Soils and Marsh Creek Evolution at a Marsh Augmentation Project in Seal Beach CA

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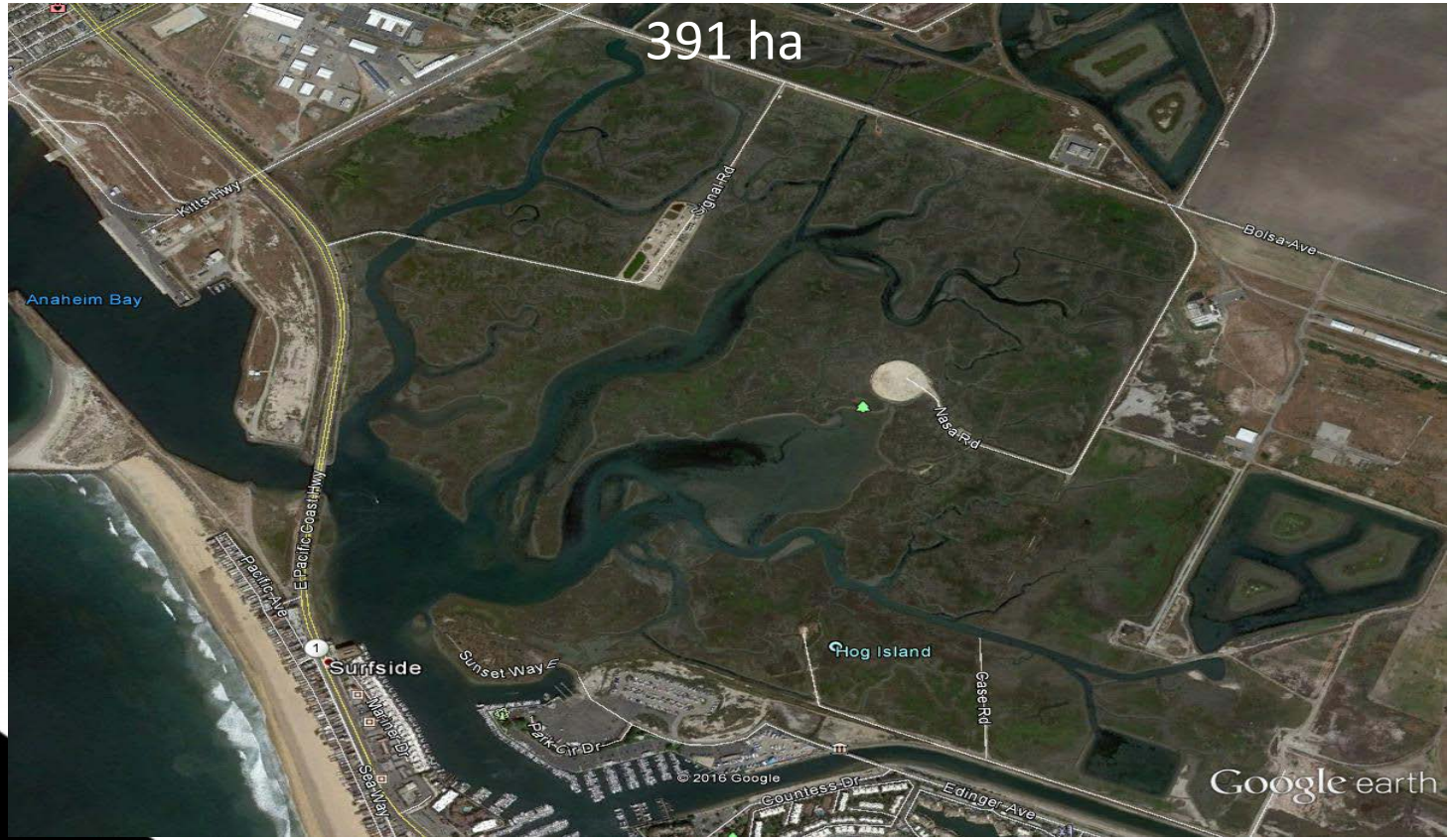
The threat of sea level rise

- Responses of salt marshes to sea level rise
  - Transgression
  - Changes in marsh plain elevation
    - Marsh plain elevation (Elevation capital)
    - Plant productivity
    - Sediment availability
- Many (but not all) California salt marshes will be able to keep pace with sea level rise until 2030 or 2050, but not after that

Management options

- Facilitate transgression
- Improve salt marsh resilience
  - Protect natural sediment supply
  - Remove other stressors
  - Add sediment to marsh plain: Thin Layer Placement

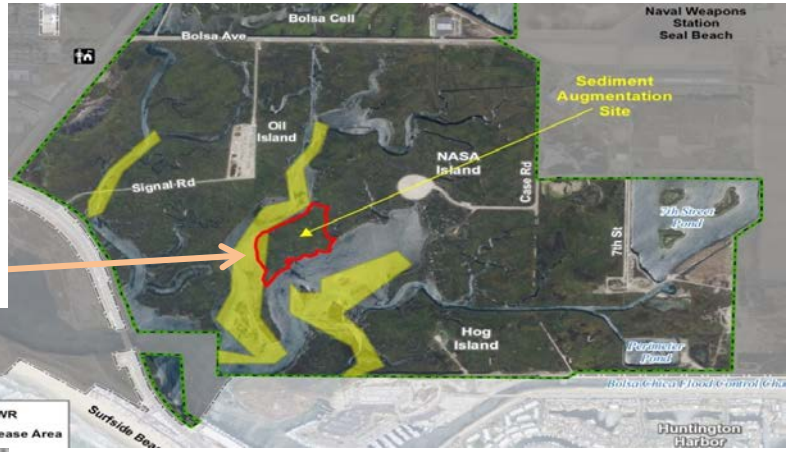
Seal Beach National Wildlife Refuge



A preview of future higher sea levels

- Subsidence from groundwater and oil extraction and removal of natural sediment source
  - Relative sea level rise 3x higher than other marshes
  - 29 cm subsidence since 1960's
- The low elevations of the Refuge has resulted in stunted *Spartina foliosa*, providing little habitat for the endangered Light-footed Ridgway's Rail

Beneficial Use of Dredge Material at Seal Beach to Raise the Marsh Plain Elevation



Goal: Apply 25 cm of clean sediment of appropriate grain size over 3.4 ha (8.5 acres).

After 2 years, thickness of at least 7.5 cm.

Sediment addition: January to April 2016

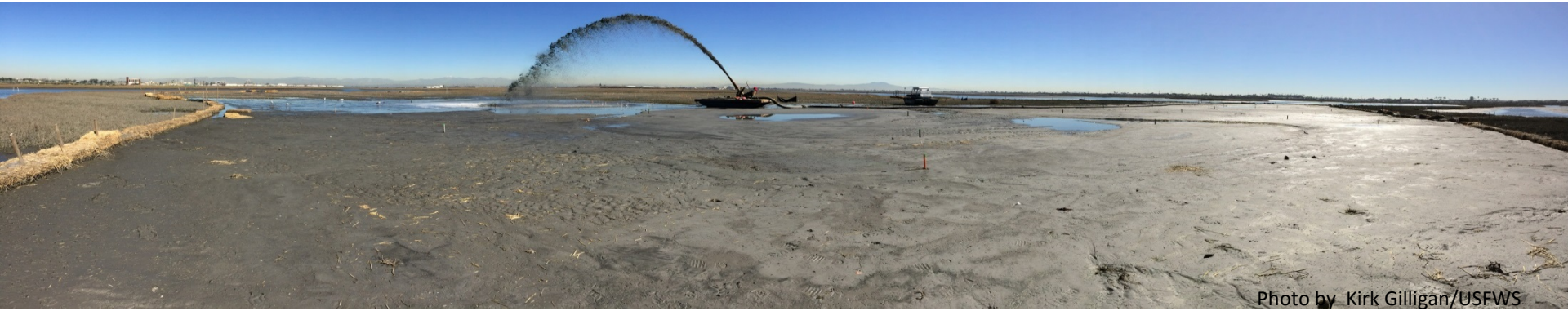


Photo by Kirk Gilligan/USFWS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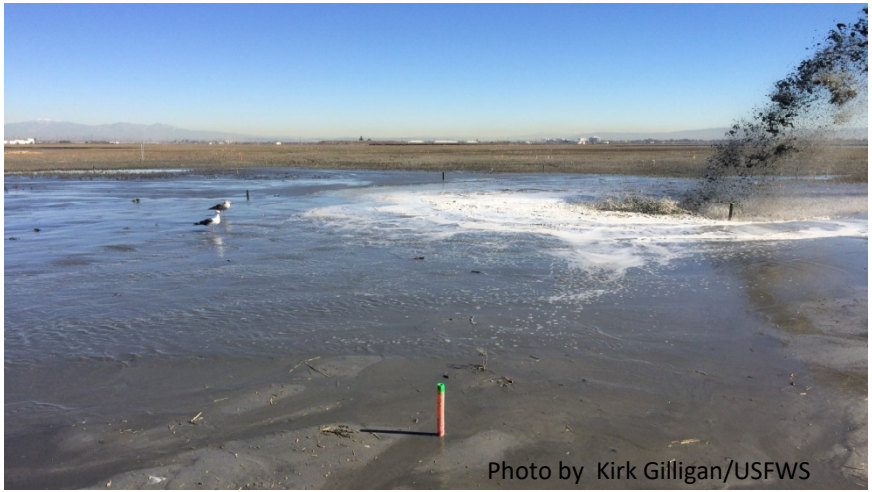


Photo by Kirk Gilligan/USFWS

Pre- and post-augmentation monitoring

- Sediments
  - Suspended sediment (turbidity) in channels
  - Precise elevations (with RTK GPS)
  - Subsidence/uplift with Surface Elevation Tables
  - Accretion/erosion with feldspar markers
  - Compaction (feldspar markers and sediment stakes)
- Tidal creek morphology
- Biological community
  - Vegetation
  - Benthic invertebrates
  - Eelgrass productivity
  - Bird counts (general and Light-footed Ridgway's Rail)
- Carbon sequestration
  - Coring
  - Greenhouse gas (methane and nitrous oxide) flux

Project sites

- Sediment Augmentation Site
- Control Site

Monitoring questions

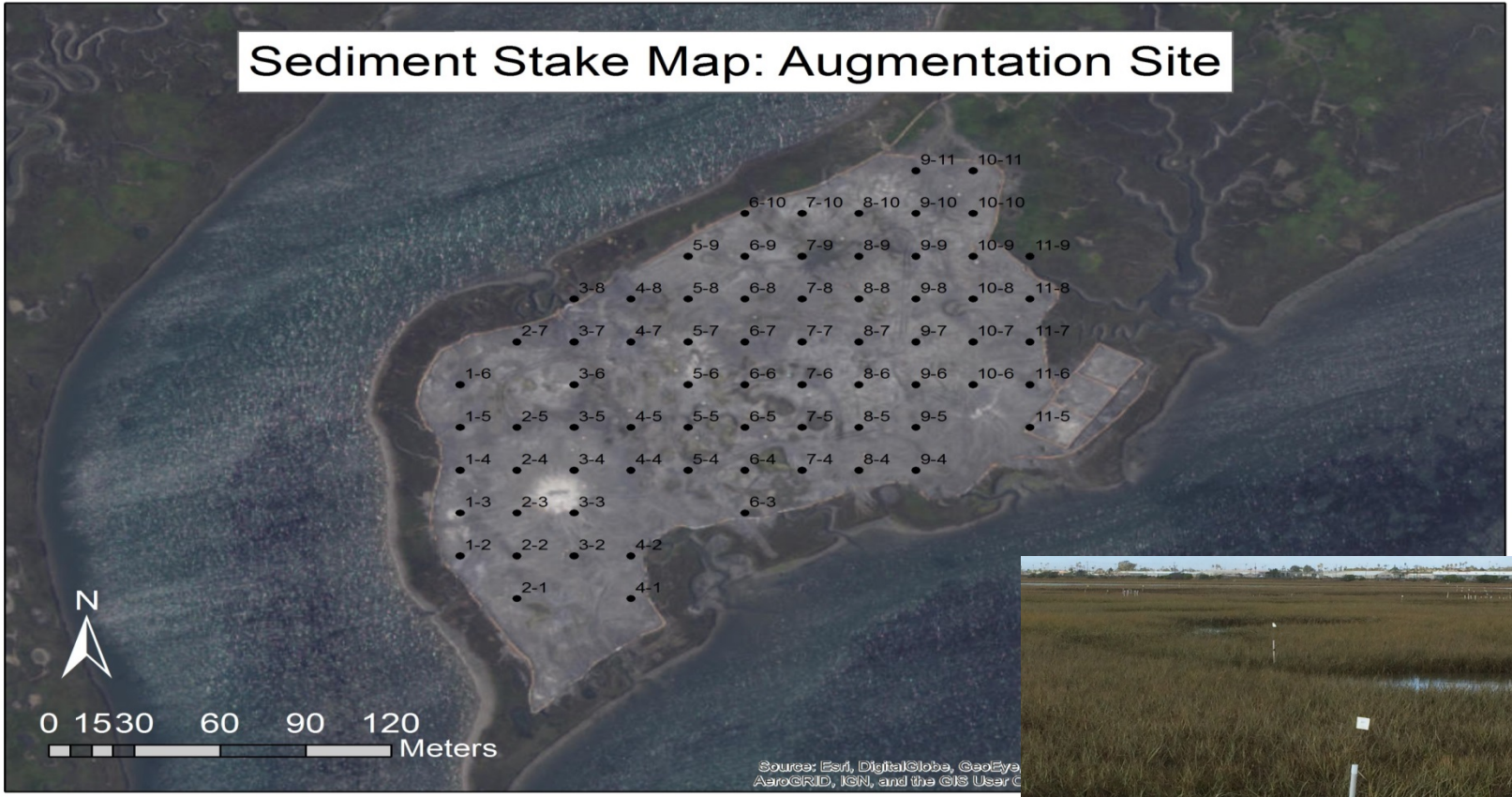
- How does the depth of the added sediment change over time?
- How do sediment characteristics (grain size, bulk density, organic content) change over time?
- Do tidal creeks re-establish themselves after sediment addition?

How does the depth of added sediment change over time?

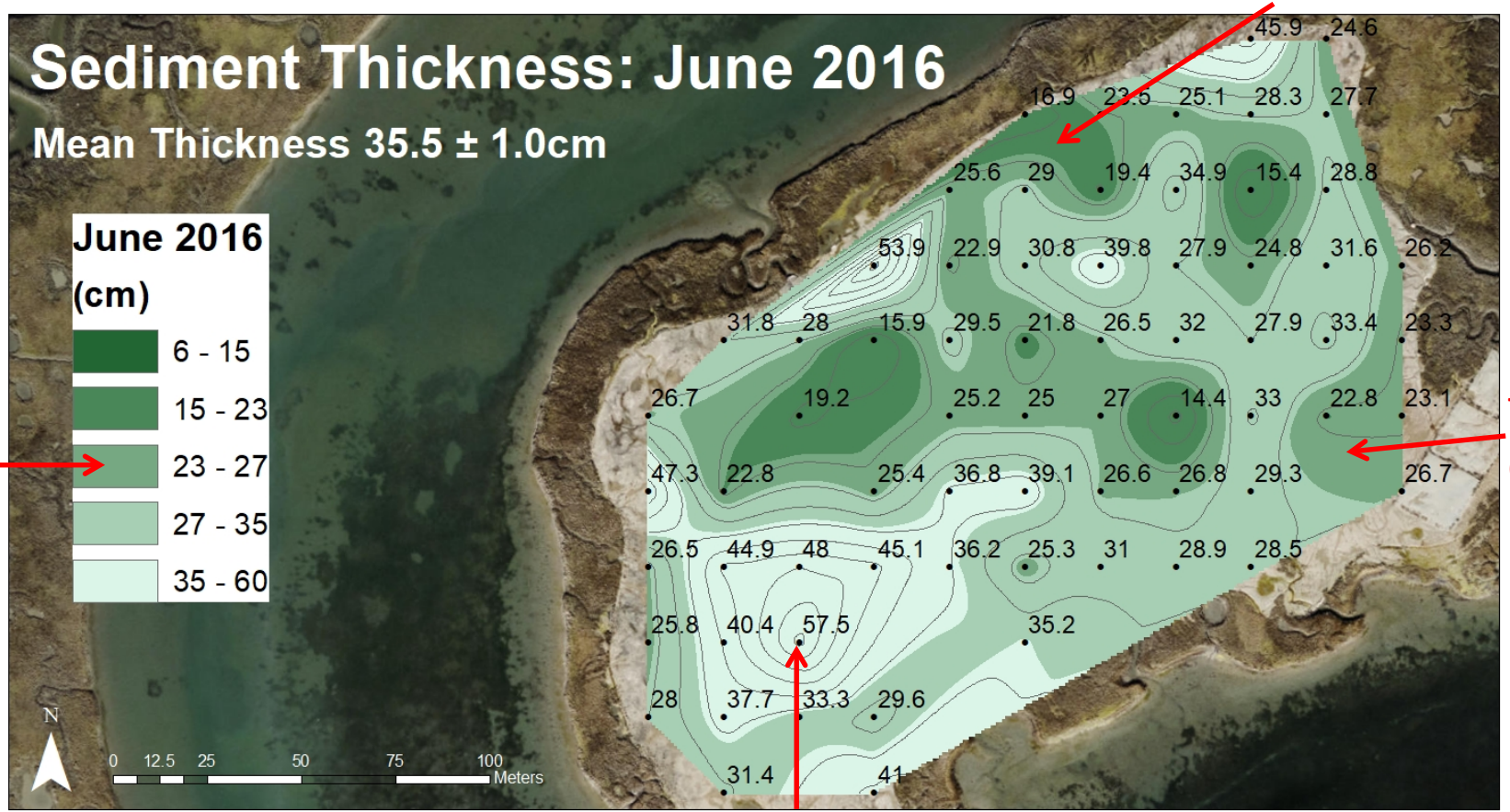
Feldspar plots

- Feldspar plots established in augmentation and control sites
  - Stratified random design
    - Three strata: *Spartina*, *Batis* and Pond
  - 24 in augmentation site, 16 in control site
  - Cores taken to measure depth to marker horizon
- Pre-augmentation plots established in October 2015
- Post-augmentation plots established in May 2016

Sediment Stake Map: Augmentation Site



2 months



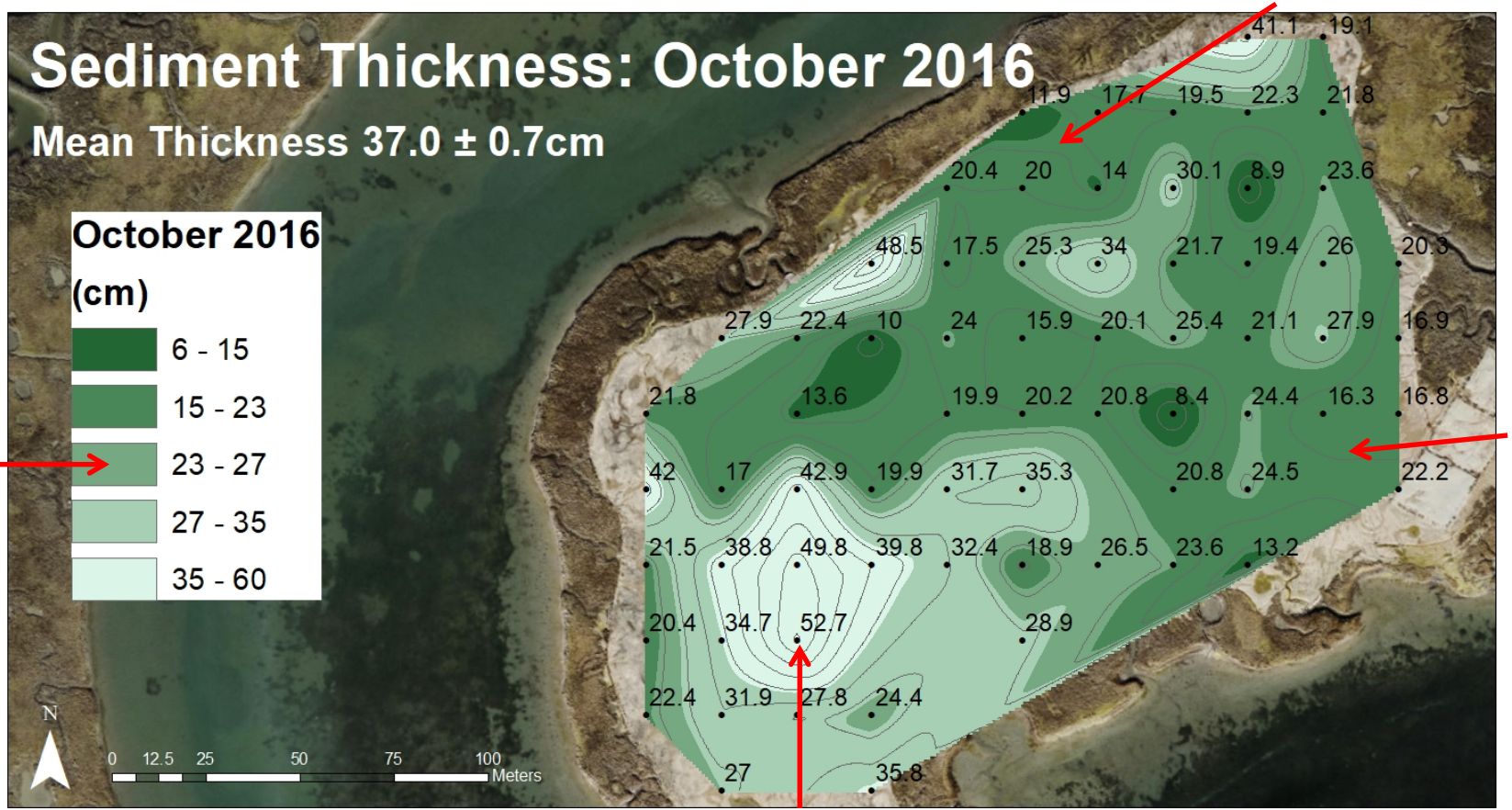
Low spot

Target depth

Target depth

High spot

6 months

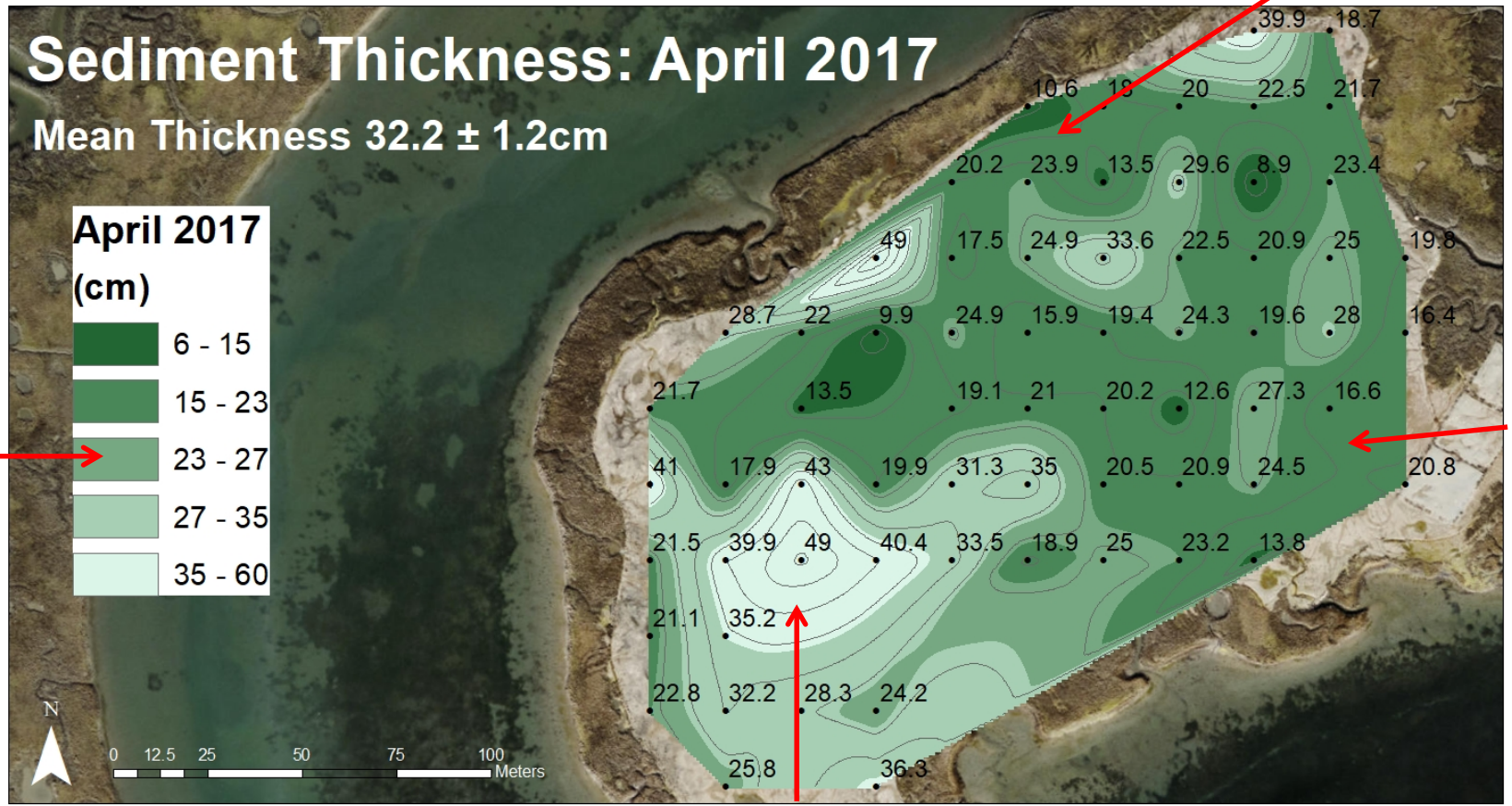


Target depth

Low spot

High spot

12 months

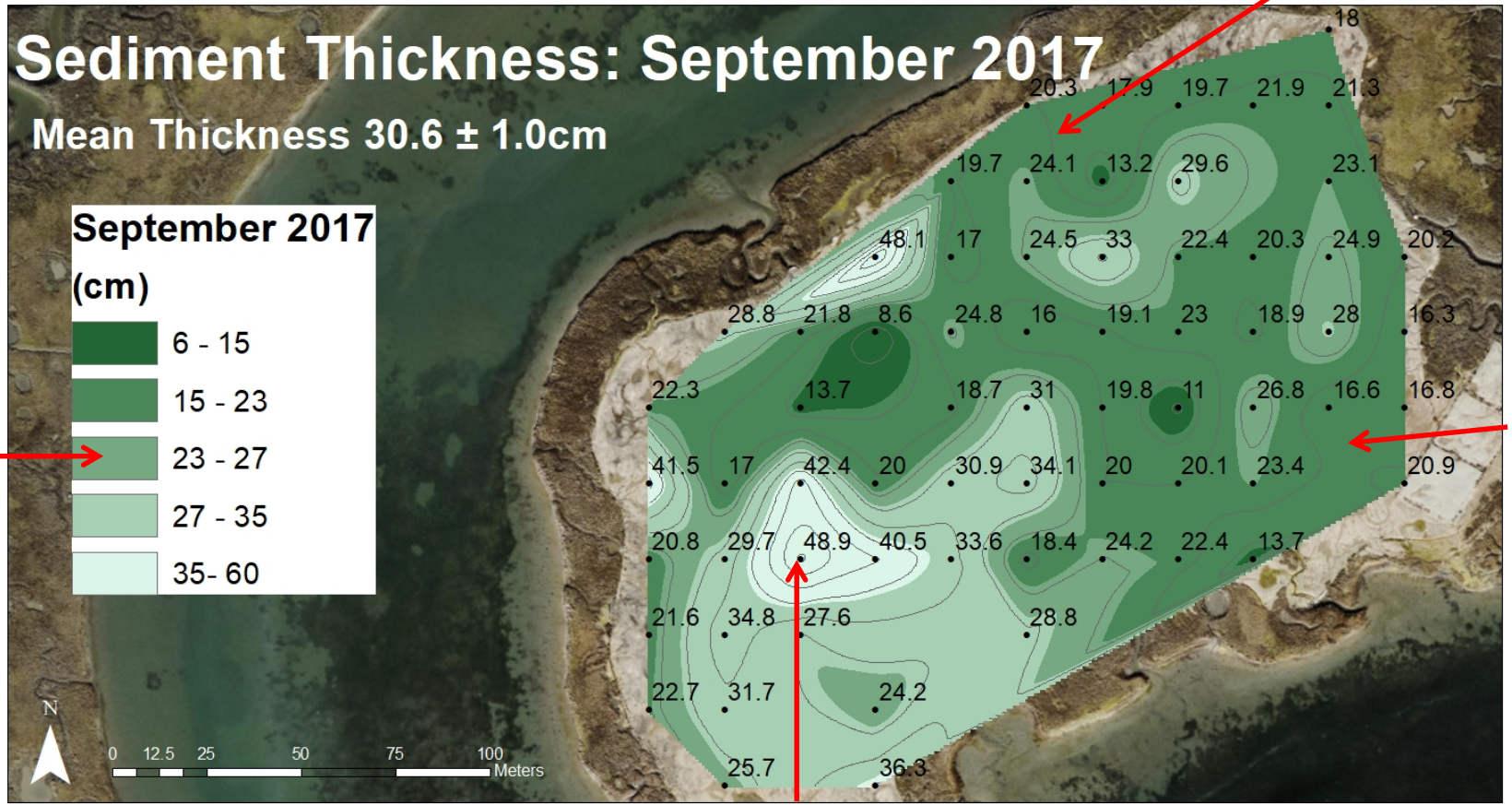


Target depth

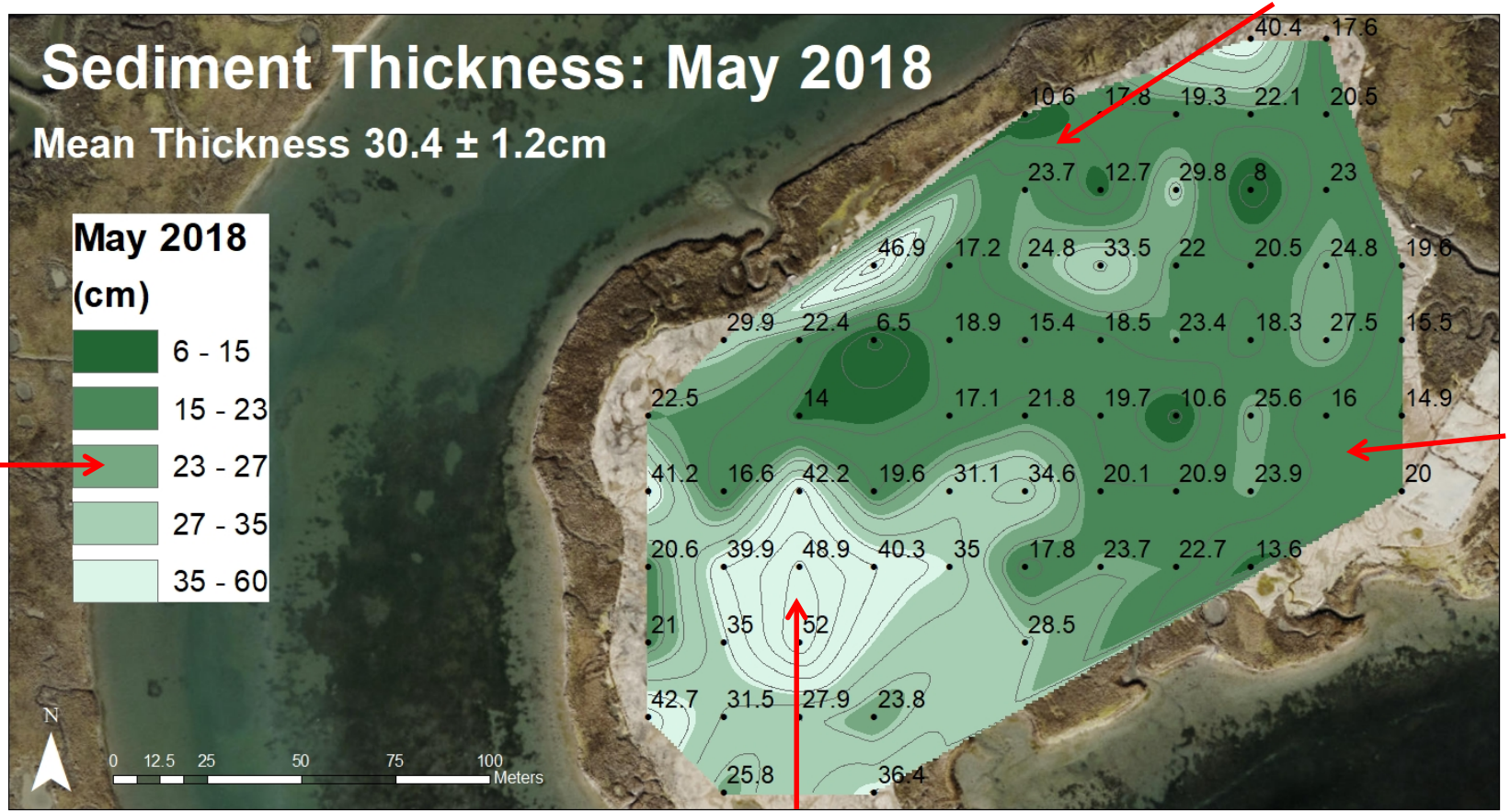
Low spot

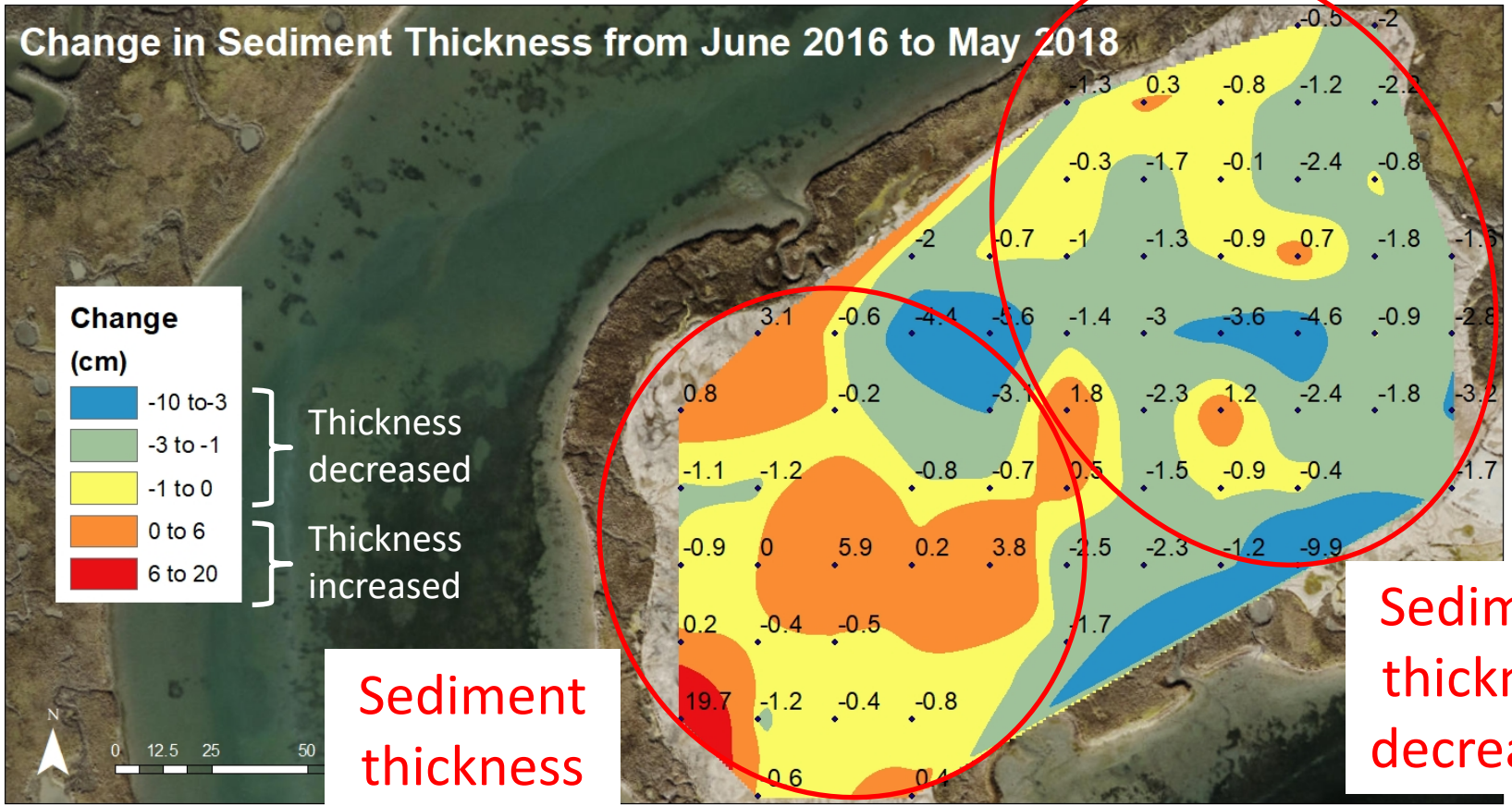
High spot

17 months

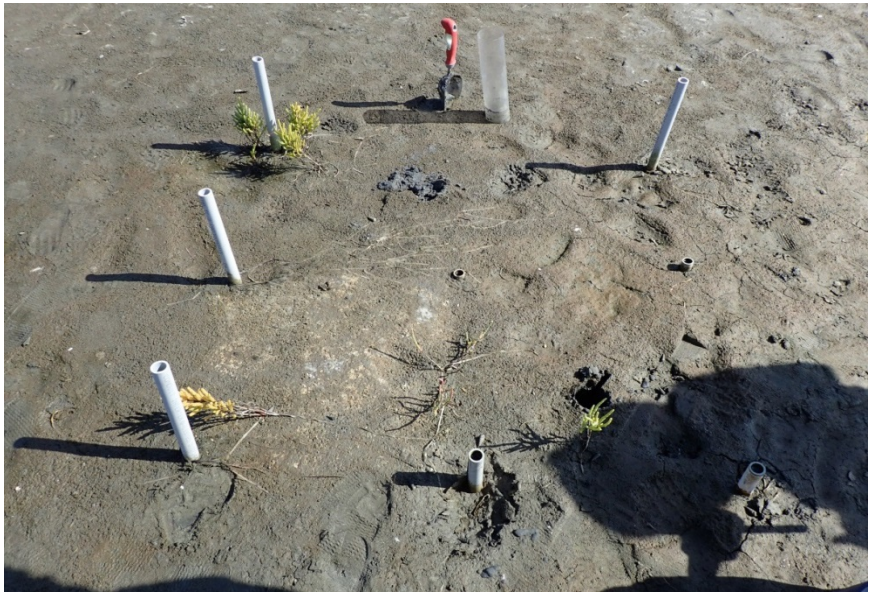

Low spot
Sediment Thickness: September 2017
Mean Thickness 30.6 ± 1.0cm
September 2017
(cm)
6 - 15
15 - 23
23 - 27
27 - 35
35- 60
Target depth
Low spot
High spot
N
0 12.5 25 50 75 100
Meters
18
20.3 17.9 19.7 21.9 21.3
19.7 24.1 13.2 29.6 23.1
48.1 17 24.5 33 22.4 20.3 24.9 20.2
28.8 21.8 8.6 24.8 16 19.1 23 18.9 28 16.3
22.3 13.7 18.7 31 19.8 11 26.8 16.6 16.8
41.5 17 42.4 20 30.9 34.1 20 20.1 23.4 20.9
20.8 29.7 48.9 40.5 33.6 18.4 24.2 22.4 13.7
21.6 34.8 27.6 28.8
22.7 31.7 24.2
25.7 36.3

25 months

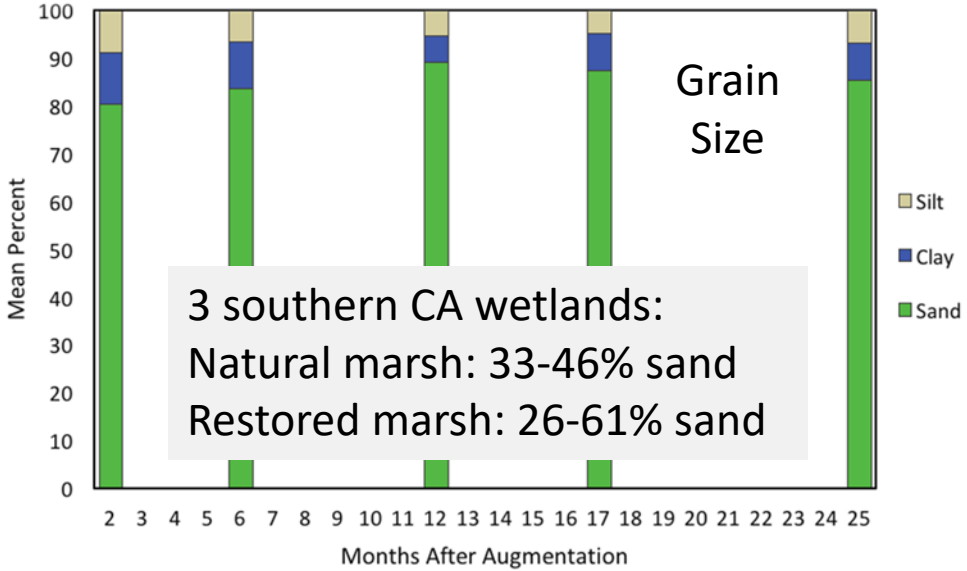

Low spot
Sediment Thickness: May 2018
Mean Thickness 30.4 ± 1.2cm
May 2018 (cm)
6 - 15
15 - 23
23 - 27
27 - 35
35 - 60
Target depth
Low spot
High spot
N
0 12.5 25 50 75 100
Meters
40.4 17.6
10.6 17.8 19.3 22.1 20.5
23.7 12.7 29.8 8 23
46.9 17.2 24.8 33.5 22 20.5 24.8 19.6
29.9 22.4 6.5 18.9 15.4 18.5 23.4 18.3 27.5 15.5
22.5 14 17.1 21.8 19.7 10.6 25.6 16 14.9
41.2 16.6 42.2 19.6 31.1 34.6 20.1 20.9 23.9 20
20.6 39.9 48.9 40.3 35 17.8 23.7 22.7 13.6
21 35 52 28.5
42.7 31.5 27.9 23.8
25.8 36.4

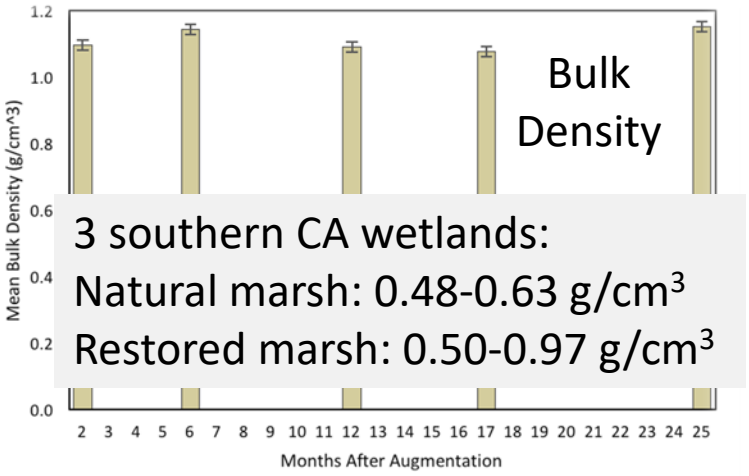

Change in Sediment Thickness from June 2016 to May 2018
Change (cm)
-10 to-3
-3 to -1
-1 to 0
0 to 6
6 to 20
Thickness decreased
Thickness increased
N
0 12.5 25 50
Sediment thickness increased
Sediment thickness decreased

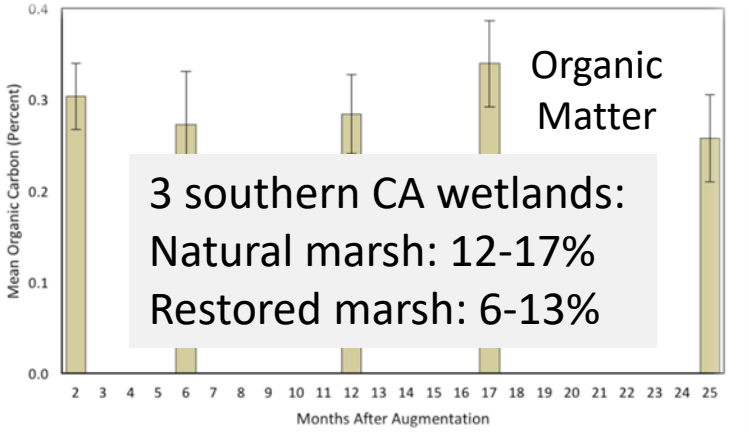
How do sediment characteristics (grain size, bulk density, organic content) change over time?



Sediment characteristics

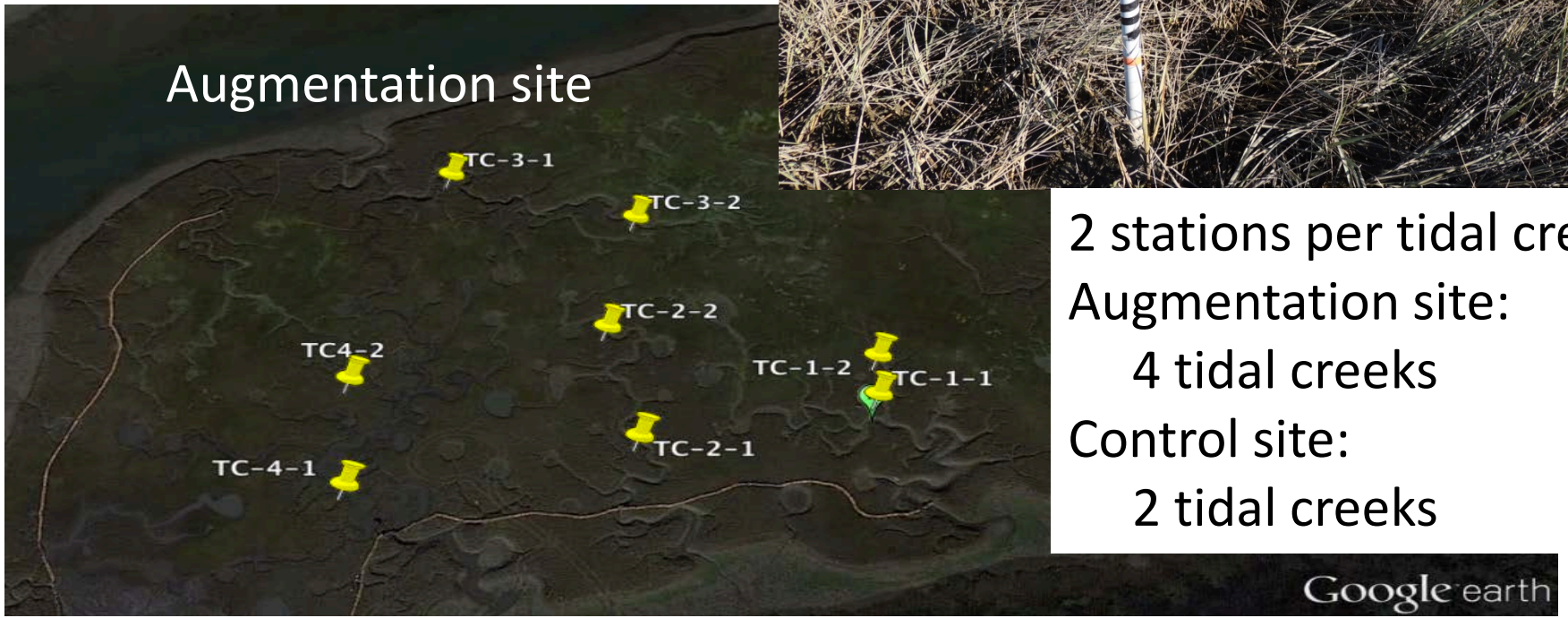






Do tidal creeks re-establish themselves after sediment addition?

Tidal creek cross sections



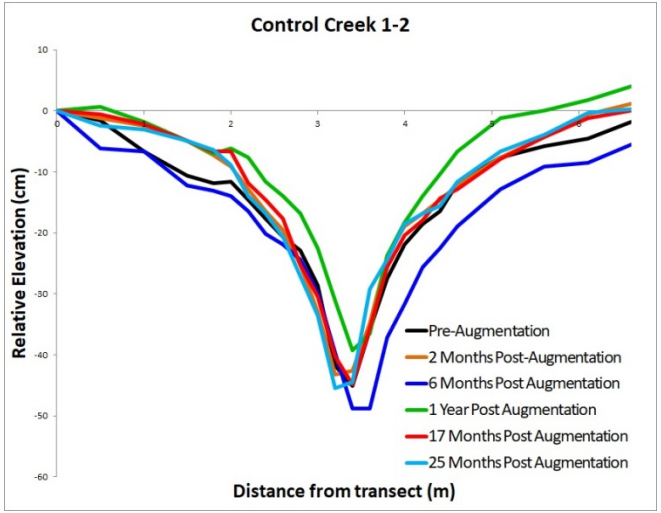
2 stations per tidal creek

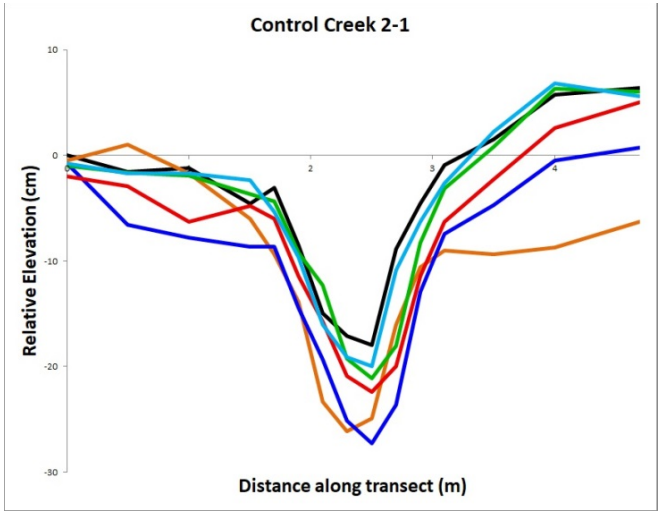
Augmentation site:

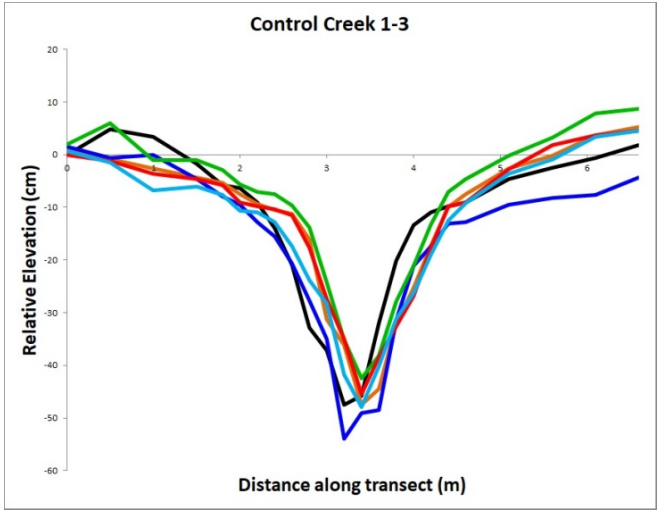
4 tidal creeks

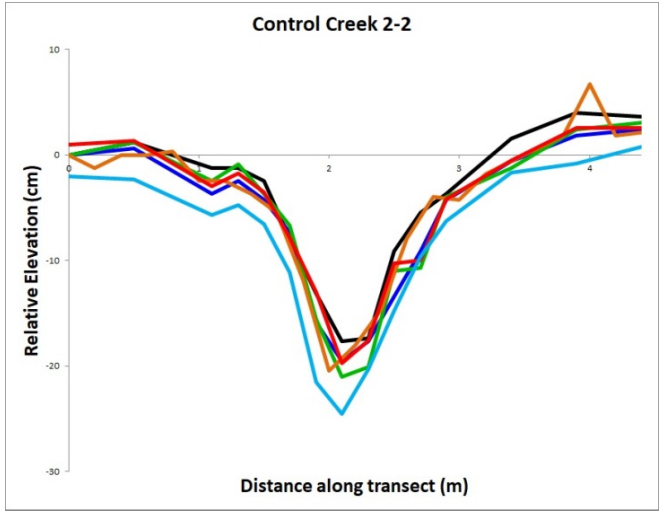
Control site:

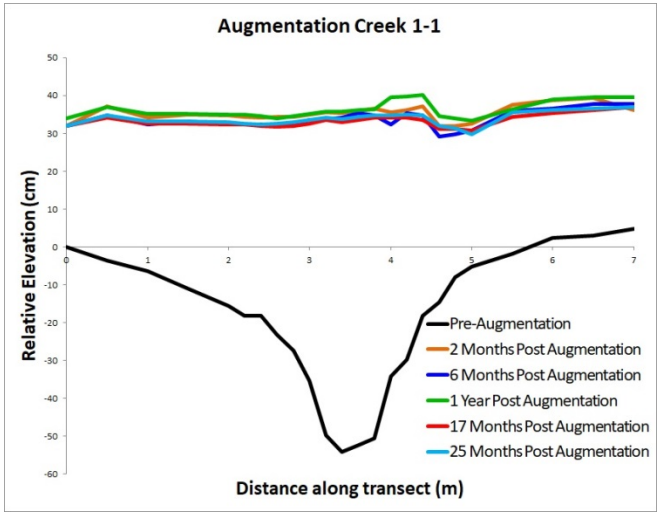
2 tidal creeks

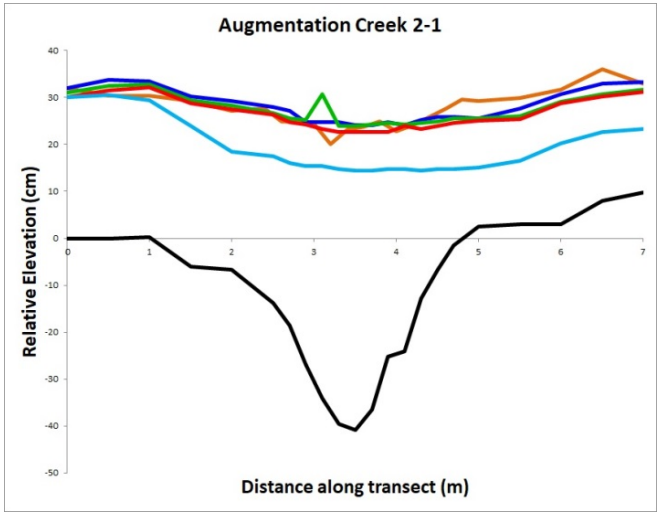

Control Creek 1-2
Relative Elevation (cm)
Distance from transect (m)
Pre-Augmentation
2 Months Post-Augmentation
6 Months Post Augmentation
1 Year Post Augmentation
17 Months Post Augmentation
25 Months Post Augmentation

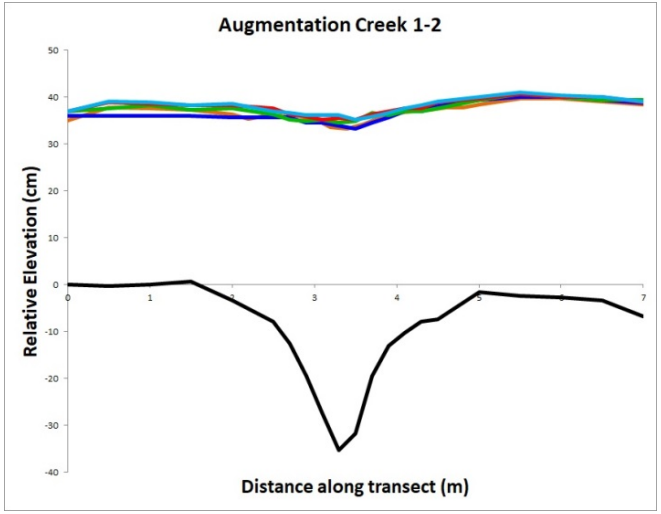

Control Creek 2-1
Relative Elevation (cm)
Distance along transect (m)

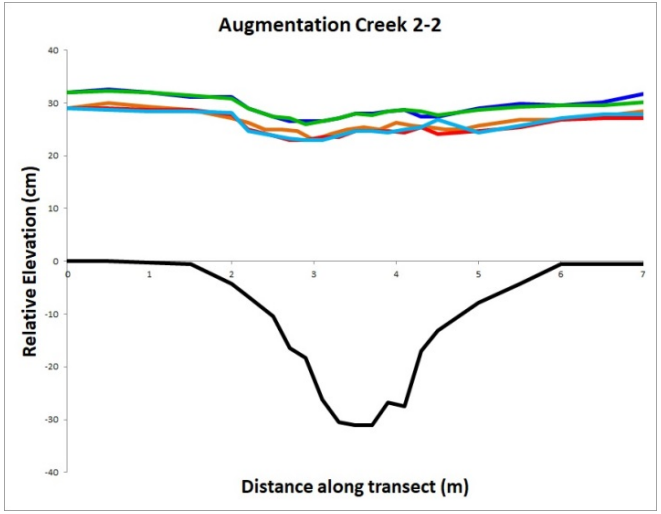

Control Creek 1-3
Relative Elevation (cm)
Distance along transect (m)

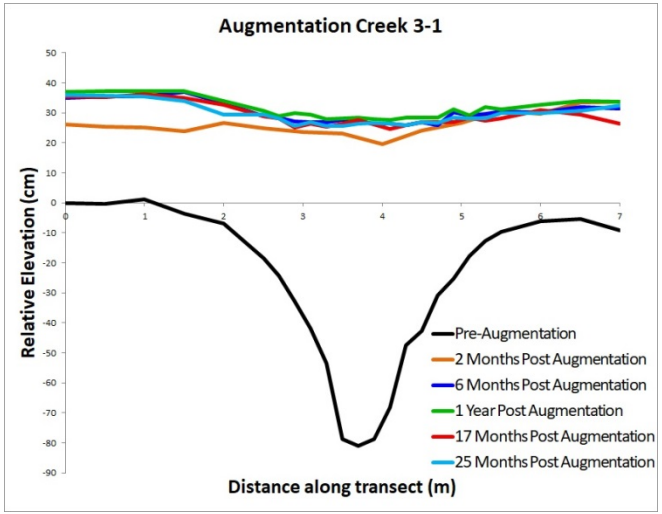

Control Creek 2-2
Relative Elevation (cm)
Distance along transect (m)

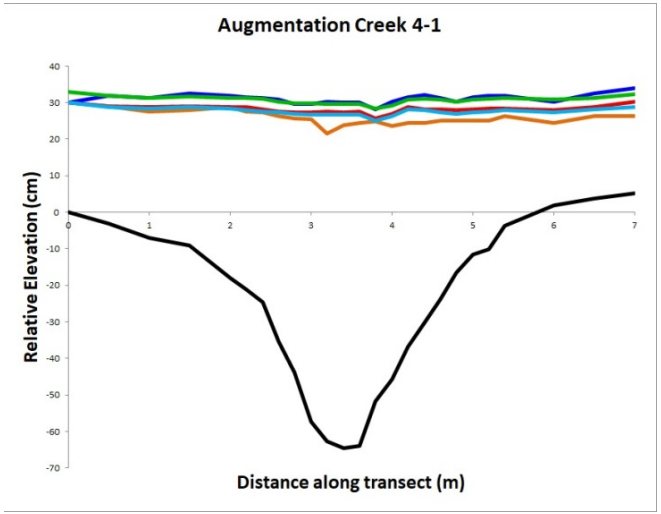

Augmentation Creek 1-1
Relative Elevation (cm)
Distance along transect (m)
Pre-Augmentation
2 Months Post Augmentation
6 Months Post Augmentation
1 Year Post Augmentation
17 Months Post Augmentation
25 Months Post Augmentation

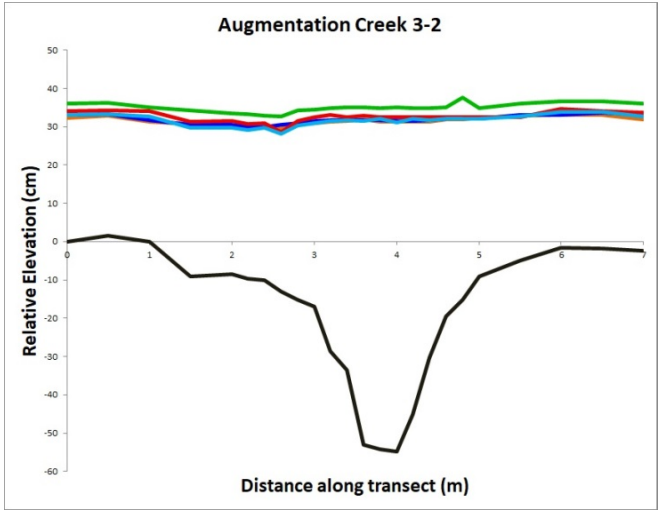

Augmentation Creek 2-1
Relative Elevation (cm)
Distance along transect (m)

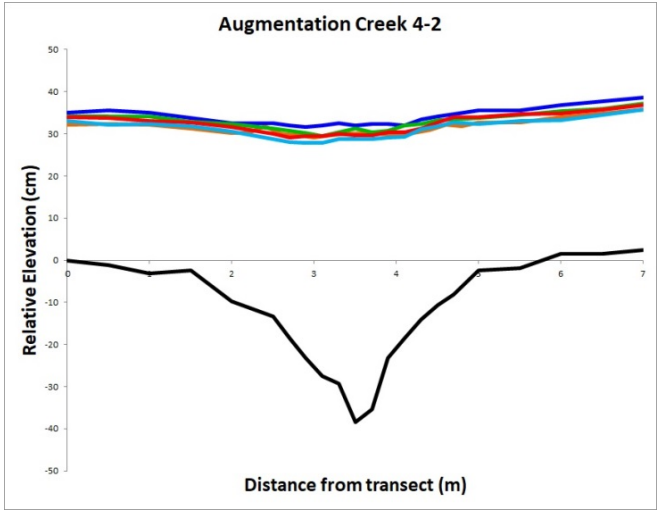

Augmentation Creek 1-2
Relative Elevation (cm)
Distance along transect (m)


Augmentation Creek 2-2
Relative Elevation (cm)
Distance along transect (m)


Augmentation Creek 3-1
Relative Elevation (cm)
Distance along transect (m)
Pre-Augmentation
2 Months Post Augmentation
6 Months Post Augmentation
1 Year Post Augmentation
17 Months Post Augmentation
25 Months Post Augmentation


Augmentation Creek 4-1
Relative Elevation (cm)
Distance along transect (m)

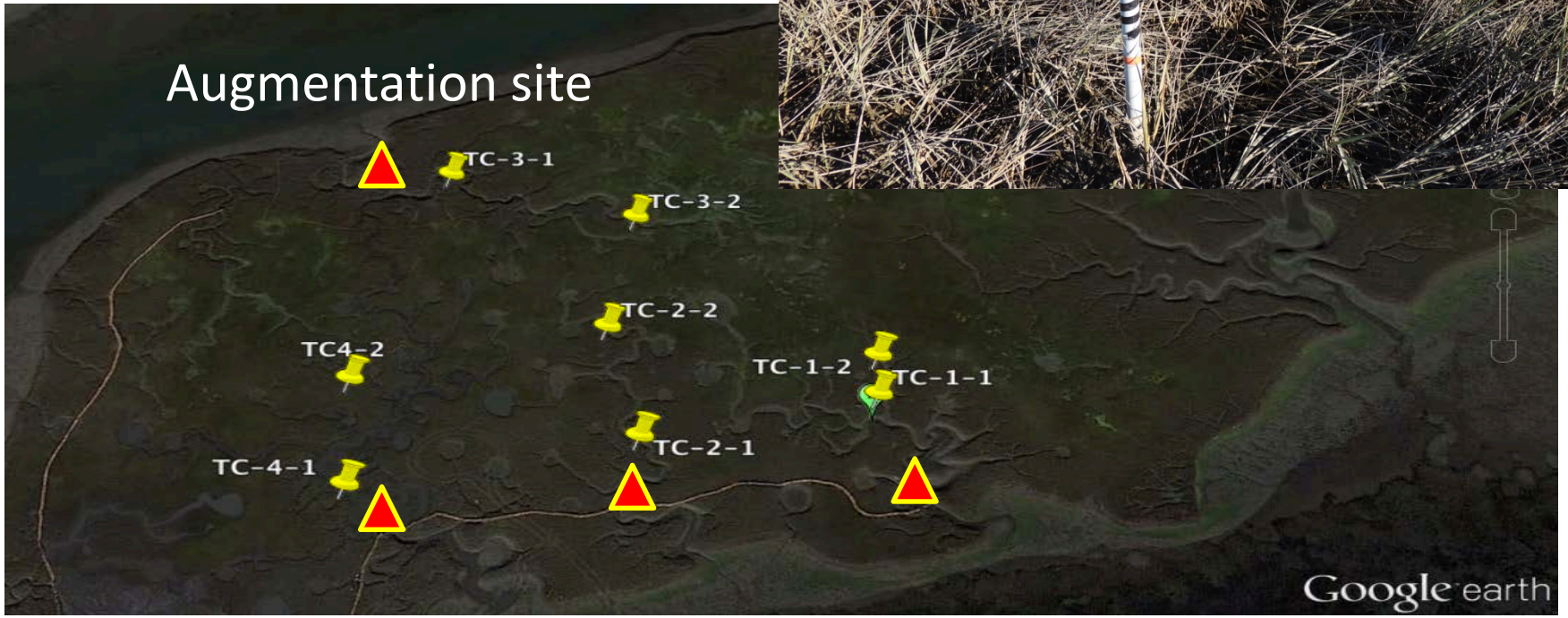

Augmentation Creek 3-2
Relative Elevation (cm)
Distance along transect (m)


Augmentation Creek 4-2
Relative Elevation (cm)
Distance from transect (m)

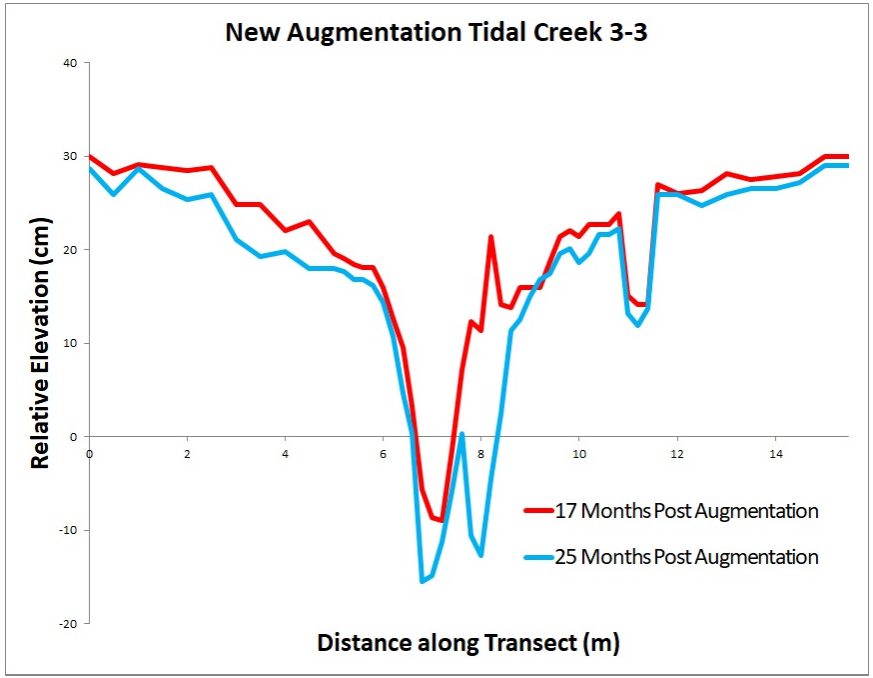
Sediment control structures

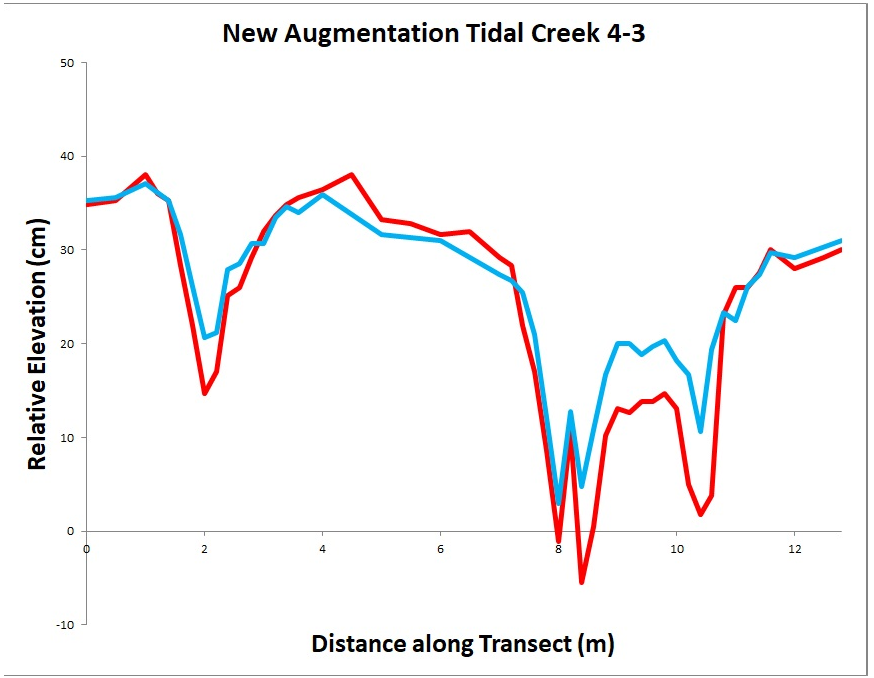
- Hay bales and sand bags placed a tidal creek mouths to minimize sediment leaving site
  - Remained in place after sediment addition
  - Appear to have inhibited tidal creek formation
- Control structures are being removed in phases to evaluate effect on tidal creek formation

New tidal creek cross sections



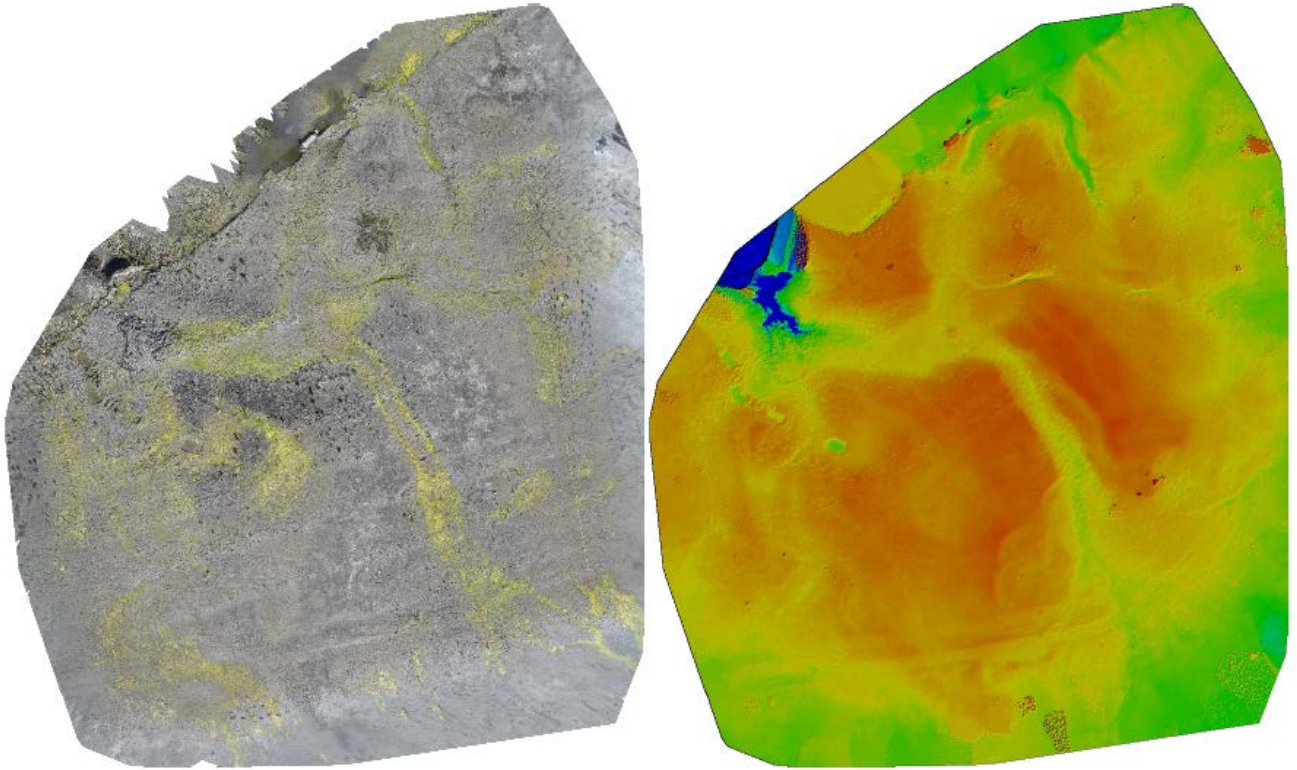
Tidal creek profiles 6 months after control structure removal





“Aerial” surveys of tidal creek formation

Orthomosaic and Digital Surface Model



Conclusions

- Sediment depth did not change as much as expected during first year
  - Some areas actually increased in depth after sediment addition
- Little change in sediment characteristics
- Tidal creeks not re-establishing themselves (yet)
  - Sediment control structures may have reduced tidal flow, inhibiting creek formation, but even after removal there has been little development of tidal creeks

Added sediment was sandier than expected

Acknowledgments

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