Fate of Soil Carbon after Wetland Submergence:
Observations and Reflections

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INTERNATIONAL BLUE CARBON SCIENTIFIC WORKING GROUP
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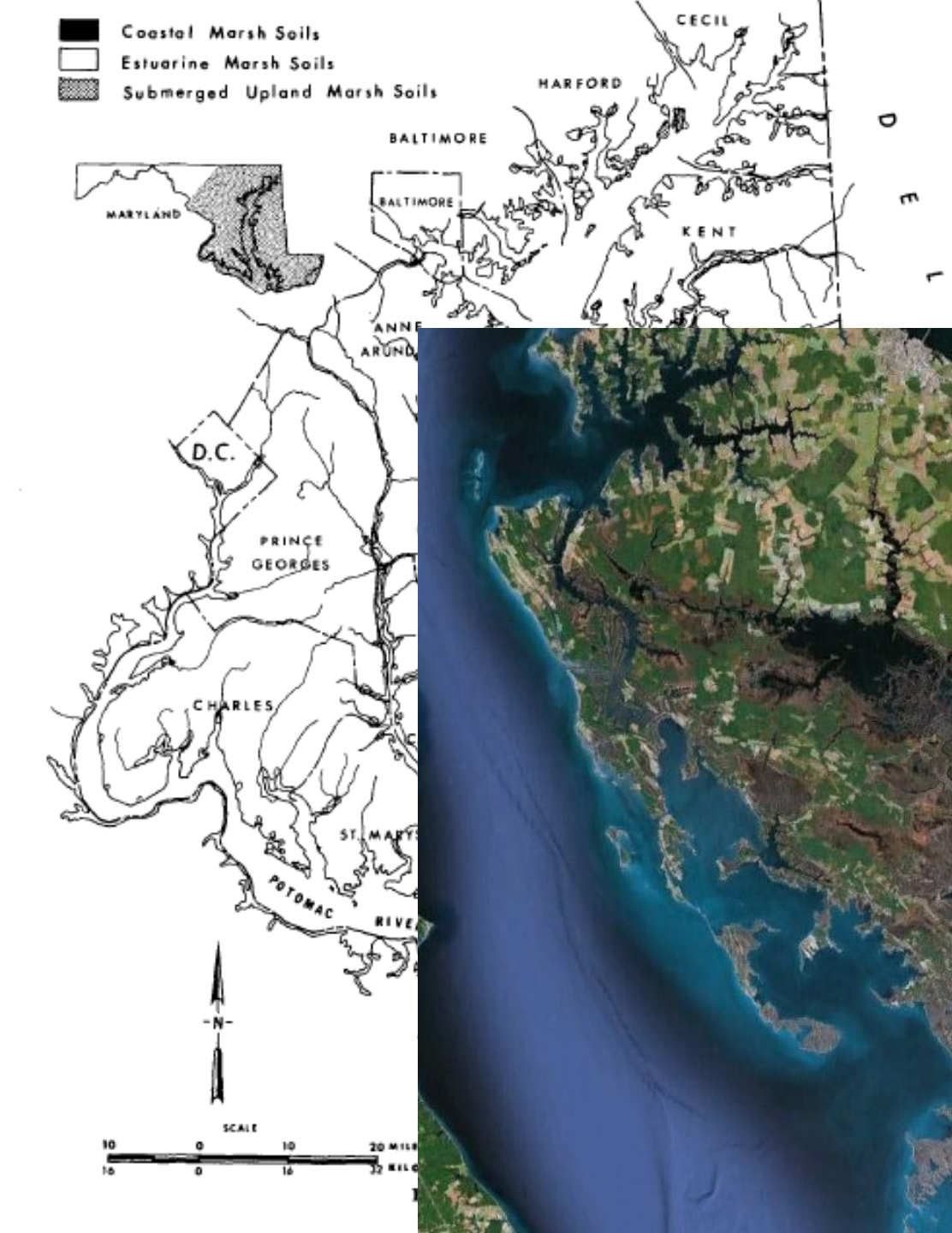
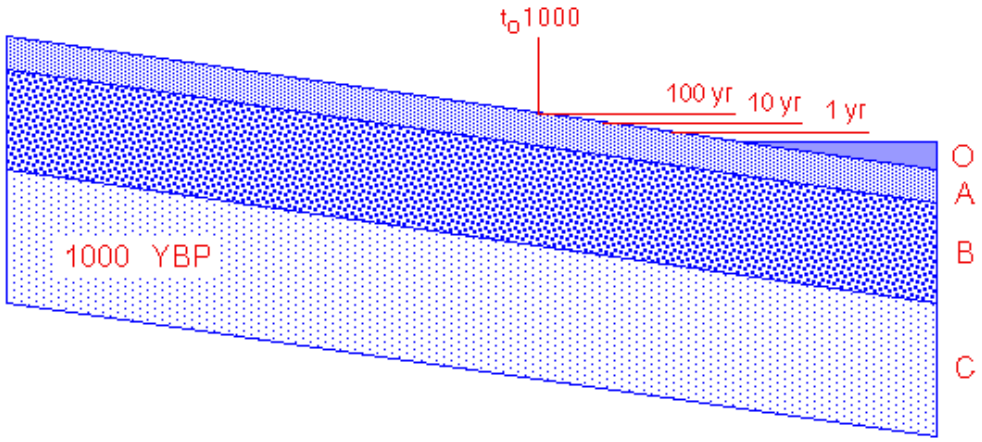
DEPARTMENT OF ENVIRONMENTAL SCIENCE & TECHNOLOGY
College of Agriculture & Natural Resources

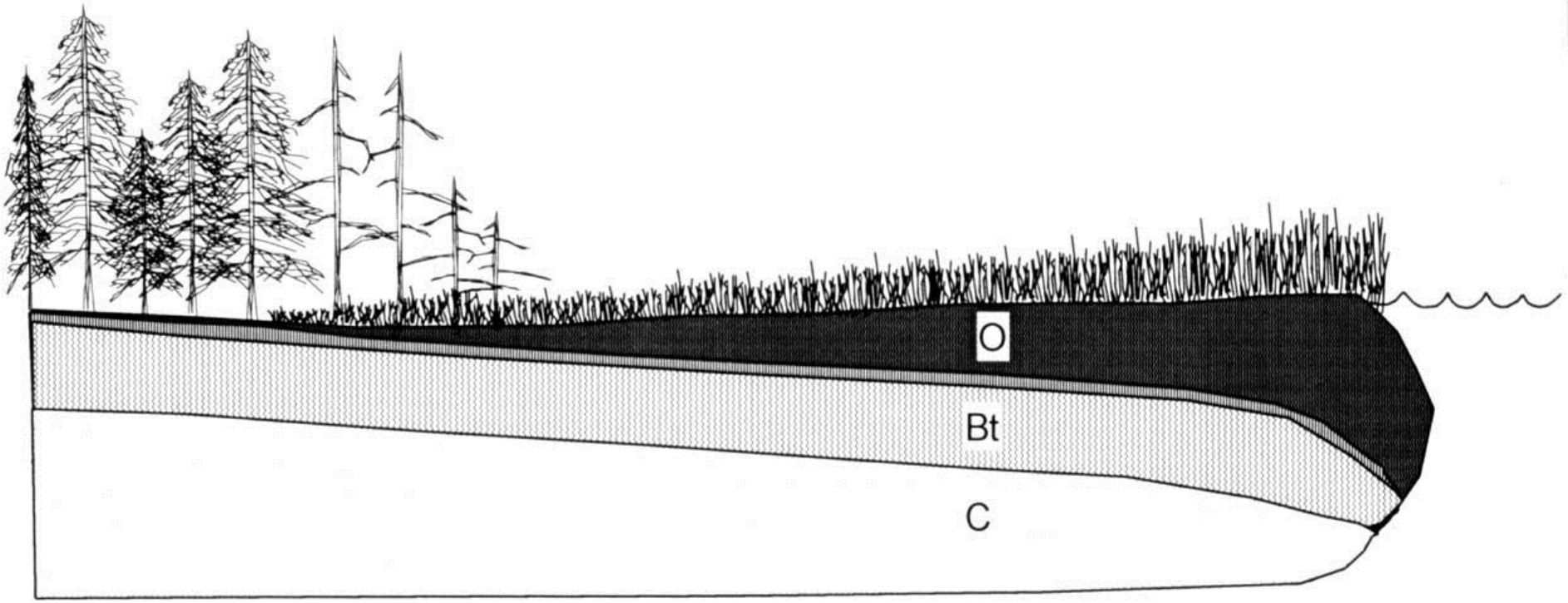
www.enst.umd.edu



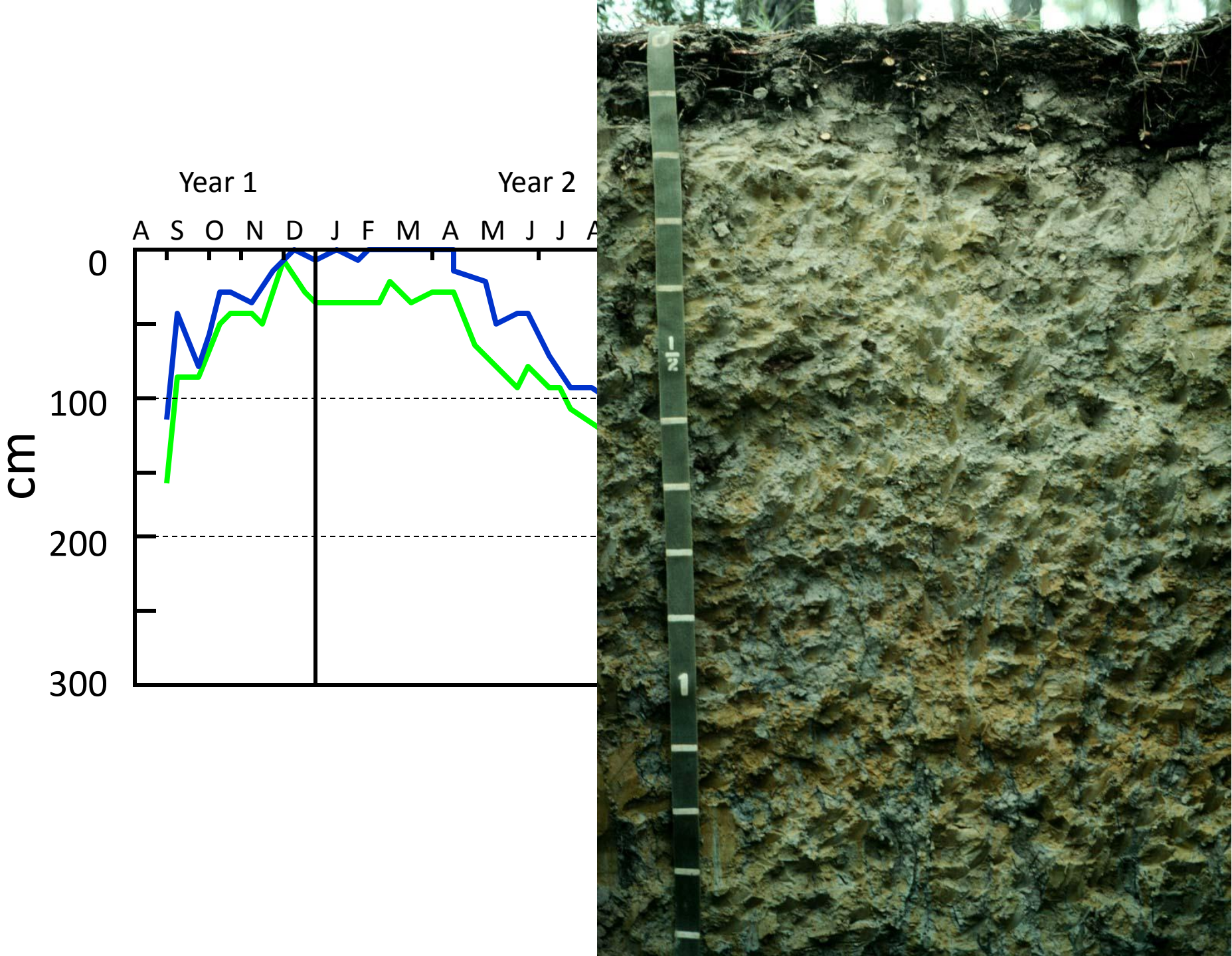
Darmody, R.G. and J.E. Foss. 1979. Landscapes of tidal marsh areas in Maryland. Soil Sci. Soc. Am. J. 43:534-541.

Submerging Environments - Continuum in Space is a surrogate for a continuum in Time



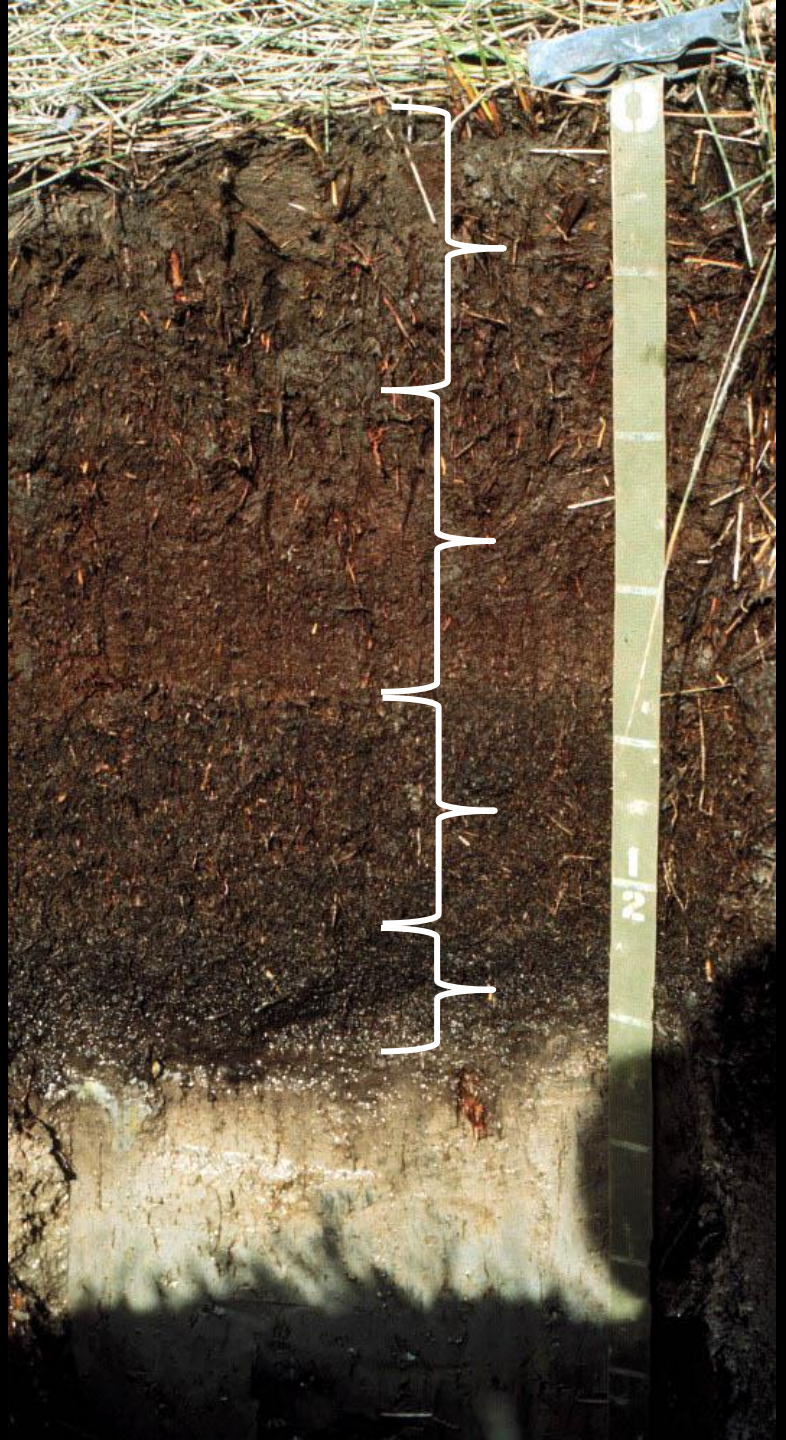


Submerged Upland Marsh

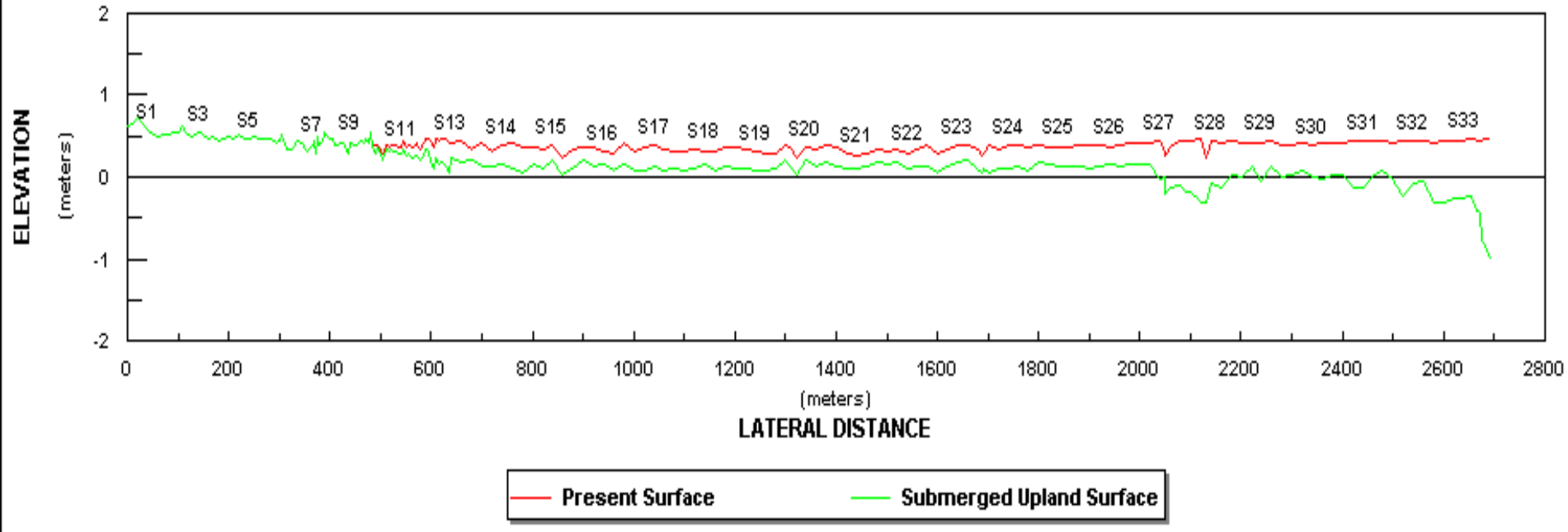

Year 1
Year 2
A S O N D J F M A M J J A
0
100
200
300
cm


20
40
60
80
1

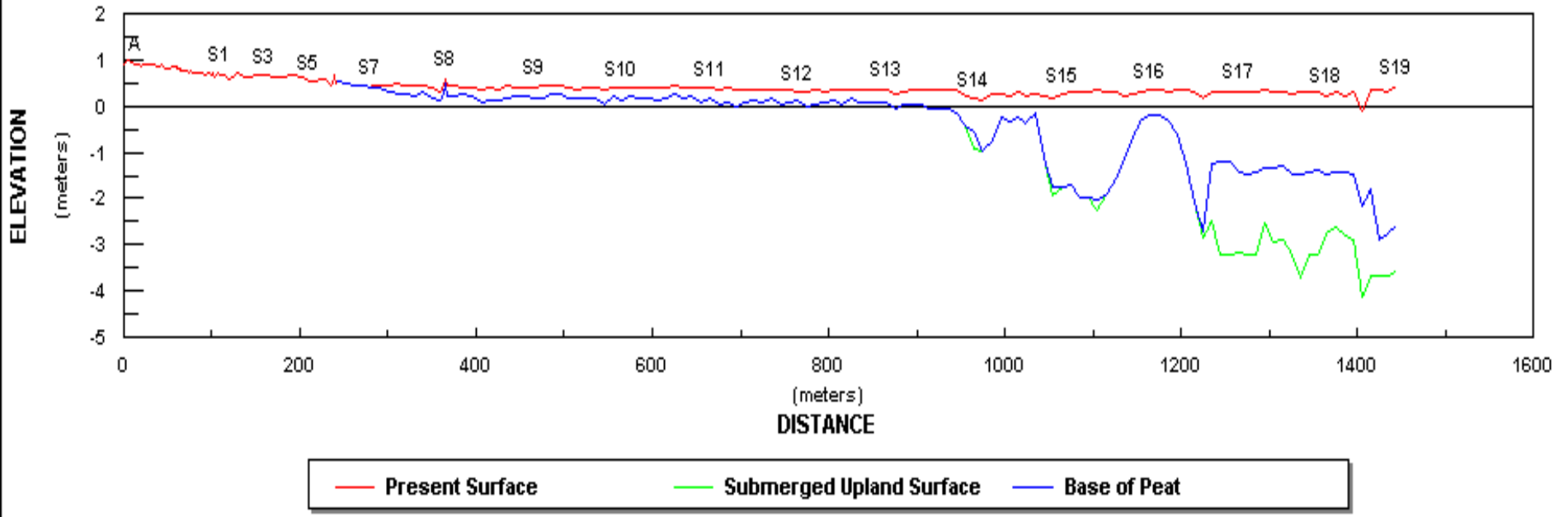

0
1
2

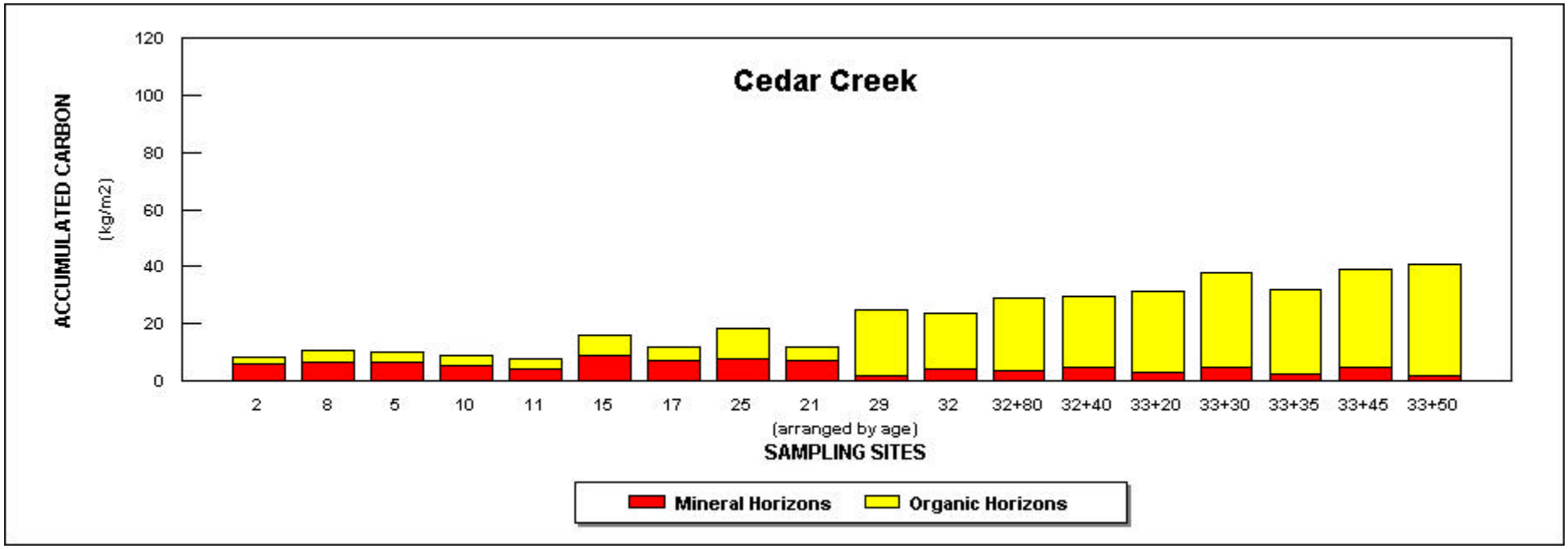

0
1
2

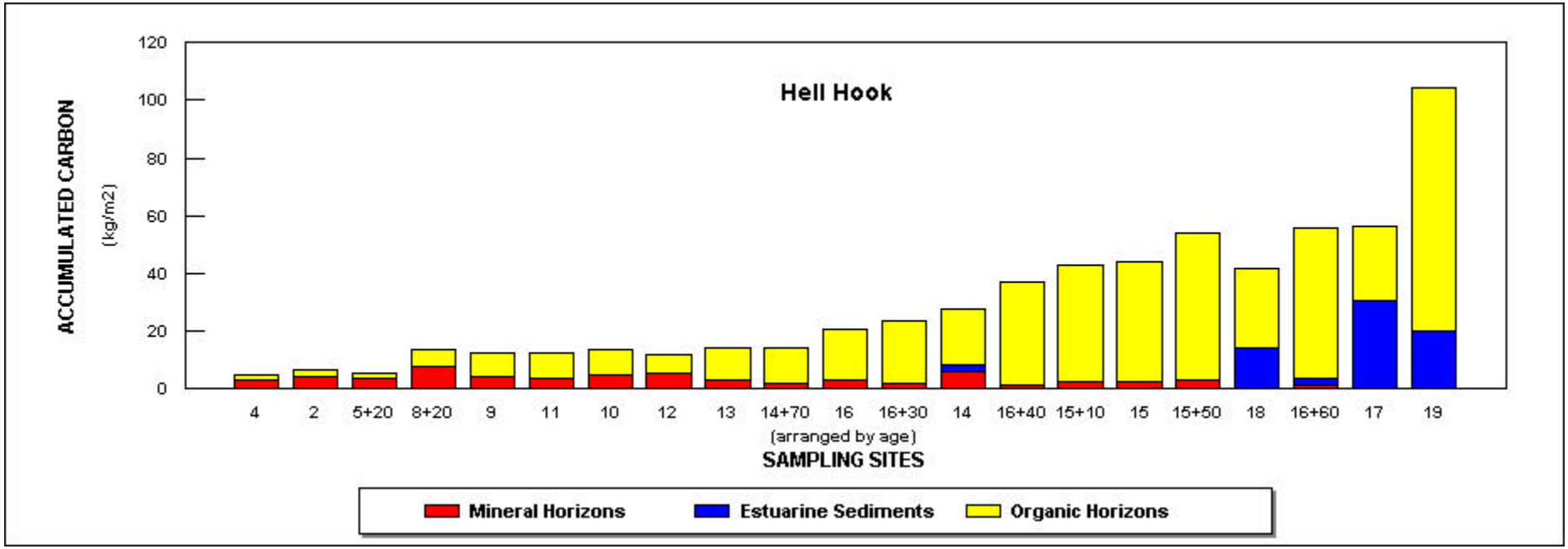
Cedar Creek Marsh Transect



Hell Hook Marsh Transect

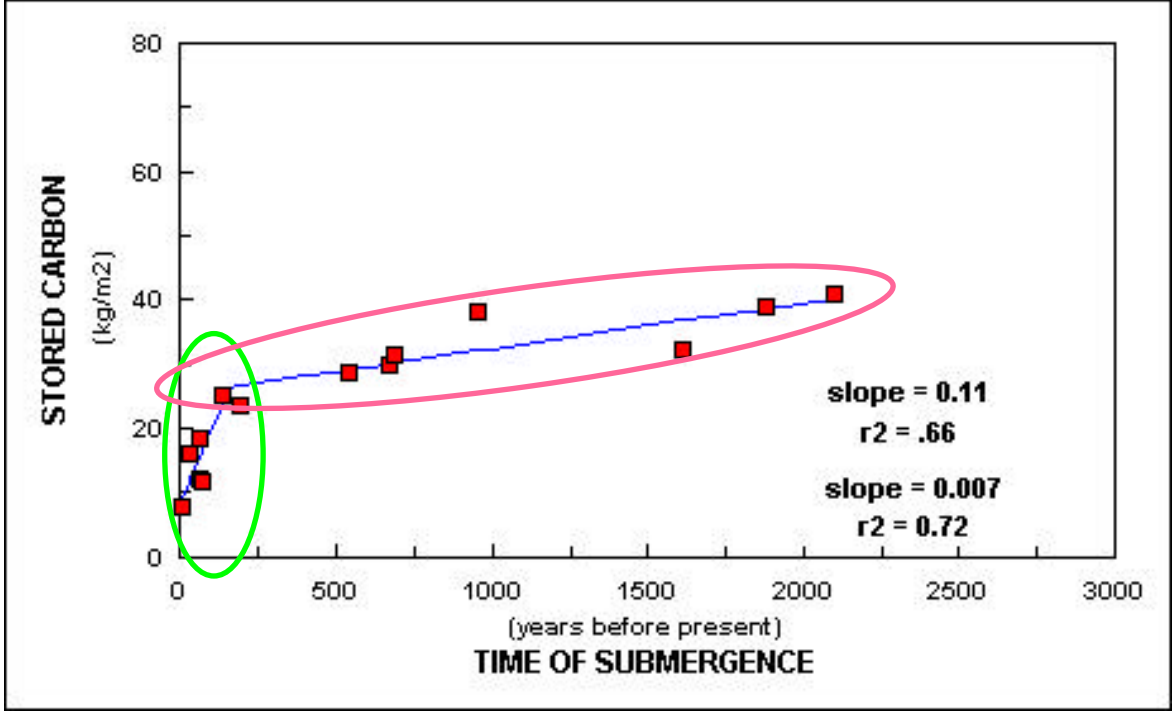



Cedar Creek
ACCUMULATED CARBON
(kg/m2)
120
100
80
60
40
20
0
2
8
5
10
11
15
17
25
21
29
32
32+80
32+40
33+20
33+30
33+35
33+45
33+50
(arranged by age)
SAMPLING SITES
Mineral Horizons
Organic Horizons


Hell Hook
ACCUMULATED CARBON
(kg/m2)
120
100
80
60
40
20
0
4
2
5+20
8+20
9
11
10
12
13
14+70
16
16+30
14
16+40
15+10
15
15+50
18
16+60
17
19
(arranged by age)
SAMPLING SITES
Mineral Horizons
Estuarine Sediments
Organic Horizons

1st century or two

50 to 110 g C m^{-2} yr^{-1}

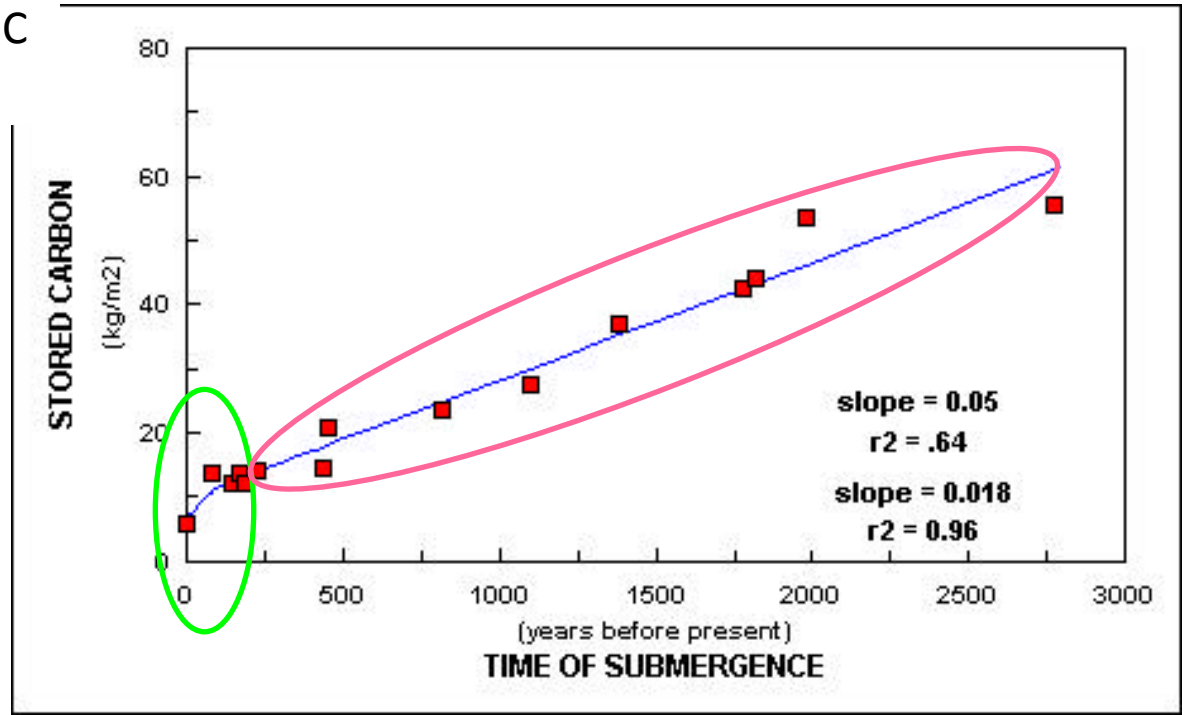


Long term rate

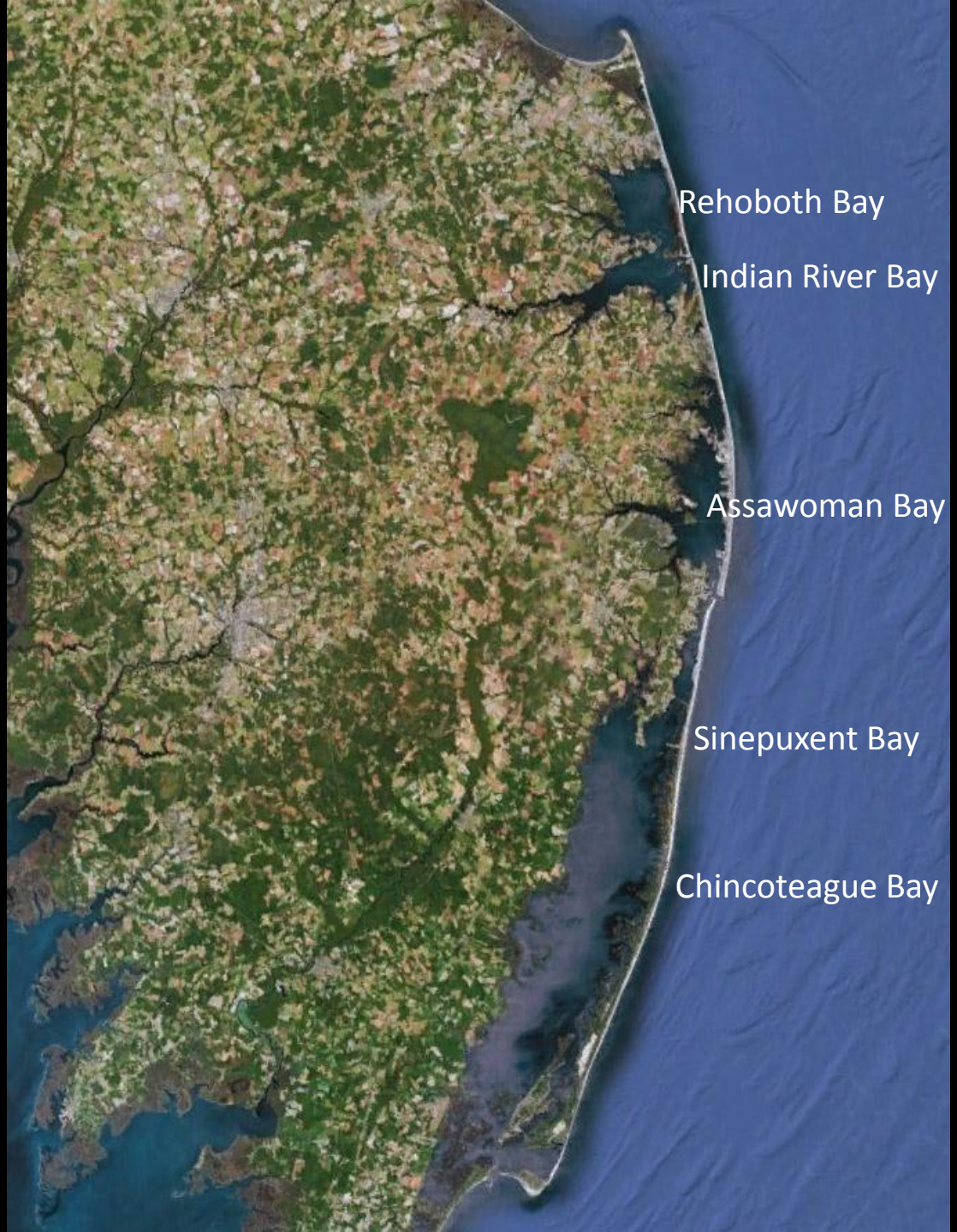
7 to 18 g C m^{-2} yr^{-1}

0.07 to 0.18 Mg C Ha^{-1} yr^{-1}

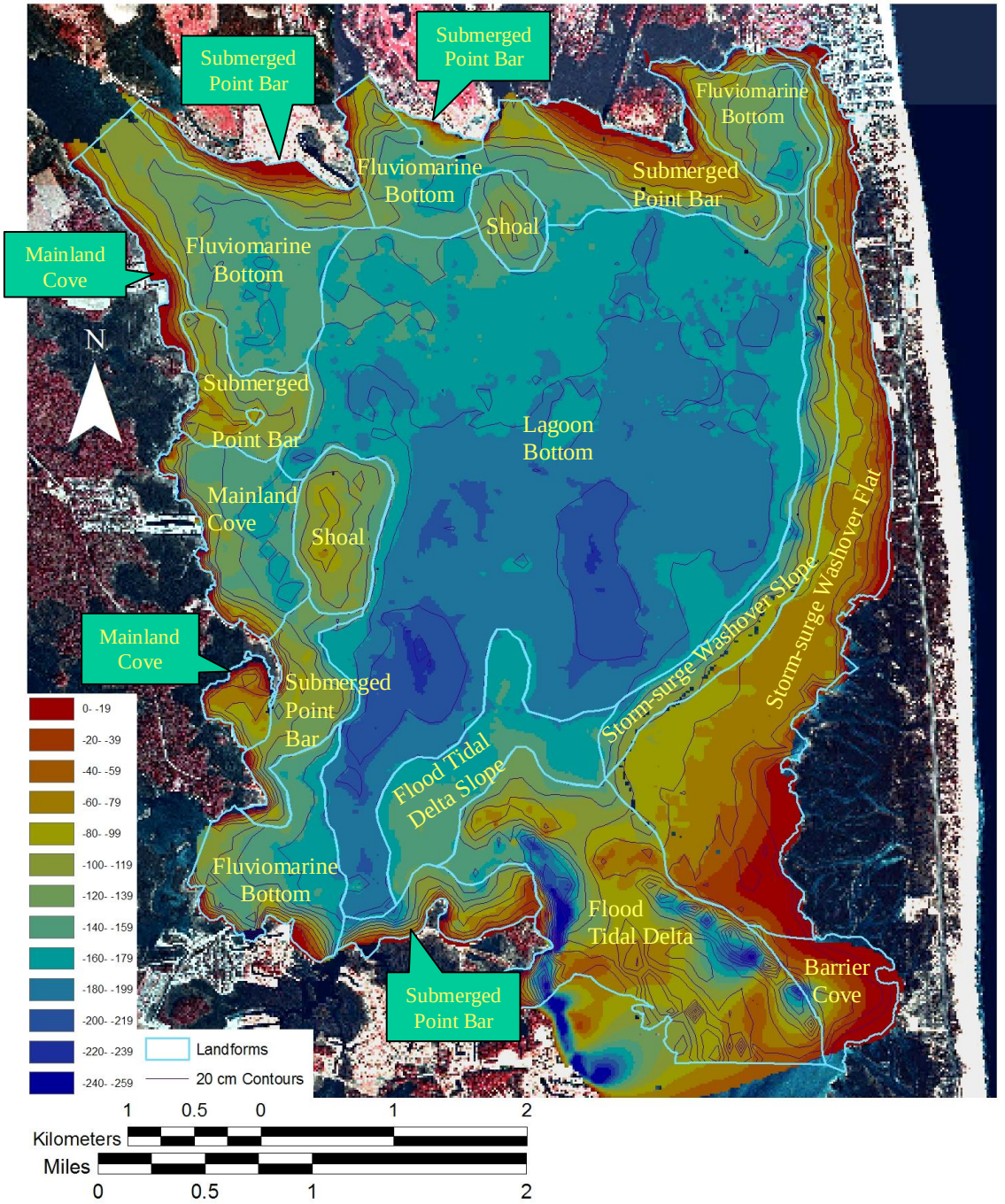
0.5 to 1.1 Mg C Ha^{-1} yr^{-1}



Buried carbon appears to become stabilized. Decomposition rate appears to be quite slow.

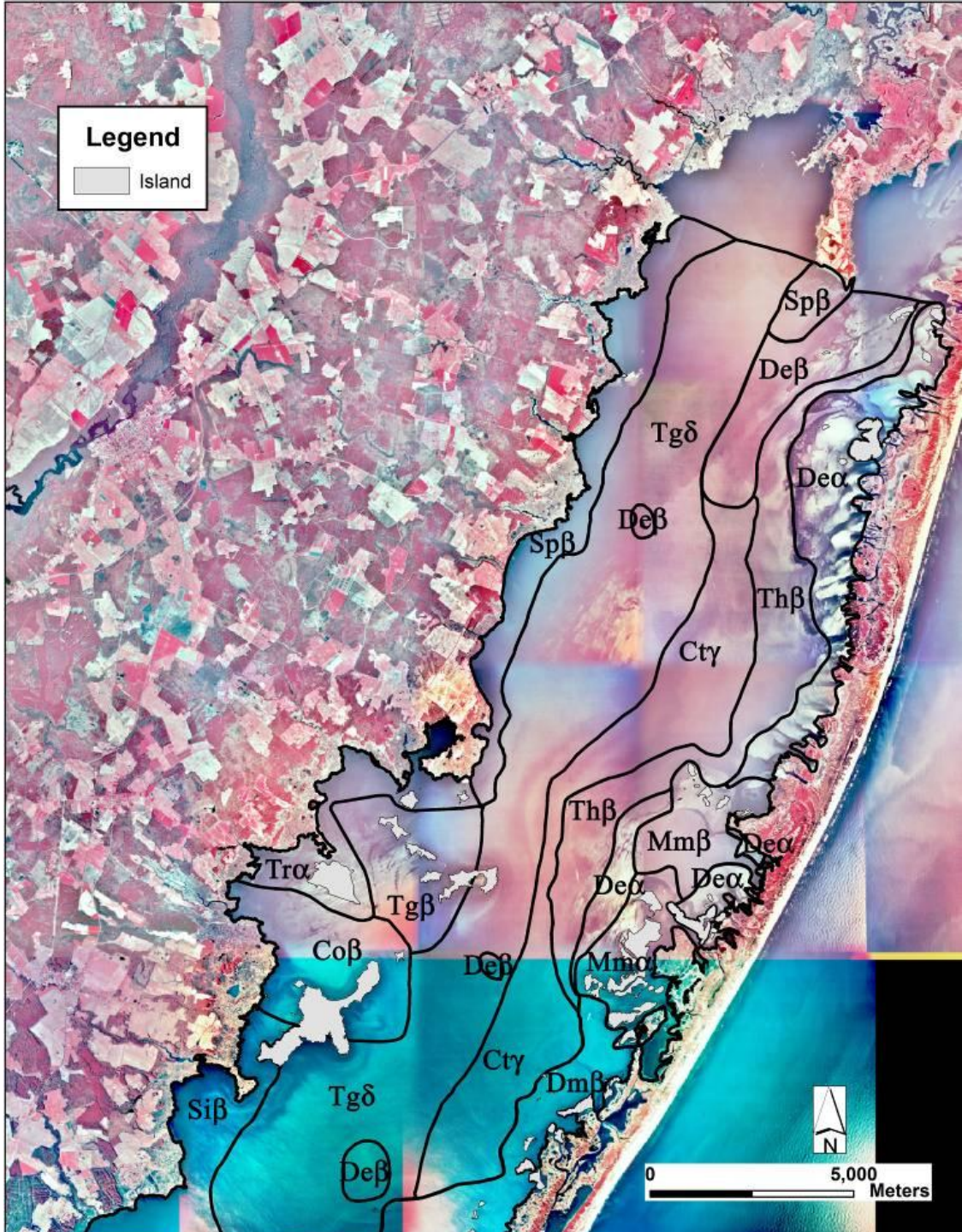

Rehoboth Bay
Indian River Bay
Assawoman Bay
Sinepuxent Bay
Chincoteague Bay

Rehoboth Bay, DE
1100 Ha Tidal Marsh
3300 Ha Subaqueous Soils



Soil Map Chincoteage Bay

Sp – Southpoint map unit



LOCATION SOUTHPOINT MD

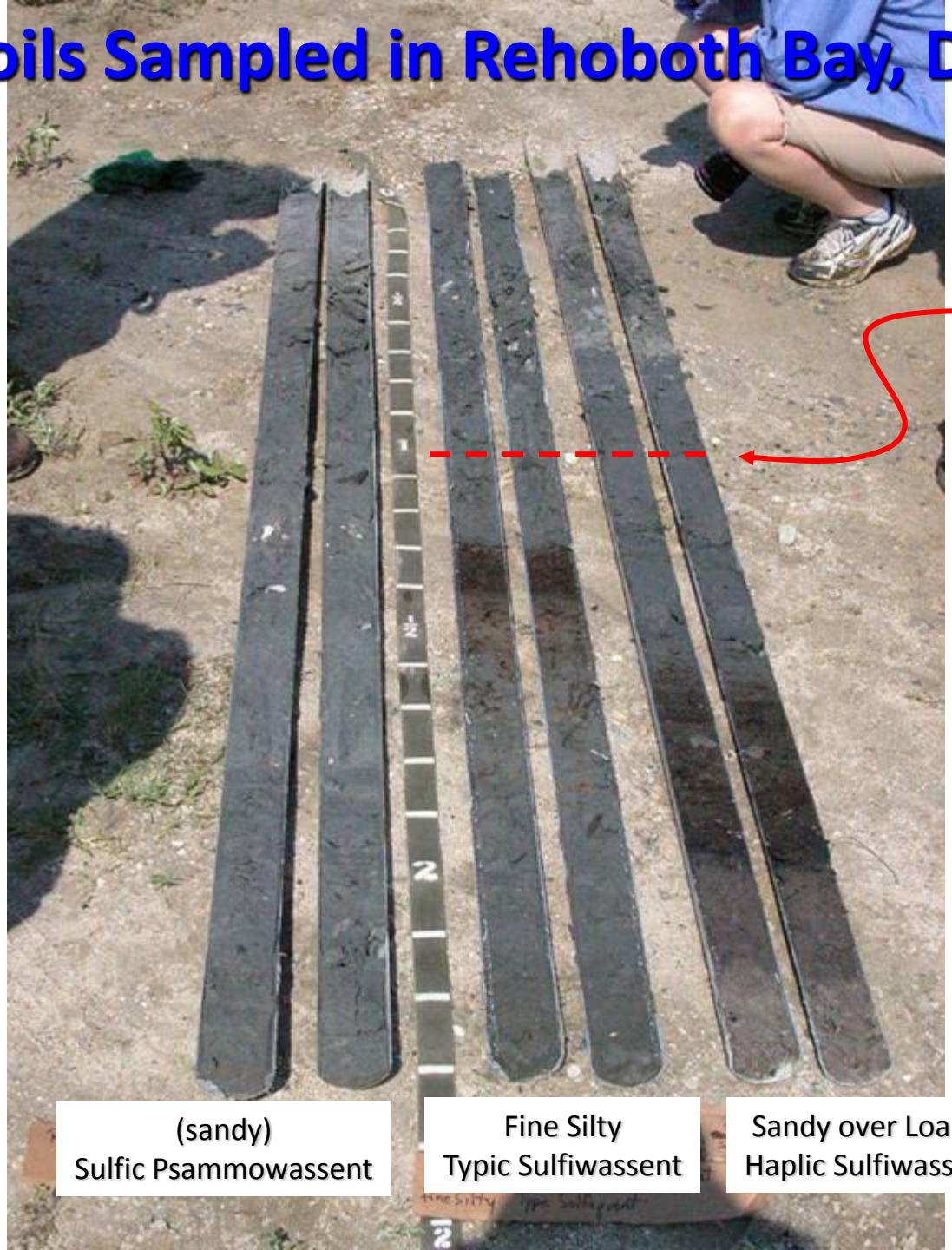
Tentative Series GPD 11/2002 **SOUTHPOINT SERIES**

- MLRA(s): 153C, 153D
MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Raleigh, North Carolina
TAXONOMIC CLASS: Fine-silty, mixed, subactive, nonacid, mesic Thapto-histic Sulfaquents (now **Thapto-histic Sulfiwassents**)

- **TYPICAL PEDON:** Southpoint sand on a smooth 0.5 percent slope in a deep mainland cove under 4.2 feet of permanent estuarine water. (Colors are for moist soil.)
- **Ag**--0 to 2 inches; black (N 2.5/0) sand; single grain; loose; 5 percent, by volume black (10YR 2/1) organic fragments; moderately alkaline; strongly saline; abrupt smooth boundary. (1 to 5 inches thick)
- **Cg1**--2 to 4 inches; very dark gray (5Y 3/1) loam; single grain; loose; moderately alkaline; strongly saline; abrupt smooth boundary. (0 to 9 inches thick)
- **2Cg2**--4 to 9 inches; dark olive gray (5Y 3/2) silty clay; massive; firm; n-value 1.0, material flows easily between fingers when squeezed; slightly alkaline; strongly saline; clear smooth boundary.
- **2Cg3**--9 to 22 inches; dark bluish gray (10B 4/1) silty clay loam; massive; firm; n-value 1.0, material flows easily between fingers when squeezed; slightly alkaline; strongly saline; clear smooth boundary.
- **2Cg4**--22 to 36 inches; olive gray (5Y 4/2) silty clay; massive; firm; n-value 1.0, material flows easily between fingers when squeezed; slightly alkaline; strongly saline; clear smooth boundary. (24 to 38 inches thick)
- **Oeb**--36 to 48 inches; dark brown (7.5YR 3/2) mucky peat; hemic soil material, 50 percent, by volume rubbed fiber; 20 percent, by volume light olive brown (2.5Y 5/4) organic fragments; slightly alkaline; strongly saline; gradual smooth boundary.
- **Oab**--48 to 60 inches; black (N 2.5/0) muck; sapric soil material, 10 percent, by volume rubbed fiber; slightly alkaline; strongly saline. (Combined thickness of the O horizon is 8 or more inches thick.)
- **TYPE LOCATION:** Worcester County, Maryland; approximately 1.2 miles north of South Point along the mainland, 100 feet east of the mainland, Sinepuxent Bay, in an unvegetated area; lat. 38 degrees, 13 minutes, 54.48 seconds N. and long. 75 degrees, 10 minutes, 51.96 seconds W.

https://soilseries.sc.egov.usda.gov/osdname.asp

Soils Sampled in Rehoboth Bay, DE

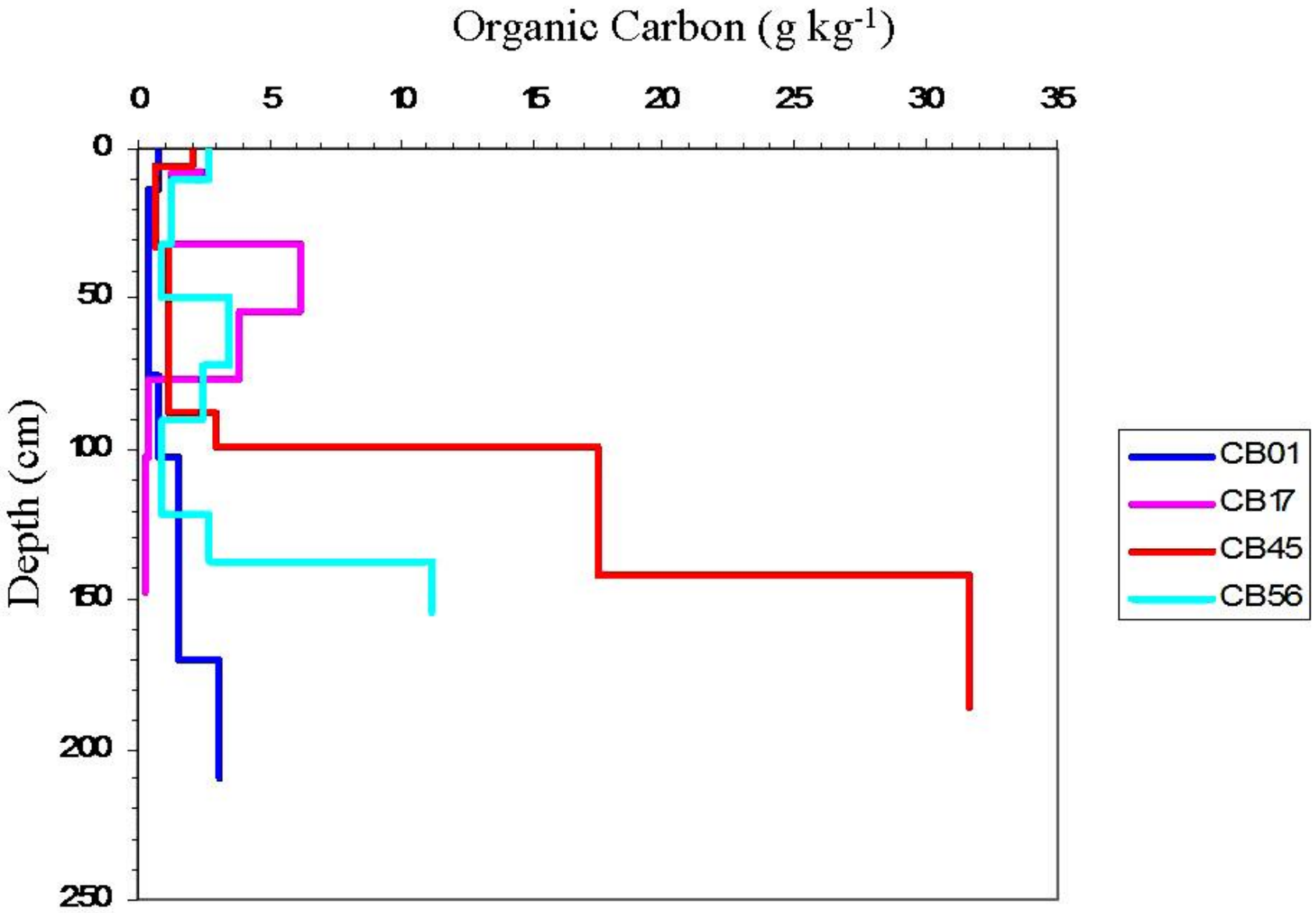


Thapto-histic Sulfiwassent
If buried O horizon starts within 100 cm

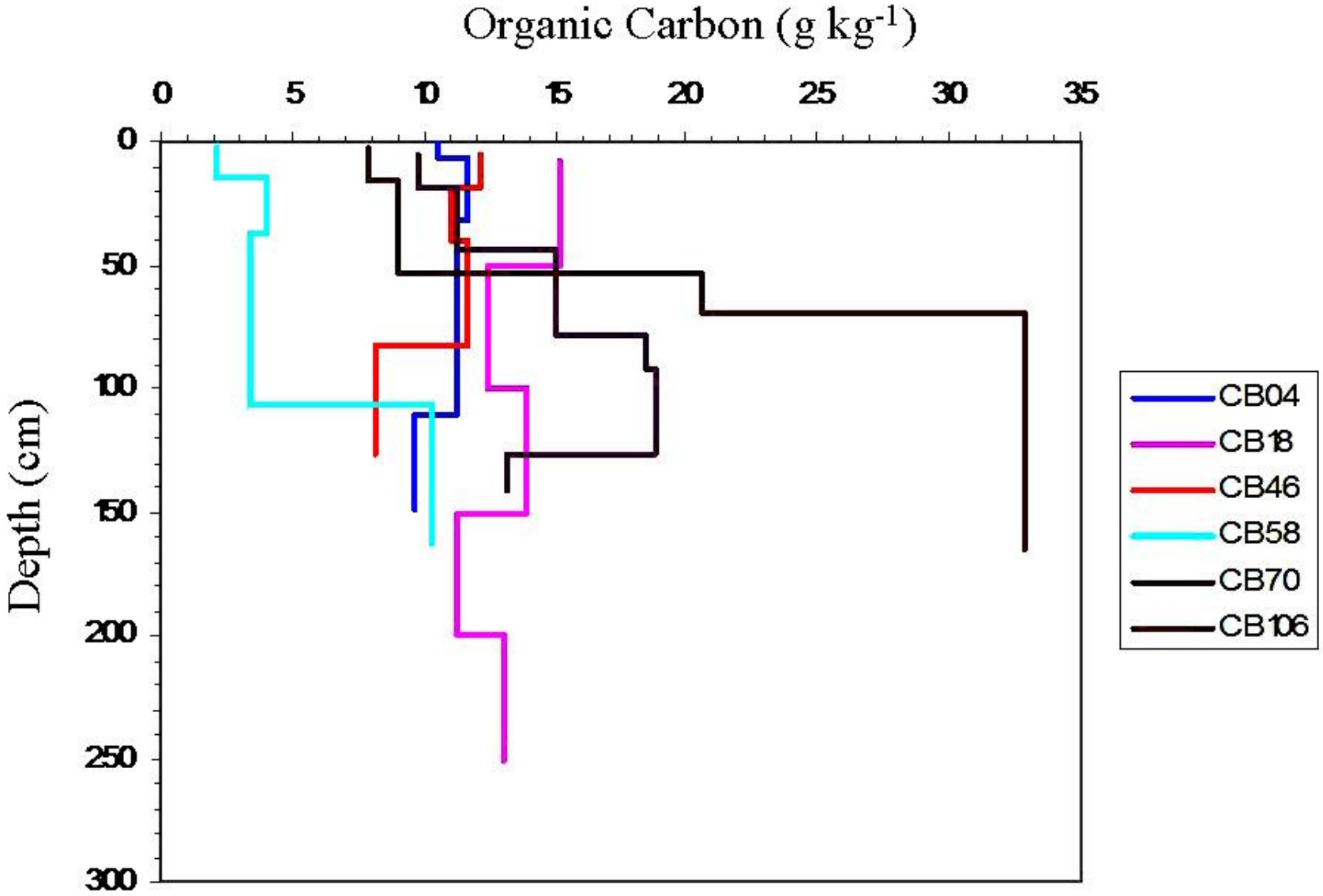
(sandy)
Sulfic Psammowassent

Fine Silty
Typic Sulfiwassent

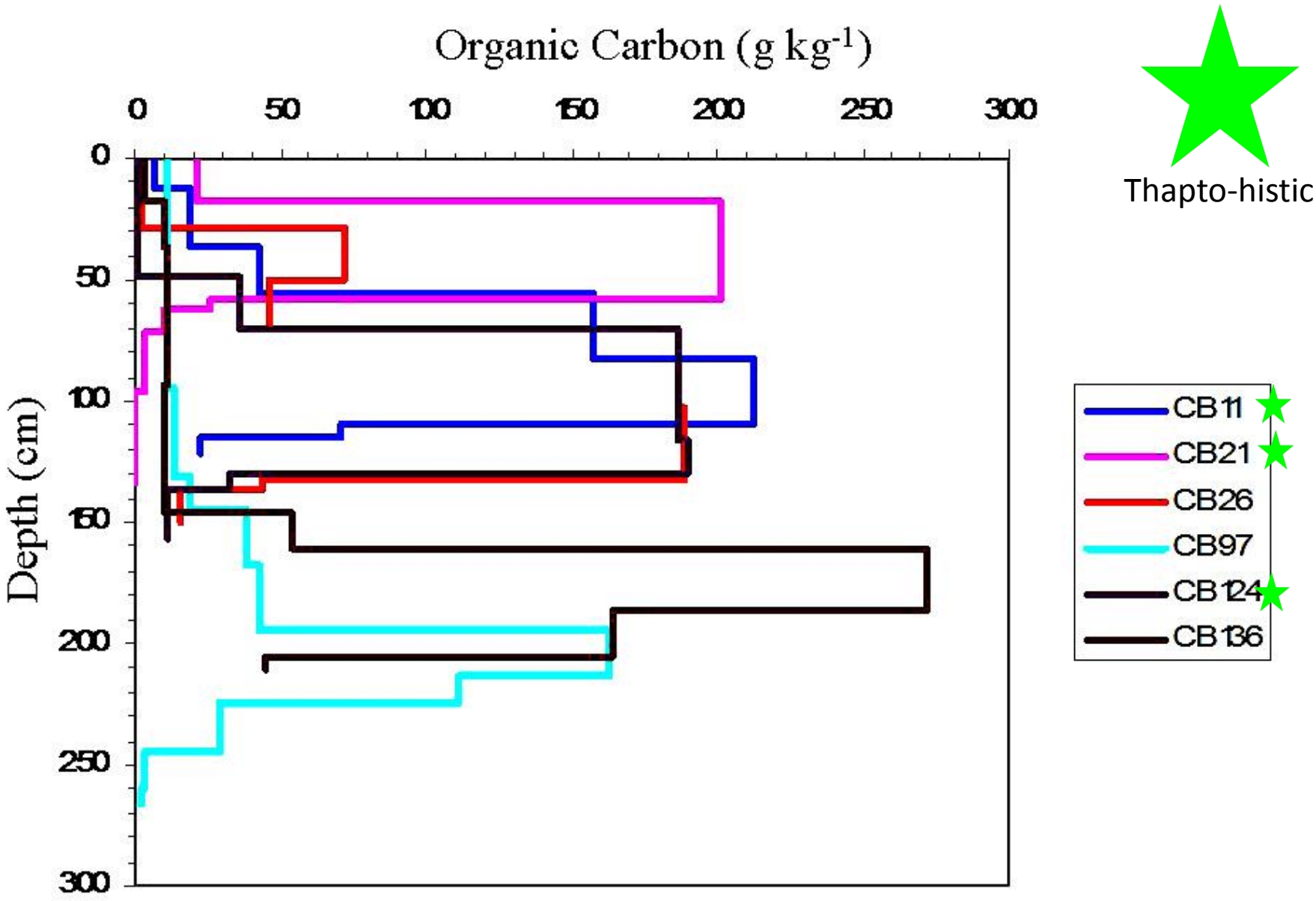
Sandy over Loamy
Haplic Sulfiwassent



Soils located on the Storm-surge washover fan flats



Soils located on the lagoon bottom



Thapto-histic

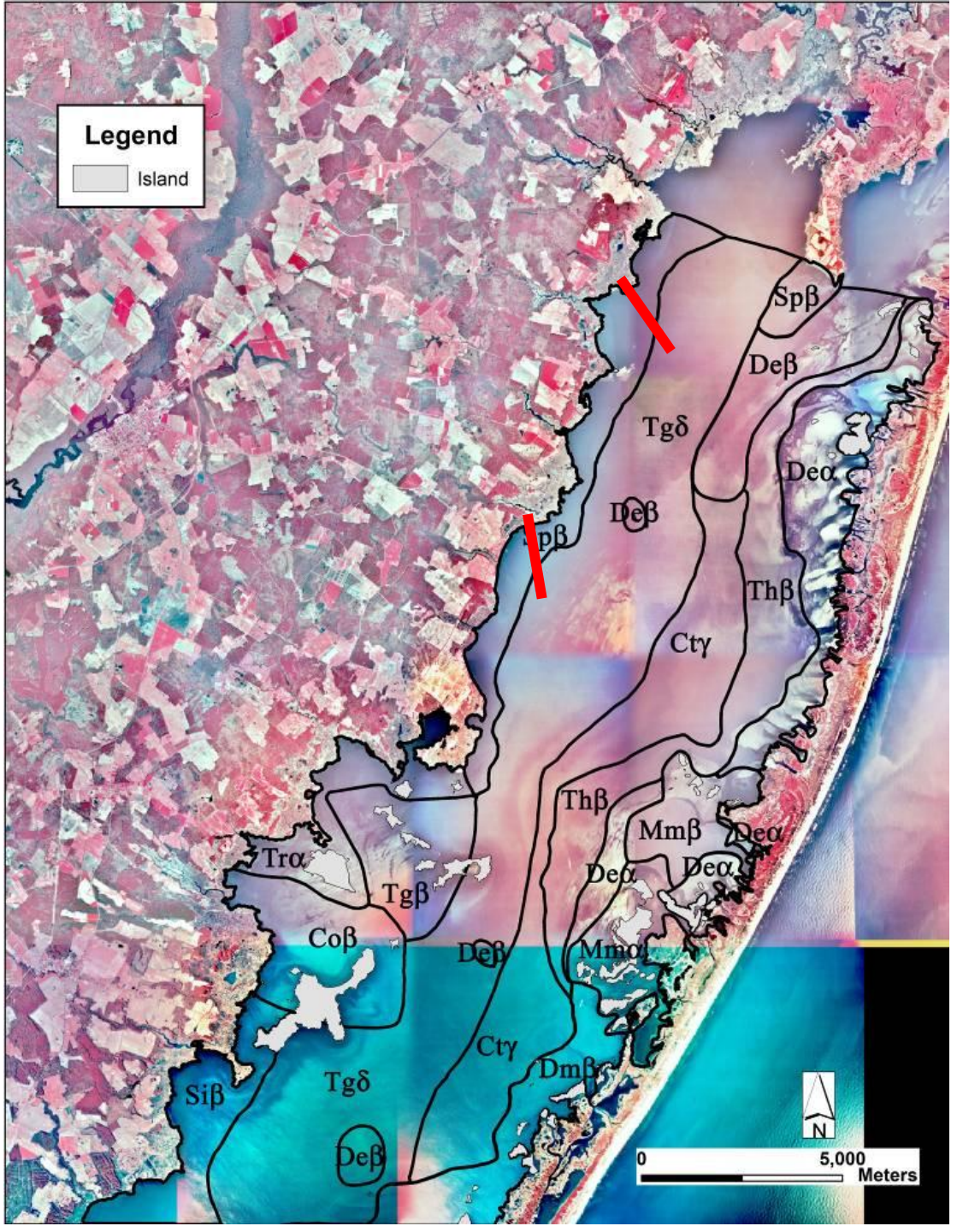
Soils located in the mainland coves, submerged wave-cut headlands, and lagoon bottom that contain buried organic horizons

Organic Carbon Stored in upper 1m of Subaqueous Soils

	N	Avg. OC contents kg m^{-2} to a depth of 1m	Range of OC contents kg m^{-2} to a depth of 1m
Storm-surge washover fan flat	4	2.2	0.7-3.5
Storm-surge washover fan slope	2	2.8	2.1-3.4
Paleo-Flood Tidal Delta	1	3.6	
Barrier Cove	3	9.8	4.0-16.8
Shoal	1	15.6	
Lagoon Bottom	18	12.3	3.5-21.7
Fluviomarine Bottom	6	9.0	4.5-10.7
Mainland Cove	10	7.5	5.2-10.6
Mainland Cove with buried organic horizons	1	34.2	
Submerged Wave-cut Headlands	3	8.8	7.4-10.6
Submerged Wave-cut Headlands with buried organic horizons	3	23.1	16.8-30.1

What is the source of the carbon? Some authigenic and some allogenic.

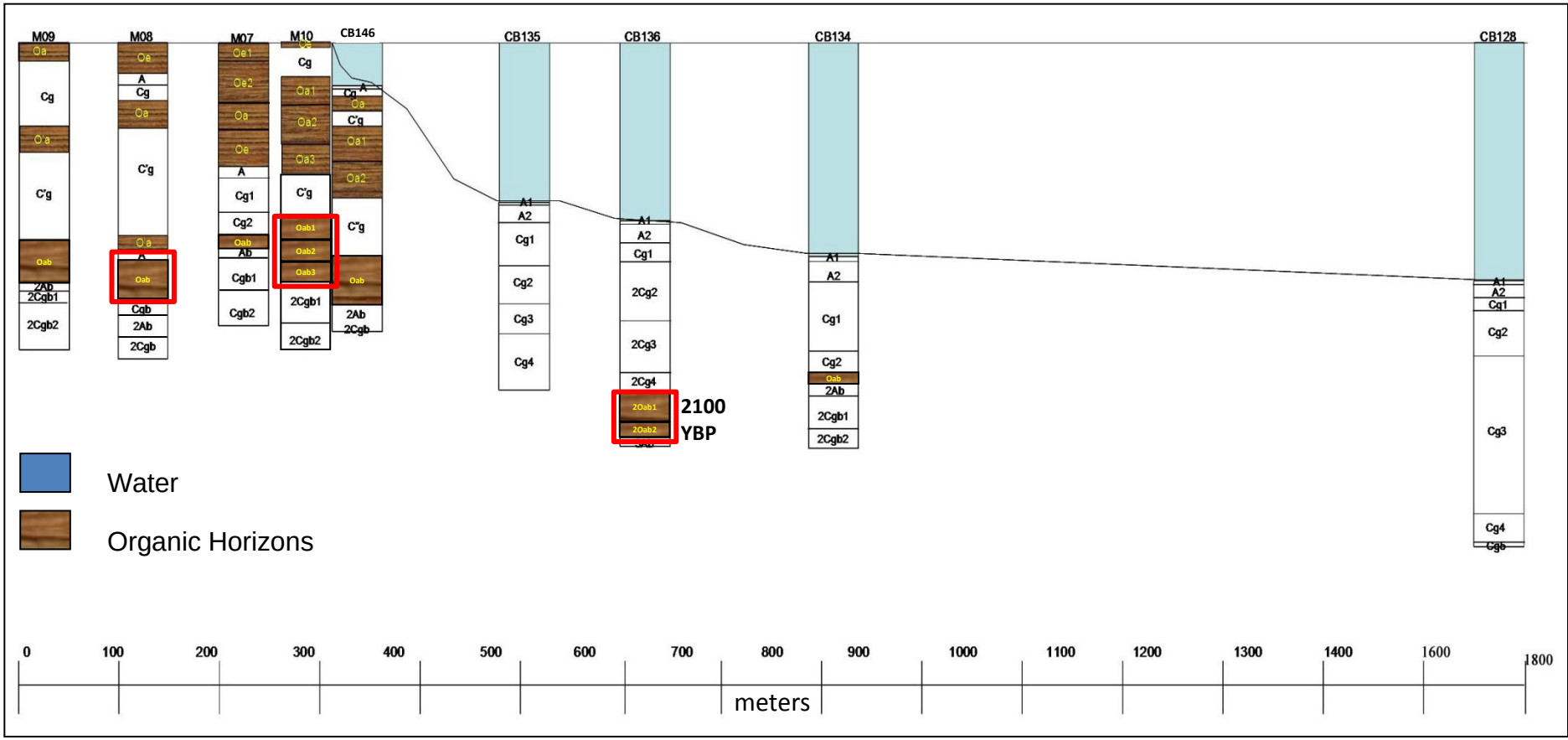
Transects across marsh and into Chincoteague Bay



22.1%
18.2%

10.7%
22.1%
30.5%

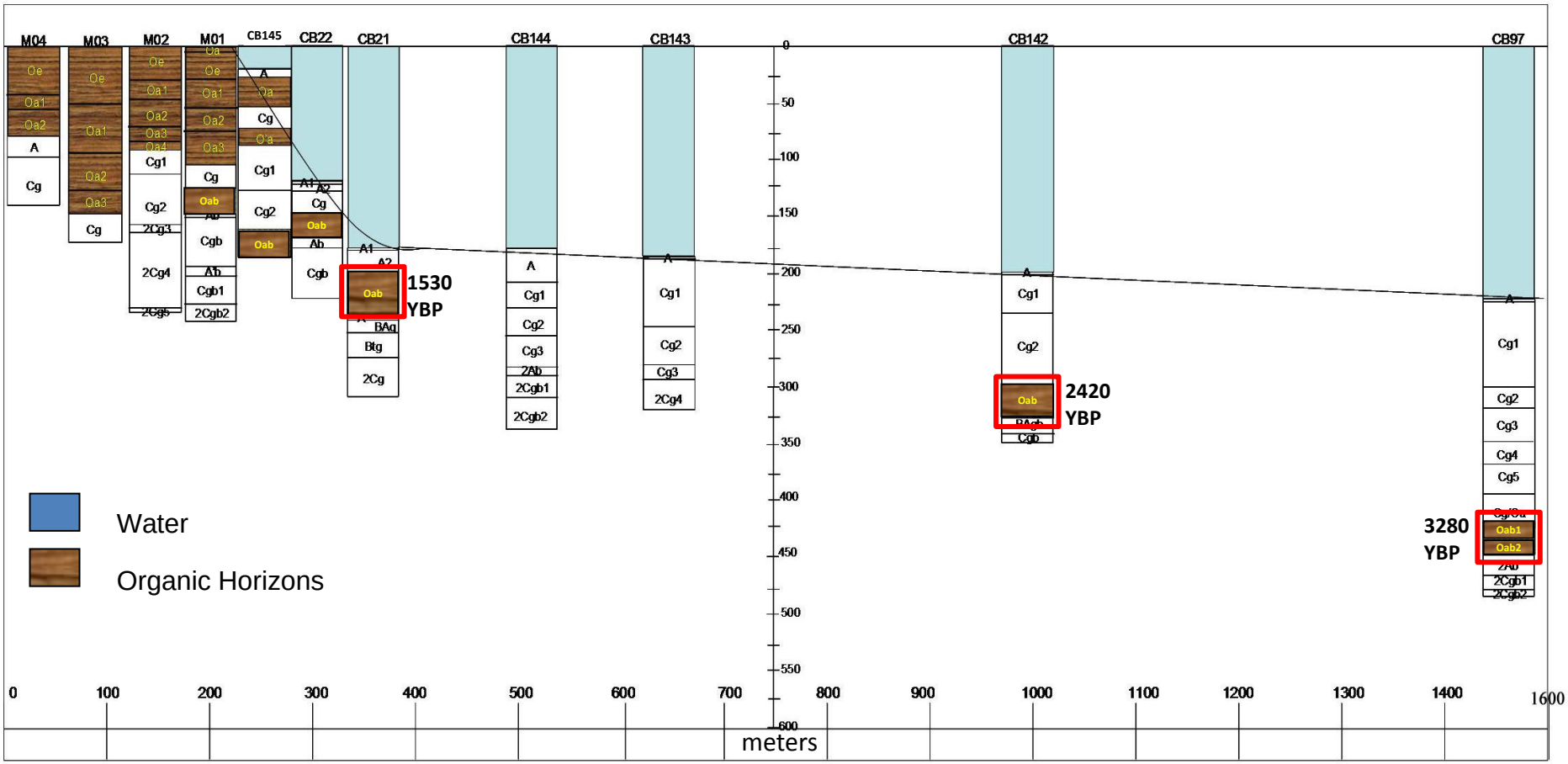
27.1%
16.4%



20.2%

23.1%

16.2%
11.1%



Long-Term Average Sea Level Rise: 1.25 mm yr^{-1}

Mean organic C content in upper meter is 13.6 kg m^{-2}

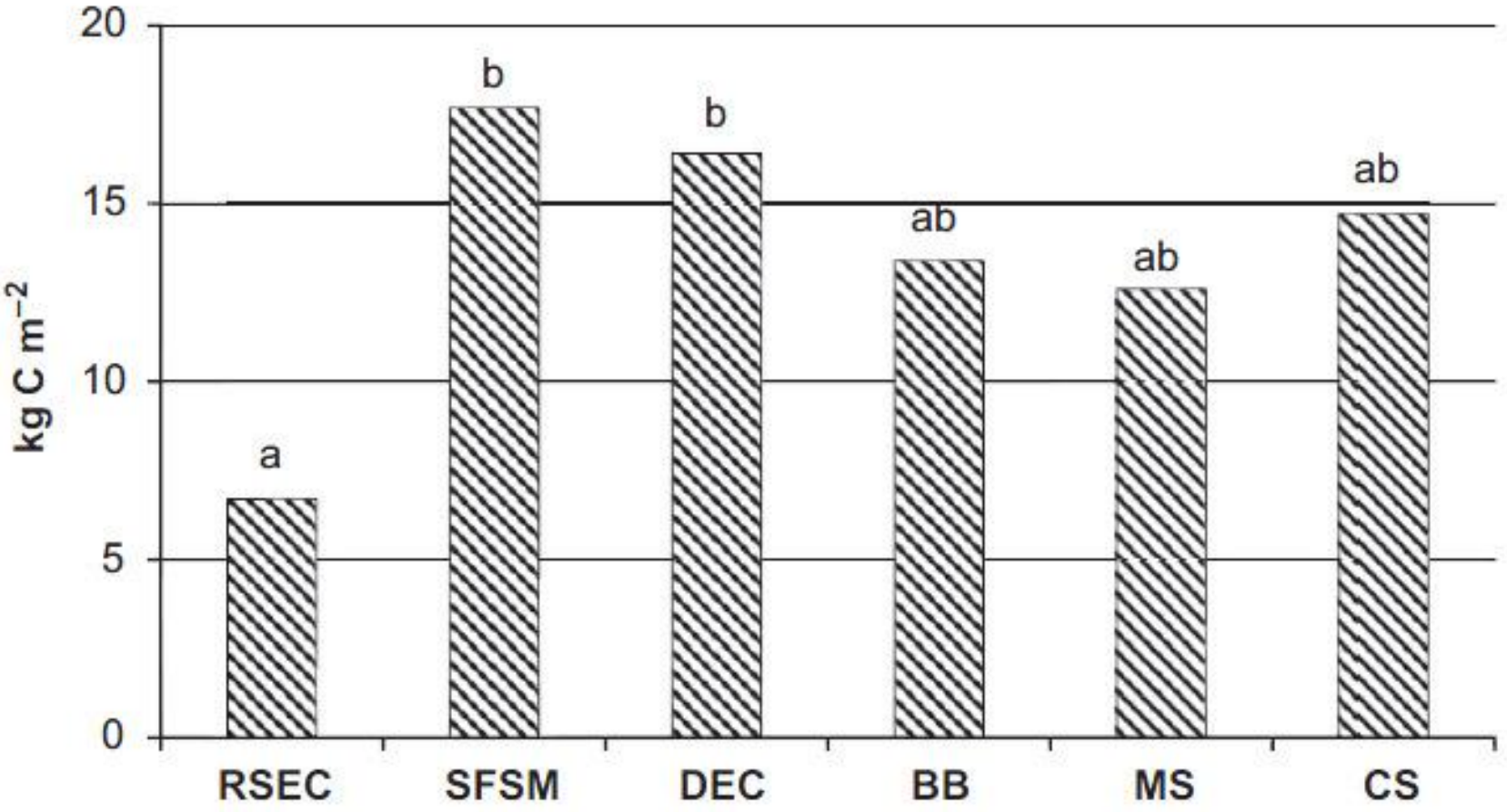
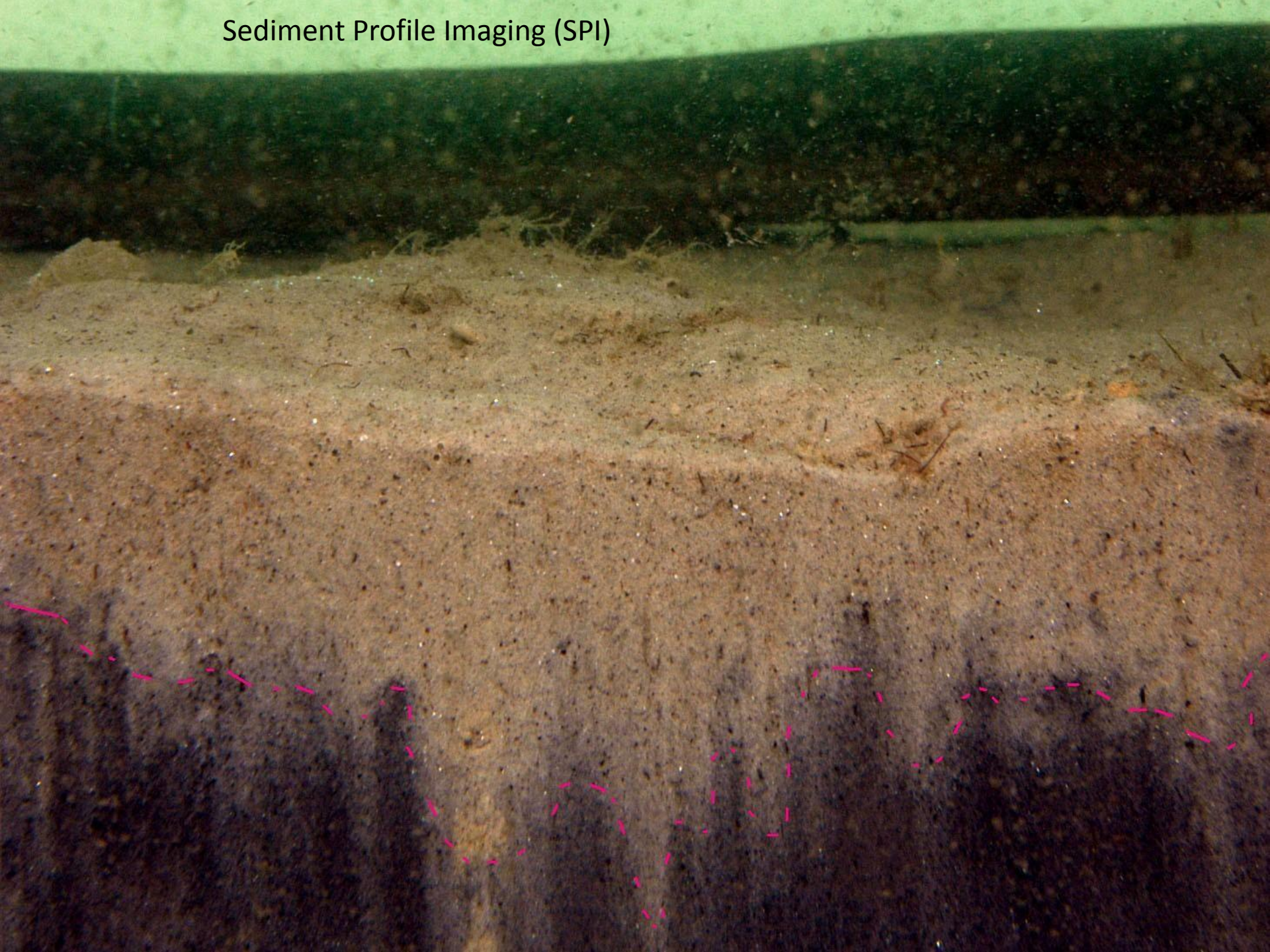


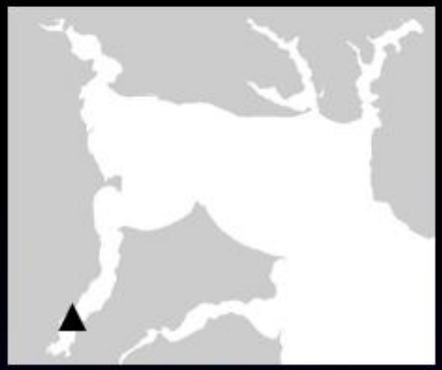
FIGURE 8 Organic C stored in various subaqueous soil map units in Taunton Bay, ME. Bars with the same letter indicate no significant difference at $\alpha = 0.05$. RSEC = Recently submerged edges and coves; SFSM = submerged fluvial streams and marshes; DEC = deep edge and cove; BB = bay bottom; MS = mussel shoal; CS = channel shoulder. *(Data from Jesperson and Osher, 2007)*

Jesperson, J. L. and L. J. Osher. 2007. Carbon Storage in the Soils of a Mesotidal Gulf of Maine Estuary. Soil Sci. Soc. Am. J. 71:372–379.

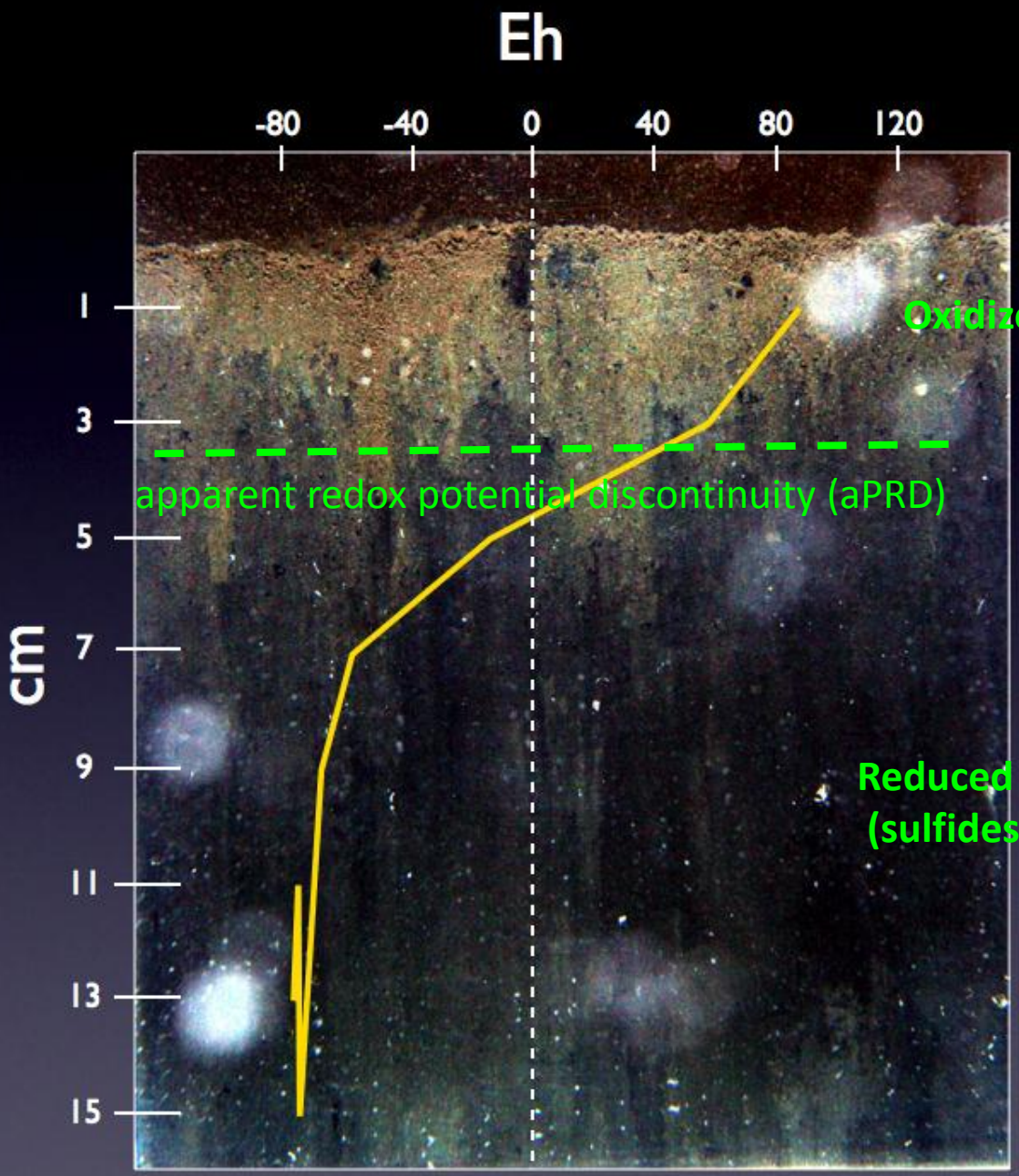
Sediment Profile Imaging (SPI)



Sediment Profile Imaging (SPI)



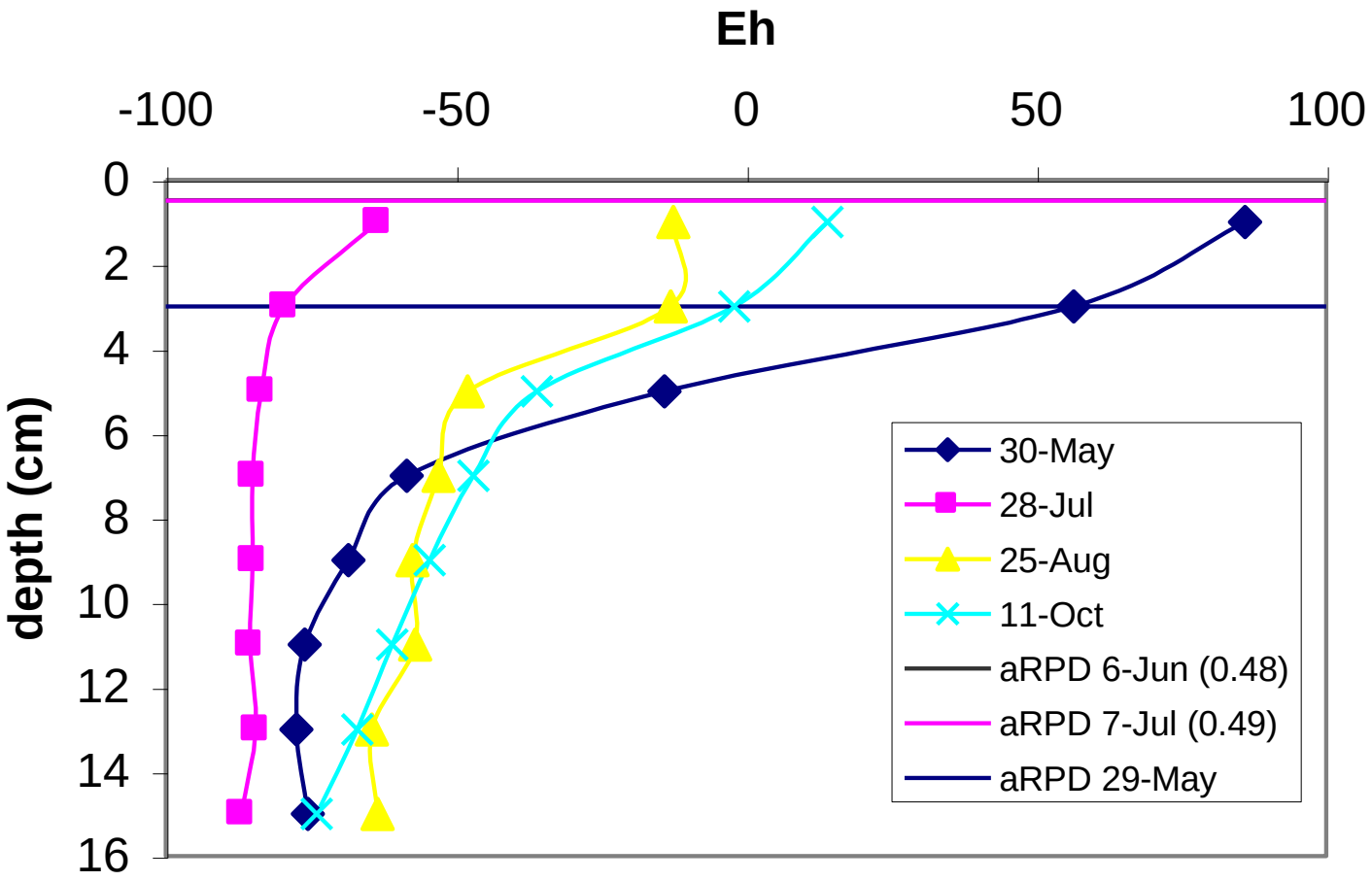
May 29/30



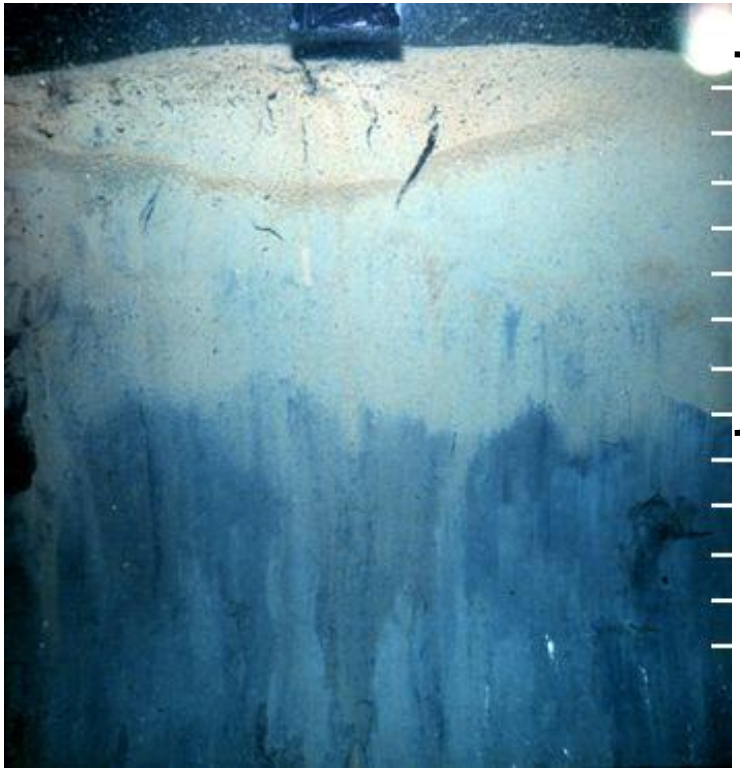
(From Payne, MS Thesis)

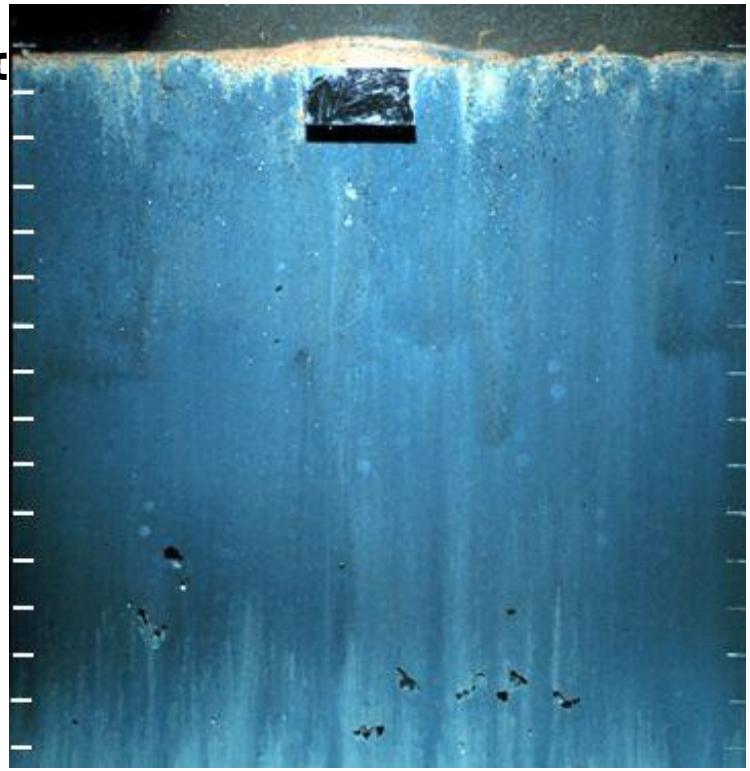
(From Payne, MS Thesis)

SPI and Redox



Not static – changes over time and with seasons.





Oxidized Horizon (A)

Forms as a function of bioturbation and diffusion of oxygen

Summary

- In the marsh environment, we know that organic carbon is protected (accumulates) by storage under anaerobic conditions
- If carbon is transported from marshes to the subaqueous soil/sediment environment and buried, it is probably, to a large degree, preserved; decomposition is relatively slow because of a similarly reducing environment
- During the transport process itself, while suspended under aerobic conditions, decomposition could be accelerated
- Therefore, factors that could affect how long the carbon might be subjected to oxidizing conditions, and how quickly it might become re-preserved include:
  - the route and transport time,
  - the time until burial
  - texture/permeability of the subaqueous soil surface

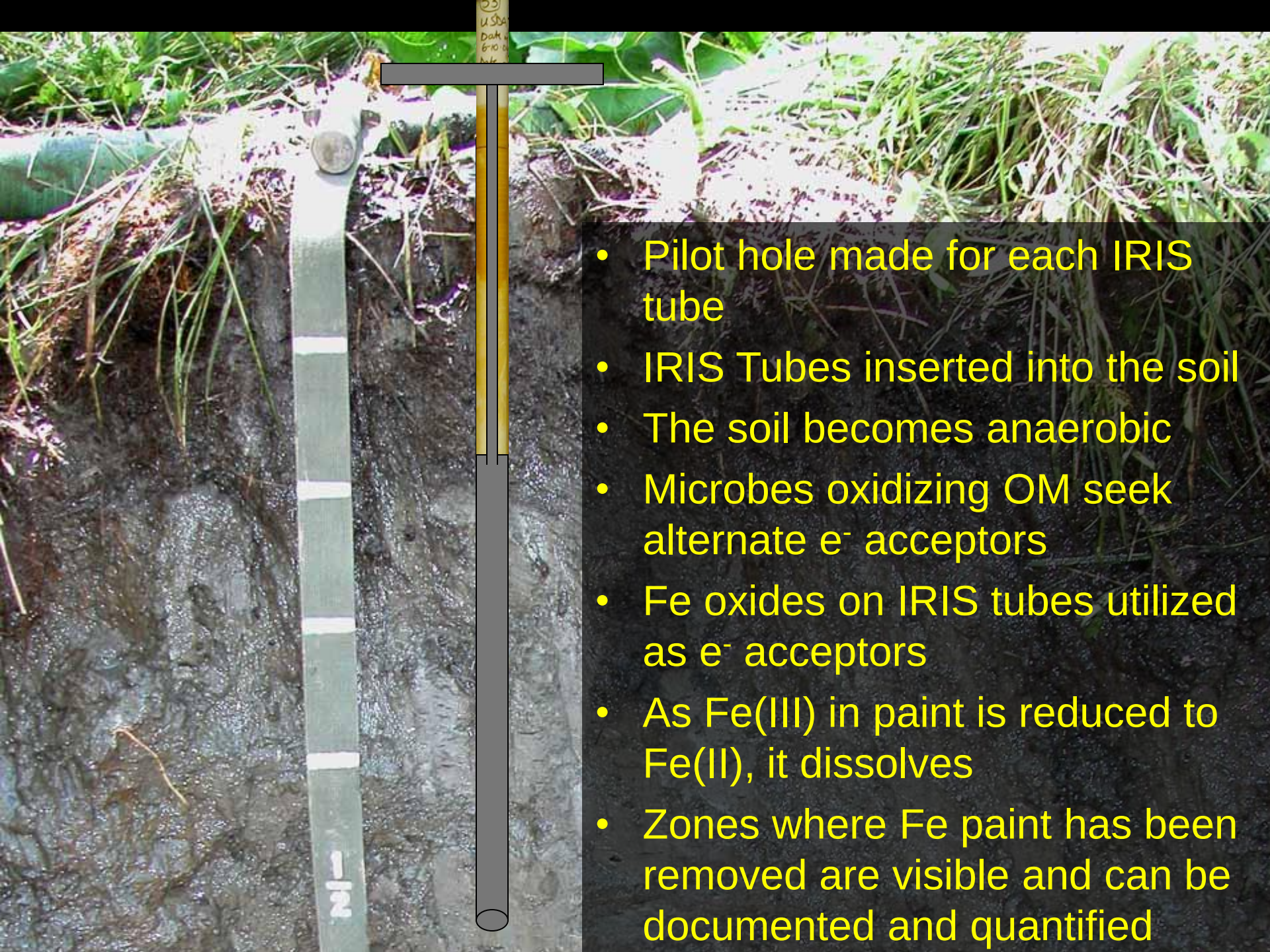
Does this represent preservation?
Or decomposition?

an aside . . .

. . . IRIS Technology

IRIS (Indicator of Reduction in Soils) Tubes

- Fe Oxide paint is applied to ½ inch schedule 40 PVC tubing while the tube is on a lathe device to ensure an even distribution of the paint.
- 40-60% goethite in ferrihydrite matrix



- Pilot hole made for each IRIS tube
- IRIS Tubes inserted into the soil
- The soil becomes anaerobic
- Microbes oxidizing OM seek alternate e^- acceptors
- Fe oxides on IRIS tubes utilized as e^- acceptors
- As Fe(III) in paint is reduced to Fe(II), it dissolves
- Zones where Fe paint has been removed are visible and can be documented and quantified

Formation of Fe monosulfides

$Fe(III) + S^{2-} \rightarrow Fe(II)$

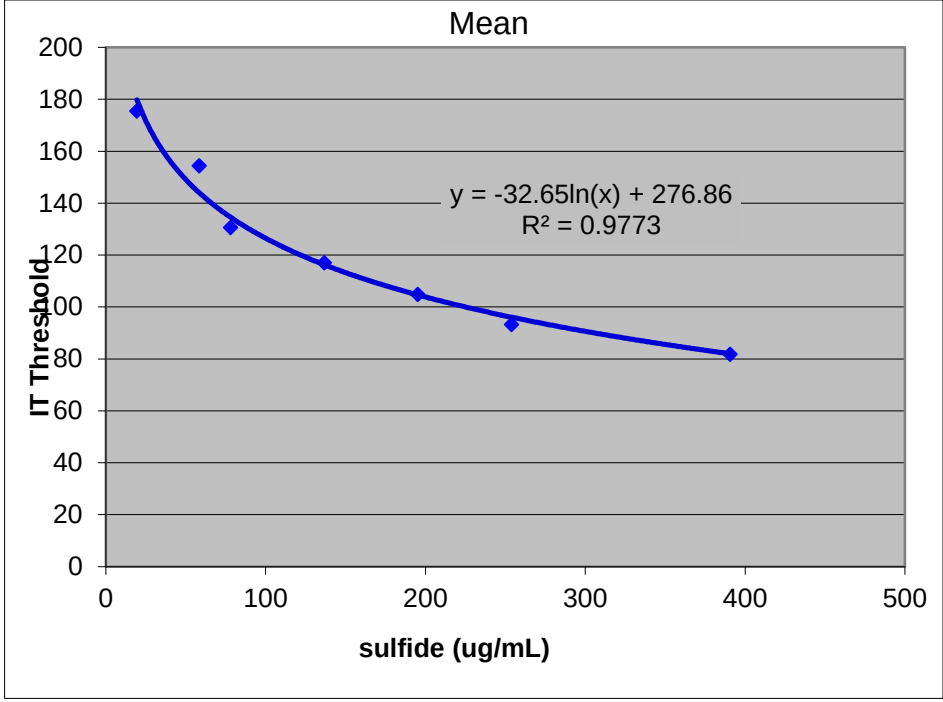
$Fe(II) + S^{2-} \rightarrow FeS$

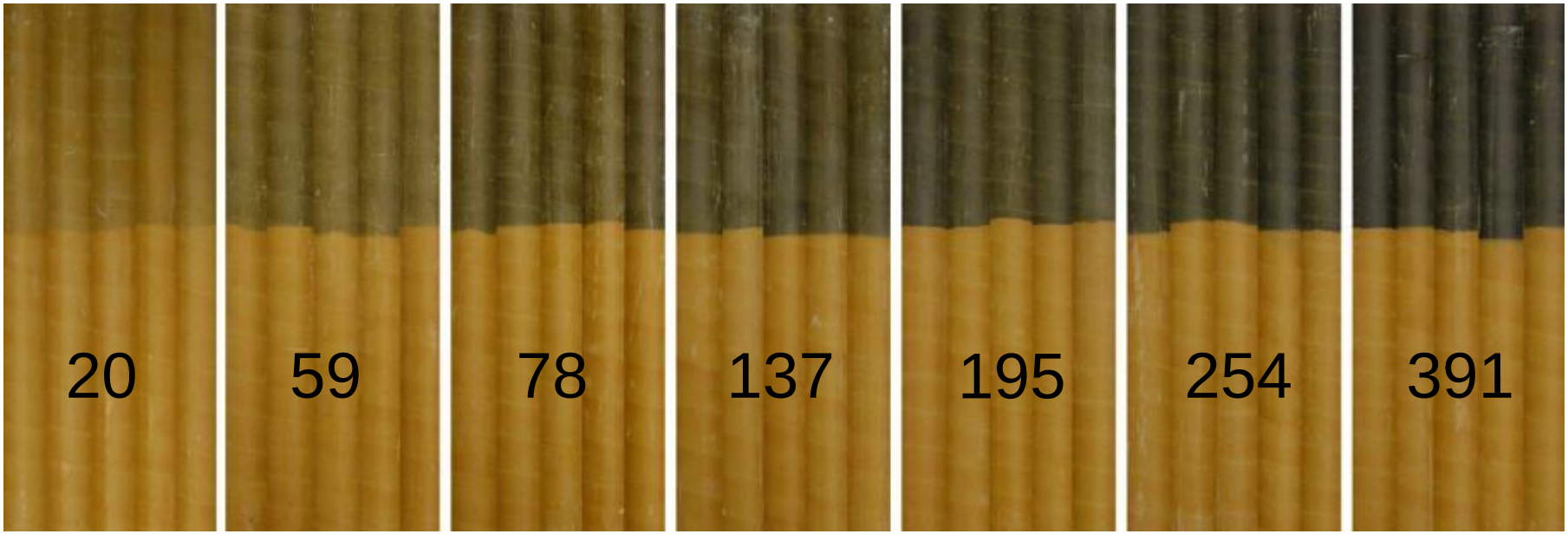
black color, but unstable

Only 5 minutes in the marsh!

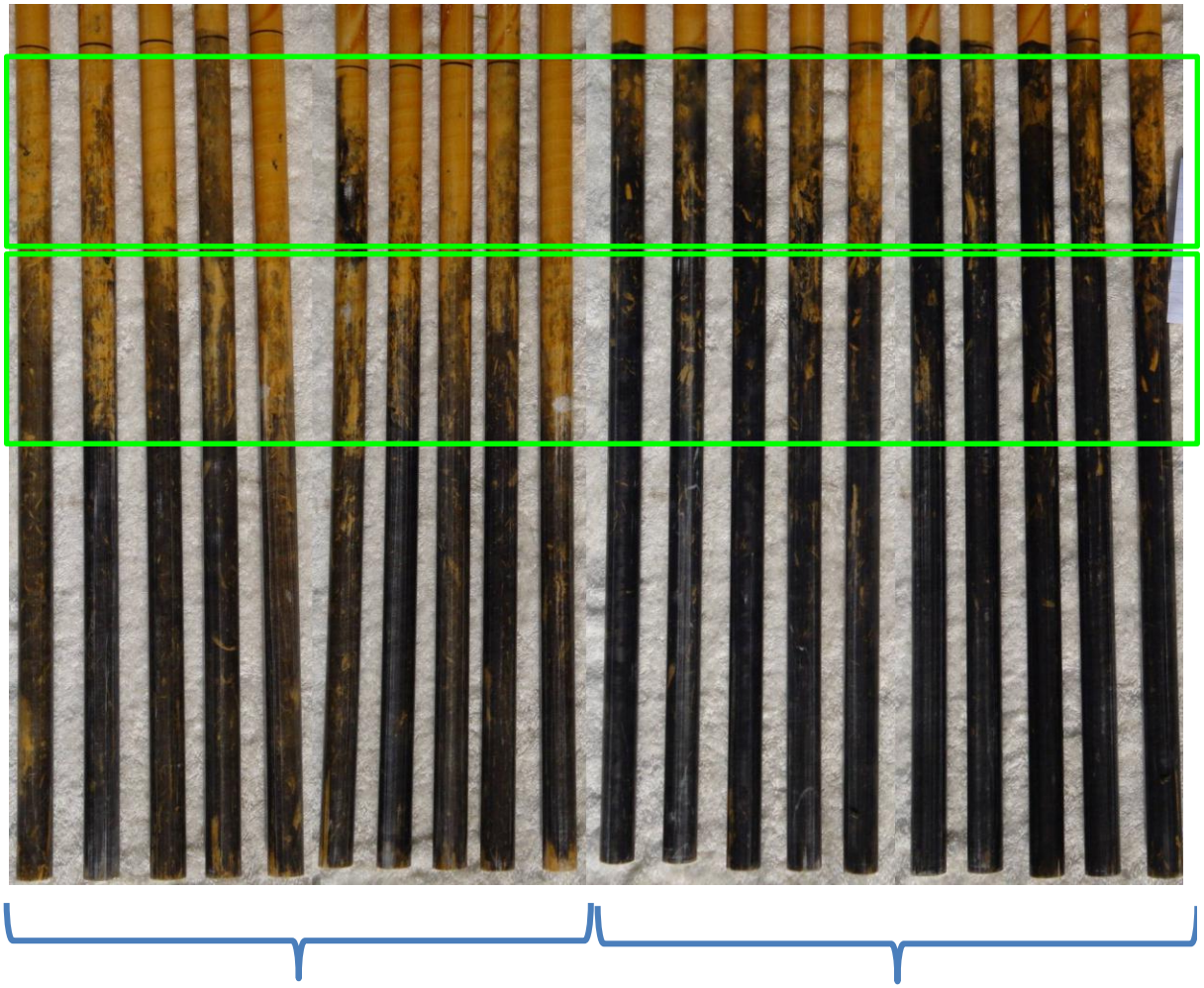
Standards

- IRIS tubes were exposed to known concentrations of sulfide for fixed time (5 min) and



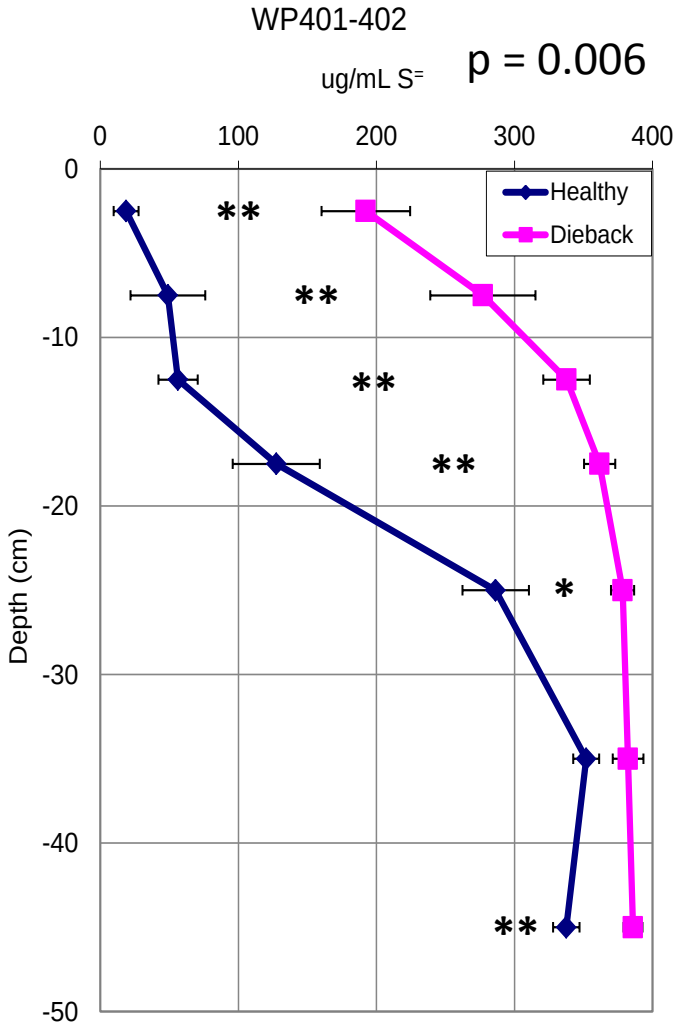


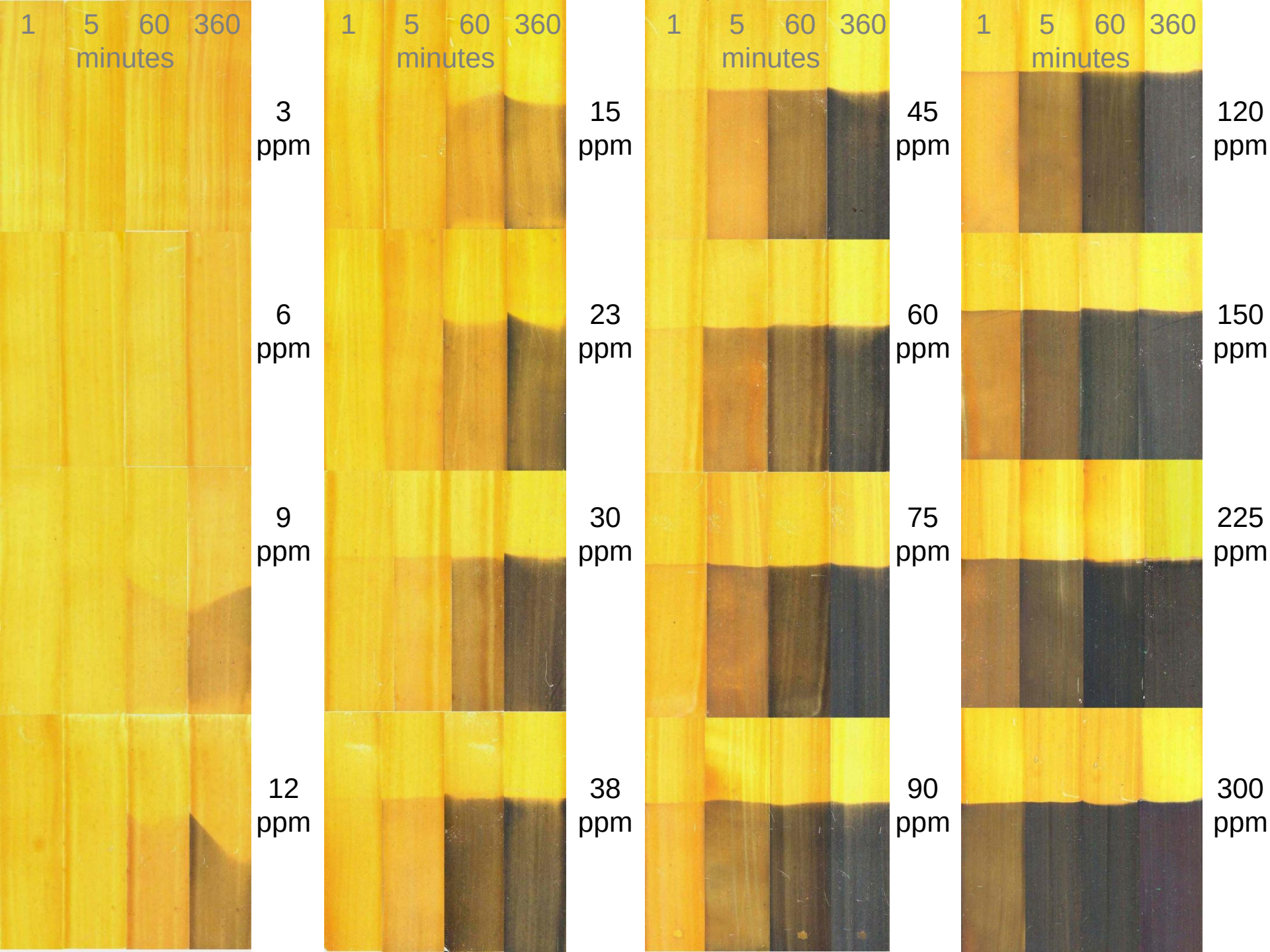
401,402



Healthy

Dieback




1 5 60 360
minutes
3 ppm
15 ppm
45 ppm
120 ppm
6 ppm
23 ppm
60 ppm
150 ppm
9 ppm
30 ppm
75 ppm
225 ppm
12 ppm
38 ppm
90 ppm
300 ppm

Thank you