MSiT Workshop 1

Note, slides do not reflect all activities, and select slides and images were removed.

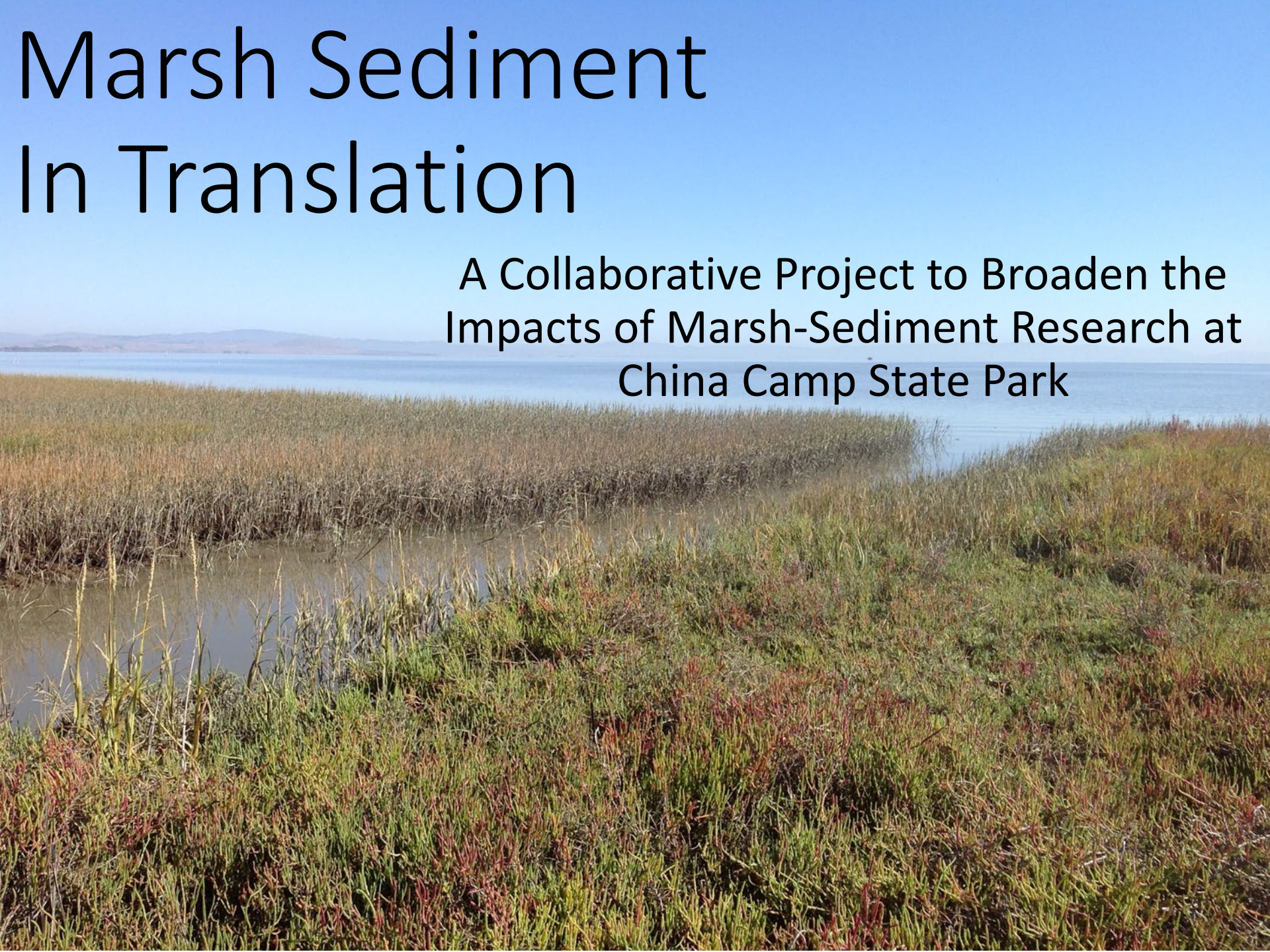
What marsh types or particular marshes come to mind when you think of sediment management for wetlands in the SF Bay Estuary?

https://pollev.com/johncallaway266

To respond to the poll, go to the website above and provide your input.

Marsh Sediment In Translation

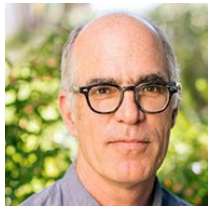
A Collaborative Project to Broaden the Impacts of Marsh-Sediment Research at China Camp State Park



Project Team

Maddie Foster-Martinez
Univ. of New Orleans

Jessie Lacy
USGS



John Callaway
Univ. of San Francisco

Aimee Good
SF Bay NERR

Brenda Goeden
BCDC

Matt Ferner
SF Bay NERR

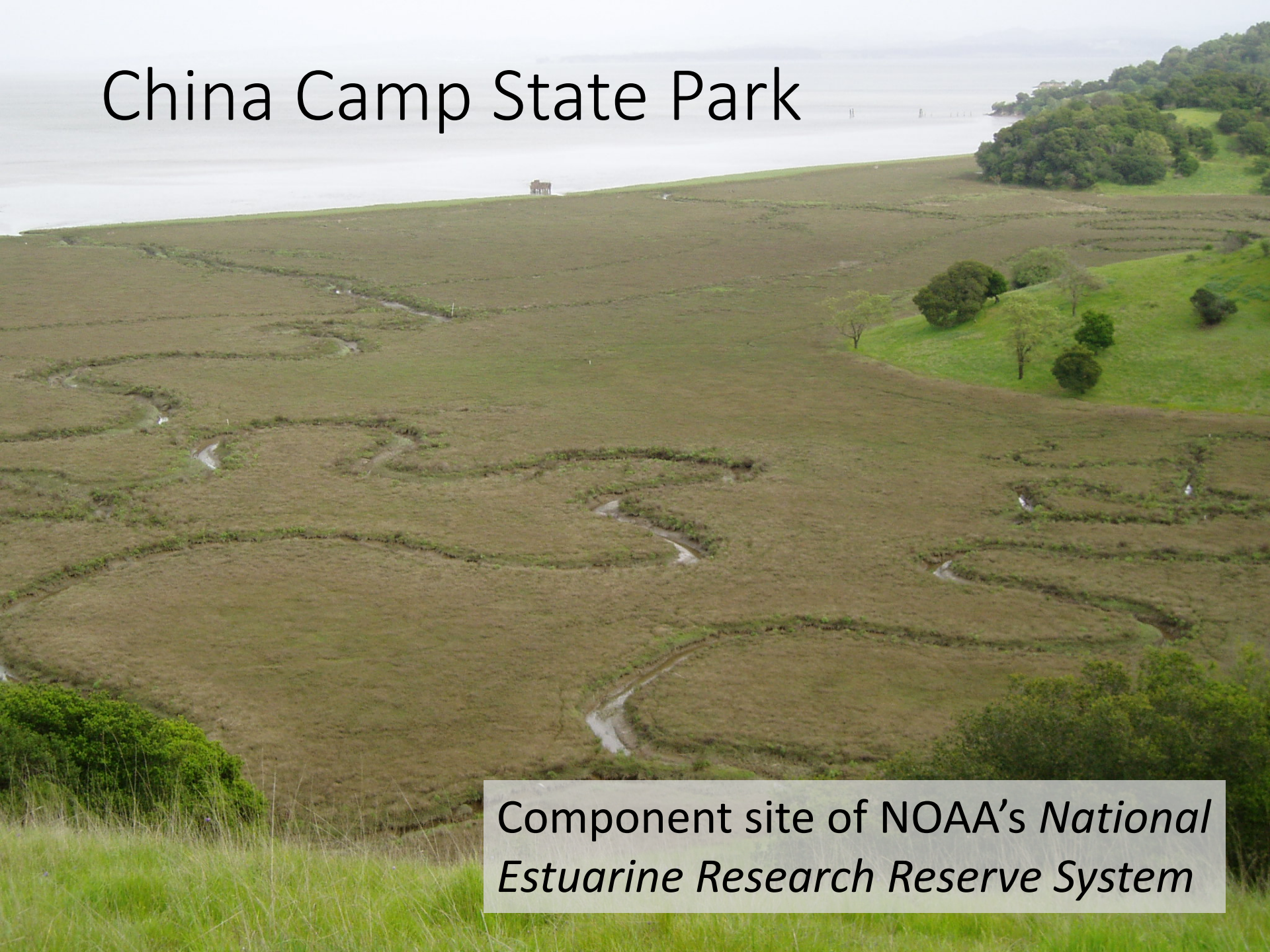
Notetakers

Julia Kelly	BCDC
Pascale Soumoy	BCDC
Samantha McGill	USGS
Catie Thow	SFSU

Regional Collaborators

Agnes Farres	RWQCB/BRRIT
Anniken Lydon	BCDC/BRRIT
Christina Toms	RWQCB
Dilip Trivedi	Moffatt & Nichol
Frances Malamud-Roam	USACE
Jennifer Siu	EPA
Jeremy Lowe	SFEI
John Krause	CDFW
Josh Collins	SFEI
Julie Beagle	USACE
Kristen Ward	NPS
Maureen Downing-Kunz	ESA
Max Busnardo	HT Harvey
Rachel Allen	USGS
Rosa Schneider	CADPR
Scott Dusterhoff	SFEI
Xavier Fernandez	RWQCB

China Camp State Park



Component site of NOAA's *National Estuarine Research Reserve System*

NOAA/NERRS Reference Sites for Restoration and Conservation

Place-based monitoring of marsh elevation, water levels, sediment accretion, plants, wildlife, & more

National Estuarine Research Reserve System Science Collaborative

Marsh-Sediment Research Collaboration

Marsh-Sediment Research Collaboration

The influence of neap–spring tidal variation and wave energy on sediment flux in salt marsh tidal creeks

Jessica R. Lacy,[1]* Matthew C. Ferner[2] and John C. Callaway[3]
[1] US Geological Survey, Pacific Coastal and Marine Science Center, Santa Cruz, CA 95060, USA
[2] San Francisco Bay National Estuarine Research Reserve, San Francisco State University, Tiburon, CA 94920, USA
[3] Department of Environmental Science, University of San Francisco, San Francisco, CA 94117, USA

Received 1 September 2017; Revised 4 April 2018; Accepted 11 April 2018

*Correspondence to: Jessica R.

ABSTRACT: Sediment
investigation of tempora
to northern San Francis
two tidal creeks during
were measured in the a

JGR Oceans

RESEARCH ARTICLE

10.1029/2018JC014825

Seasonal, Spring-Neap, and Tidal Variation in Cohesive Sediment Transport Parameters in Estuarine Shallows

Rachel M. Allen[1,2], Jessica R. Lacy[2], Mark T. Stacey[1], and Evan A. Variano[1]

[1]Civil ar
Coastal

Key Points:
- Field observations ground-truth parameters for sediment transport modeling
- The roughness parameter and bed erodibility fluctuate on seasonal time scales
- Floc size fluctuates on a tidal scale; flocs are larger and settle faster during slack water

Correspondence to:
R. M. Allen,
rachelallen@berkeley.edu

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Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng

Wave attenuation across a tidal marsh in San Francisco Bay

M.R. Foster-Martinez [a,*], J.R. I

[a] Civil and Environmental Engineering, University of
[b] U.S. Geological Survey Pacific Coastal and Marine
[c] San Francisco Bay National Estuarine Research Res

ARTICLE INFO

JGR Oceans

RESEARCH ARTICLE

10.1029/2019JC015268

Seasonal Variation in Sediment Delivery Across the Bay-Marsh Interface of an Estuarine Salt Marsh

Jessica R. Lacy[1], Madeline R. Foster-Martinez[2,3], Rachel M. Allen[1,2], Matthew C. Ferner[4], and John C. Callaway[5,6]

[1]Pacific Coastal and Marine Science Center, U.S. Geological Survey, Santa Cruz, CA, USA, [2]Department of Civil and Environmental Engineering, University of California, Berkeley, CA, USA, [3]Pontchartrain Institute for Environmental Sciences, University of New Orleans, New Orleans, LA, USA, [4]San Francisco Bay National Estuarine Research Reserve, Estuary and Ocean Science Center, San Francisco State University, Tiburon, CA, USA, [5]Department of Environmental Science, University of San Francisco, San Francisco, CA, USA, [6]Delta Science Program, Delta Stewardship Council, Sacramento, CA, USA

Key Points:
- We collected SSC time series and measured accretion along a transect spanning mudflats to marsh
- Deposition in the marsh increased with wave energy and was greater in summer than winter
- Accretion was about twice as great adjacent to the wave-exposed marsh edge as adjacent to a tidal creek

Correspondence to:
J. Lacy,
jlacy@usgs.gov

Abstract Sediment transport across bay-marsh interfaces depends on wave energy, vegetation, and marsh-edge morphology and varies over a range of timescales. We investigated these dynamics in a tidal

Marsh Sediment in Translation (MSiT)

Publishing in scientific journals is not the full extent of this research's usefulness

The influence of neap–spring tidal variation and wave energy on sediment flux in salt marsh tidal creeks

Jessica R. Lacy,[1]* Matthew C. Ferner[2] and John C. Callaway[3]
[1] US Geological Survey, Pacific Coastal and Marine Science Center, Santa Cruz, CA 95060, USA
[2] San Francisco Bay National Estuarine Research Reserve, San Francisco State University, Tiburon, CA 94920, USA
[3] Department of Environme

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JGR Oceans

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Correspondence to:
R. M. Allen,
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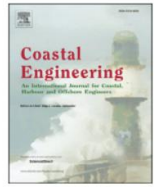

Wave attenuation across a tidal marsh in San Francisco Bay

M.R. Foster-Martinez [a,*], J.R. Lacy [b], M.C. Ferner [c], E.A. Variano [a]

[a] Civil and Environmental Engineering, University of Californ
[b] U.S. Geological Survey Pacific Coastal and Marine Science
[c] San Francisco Bay National Estuarine Research Reserve, S

ARTICLE INFO

Keywords:

JGR Oceans

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Seasonal Variation in Sediment Delivery Across the Bay-Marsh Interface of an Estuarine Salt Marsh

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Correspondence to:
J. Lacy,

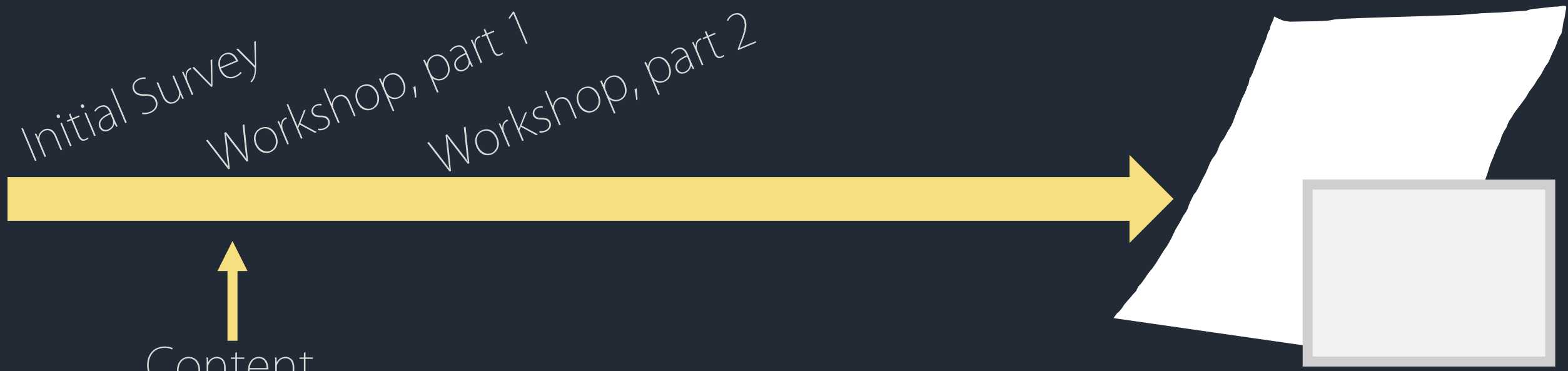
Communication Product

Goal of our NERR Science Collaborative project is a product that extracts and conveys sediment management and marsh restoration applications from the research results

???

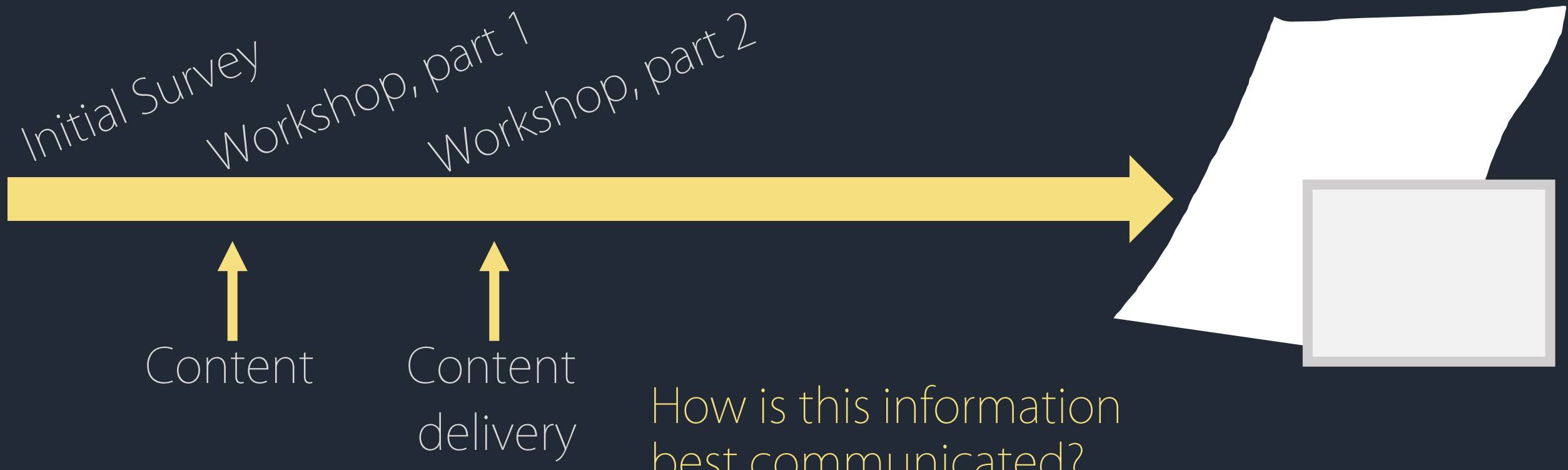
???

MSIT project timeline



Making connections between the research results and sediment management & marsh restoration

MSIT project timeline



MSIT project timeline

Today's Agenda, Workshop part #1

9:00 - 9:25	Welcome and project overview
9:25 – 10:20	Summary of China Camp marsh-sediment research
10:20 – 10:25	Break
10:25 – 10:35	Introduction to breakout rooms
10:35 – 11:25	Breakout room activity and discussion
11:25 – 11:50	Assign and explain homework for Day 2 of kickoff workshop

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Technical background marsh-sediment processes

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Gather input from everyone on the connections between the processes and management applications

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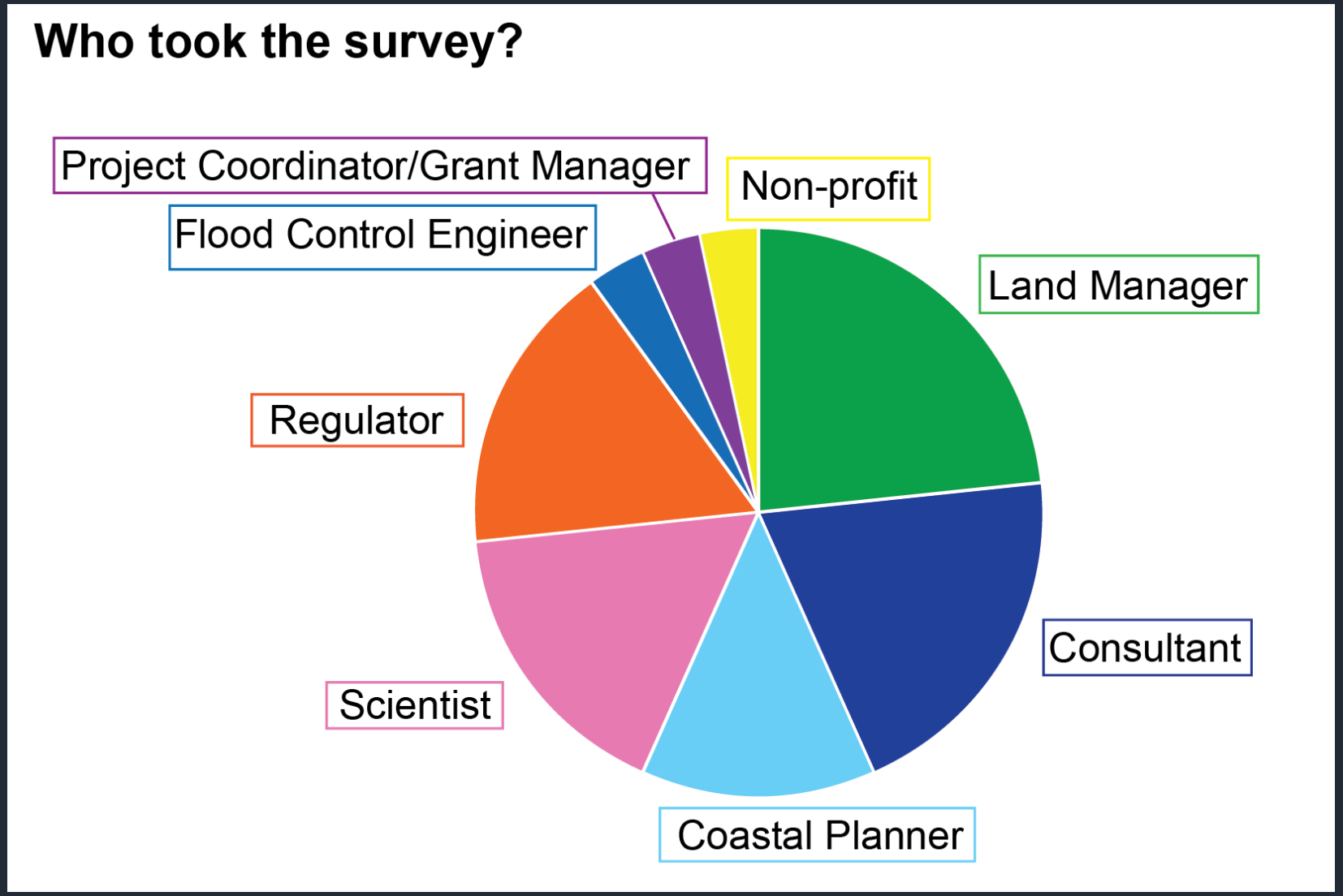
Gather input from everyone on the connections between the processes and management applications

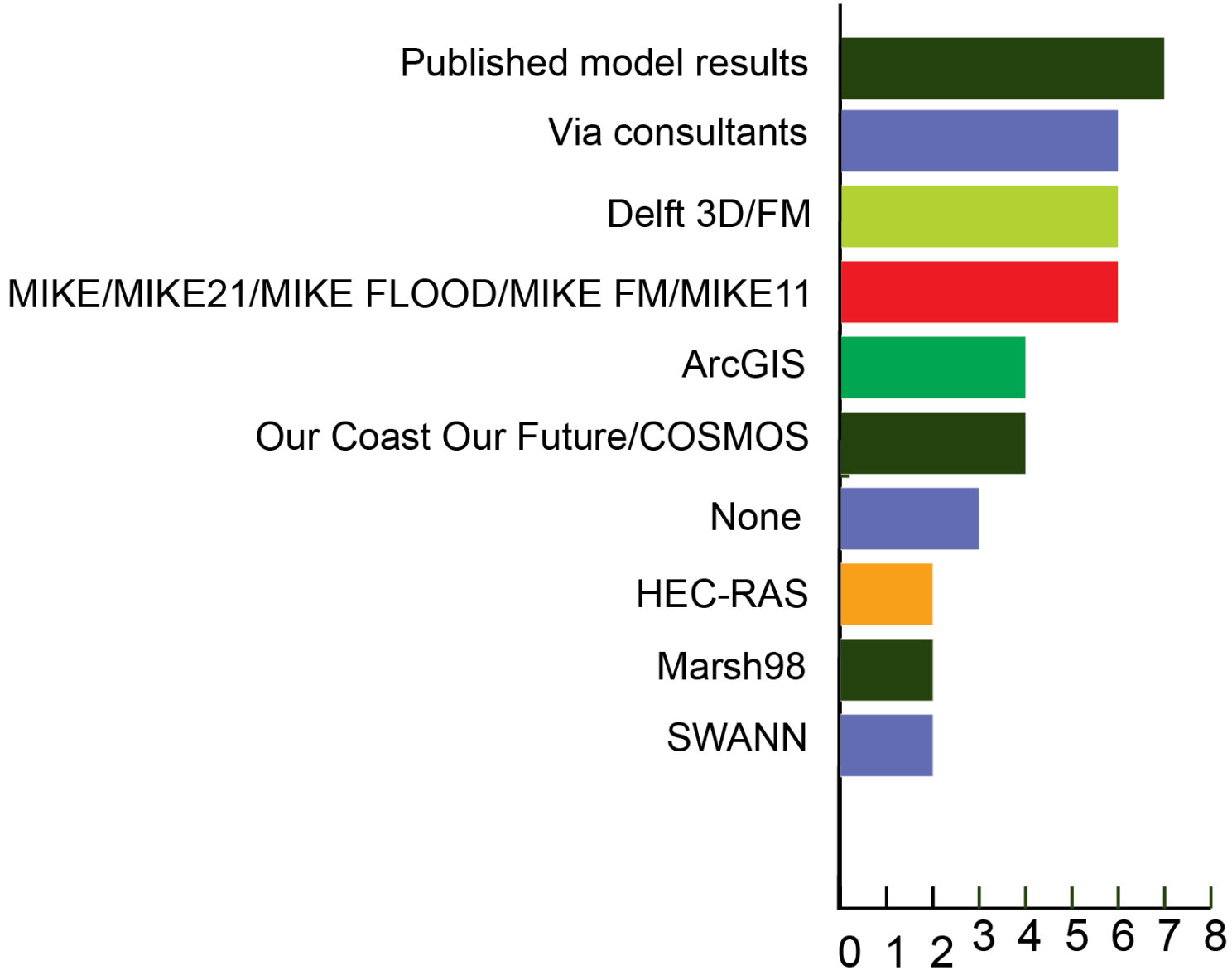
Who took the survey?

32 people



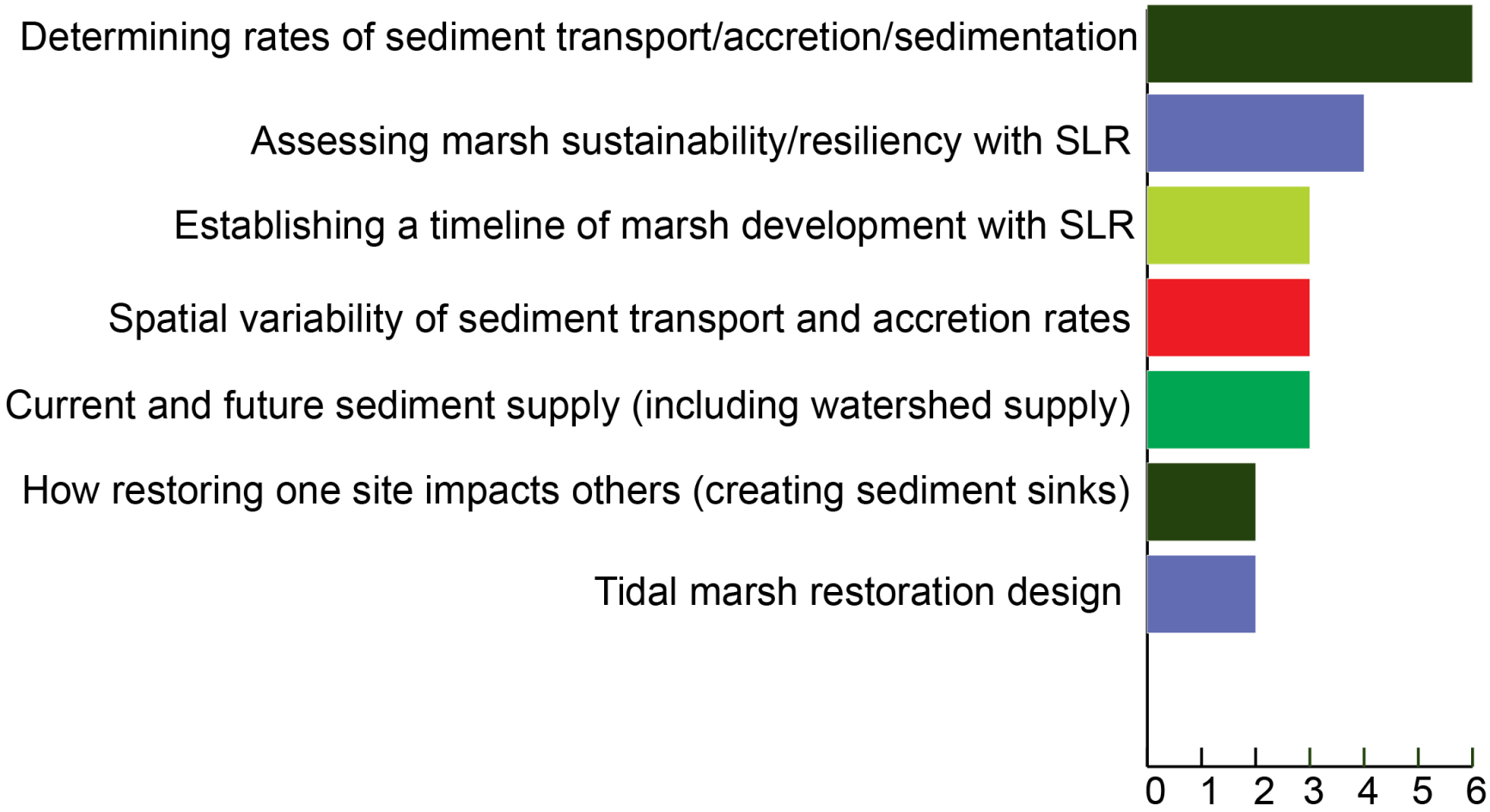
Tools in use

Do you use any software, modeling tools, or published model results to support your decision making?



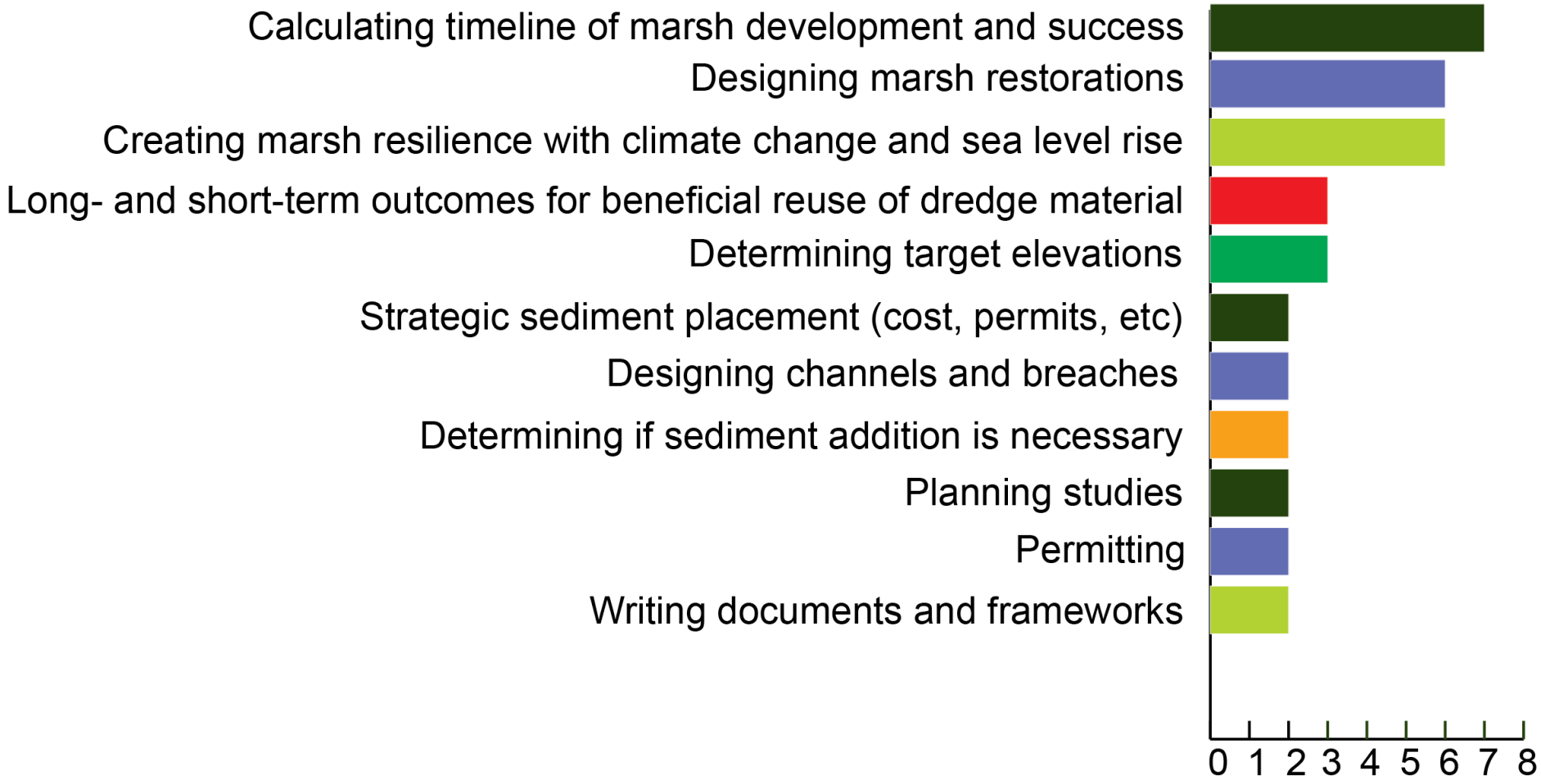
Information Needs

Provide 1 or 2 recent examples of decisions you faced where you lacked information on sediment transport in and to marshes.



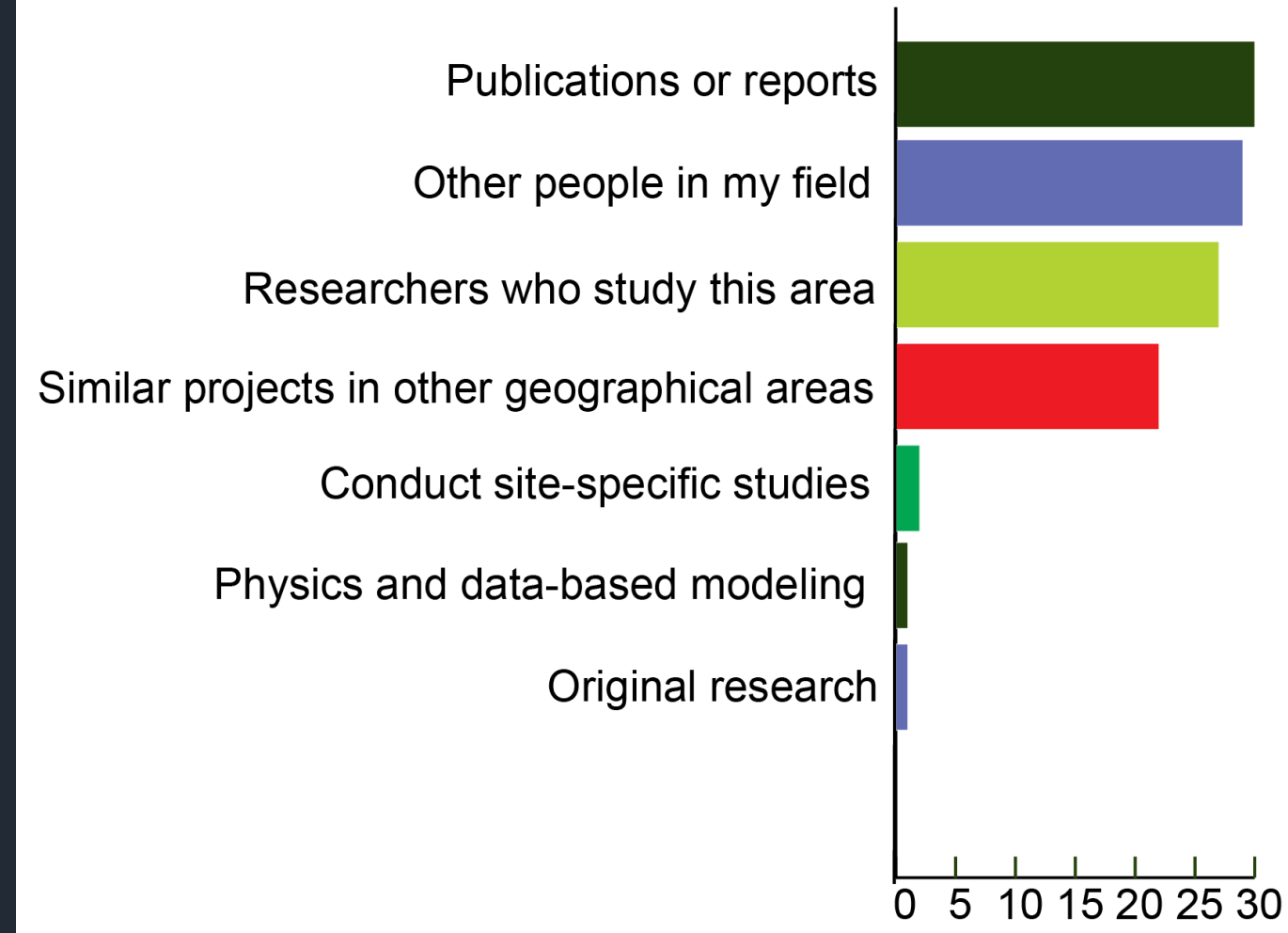
Context

How do you use information on sediment transport and marsh accretion in your work?



Information sources

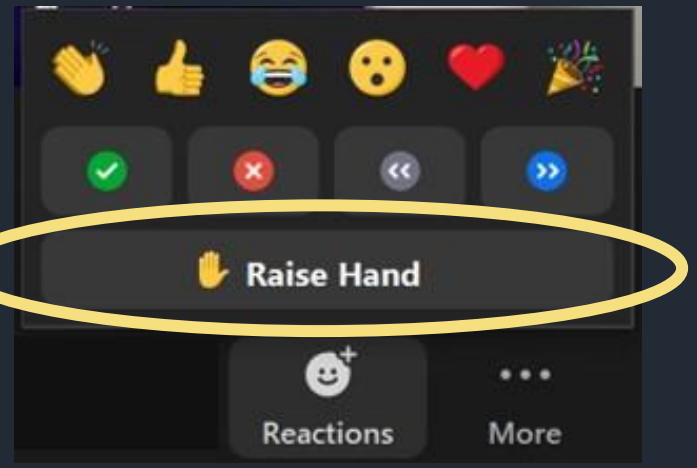
When faced with a decision where more information is needed, where do you turn for information?



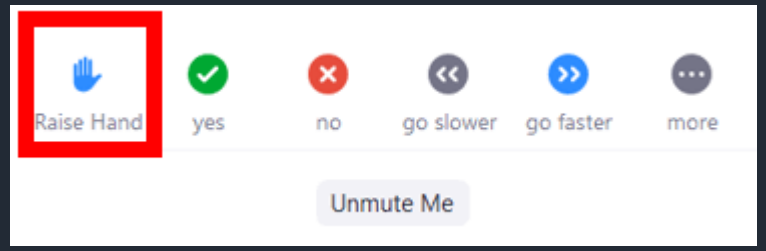
Zoom Guidelines

1) Please stay on mute when we're all together. In the breakout groups, unmuting yourself is encouraged.

2) Ask questions by typing them into the chat and/or using the raise hand button. Questions will be addressed at the end of the presentations.



3) Let's avoid the chat becoming a separate conversation.



Sediment sources for China Camp marsh: shallows and tidal creeks

Jessie Lacy *USGS PCMSC*

MSIT Workshop April 19, 2021

Collaborative study: USGS, SF Bay NERR , USF, and UCB

Matt Ferner, John Callaway, Maddie Foster-Martinez and Rachel Allen

Tim Elfers, Joanne Ferreira, Cordell Johnson, Pete Dal Ferro, Jenny White, Rob Wyland, Peter Harkins, Anna Deck, Josh Logan, Emily Carlson, Christie Hegermiller

Thanks to China Camp State Park

Background

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

Deposition of sediment from adjacent waters can counter drowning and help marshes maintain elevation as sea level rises.

China Camp marsh during King tides

Questions:

How does sediment supply to the marsh vary with wave conditions, seasons?

How much are waves attenuated at the marsh edge?

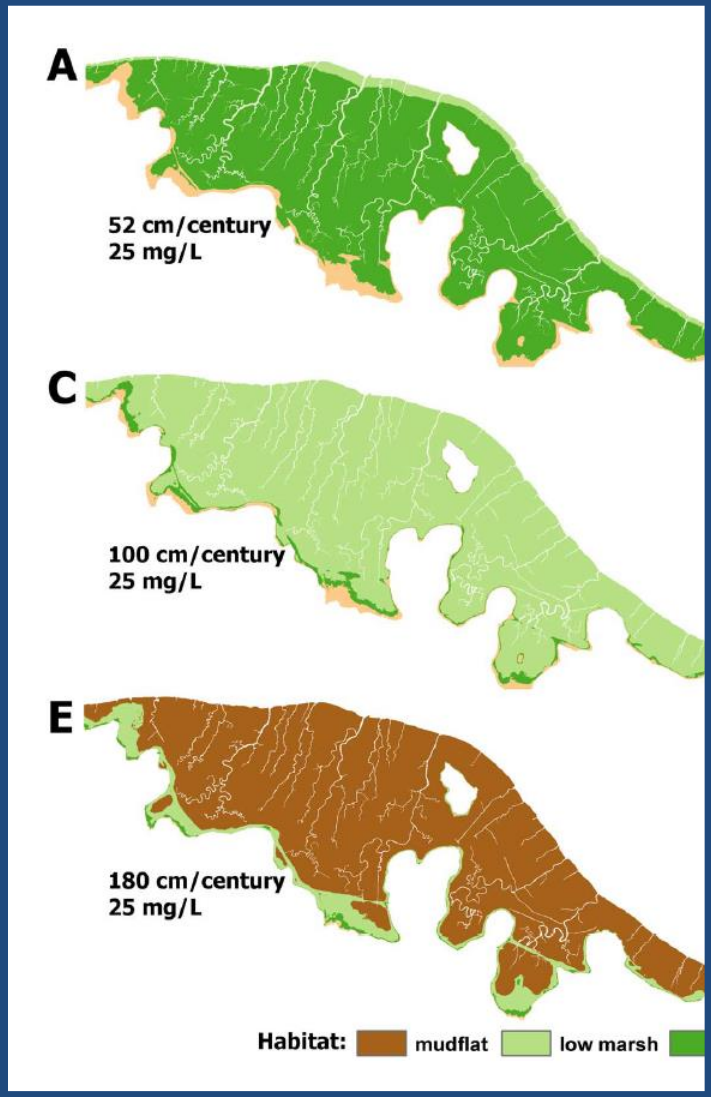
Elevation-based models of marsh evolution

Indicate that many SF Bay marshes may be drowned by sea-level rise in the next century

Results depend strongly on
- rate of SLR
- magnitude of sediment supply

Do not account for edge erosion or export

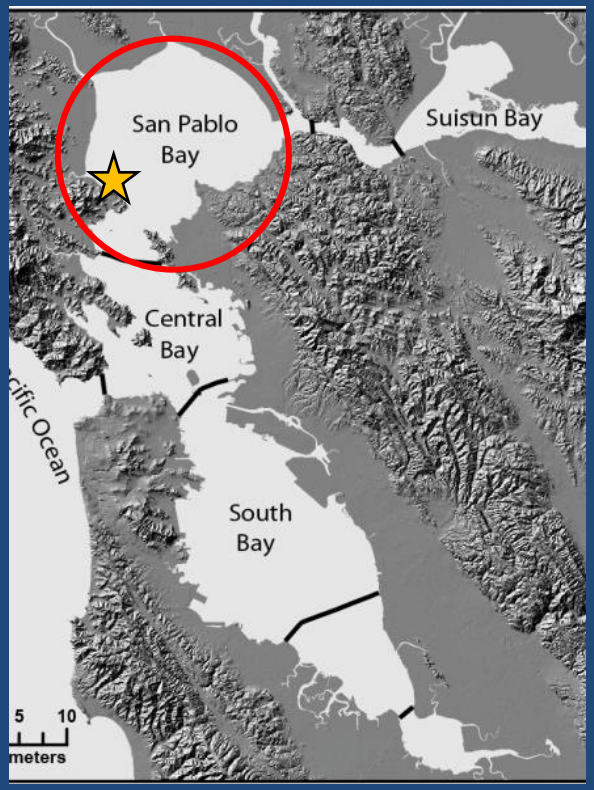
Do not account for temporal variation in sediment delivery



China Camp predictions, MEM
Schile et al. (2014)

Focus on wave-exposed marsh edge

- provides coastal protection by attenuating waves
- strong potential for both erosion and sediment delivery
- less studied than tidal creeks as a pathway for sediment delivery
- strong connection to conditions in adjacent shallows (marsh-mudflat system)



China Camp location

China Camp marsh is keeping up with recent rate of sea-level rise:
Long-term accretion rate
> 3 mm/yr
(*Callaway et al., 2012*)

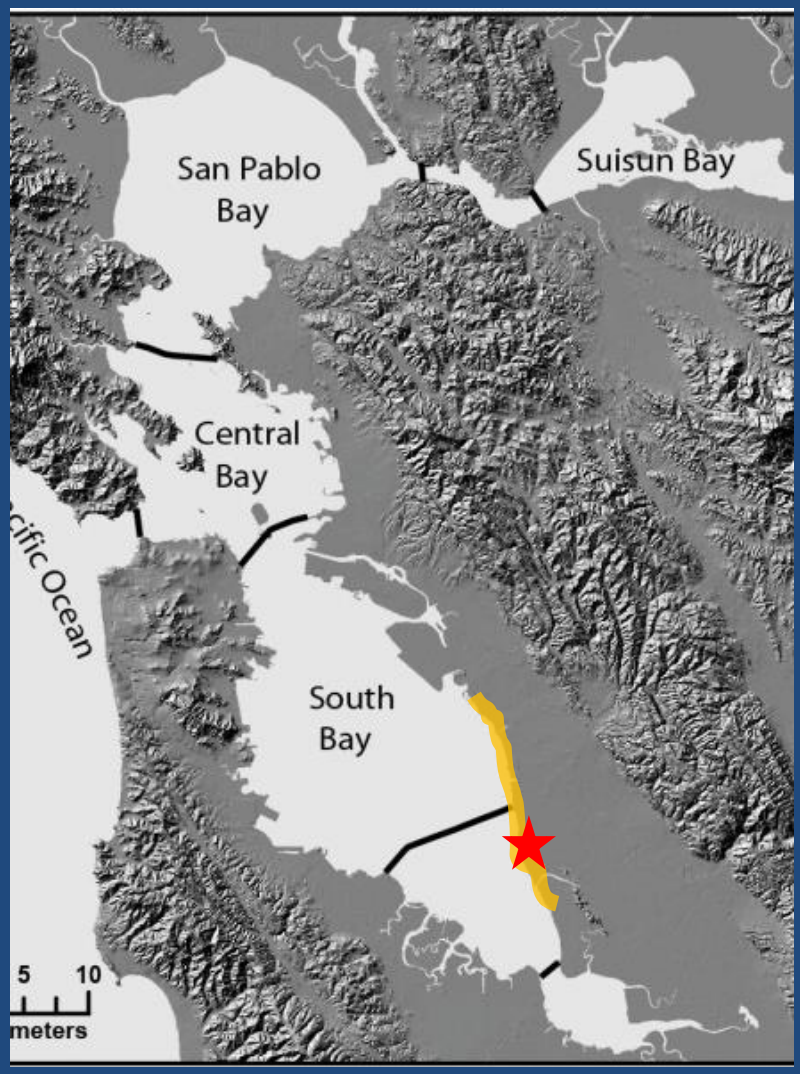
In context of Bay marshes:

- marsh edge is ramped (gently sloped)
- fronted by extensive mudflats
- local watershed input relatively minor

Upcoming study in South San Francisco Bay
(Lacy and Thorne, USGS and RMP)

Whale's Tail marsh:

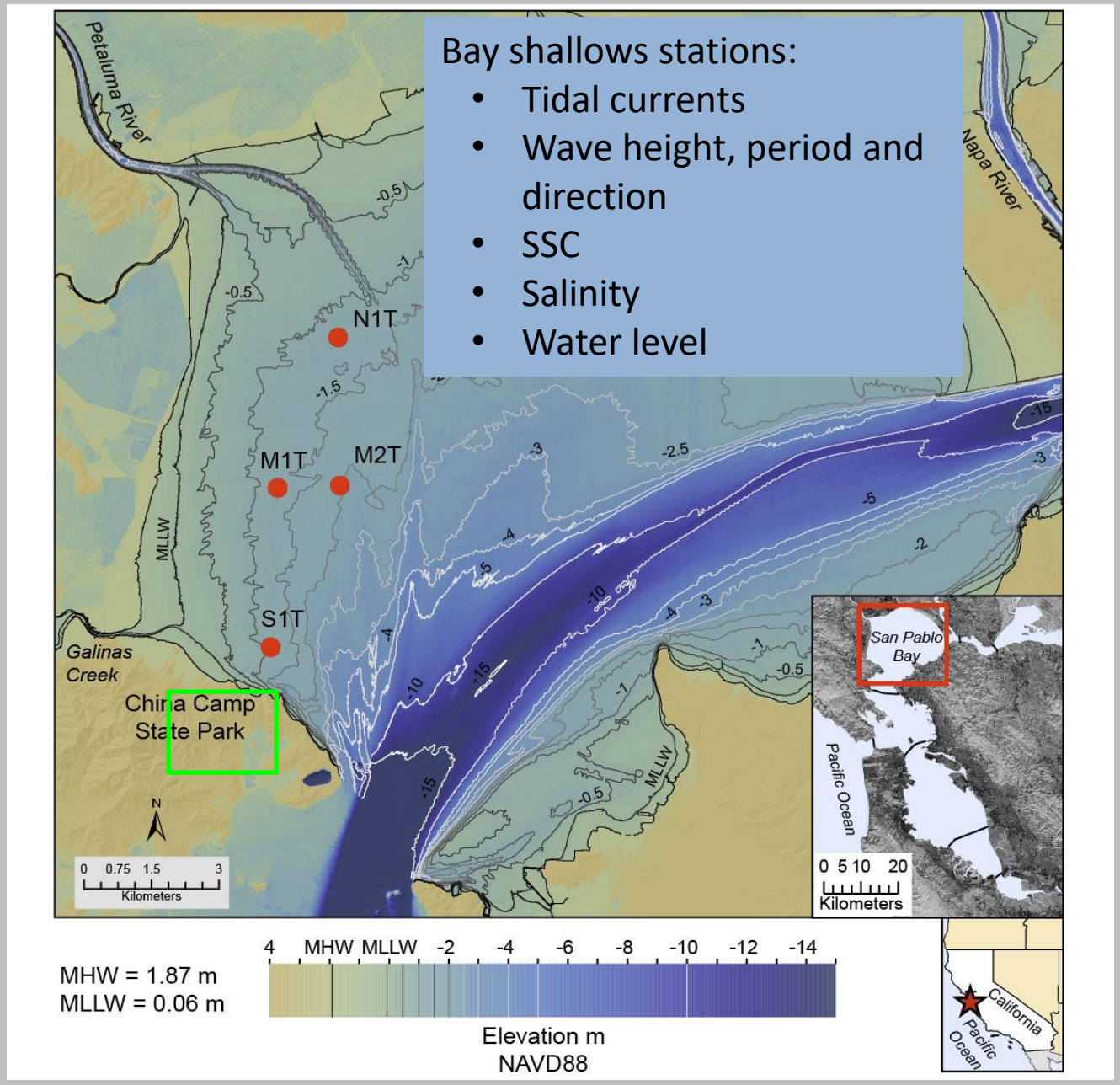
- Large wave fetch
- steep scarp/erosional edge
- Bigger tide range than San Pablo Bay
- ongoing marsh restoration
- data collection: sediment supply from shallows, accretion on marsh, and shoreline retreat
- summer 2021, winter 21/22



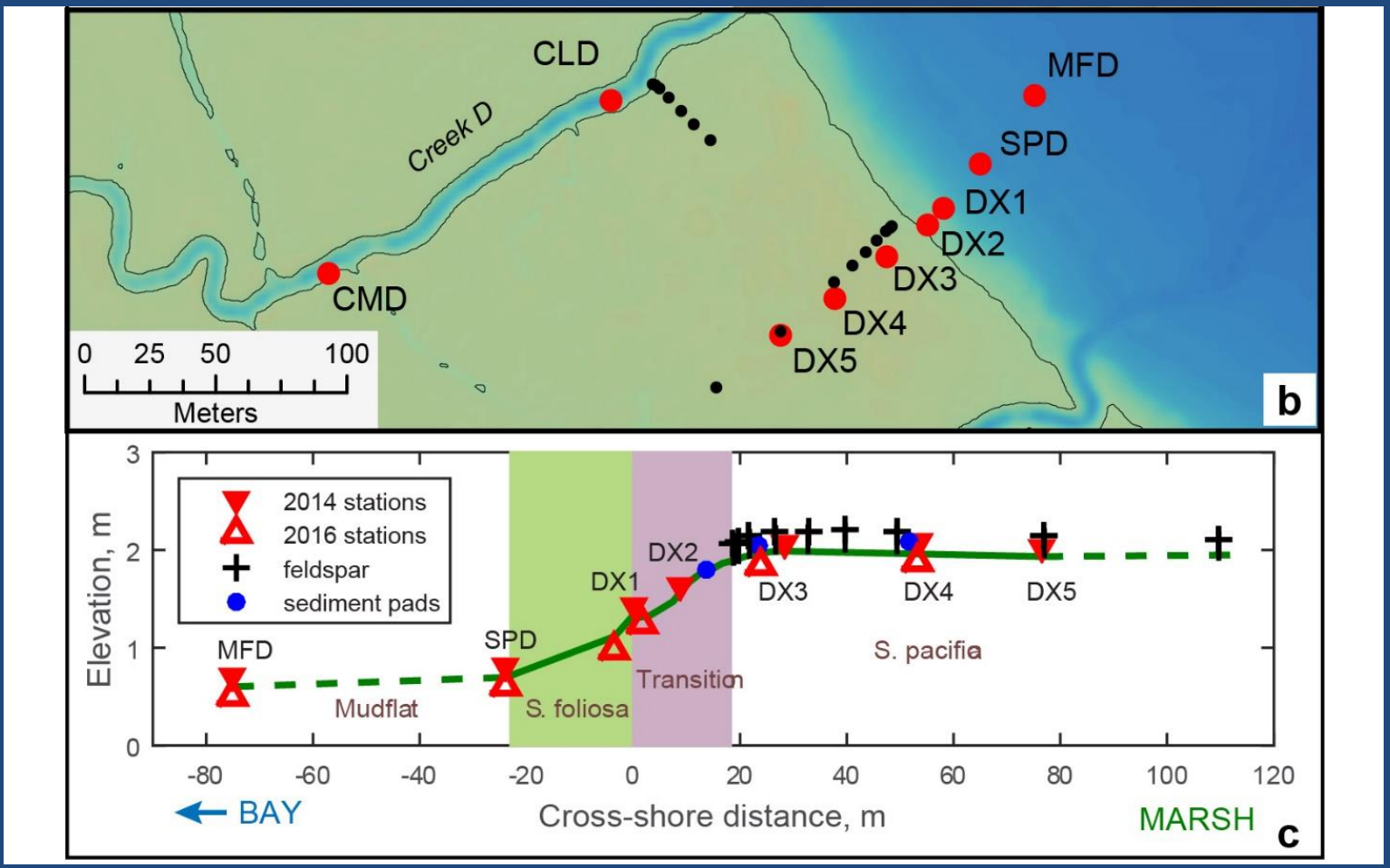
Sediments on tidal flats and marsh are mud: D_{50} ~ 10 microns

Marsh elevation mostly close to MHHW, significant inundation only during spring tides

3 study periods: Winter 2013/14 and 2014/2015, Summer 2016, spanning biggest tides of the year



Allen, R. M., Lacy, J. R., Stacey, M. T., & Variano, E. A. (2019). Seasonal, Spring-Neap, and Tidal Variation in Cohesive Sediment Transport Parameters in Estuarine Shallows. Journal of Geophysical Research: Oceans, 124(11), 7265–7284. https://doi.org/10.1029/2018JC014825



Lacy et al. 2020

Measured SSC and wave energy adjacent to marsh and at 5 locations within the marsh, in winter (W14) and summer (S16).

Measured accretion within the marsh over 4 years at 8 locations.

Lacy, J. R., Foster-Martinez, M. R., Allen, R. M., Ferner, M. C., & Callaway, J. C. (2020). Seasonal Variation in Sediment Delivery Across the Bay-Marsh Interface of an Estuarine Salt Marsh. Journal of Geophysical Research: Oceans, 125(1). https://doi.org/10.1029/2019JC015268

SSC in bay shallows

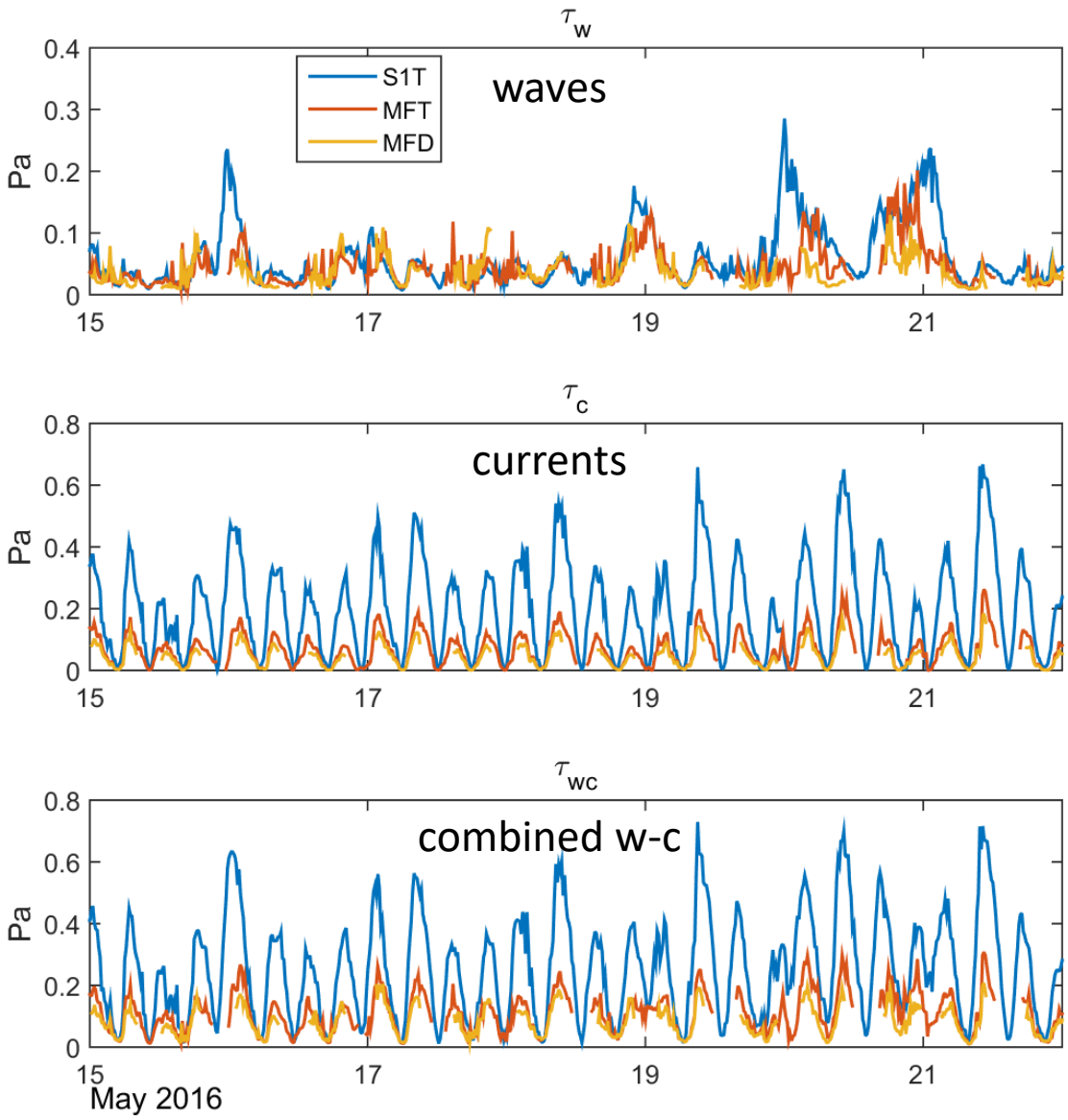
Bed shear stress: summer 2016

Waves more important closer to shore

S1T: -1 m MLLW

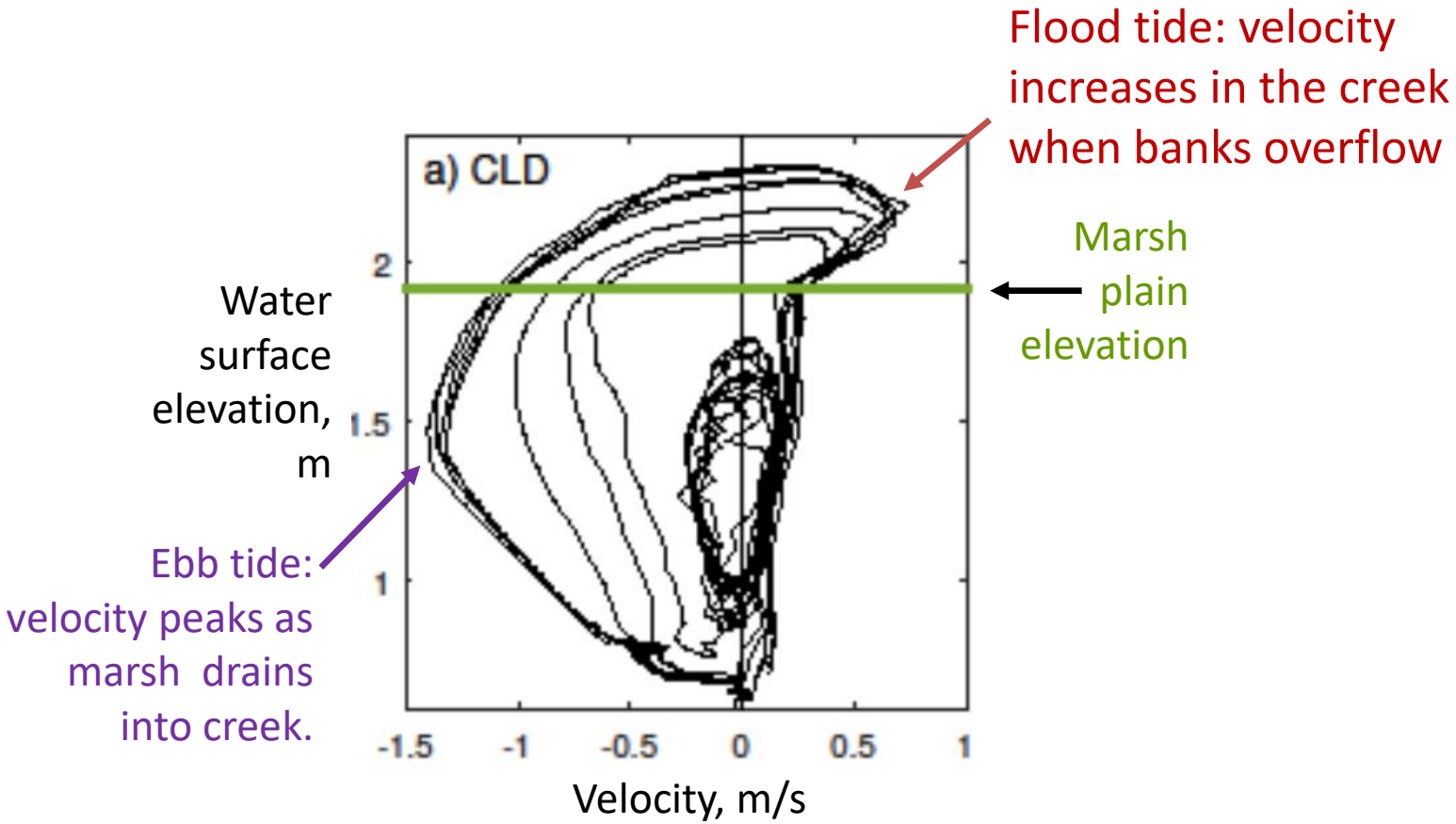
MFT: 0 m MLLW

MFD: 0.6 m MLLW



Lacy, J. R., Allen, R. M., Foster-Martinez, M. R., Ferreira, J. C., & O'Neill, A. C. (2017). Hydrodynamic and sediment transport data from San Pablo Bay and China Camp marsh (northern San Francisco Bay), 2013-2016. U.S. Geological Survey Data Release. https://doi.org/10.5066/F7HM56MX

Velocity in tidal creek: tidal variation



Marsh vegetation slows draining of marsh, producing greater water surface gradient and stronger currents in the creek during ebb tides

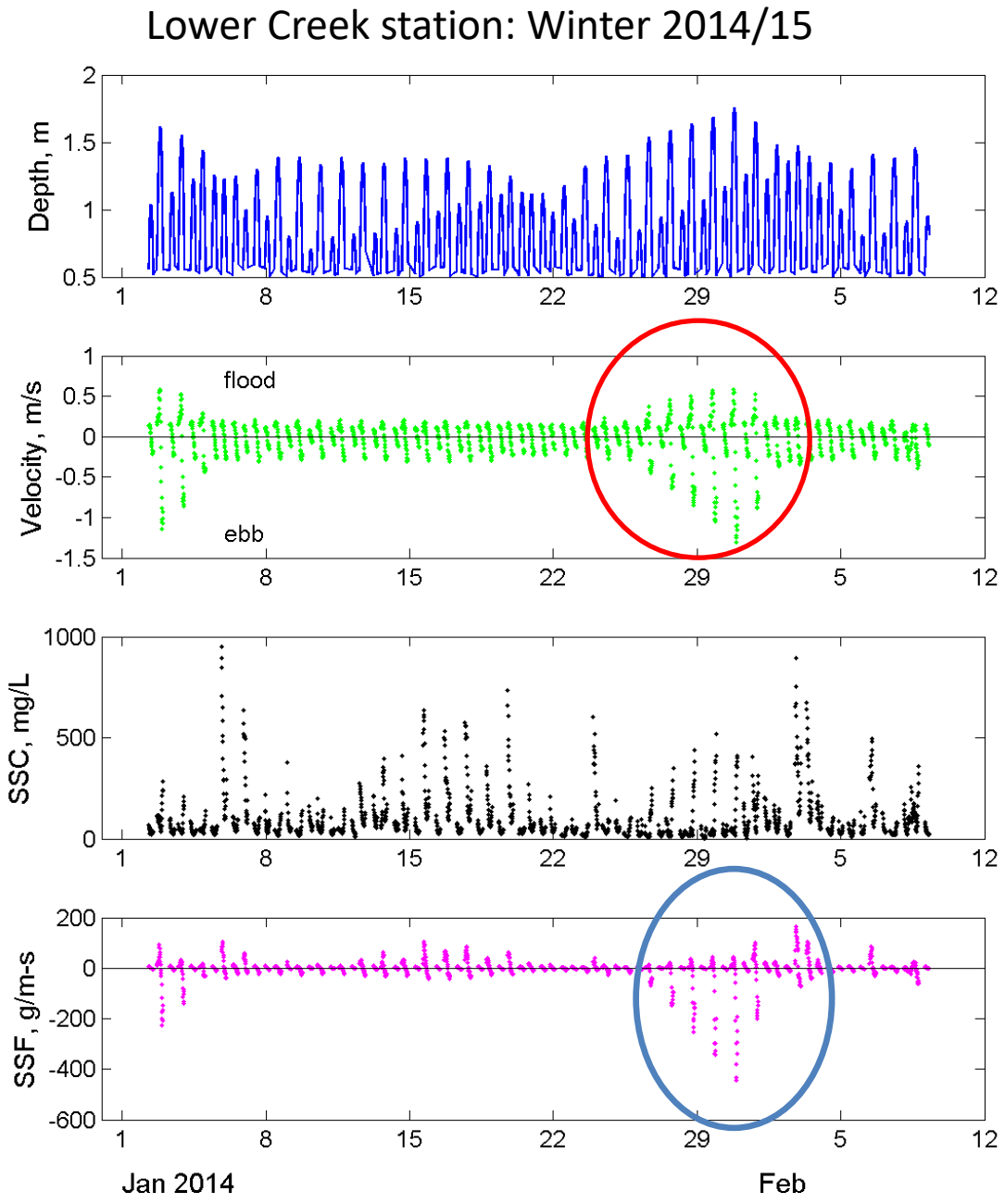
Lacy, J. R., Ferner, M. C., & Callaway, J. C. (2018). The influence of neap-spring tidal variation and wave energy on sediment flux in salt marsh tidal creeks: Marsh Tidal Creek Sediment Flux. Earth Surface Processes and Landforms, 43(11), 2384–2396. https://doi.org/10.1002/esp.4401

Sediment flux

Very high velocities on ebb
King tides produce large negative SSF

SSF = *uhc*

u: velocity
h: depth
c: SSC

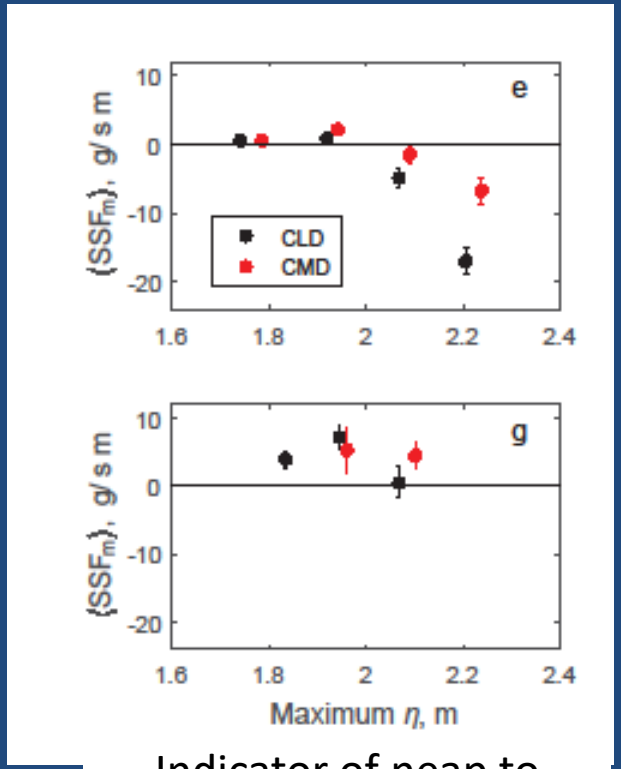


Lacy et al. 2017

Data from 3 deployments (2 winter, 1 summer) showed 30 to 40 tons of export per tidal creek during large spring tides

Measured export likely represents creek scour more than marsh plain erosion

- Sediment exported from marsh tidal creeks during spring tides
- Export greatest close to creek mouth
- Import when conditions are wavy in adjacent shallows



Calm

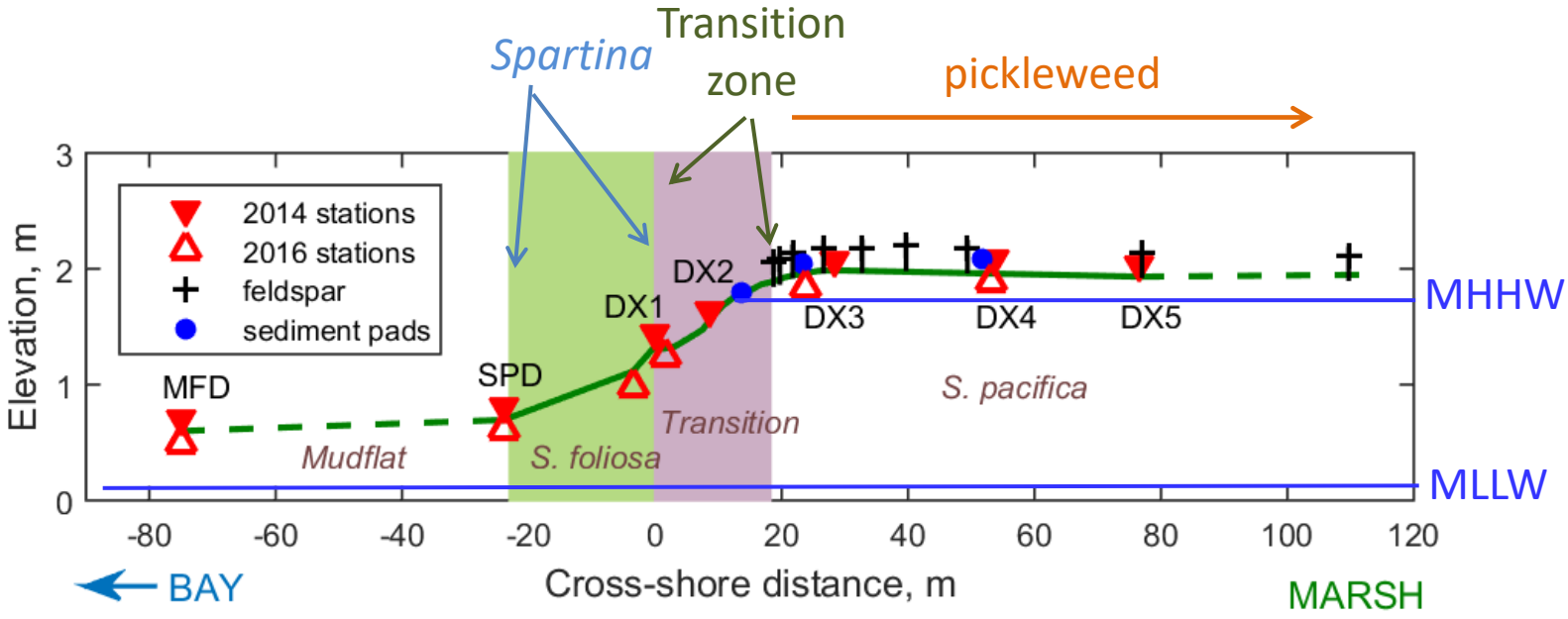
Wavy

Indicator of neap to spring

Lacy et al. 2018

- Spring tides are important for marsh deposition (because of extended inundation), yet sediment is exported
- How well does SSF in tidal creeks represent delivery to marsh?

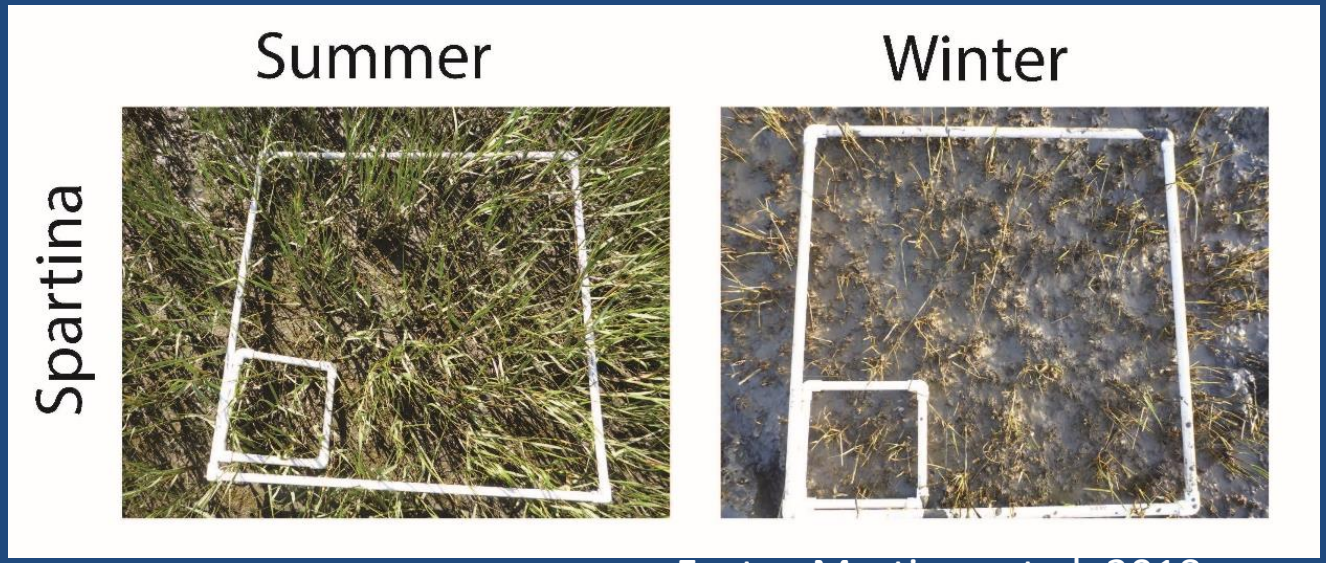
Marsh edge at China Camp



Lacy et al. 2020

Seasonal vegetation surveys

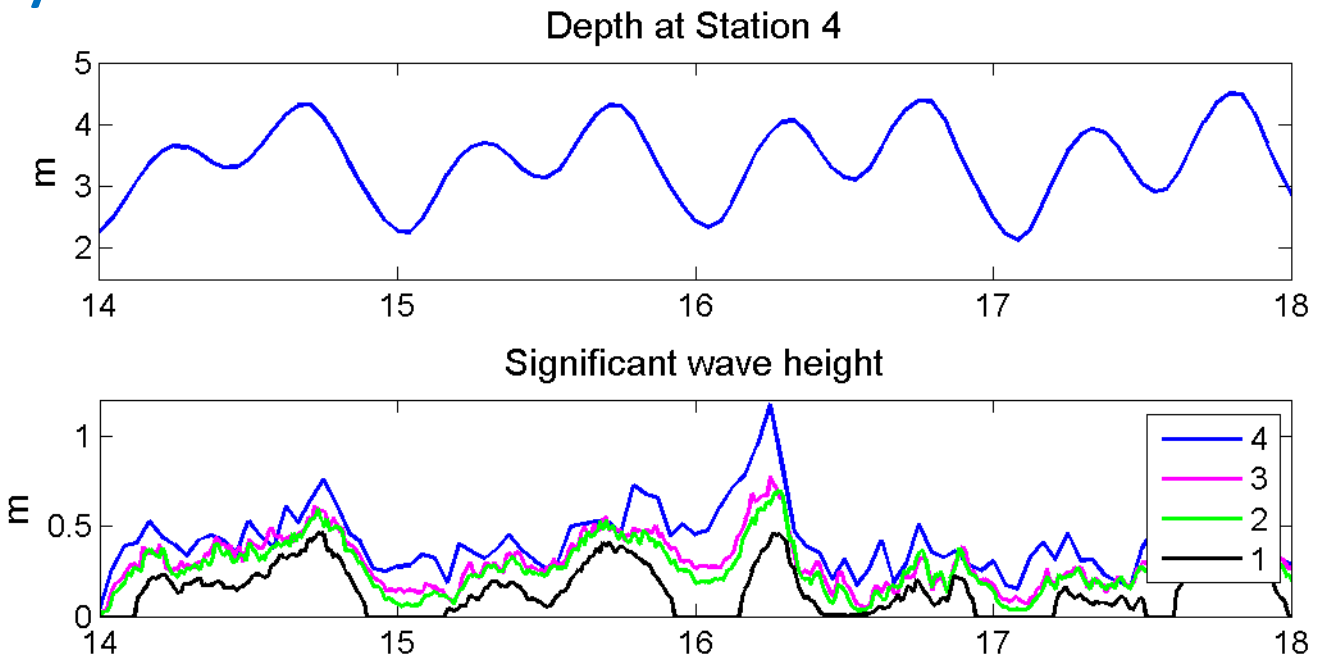
Spartina is taller and more dense in summer than winter.



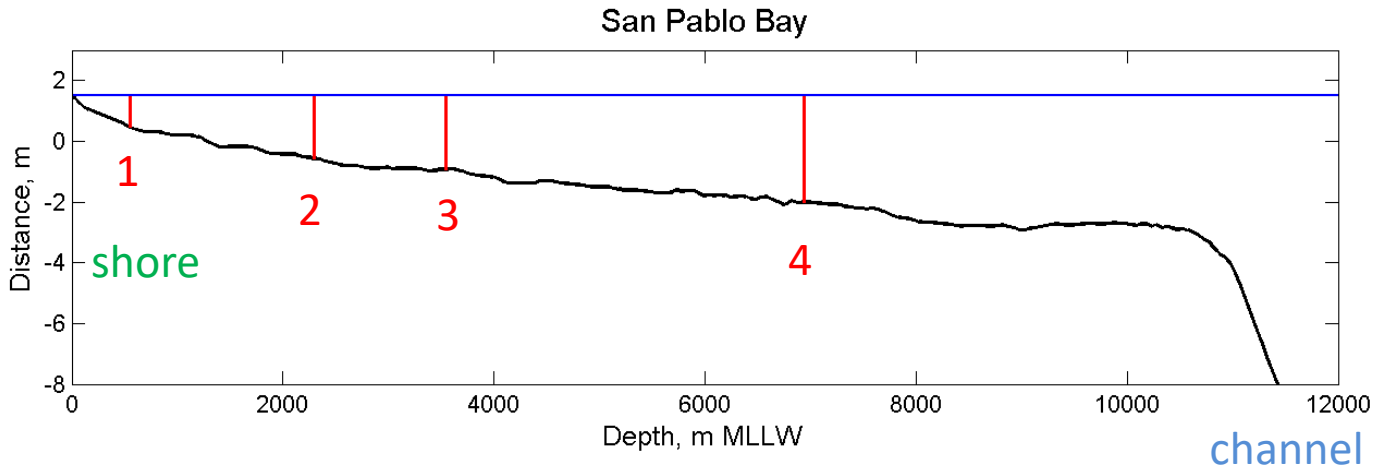
Foster-Martinez et al. 2018

San Pablo Bay

Wave height attenuation up to 50% across 6 km of mudflats



February 2011



Lacy and MacVean 2016

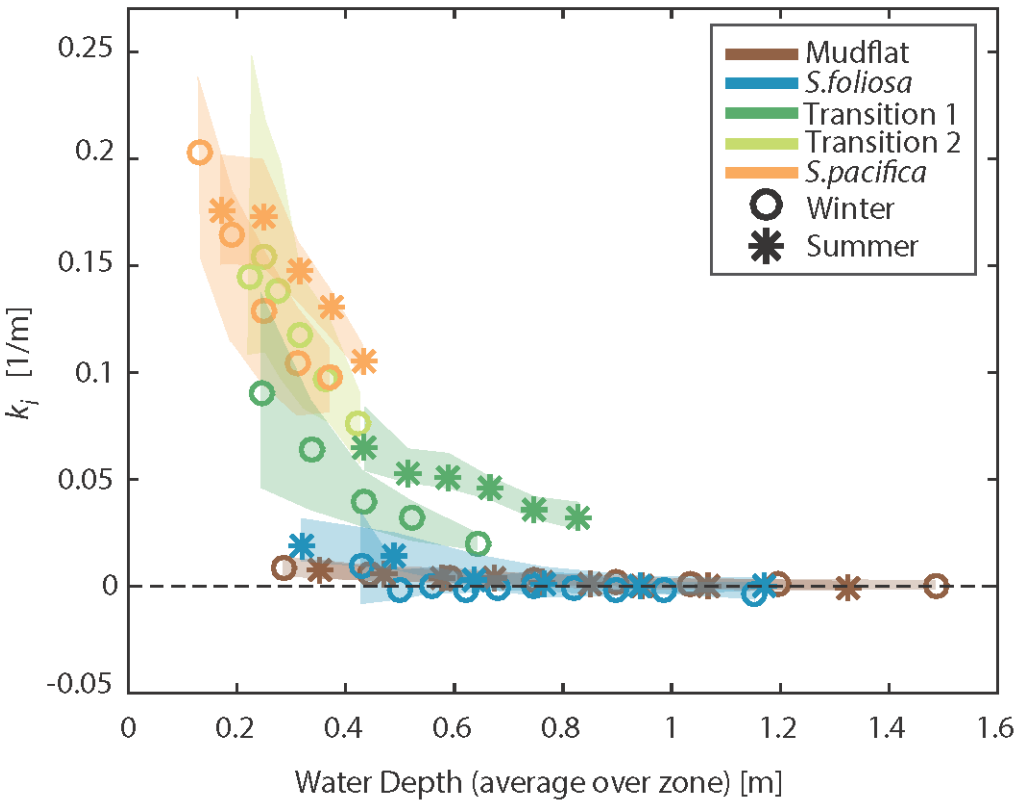
Wave attenuation in marsh

Assume exponential decay:

$$H = H_0 e^{-kx}$$

- Attenuation varied between vegetation types
- Attenuation was less in winter: vegetation less dense and shorter
- Includes shoaling effects
- 90% reduction of wave height within 50 m of edge of vegetation

Wave height exponential decay constant (*k*) binned by water depth



Foster-Martinez, M.R., J.R. Lacy, M.C. Ferner, and E.A. Variano, 2018. Wave attenuation across a tidal marsh in San Francisco Bay. *Coastal Engineering* **136**, 26-40.

How much does the seasonal variation in attenuation affect waves in the marsh?

- In both seasons, waves are attenuated by more than 90% within 50 m of the bayward edge of the *Spartina* (~10 m into pickleweed)
- Wave exposure in the transition zone is greater in winter than summer

Effect of sea-level rise?

- Currently, wave height is significantly reduced (~50%) as waves cross the mudflats adjacent to marshes, due to bottom friction. SLR will reduce this effect, so that larger waves reach the marsh.
- Wave attenuation in the marsh decreases with increasing water depth. Marshes will be less effective in attenuating waves as sea level rises.

Summary: sediment sources and wave attenuation

- SSC in the shallows increases towards the marsh edge, and is lowest at high tide
- SSC in shallows and tidal creeks increases with wave energy
- We observed significant export form tidal creeks during King and large spring tides
- Marsh vegetation attenuates waves within 50 m in both winter and summer, shorter distance in summer.

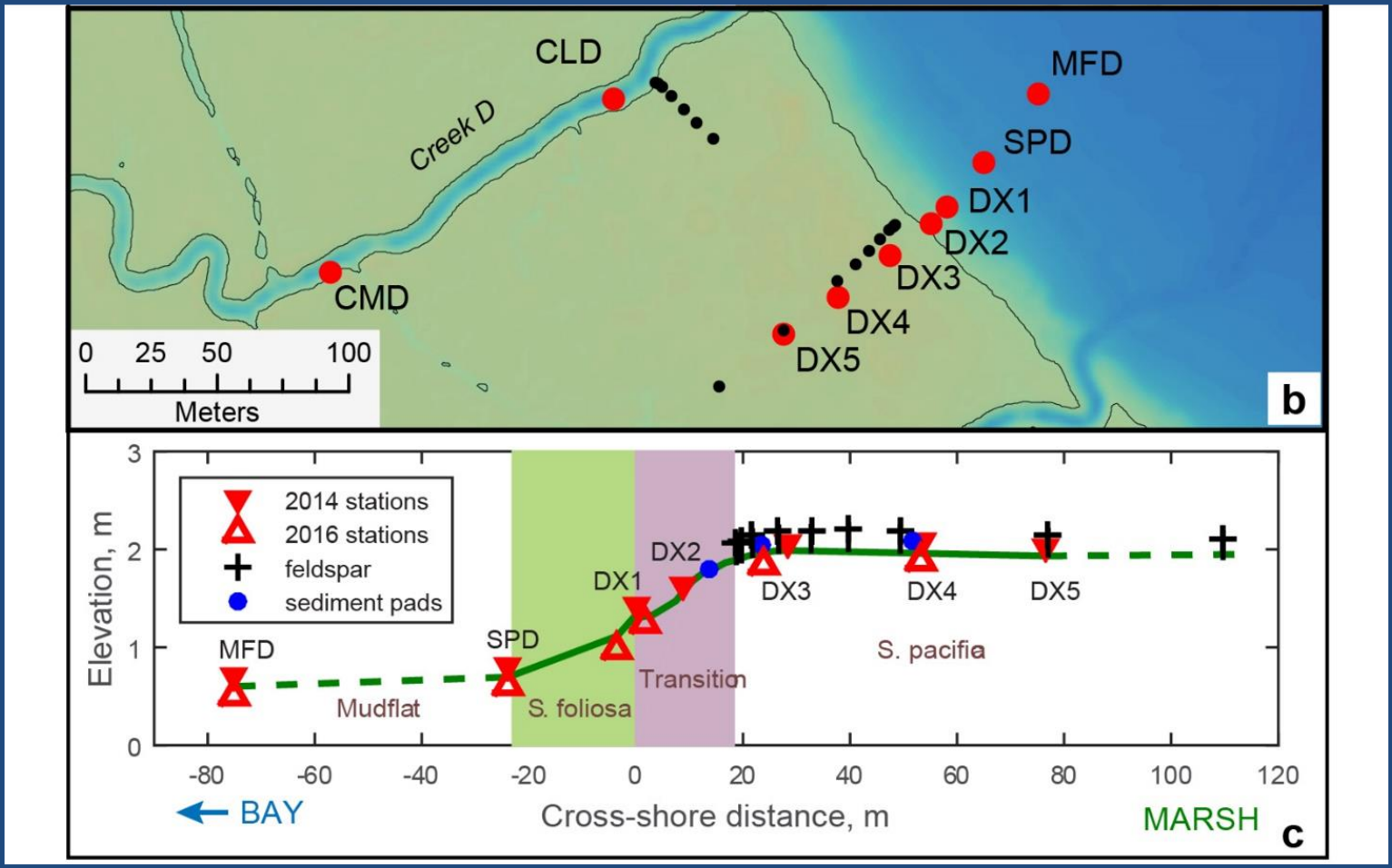
Next up: SSC and deposition on the marsh

What happens as suspended sediment moves across the marsh?

John Callaway *University of San Francisco*

MSIT Workshop April 2021

Evaluating delivery across marsh edge vs. tidal creeks



Lacy et al. 2020

Measured accretion within the marsh with transects at:

- Bay edge
- Multiple creek locations

Accretion measurements: Methods

Feldspar plots
Established 2014 & measured 2015, 2017, 2018

Long-term plots established 2008

Sediment pads
Deployed for 5 tidal cycles during spring tides in June 2016

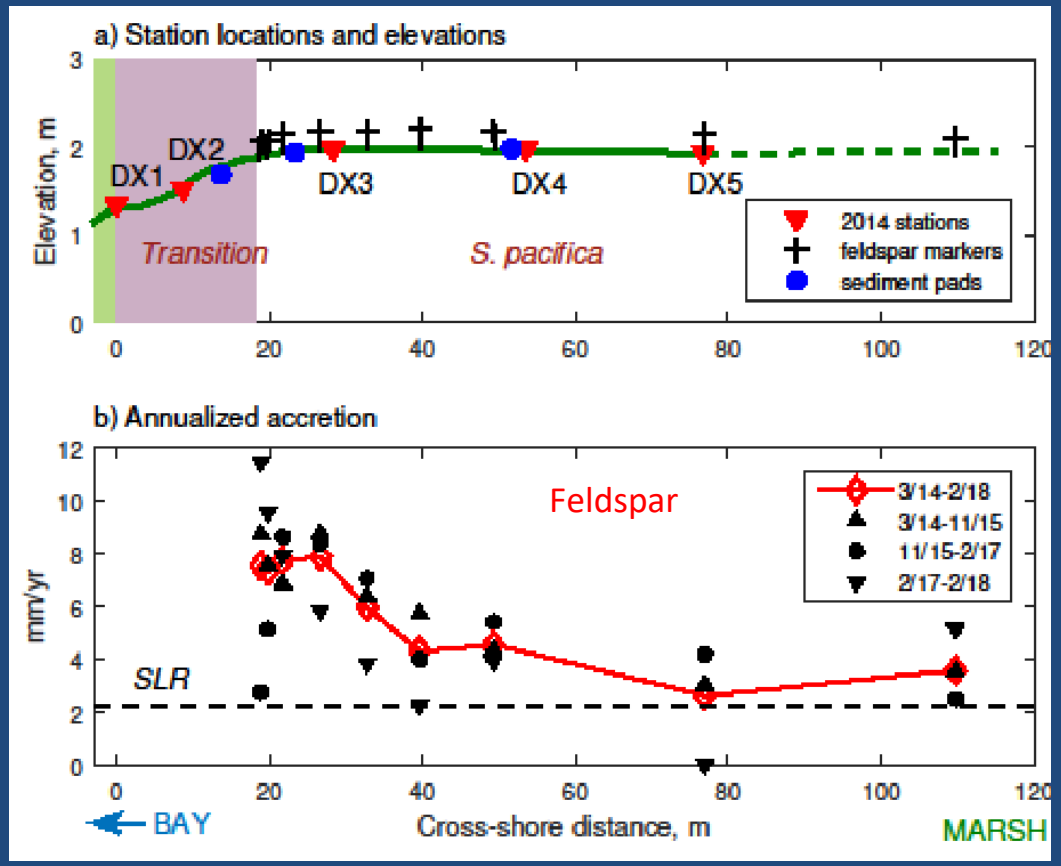
Sediment cores
Collected in 2010 and measured with ^{137}Cs and ^{210}Pb

Accretion results

Accretion up to 9 mm/yr in the upper transition zone!

Highly variable between years in the transition zone and the bayward edge of the *Salicornia*.

Accretion rates are greater adjacent to the Bay margin than adjacent to tidal creeks.

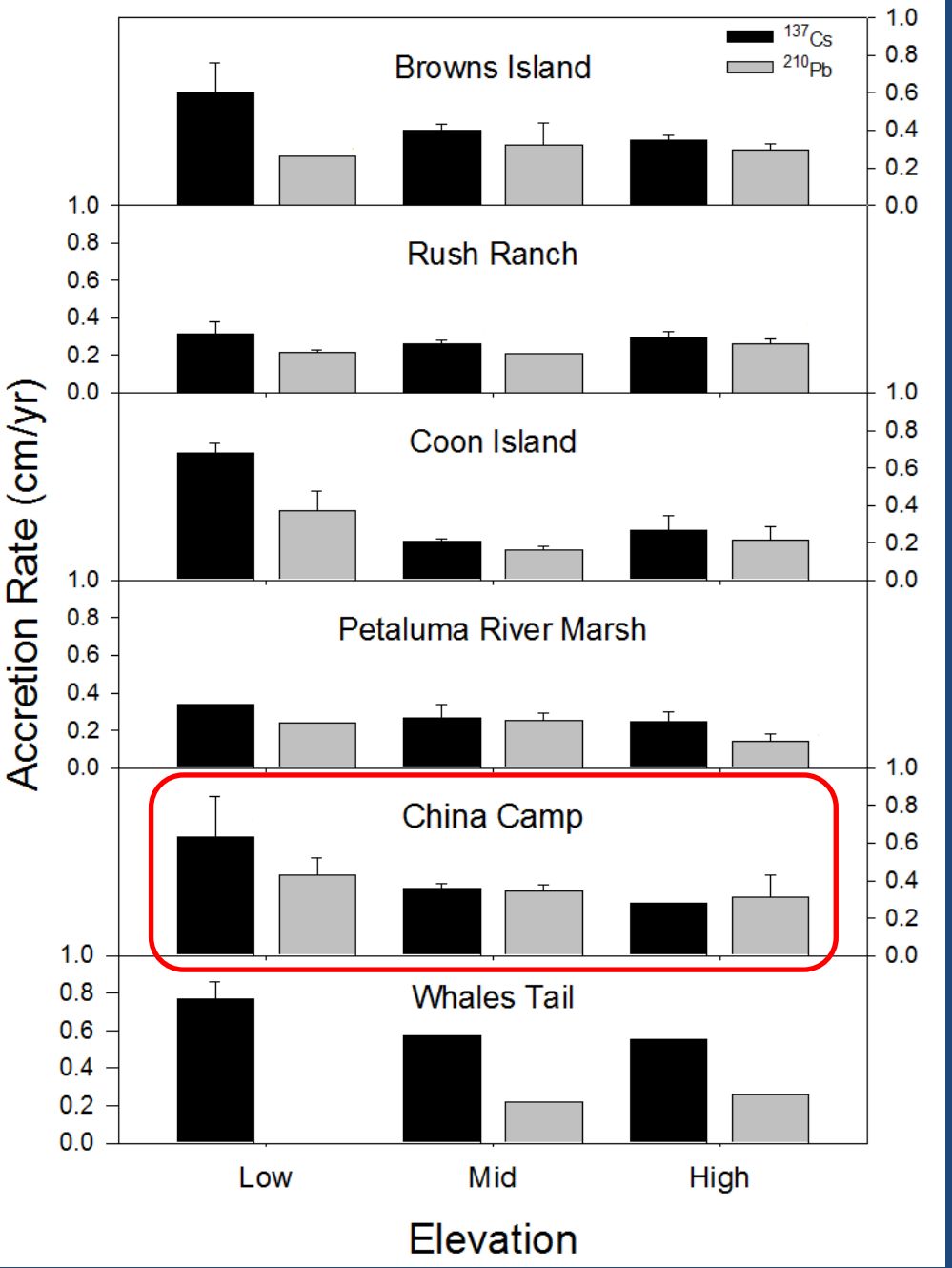


Lacy et al. 2020

How important is supply across the marsh edge to the marsh sediment budget?

~24 tons/yr of sediment delivery across 200 m of shoreline (distance between tidal creeks) within 60 m of the marsh edge.

~10 tons/month of import via tidal creeks during moderate tides and 30 to 40 tons of export during the largest spring tides of the year.



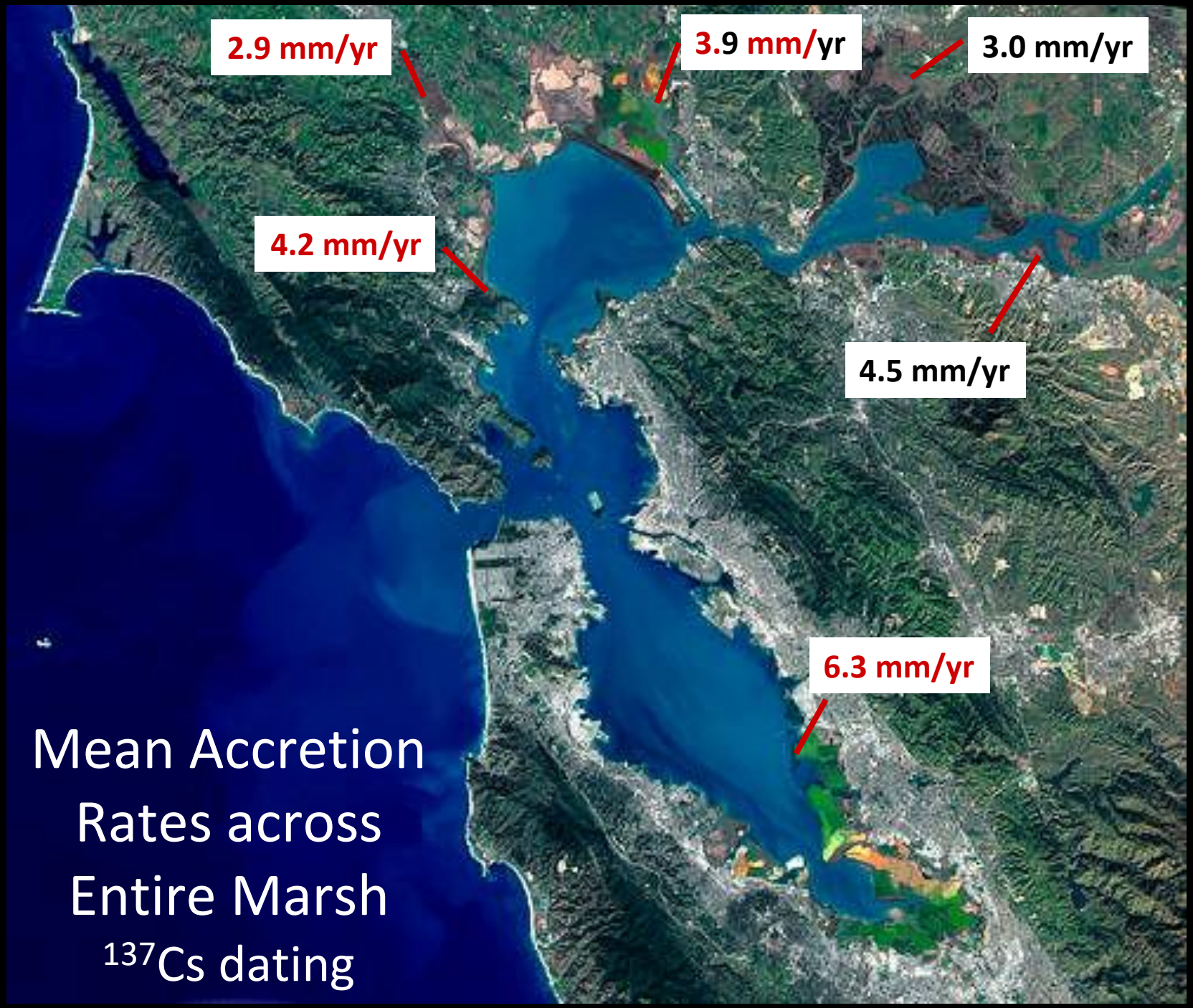
Historical accretion rates: 50-100 year time scale

Dated cores using both ^{137}Cs and ^{210}Pb across the Estuary

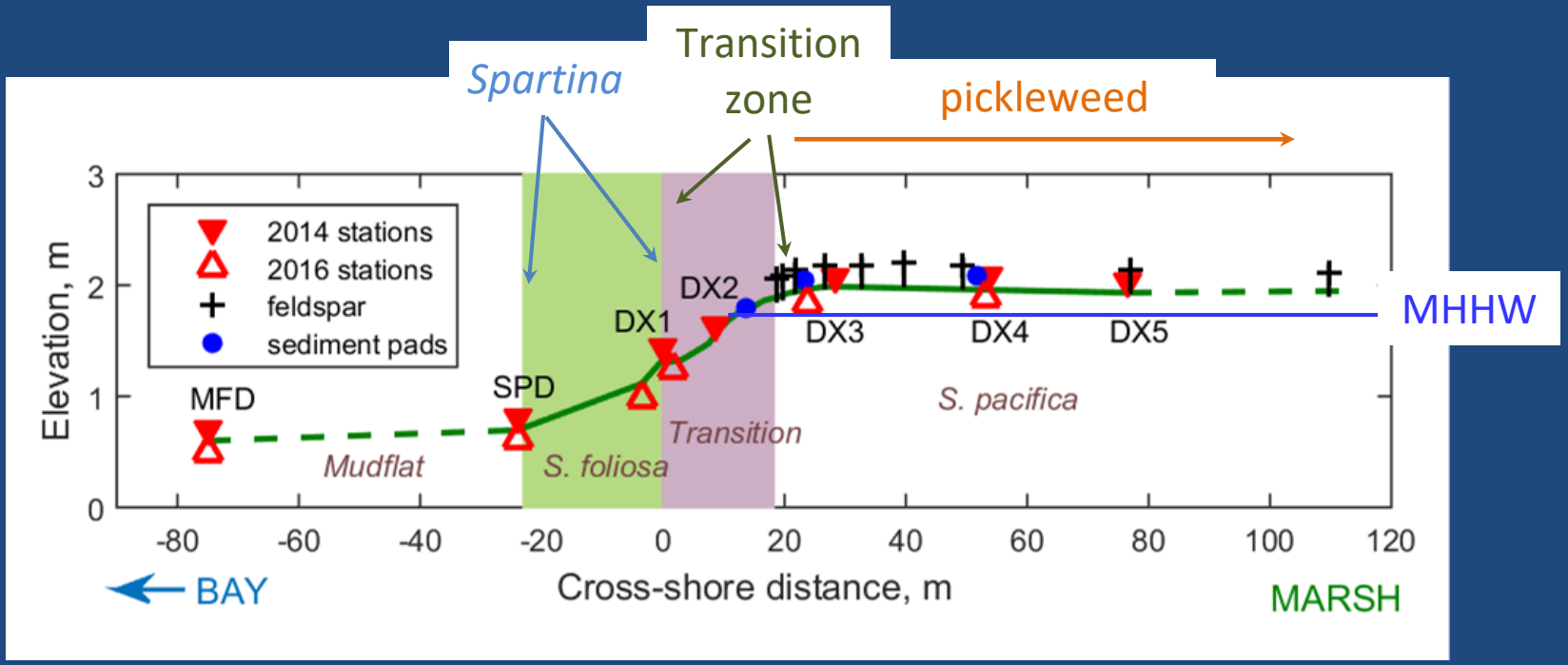
China Camp:

- 3-4 mm/yr in mid and high marsh
- 4-6 mm/yr in low marsh

Callaway, J. C., Borgnis, E. L., Turner, R. E., & Milan, C. S. (2012). Carbon Sequestration and Sediment Accretion in San Francisco Bay Tidal Wetlands. Estuaries and Coasts, 35(5), 1163–1181. https://doi.org/10.1007/s12237-012-9508-9


2.9 mm/yr
3.9 mm/yr
3.0 mm/yr
4.2 mm/yr
4.5 mm/yr
6.3 mm/yr
Mean Accretion Rates across Entire Marsh
^{137}Cs dating
Callaway et al. (2012)

Effect of wind waves and vegetation on marsh accretion



Lacy et al. 2020

Data classified by water level and wave height at the marsh edge

Wave categories:
Calm: $H_s < 2.5$ cm
Moderate: $2.5 < H_s < 6$ cm
Wavy: $6 < H_s < 14$ cm

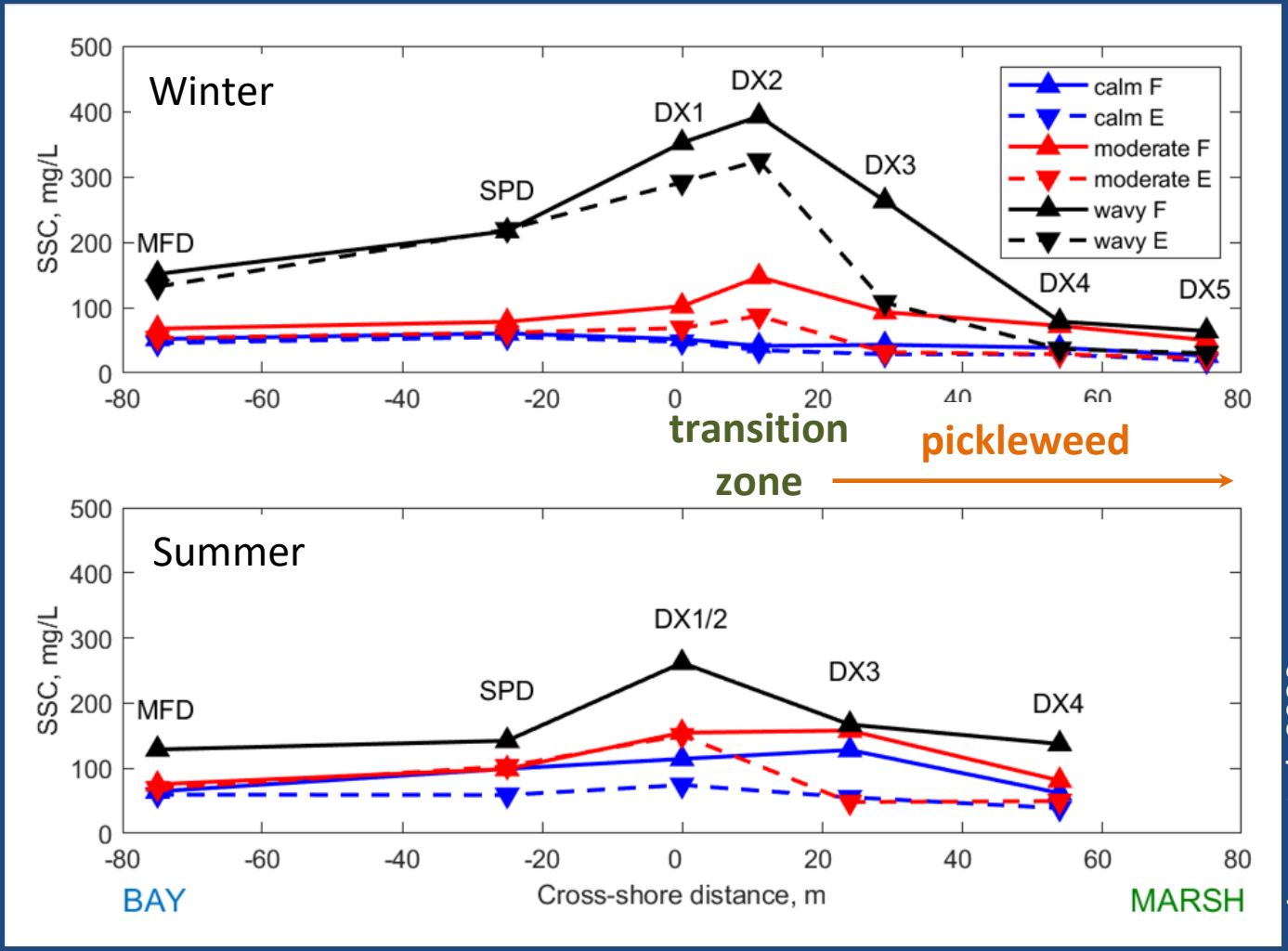
Average SSC for flood and ebb

Flood:

Δ

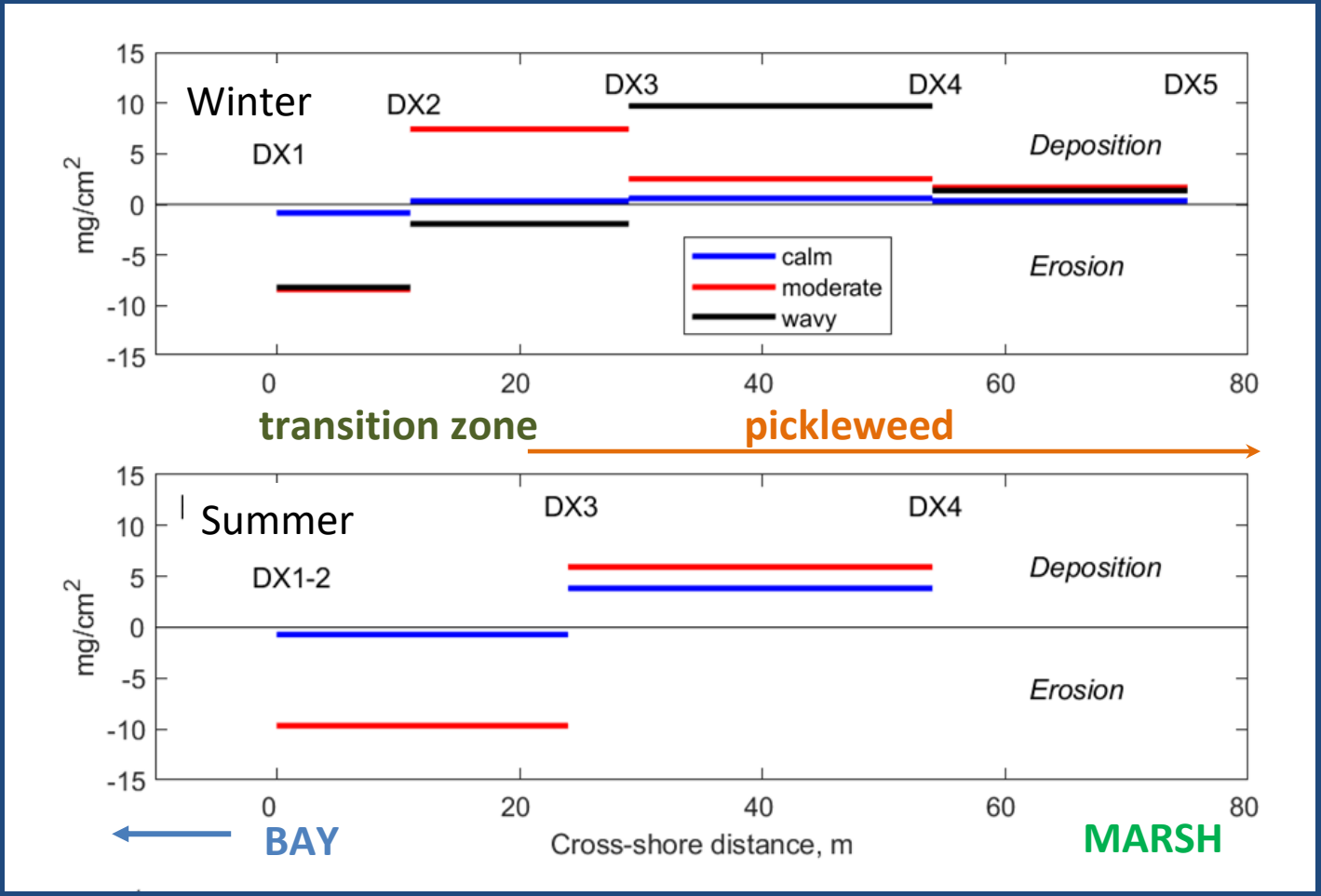
Ebb:

∇



- SSC increases with wave energy in both summer and winter, but wave effects are less in pickleweed.
- SSC less dependent on wave energy during ebb than flood.
- Flood-ebb differential greater in summer than winter.

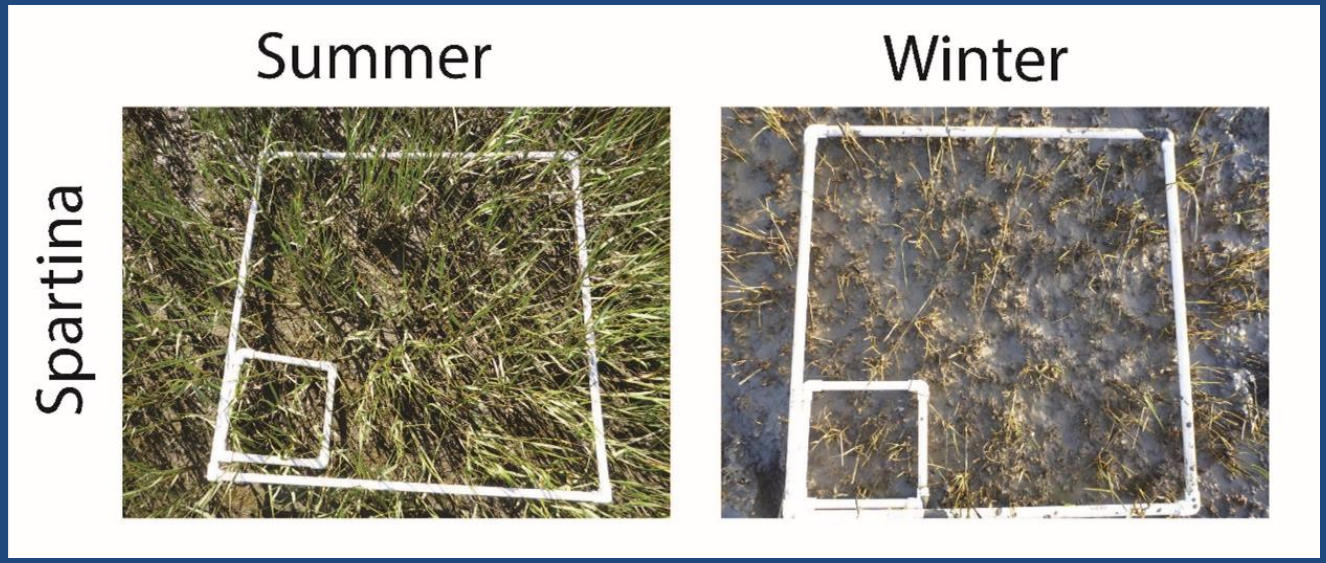
Deposition estimated from SSC: divergence of sediment flux



- Erosion in transition zone, deposition in pickleweed zone
- Both erosion and deposition increase with wave energy
- More deposition in pickleweed in summer than winter, for a given wave class

What is different in the summer?

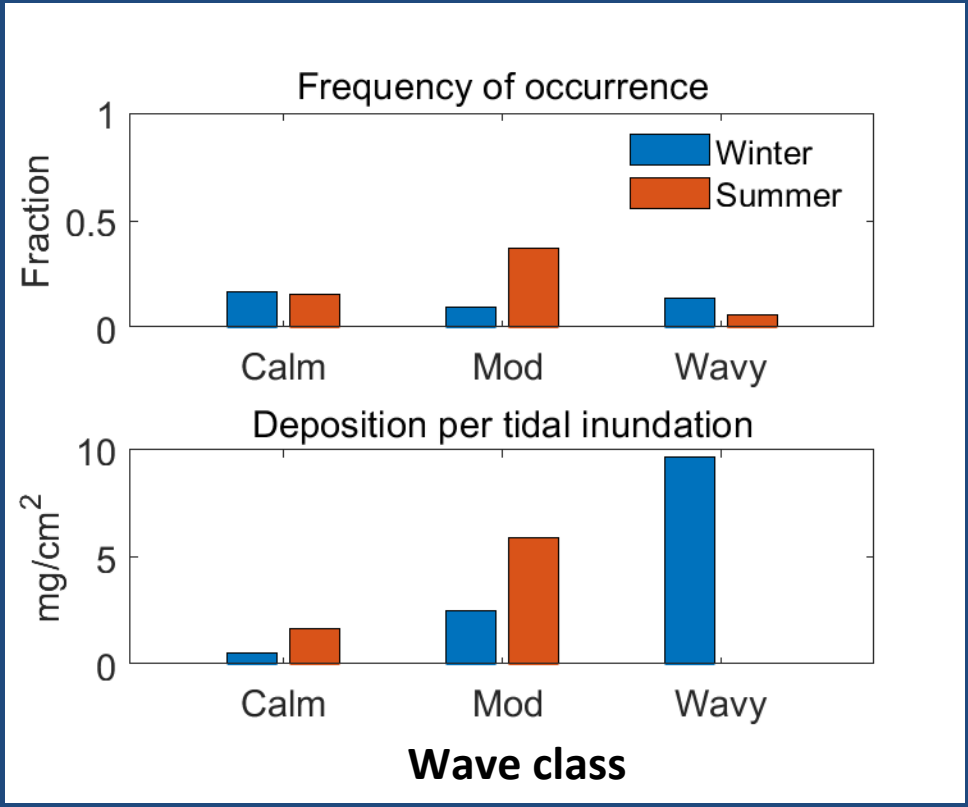
Spartina is taller and more dense in summer than winter.



Foster-Martinez et al 2018

How important are the wave classes to marsh deposition over the course of the year?

- Depends on frequency of occurrence as well as deposition for each wave class



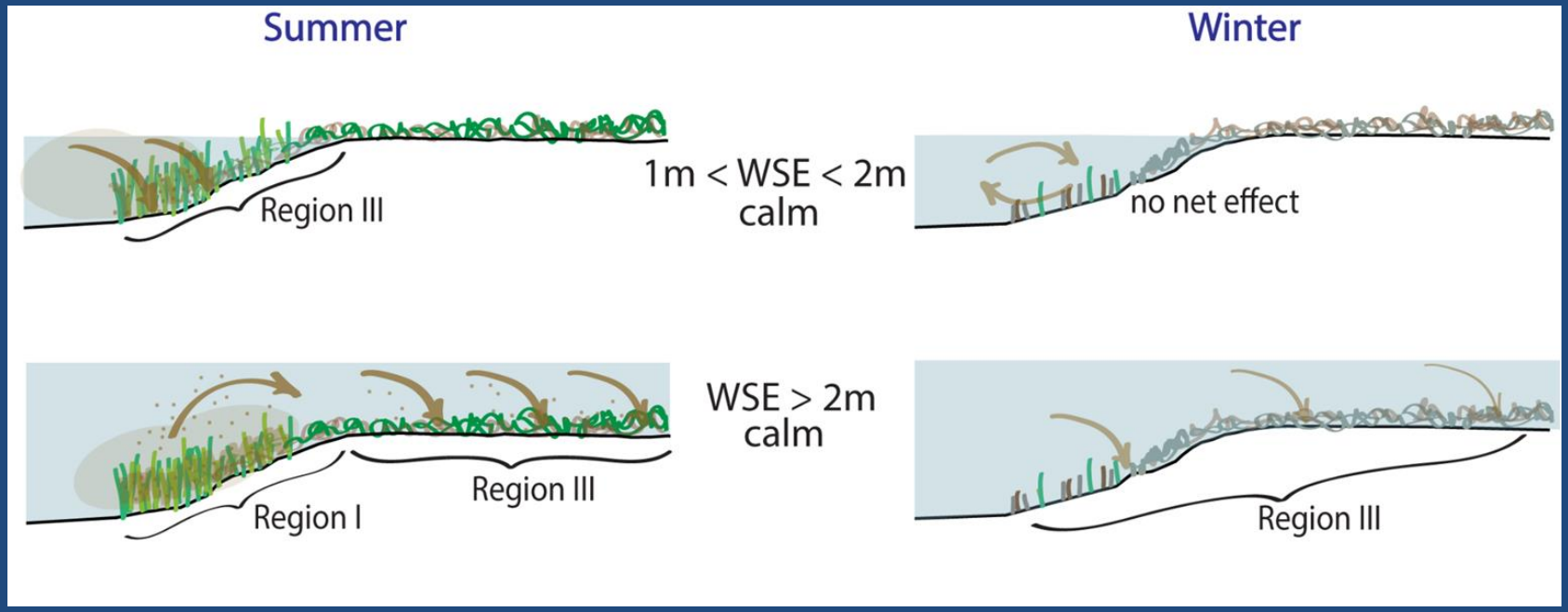
Lacy et al. 2020

On an annual basis, moderate waves of summer contribute more to annual deposition than winter storms

Total annual estimate for this region is 7 mm/yr: compare to 7.8 mm/yr measured at DX3 and 4.7 mm/yr at DX4

Why more deposition in summer? Hypothesis:

- At lower high tides, that do not inundate the marsh, the denser *Spartina* traps more sediment
- That sediment is carried on to the marsh during the next high tide.



Lacy et al. 2020

Marsh Accretion Conclusions

- Marsh sediment accretion at China Camp is currently keeping pace with sea-level rise
- Sediment delivery across the marsh front is more important than delivery via tidal creeks at China Camp
- Wind waves and vegetation play important roles in sediment delivery and marsh accretion, with seasonal variations important for both

Breakout Groups

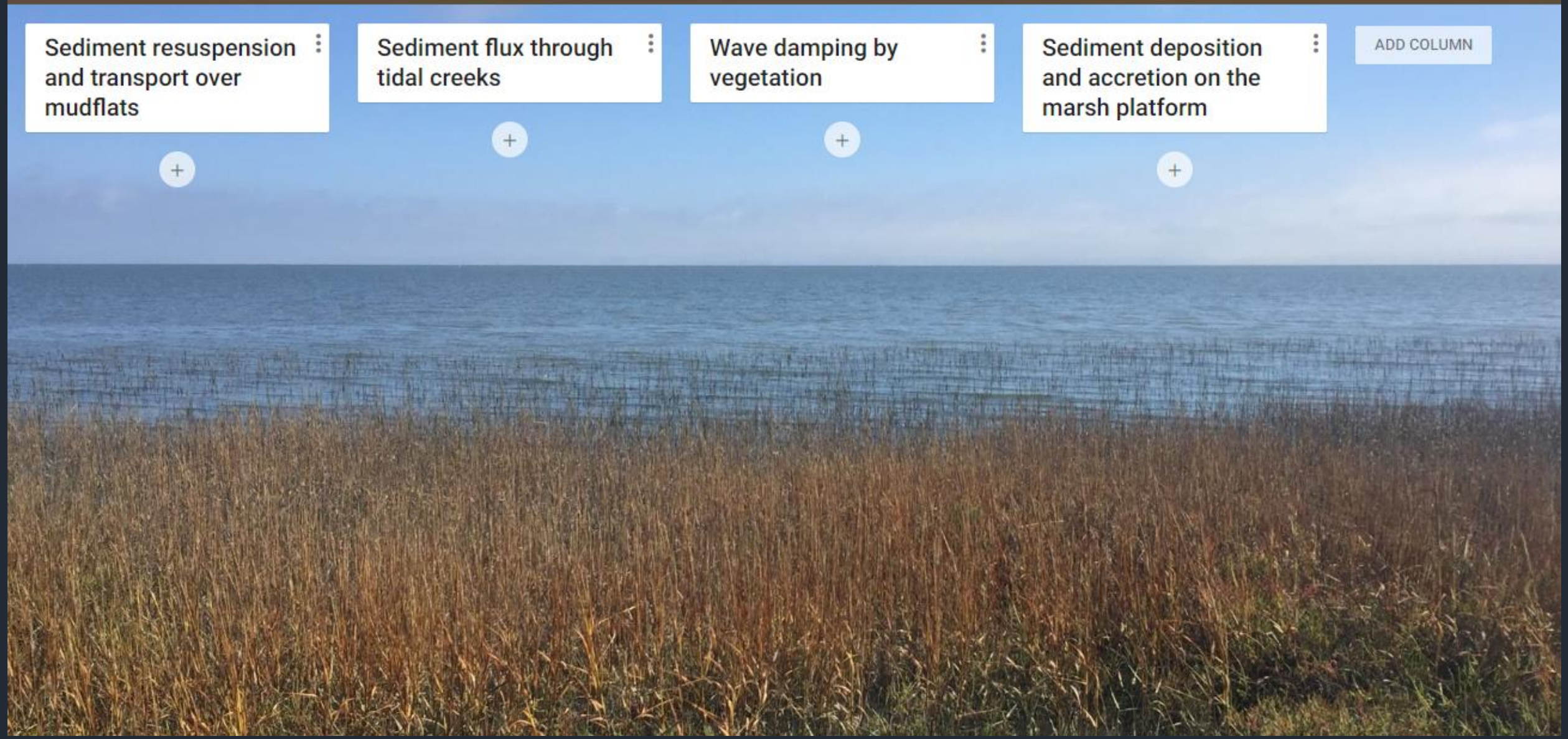
- Three groups led by Jessie, John, and Maddie
- Each group will have its own padlet to work
- Padlet is an online interactive workspace
  - Access it through a web browser with a link
  - Contribute to it simultaneously

Padlet features and notes

- Add posts by clicking on the ‘ + ‘ below each column
- Add comments below posts
- All comments and posts are anonymous
- As the columns get longer, you can scroll through each column individually (shaded – slightly hidden – scroll bar on the right)
- Link to the padlet will be given to you in the breakout room

Matt Ferner · 1m

MSIT Workshop: How is each process relevant to sediment management and tidal marsh restoration actions?



Matt Ferner • 1m

MSIT Workshop: What management actions are most appropriate for the marsh types below?

Marsh with no wave exposure	Scarped and eroding marsh edge	Subsided marsh platform recently restored to tidal flows	Brackish marsh	Other marsh or environment types (fill in below)

Feedback Polls

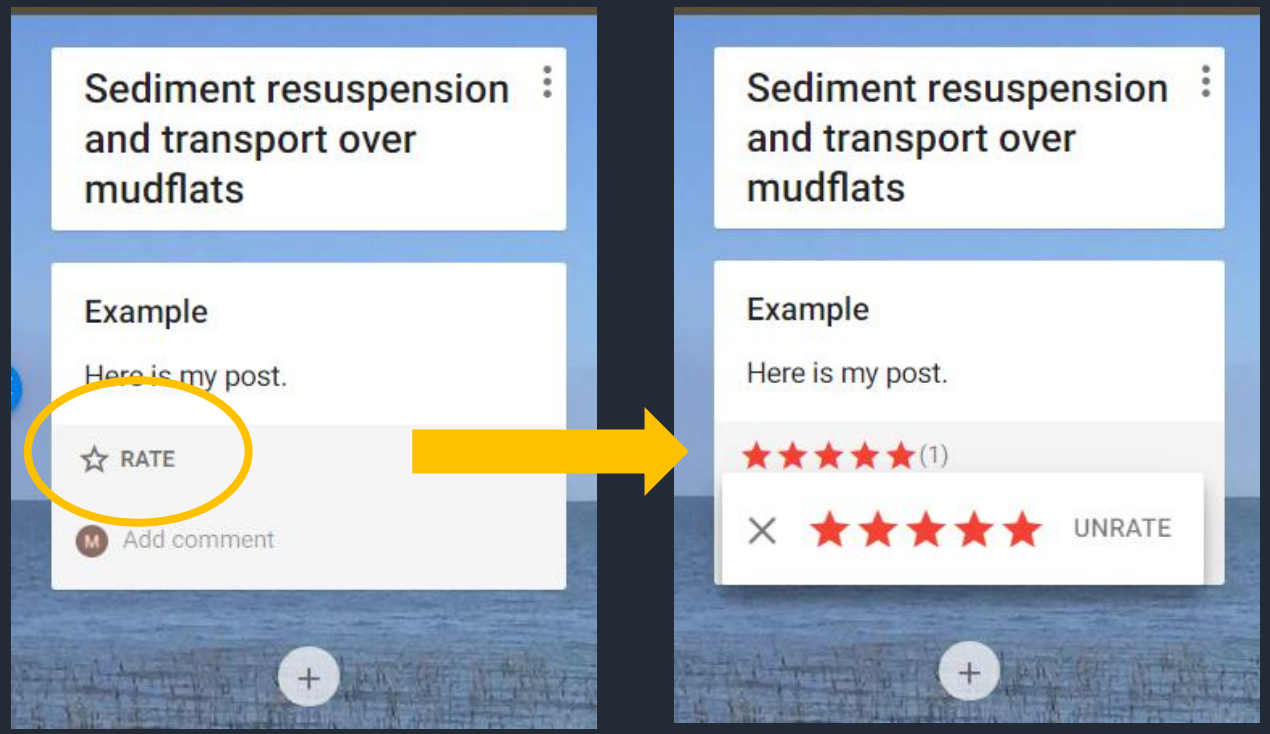
Preview of Kickoff Workshop, part 2

- Provide a summary of the content from all three of the breakout rooms
- Present options for project output format
- Evaluate and discuss the product output, content and format

Requests

1) Continue to fill out the padlets with any ideas that come to mind (posts or comments on others' ideas)

2) Rate – on a scale of 1 to 5 stars – posts that should be prioritized for the project outputs and/or for further discussion by this group



Complete 1&2 by Friday, April 23


Thank you!
You’re welcome to stick around