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Bed erodibility as a function of sediment properties and environmental conditions within the York River Estuary

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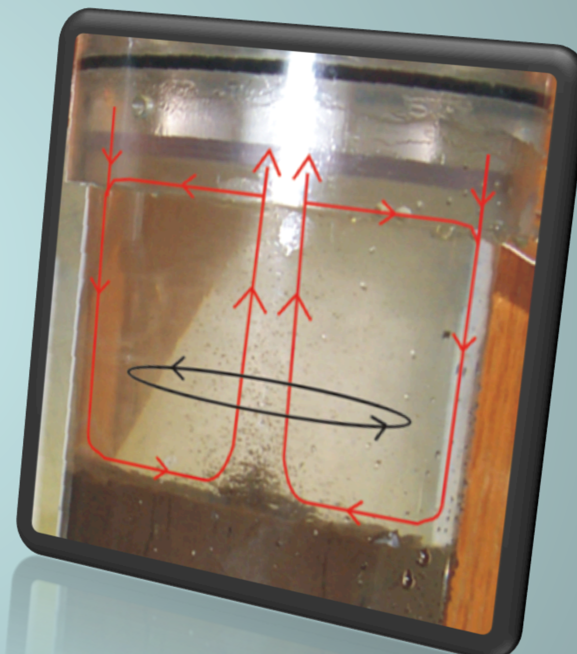
Bed erodibility as a function of sediment properties and environmental conditions within the York River Estuary



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CERF Monday Nov. 7th 8:45am

WILLIAM & MARY VIMS Virginia Institute of Marine Science School of Marine Science

Coastal Hydrodynamics CHSD & Sediment Dynamics

NSF

CGOP

Motivation

NSF MUDBED Project (Multi-disciplinary Benthic Exchange Dynamics)

Understanding fine sediment transport is critical to managing coastal water quality and ecological health, and to understanding coastal ecology, chemical fluxes and the geological record.

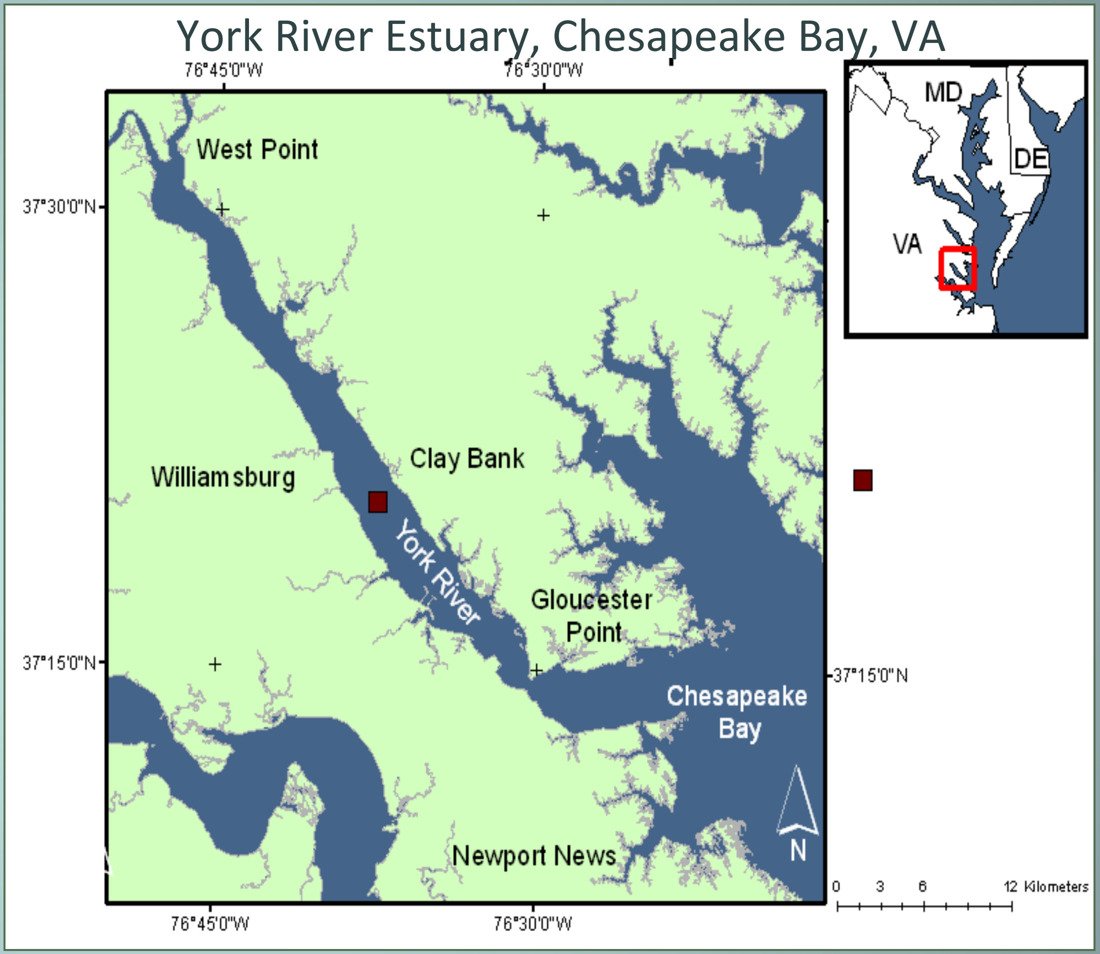
What are the key differences in the bed and/or hydrodynamics for low versus high erodibility cores?

Mark Schmeeckle ~ YouTube

Erodibility and settling velocity are difficult to predict because physical and biological effects fundamentally impact them **over short scales** and physical and feedback on each other

York River

- Characterized by:
  - main channel ~ 10 m
  - secondary channel ~ 5 m
  - Tidal currents ~ 1 m s^{-1}
- ETM located at West Point
- STM found seasonally at Clay Bank



<u>Physical-Biological Gradient</u>:

-- In the middle to upper York River estuary, disturbance by sediment transport reduces macrobenthic activity and sediment layering is often preserved.

-- In the lower York and neighboring Chesapeake Bay, layering is often destroyed by bioturbation.

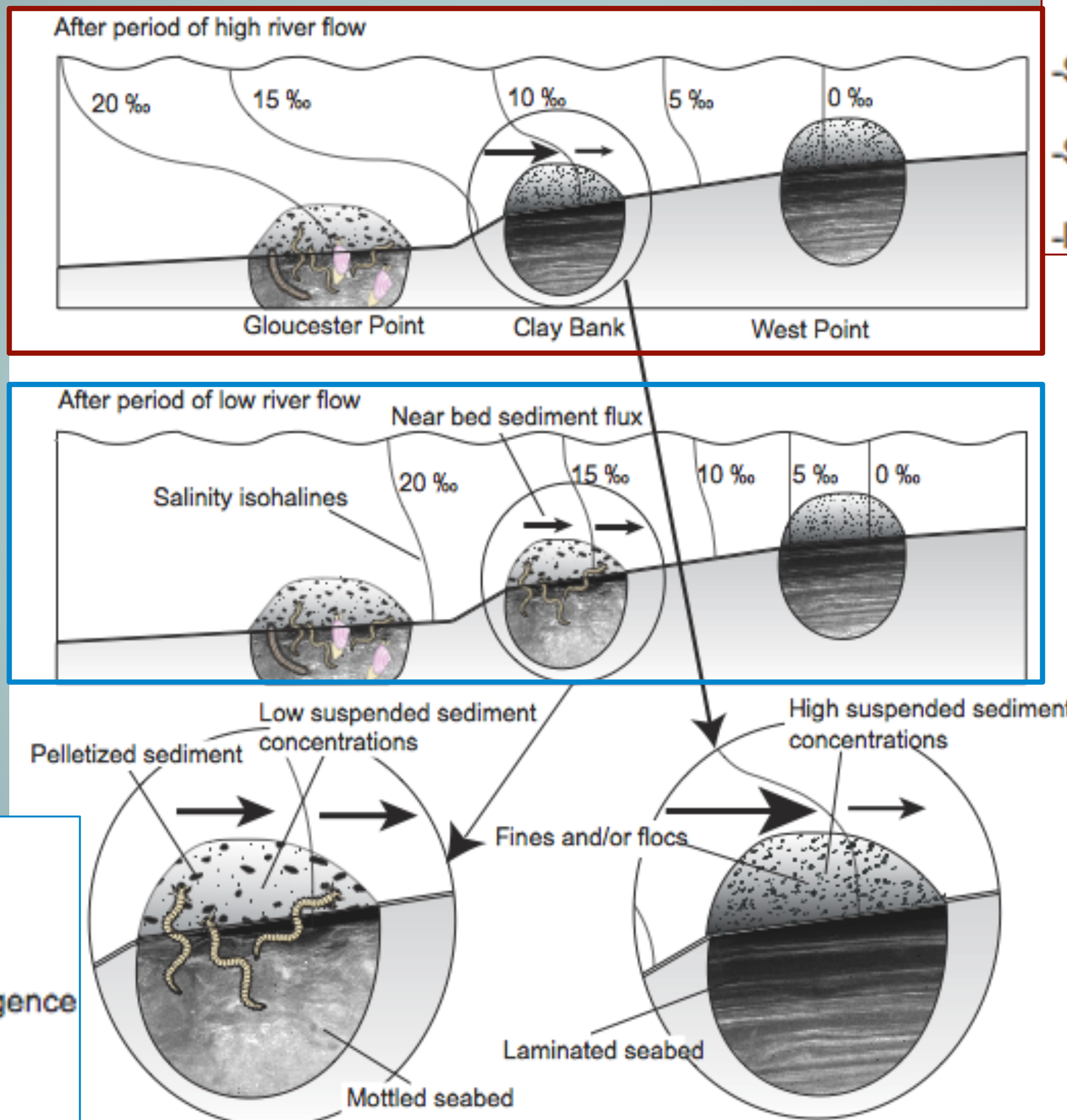
York River Conceptual Model

River Flow

Wetter in Spring

Drier in Summer

- After high river flow
- Stratified
- Sediment flux convergence
- STM
- High erodibility



- After low river flow
- Little or no stratification
- No sediment flux convergence
- No STM
- Low erodibility

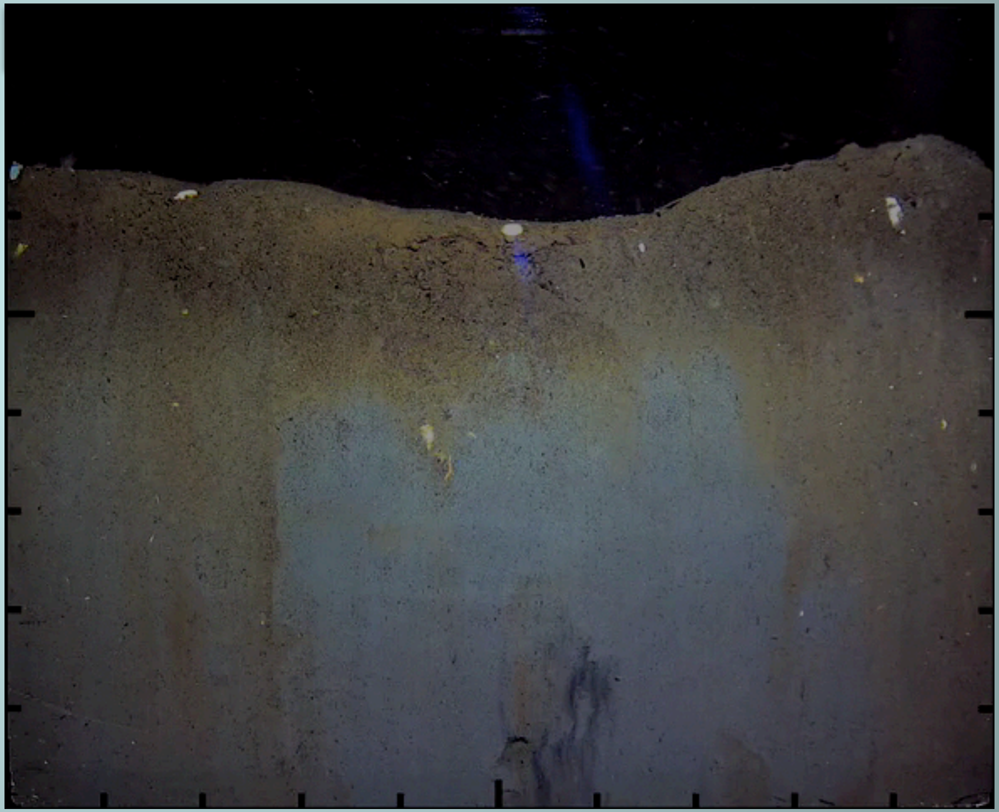
Dickhudt et al, 2009

Objectives

1. Observe the transition between periods of high and low river flow

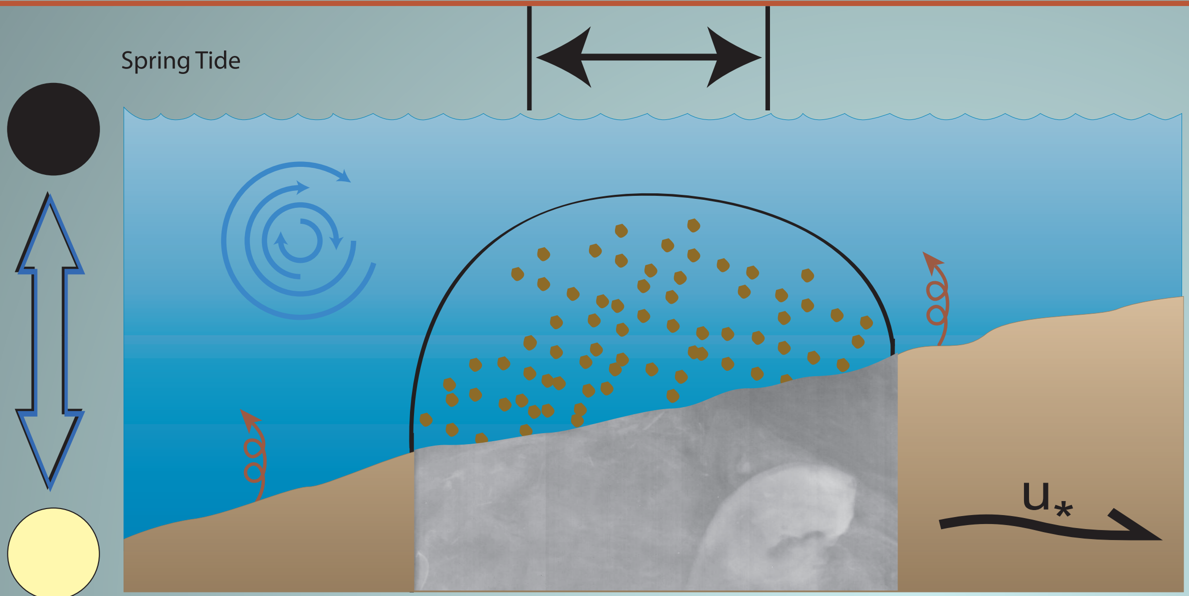
2. Assess the role of spring and neap tidal currents on the erodibility of cohesive sediments

3. Distinguish sediment bed properties (including particle types) to decipher controls on bed erodibility

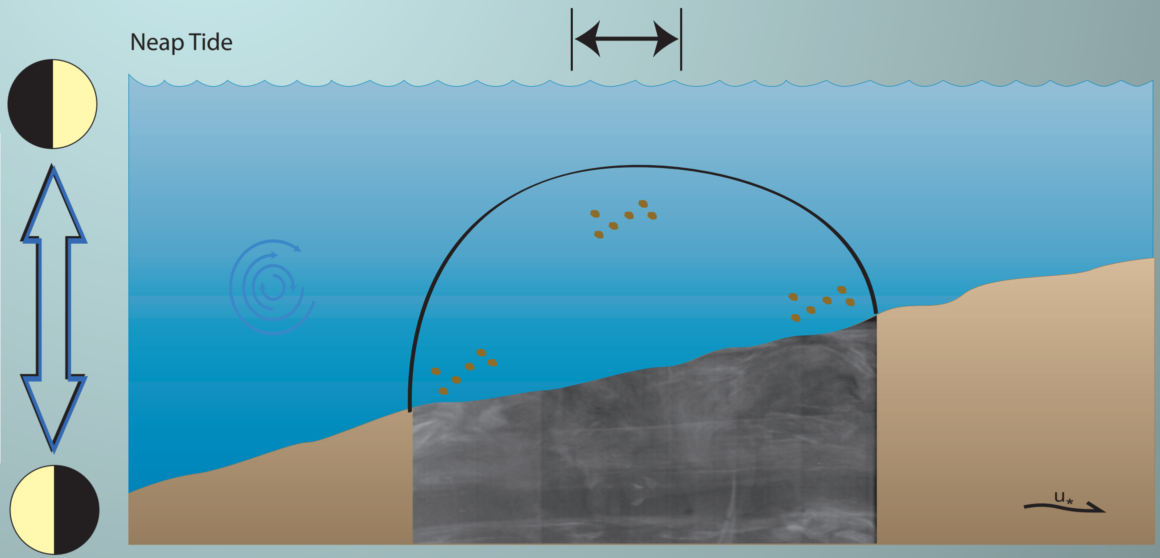


Bob Diaz Worm Cam
Clay Bank, York River VA June 2008

Spring vs. Neap



Larger tidal ranges
Higher current velocities
Increased water column mixing
Resuspension of bottom sediments
Less time for bed consolidation
Easily erodible material



Small Tidal Range
Decreased current velocities
Minimal water column mixing
Decreased bottom shear stresses
More time for bed consolidation
Less erodible material

Methods

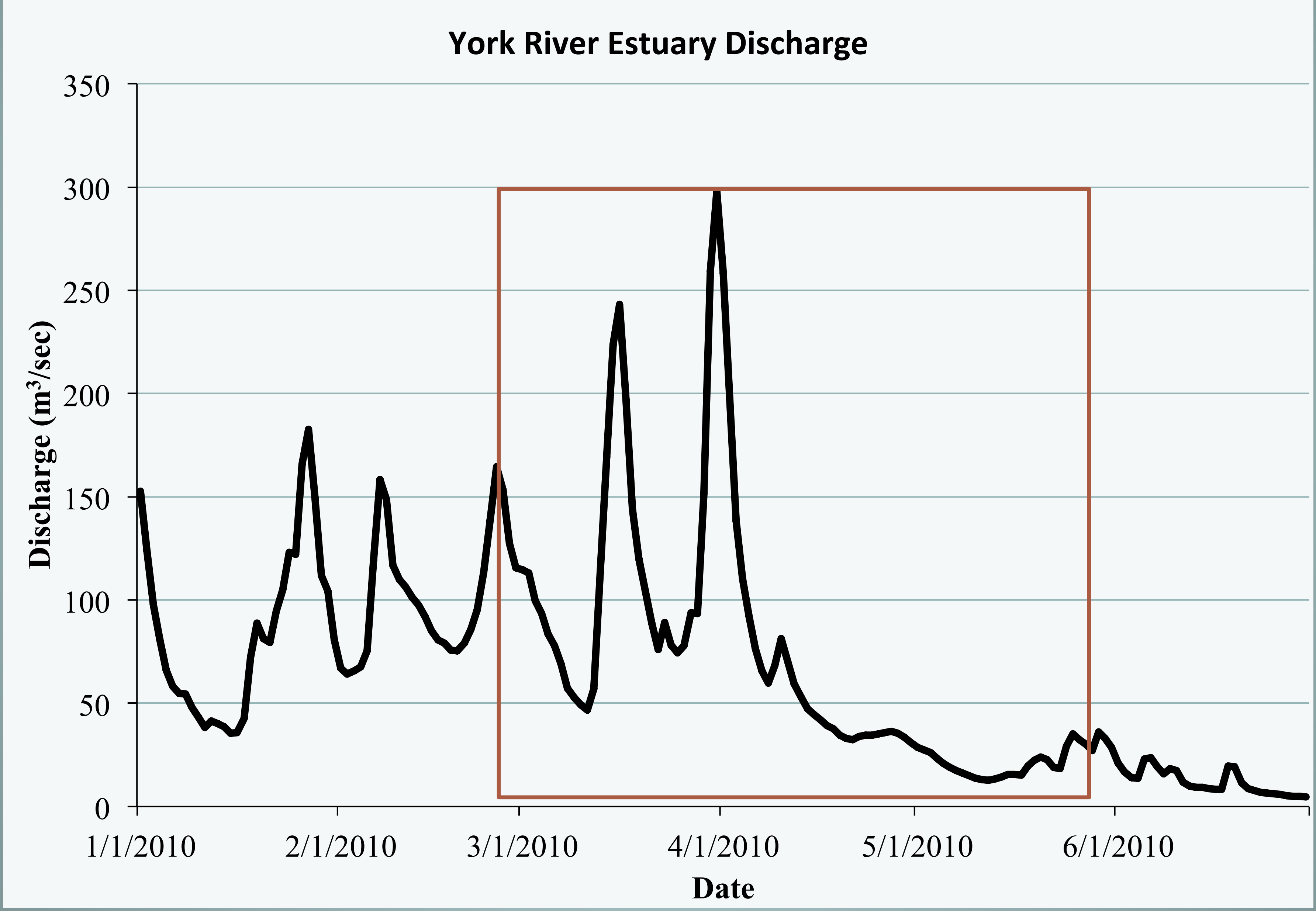
Sediment sampling cruises were taken to coincide with spring/neap in 2010

- Spring ~ 3 samples
- Neap ~ 2 samples

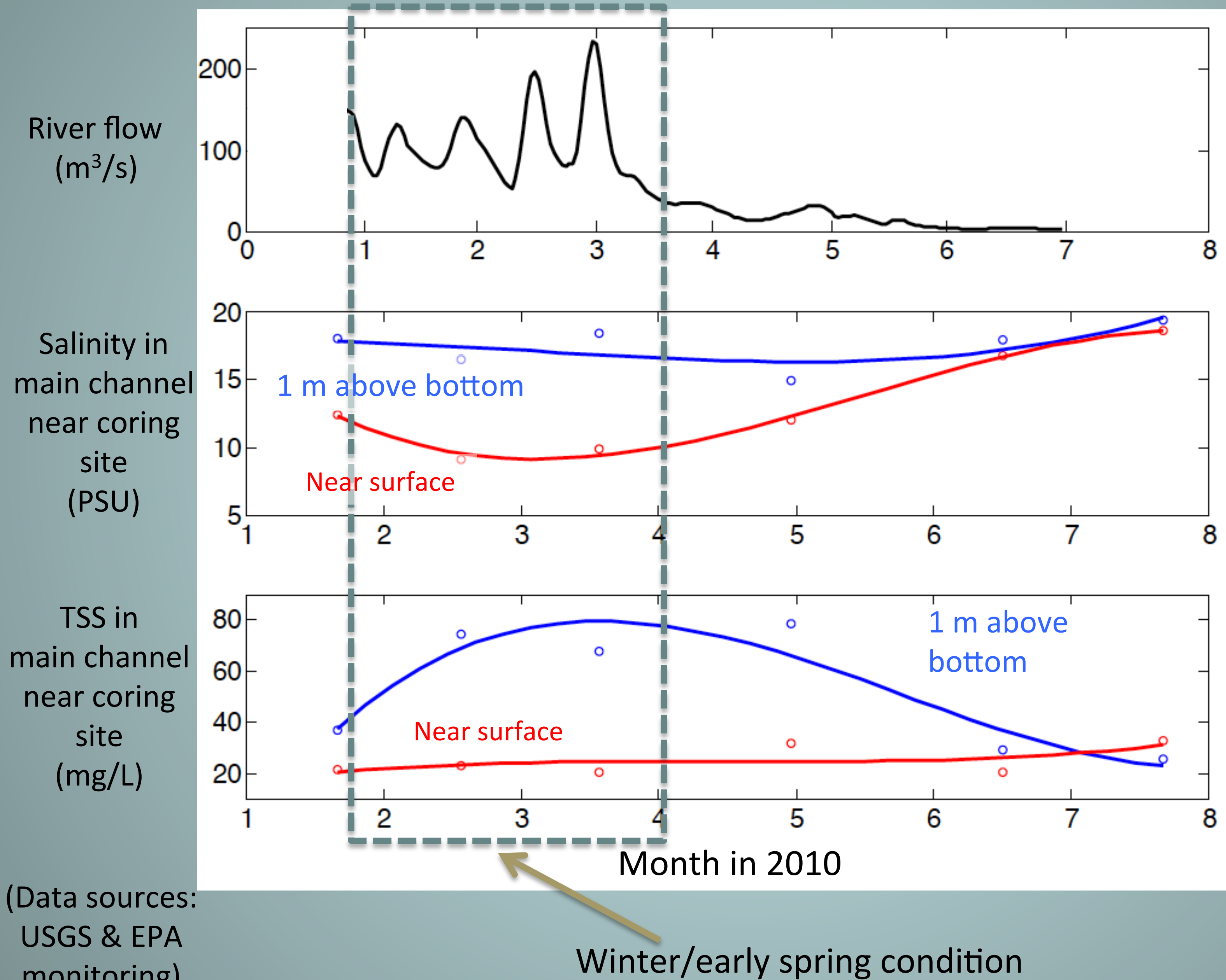
Samples collected using a Gomex Box Core

- Sliced at 1 cm intervals
- Sampled for
  - water content
  - grain size
  - resilient pellet presence and concentration
  - Be 7 radioisotope activity
- Addition samples were collected for :
  - Gust Microcosm Erodibility
  - X-ray analysis
  - Core logger

Capturing the transition



Environmental Conditions ~ Prior to sampling



↑ Discharge occurs in winter/ early spring

Salinity stratification develops (lagging discharge)

Stratification favors:

- convergence of sediment flocs
- net deposition
- lower erodibility
- higher TSS

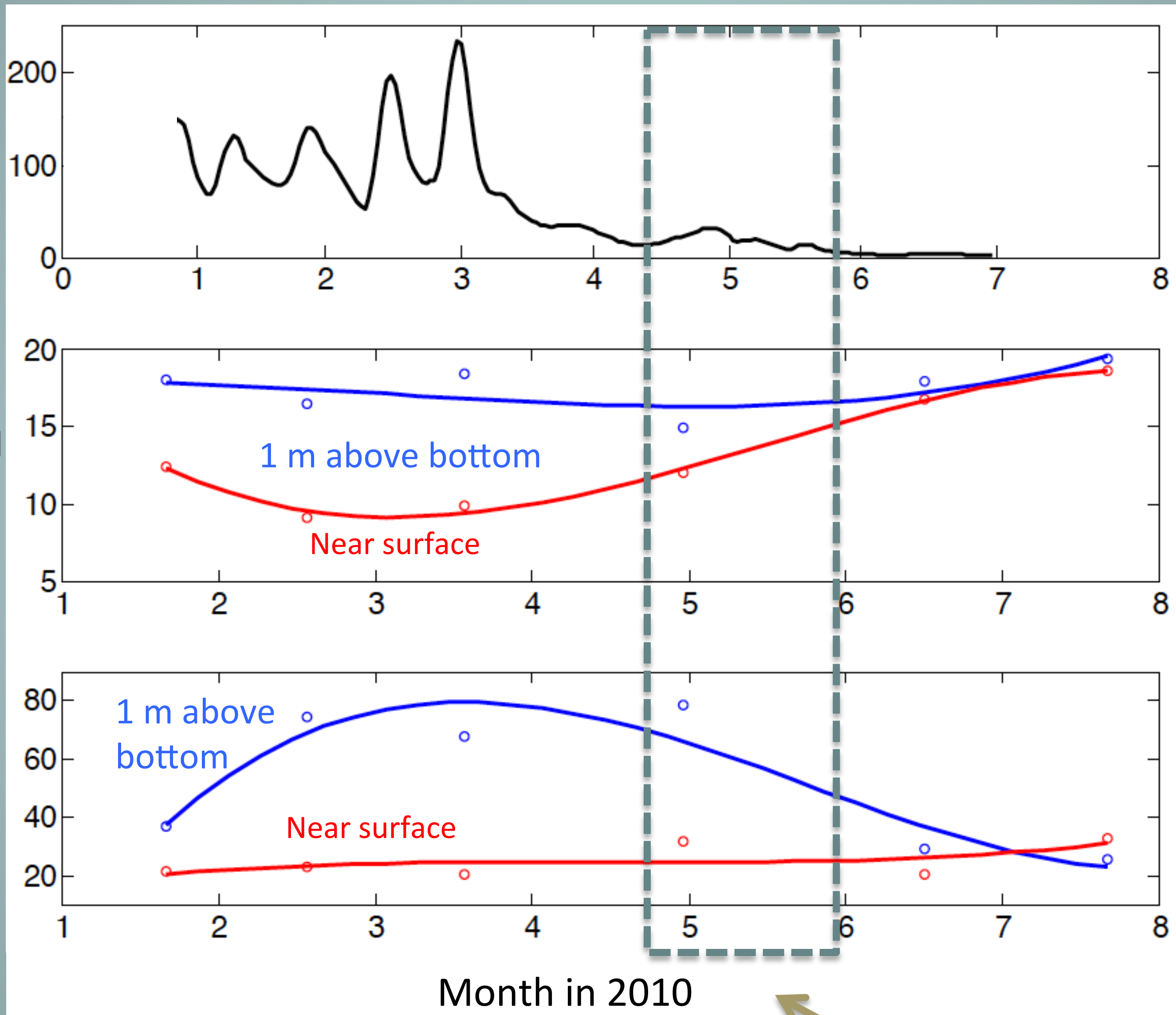
(Data sources: USGS & EPA monitoring)

Environmental Conditions ~ During Sampling

River flow (m^3/s)

Salinity in main channel near coring site (PSU)

TSS in main channel near coring site (mg/L)



Study Focus: ~1 month after river discharge peak

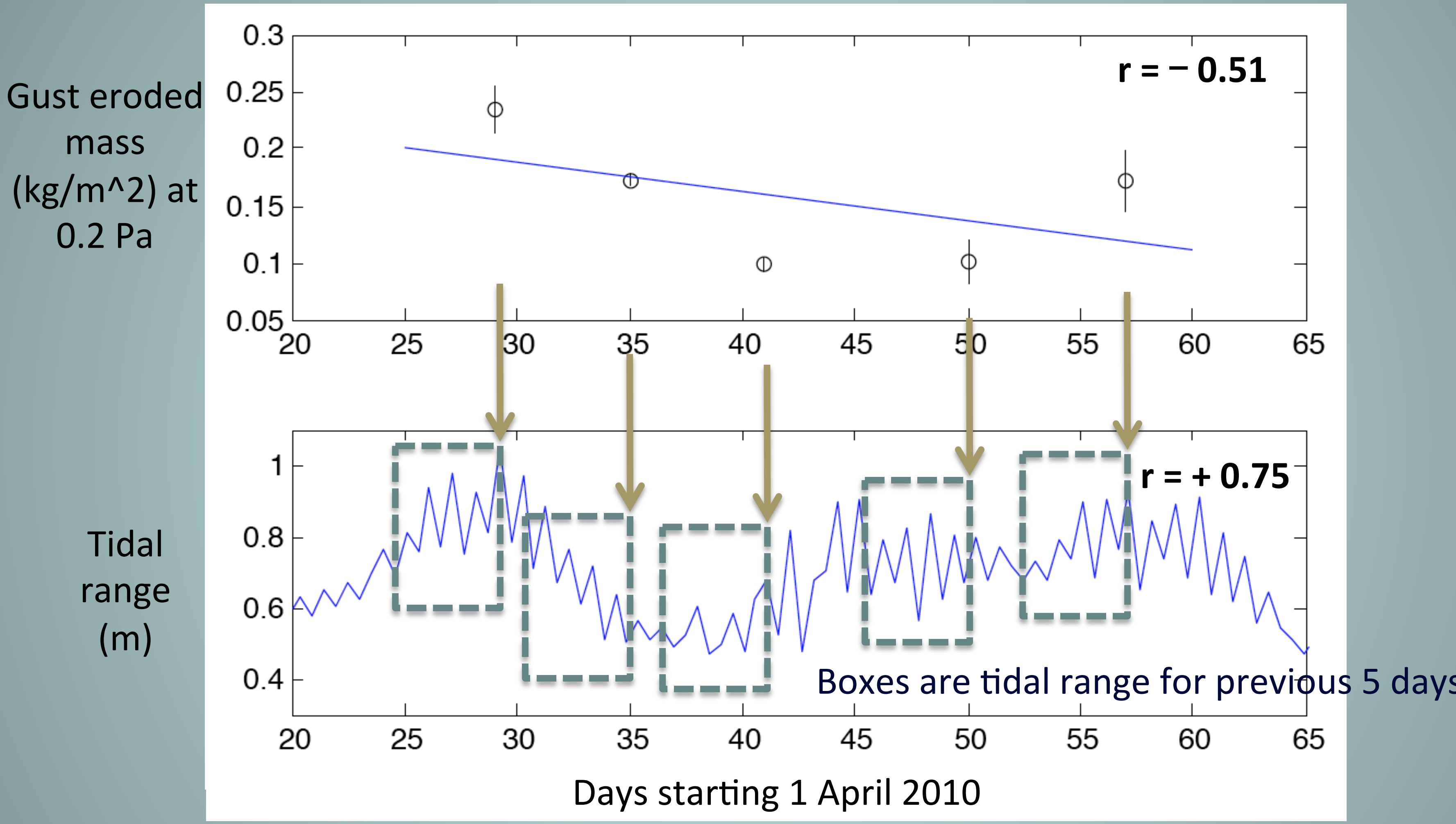
Salinity stratification significantly decreases

Leads to transition from convergence to net erosion of flocs

Coring study during late spring transition period

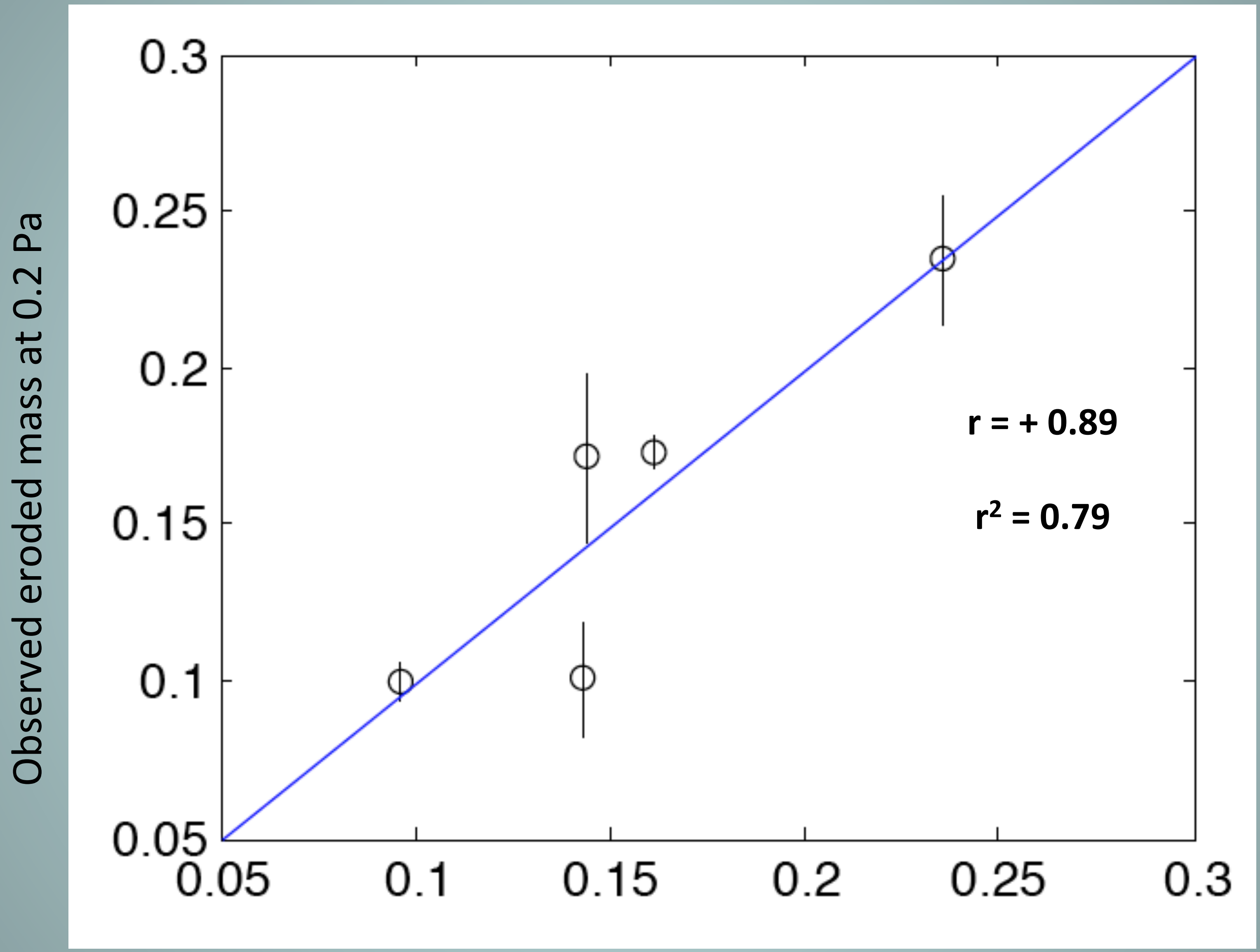
(Data sources: USGS & EPA monitoring)

1) Expect general decrease in erodibility with time due to seasonal net erosion and divergent floc transport.



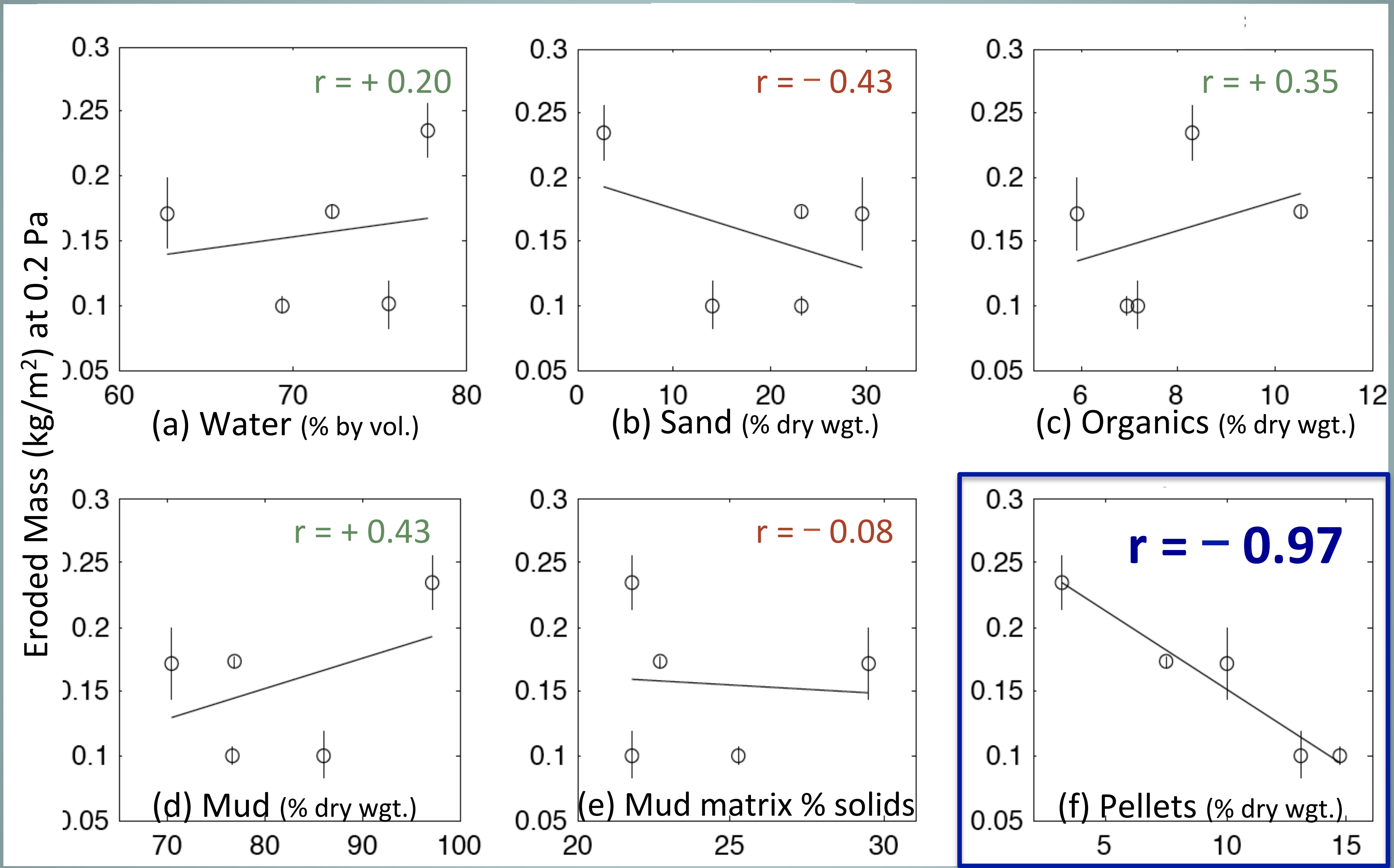
2) Also expect temporary periods of increased bed disturbance and shorter consolidation time when tides are stronger. I.e., just after spring tide → expect higher erodibility; just after neap tide → expect lower erodibility.

Multiple Regression combining seasonal discharge and tides



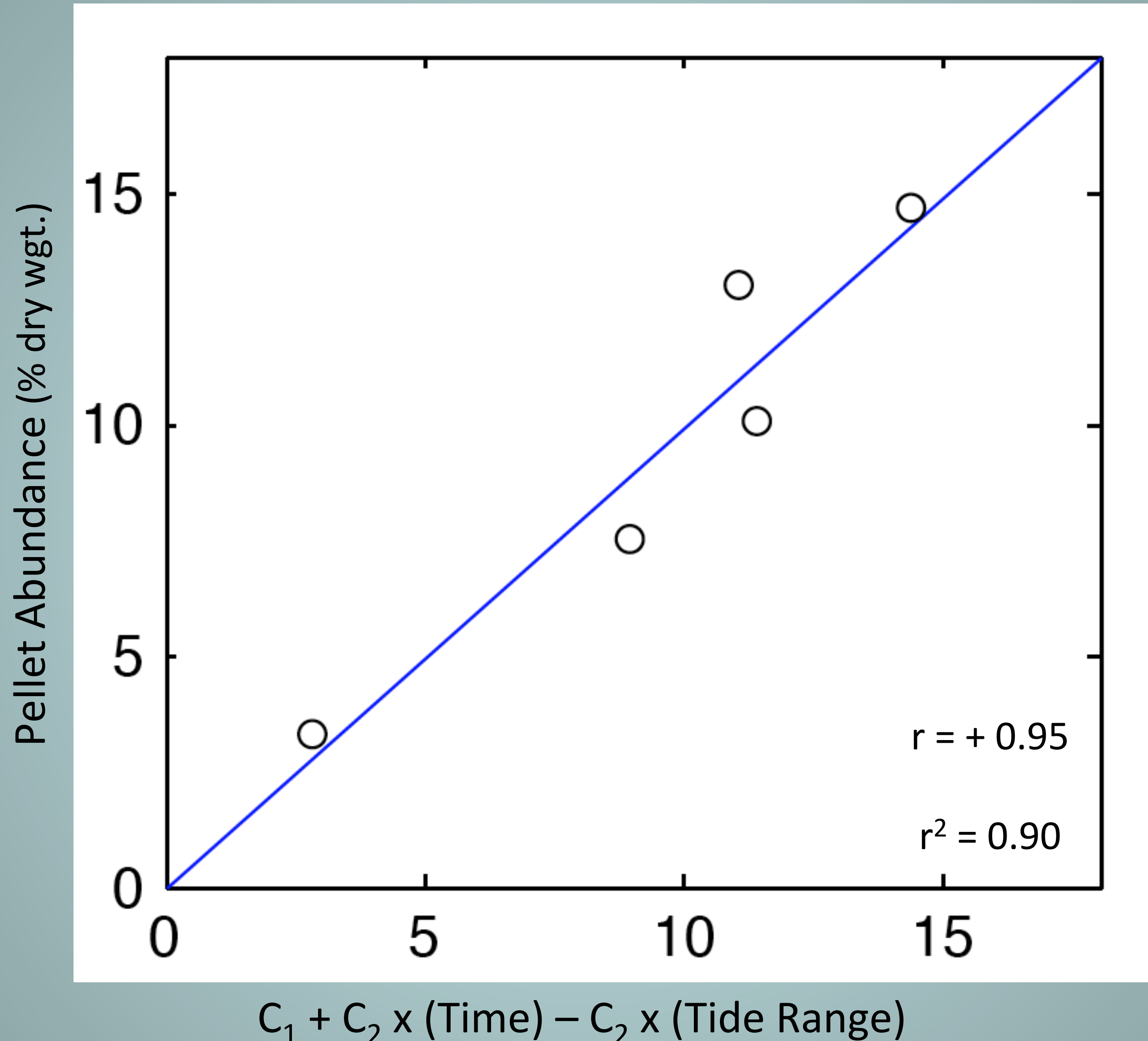
$C_1 - C_2$ x Time (net erosion effect)
+ C_3 x Tide Range (lower consolidation effect)

Eroded Mass vs. Percentages of Various Sediment Components



Only significant 1-component regression

Pellet abundance vs. time and tidal range



Pellet abundance increases with time and decreases with tide range

Summary

Two main factors affecting bed erodibility

- The convergence and divergence of sediment due to stratification
- The spring-neap effect on tidal velocity

Environmental factor analysis

- Erodibility was negatively correlated to lagged decreases in river discharge and therefore stratification
- Erodibility was positively correlated to previous changes in tidal range
  - Spring Tide ~ Increases erosion potential
  - Neap Tide ~ Decreases erosion potential
- The combination of the two factors leads to a correlation of .89

Sediment Bed Properties and Comparisons

- No classically expected bed parameters directly affect bed erodibility
- EXCEPT…the abundance of resilient fecal pellets

Resilient Fecal Pellets may be serving as a proxy for other parameters influencing the area

- Bed armoring
- Cohesion
- Winnowing of fines

Thank you!

- NSF (CoOp) Mudbed Project
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