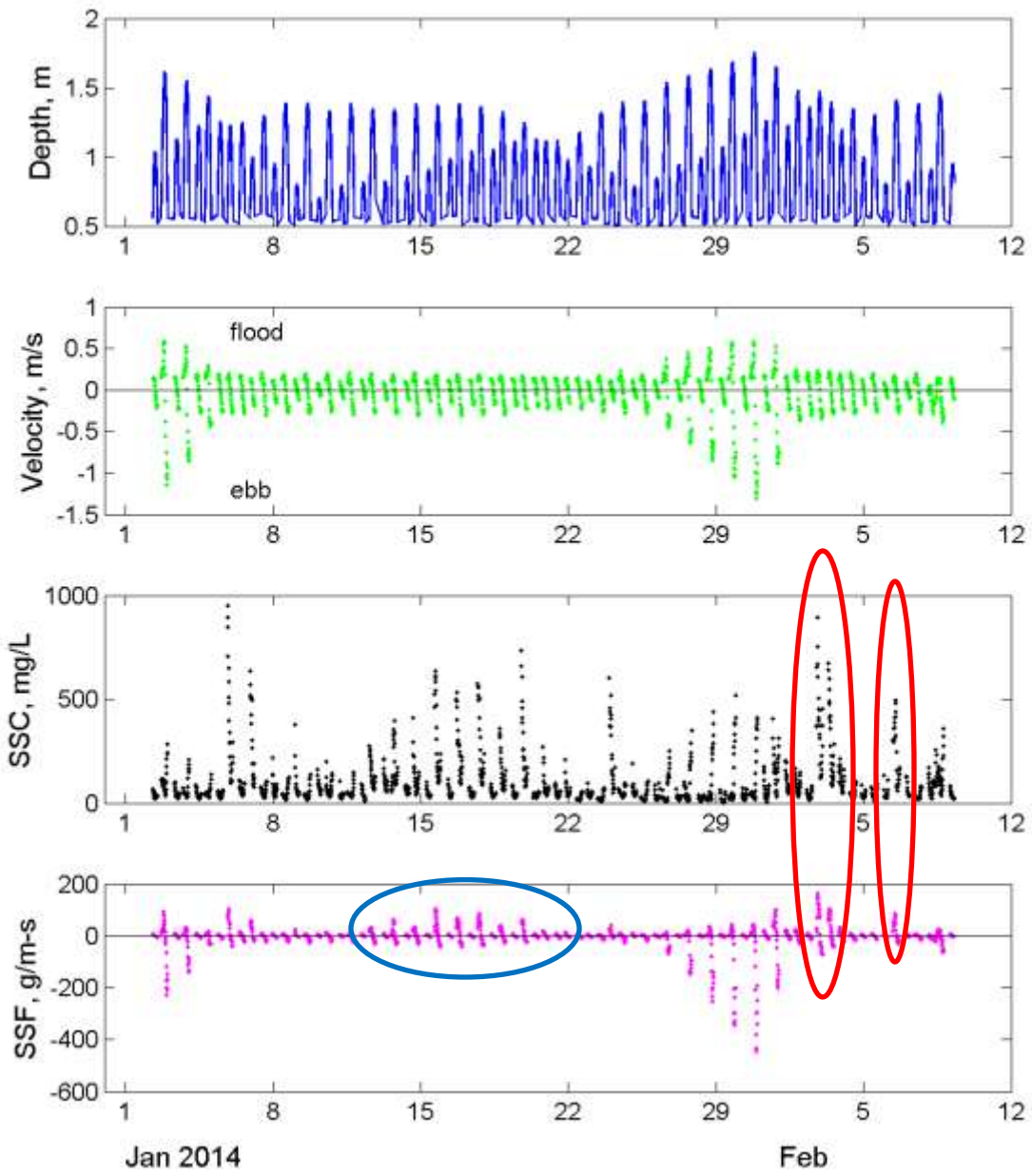




Wind wave resuspension in Bay produces greater SSC on flood than ebb tides, and positive SSF.



SSF is also slightly positive during neap tides.



Conclusions

- During January 2014 King tides, two creeks in China Camp marsh exported 32-40 tons of sediment each in four days.
- Water balance indicates that some sediment was supplied across Bay-marsh interface, but likely less than lost through creeks.
- Sediment was supplied to the marsh creeks during neap tides and wind wave events, but less than was exported during King tides.
- Follow up study this winter will investigate transport across marsh-Bay interface, and (hopefully) influence of stormier conditions.