Soil Carbon in Estuaries

(Blue Carbon)

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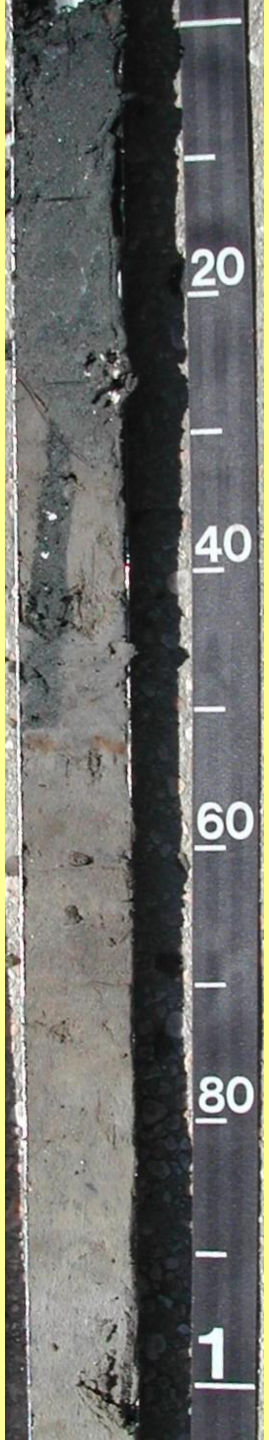
Soils Work!

Blue Carbon

Carbon stored in the soils and plants of salt marshes, mangroves, and shallow subtidal wetlands



Vibracore

Measured

- SOC content
- Bulk density
- Horizon thickness

SOC x Bulk Density x Thickness = mass/area

sum for a certain depth

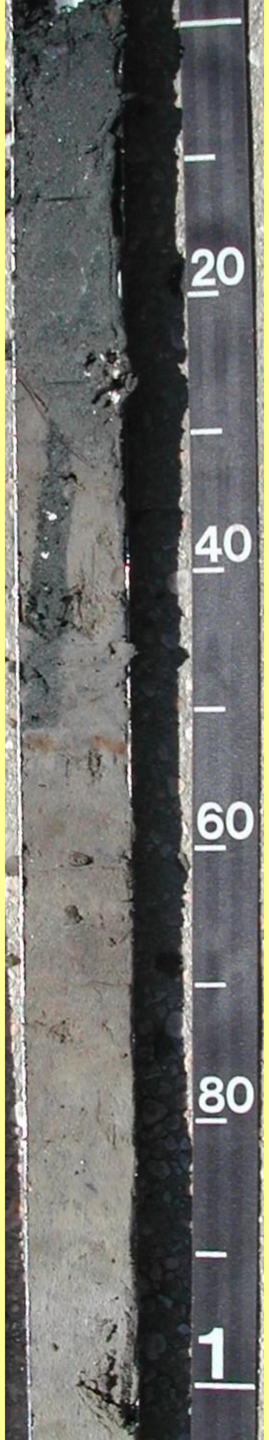
Calculate SOC pools to 1 meter depth

Macaulay Peat Sampler

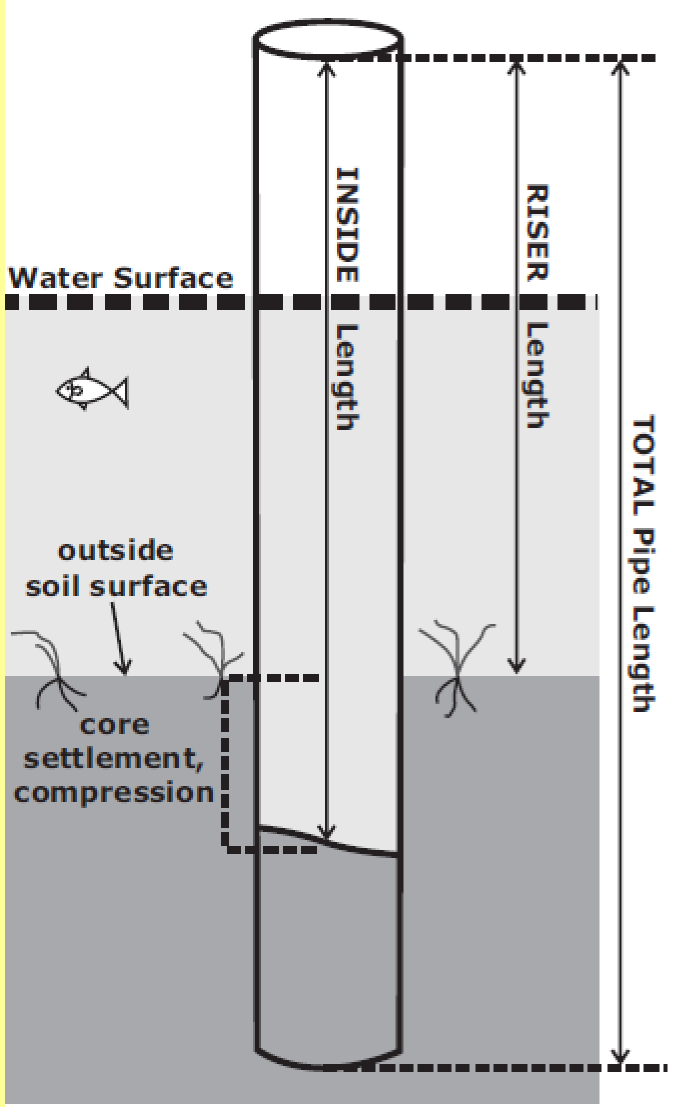
SOC x Bulk Density x Thickness = mass/area $\sum$ for a certain depth

Is really more complicated than this………

How was the soil sampled?
What part of the sample was analyzed?
How was SOC determined?
How was bulk density determined?
How were coarse fragments accounted for?



Vibracore Collapse



Macaulay Peat Sampler

What part of the sample do you analyze for carbon?

All of the sample? **Just the fine-earth fraction?** **What about live roots?**

How was SOC determined?

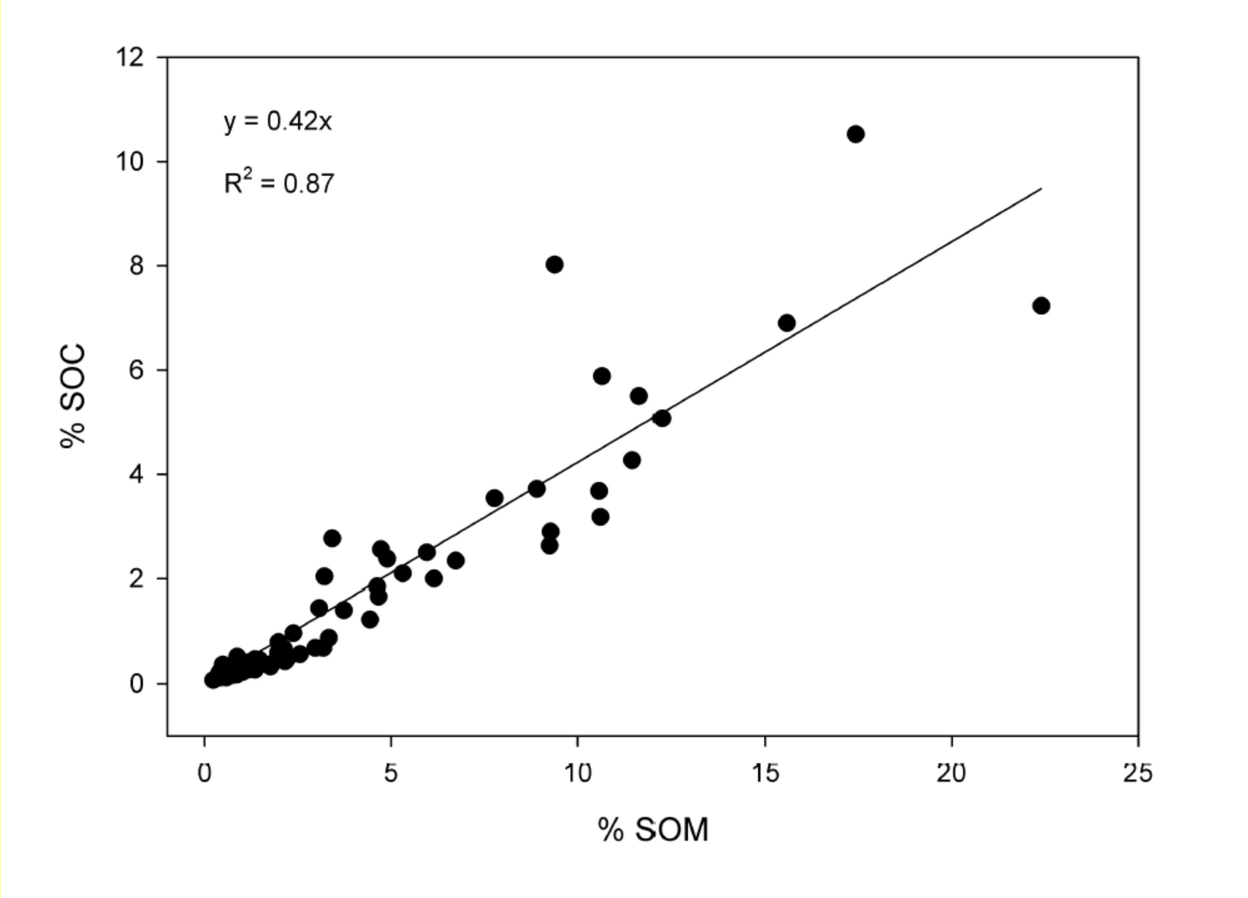
Combustion @ 1050◦C?

Loss-on-Ignition	
OC %	$CaCO_3$ %
0.9	1.6
0.6	1.0
2.2	2.4
1.5	1.6
5.5	6.8
3.8	3.9
0.4	0.9
0.4	0.8
2.6	2.9
0.7	1.2
0.2	0.8
0.2	0.6
0.9	1.1

Treat first with an acid to remove carbonates

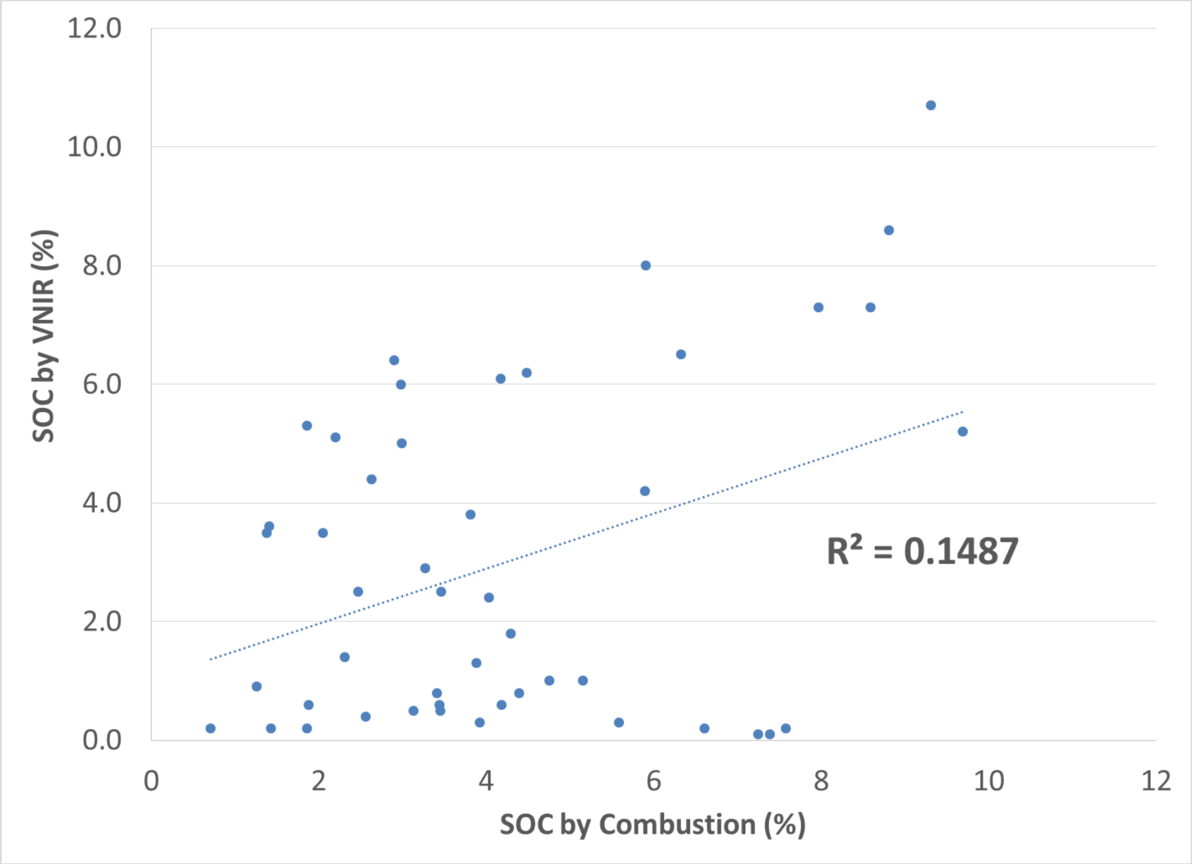
Balduff (2007) found that on average 5% of the carbon was oxidized by the acid

Loss on Ignition @ 550◦C?

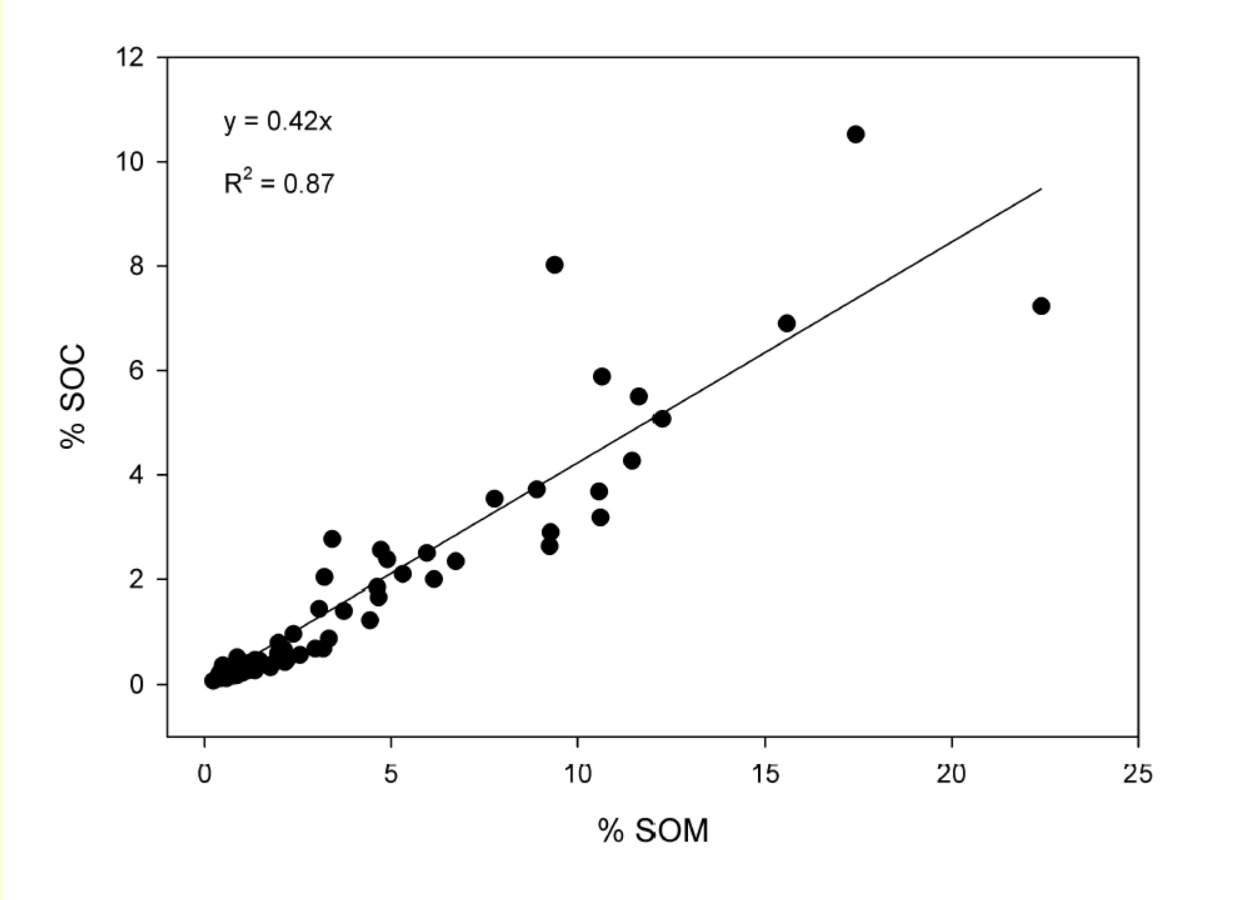


How was SOC determined?

VNIR



Loss on Ignition @ 550◦C?



How was bulk density determined?

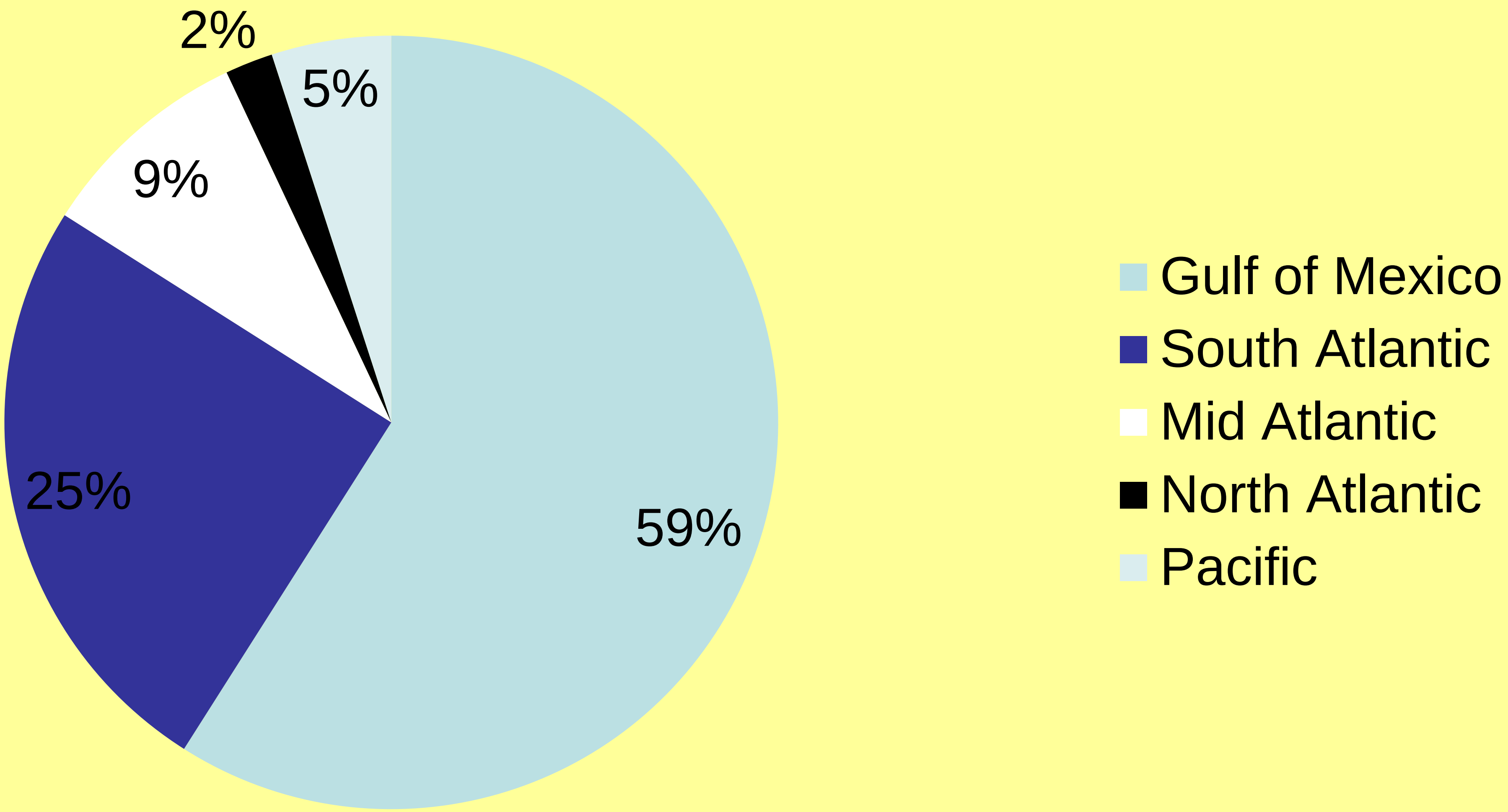
How were coarse fragments accounted for?

1) Collect a known volume at the field moisture state (satiated). Bulk density is then calculated based on the dried weight of a known volume of soil at the field moisture status.
   Calculations (Soil Survey Staff, 2009)
   Db = (ODW – RF – CW)/[CV – (RF/PD)], where:
   - Db = Bulk density of <2-mm fabric at sampled, field water state (g cm^{-3})
   - ODW = Oven-dry weight
   - RF = Weight of rock fragments
   - CW = Empty core weight
   - CV = Core volume
   - PD = Density of rock fragments

2) For vibracore samples (opened by cutting the sampling tube rather than by compressive extrusion), a 50-ml syringe with the end removed and shaped to fit the curved core is used as a mini-corer to extract a 10- to 30-ml volume sample. The cylinder is removed, extracting a sample of known volume. The sample is then analyzed following method 1 (above).

3) Samples collected in a peat sampler (e.g., Macaulay sampler) can be analyzed for bulk density following method 2 if a known volume (e.g., a core segment) is collected and dried.

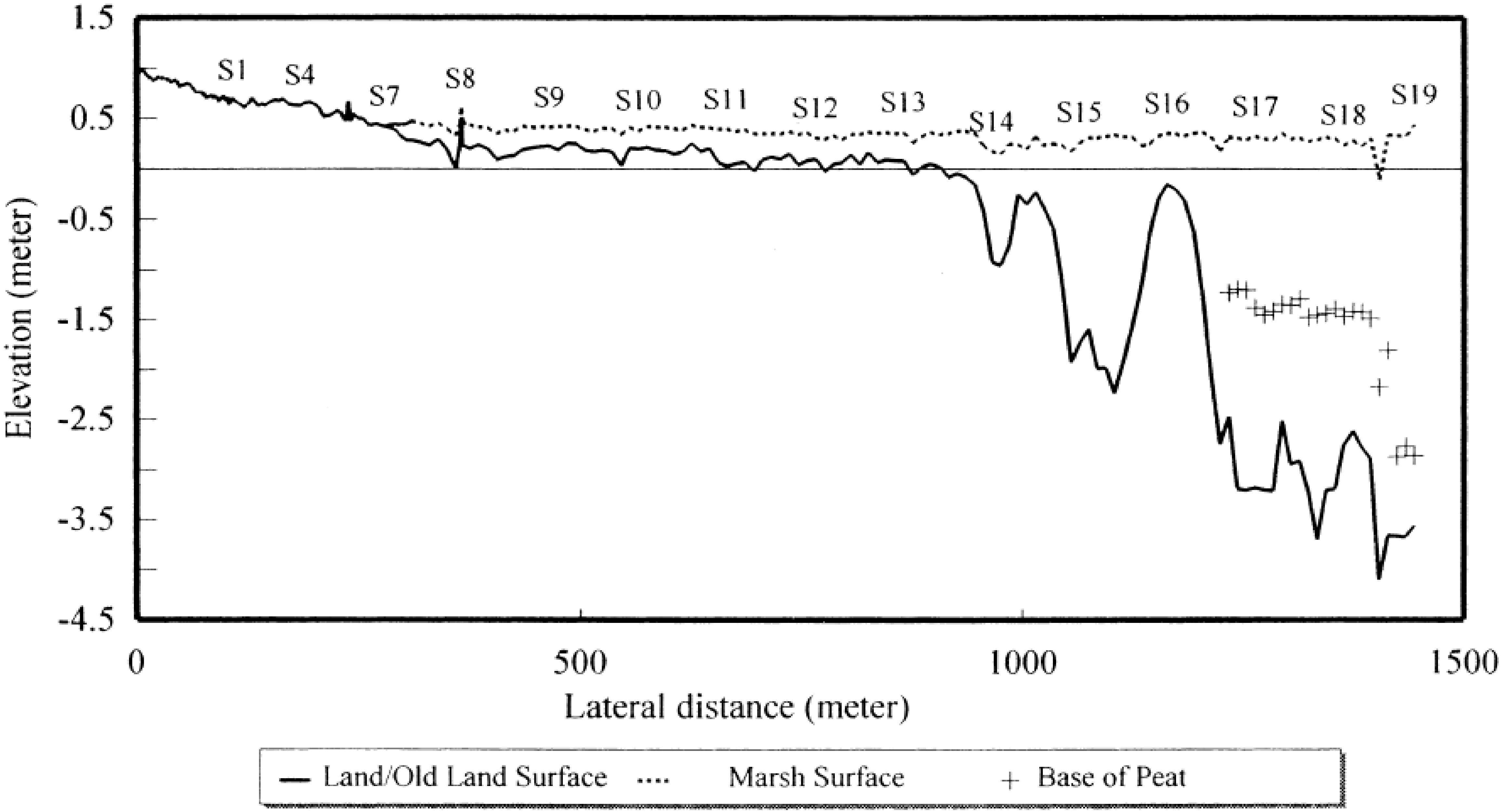
Distribution of coastal marshes in the US



Data from Fields et al. 1991

SOIL SCI. SOC. AM. J., VOL. 68, SEPTEMBER–OCTOBER 2004

Hussein et al. 2004



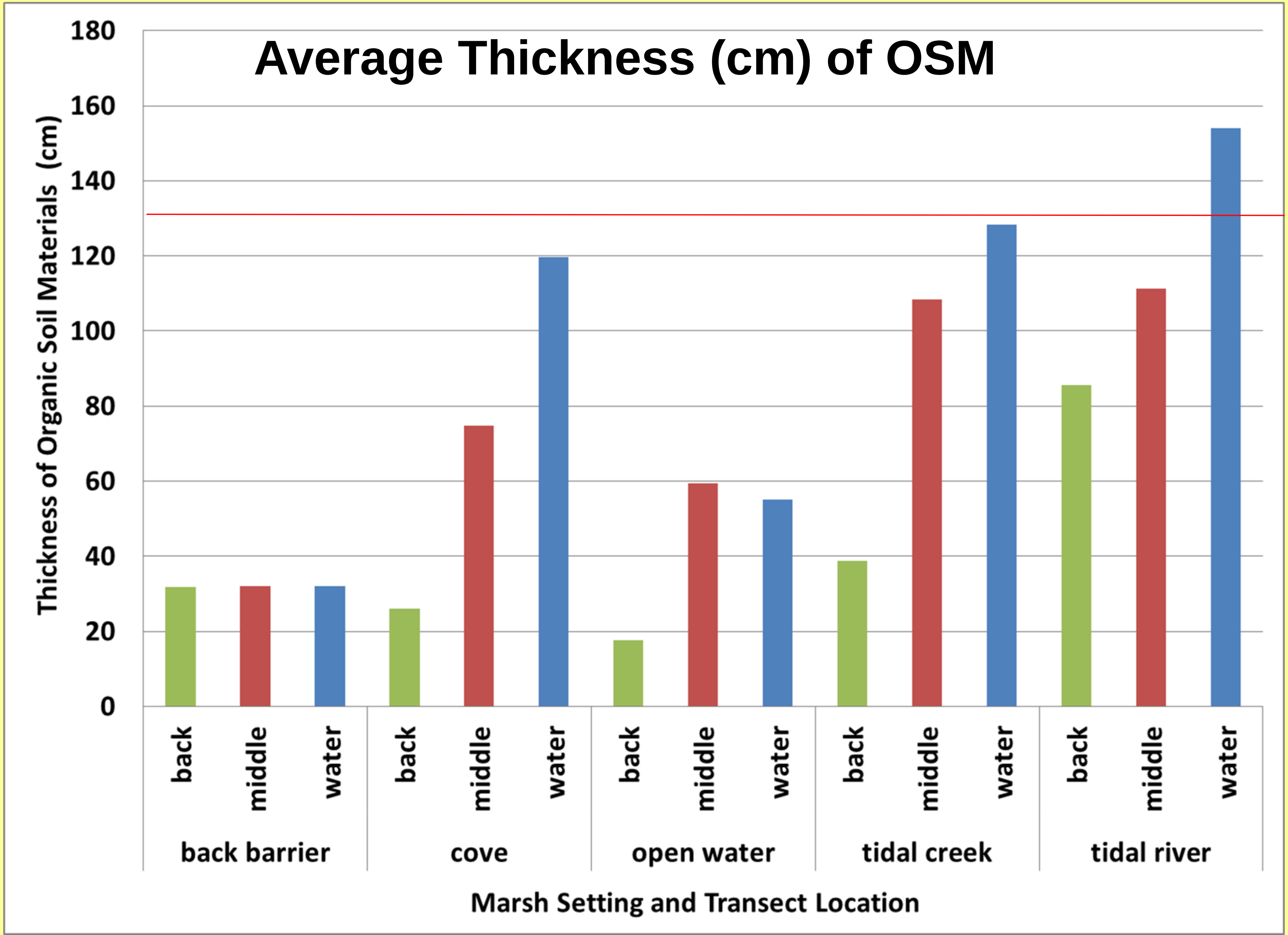
Back Barrier

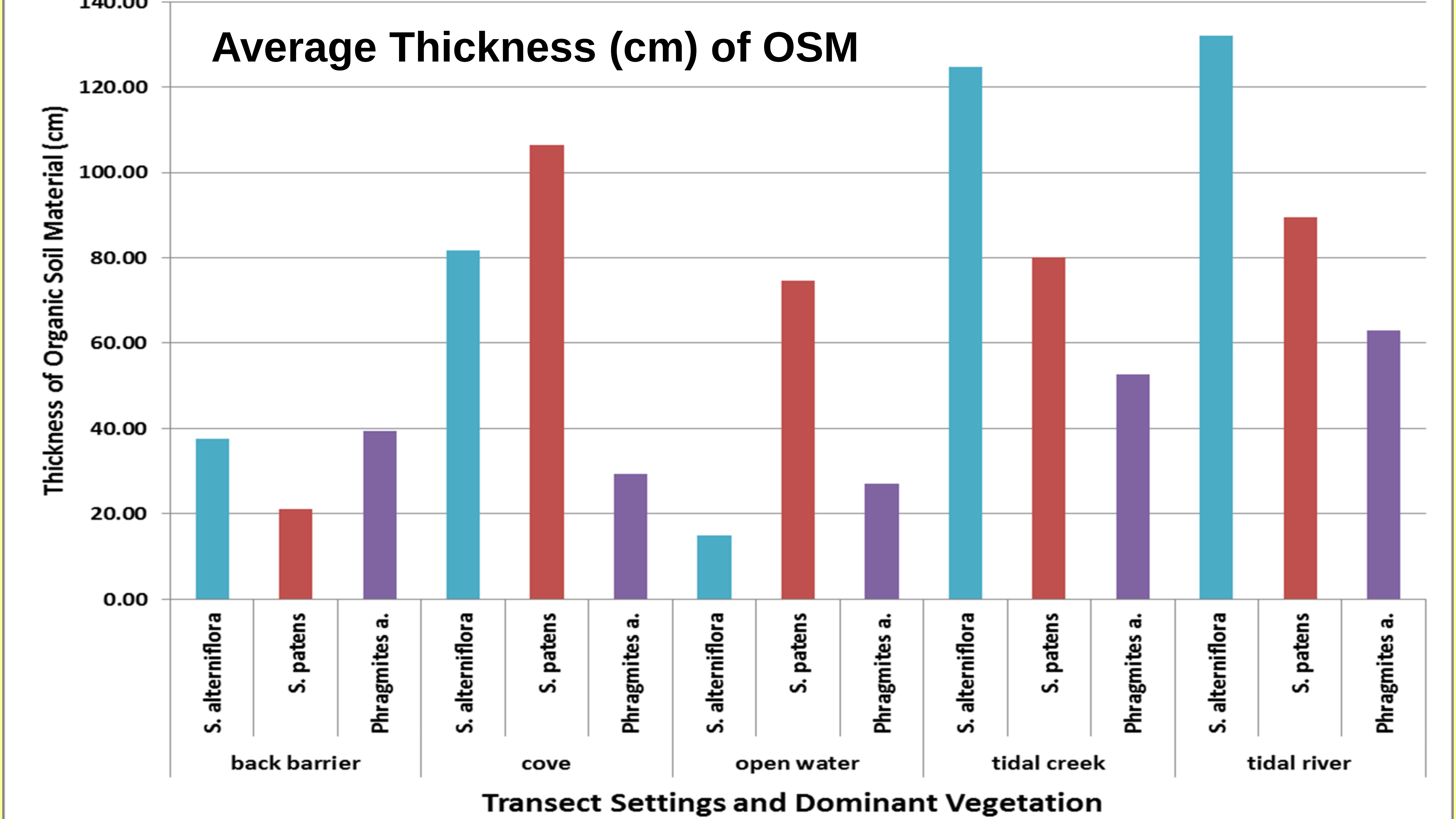
Cove

Tidal River

Tidal Creek

SoilWeb


Average Thickness (cm) of OSM
Thickness of Organic Soil Materials (cm)
180
160
140
120
100
80
60
40
20
0
back
middle
water
back barrier
cove
open water
tidal creek
tidal river
Marsh Setting and Transect Location


Average Thickness (cm) of OSM
Thickness of Organic Soil Material (cm)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
S. alterniflora
S. patens
Phragmites a.
back barrier
cove
open water
tidal creek
tidal river
Transect Settings and Dominant Vegetation

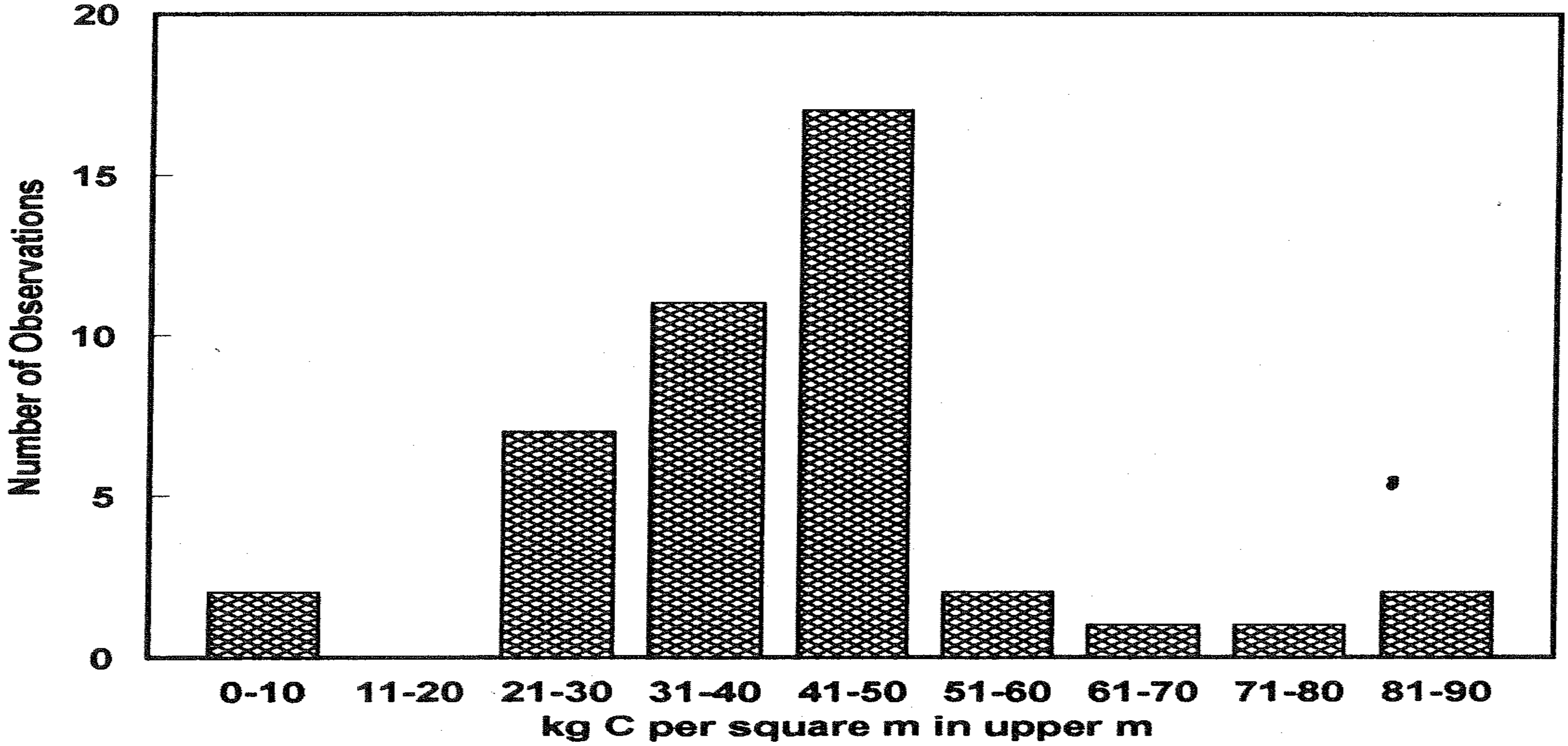
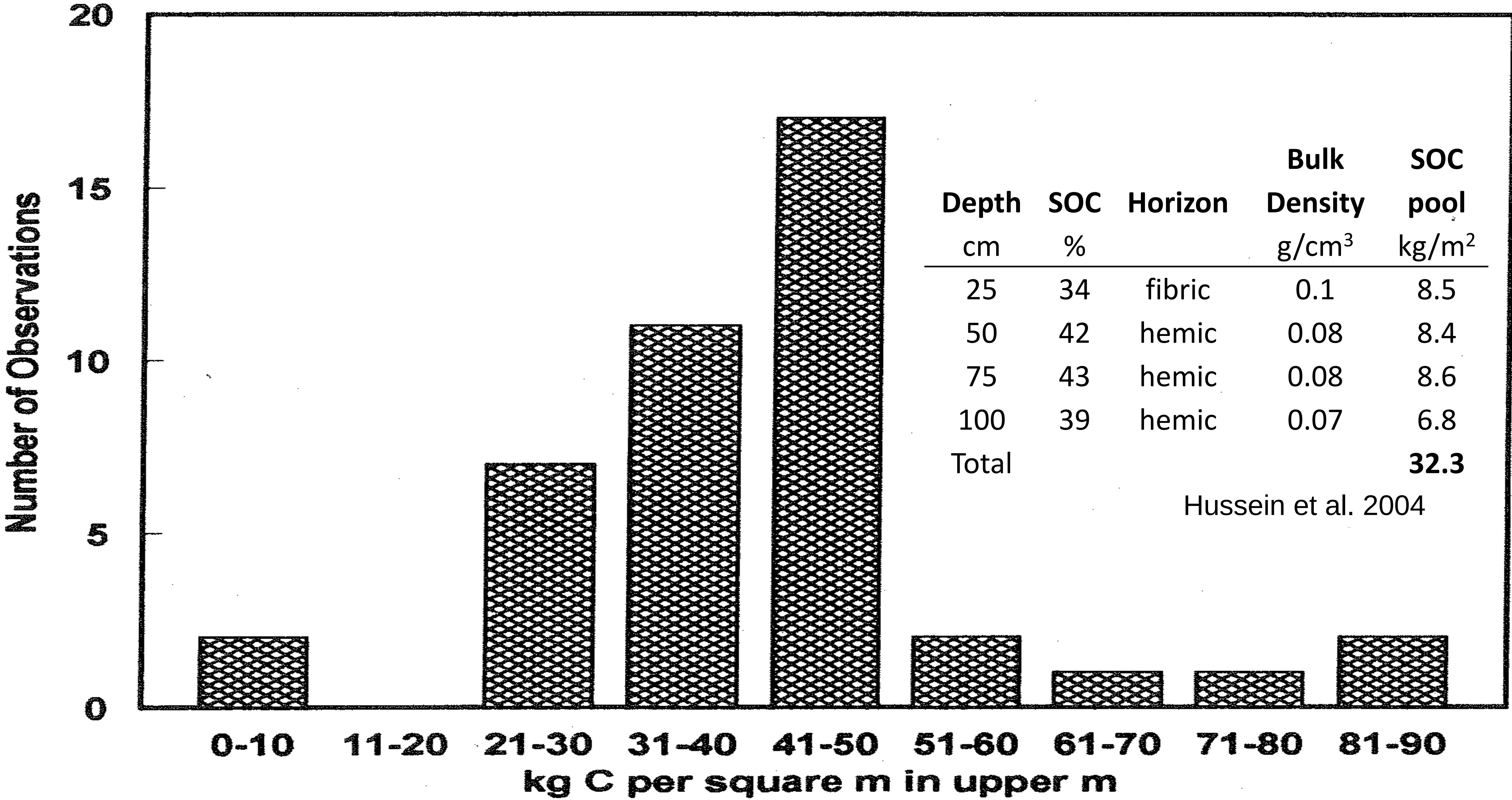
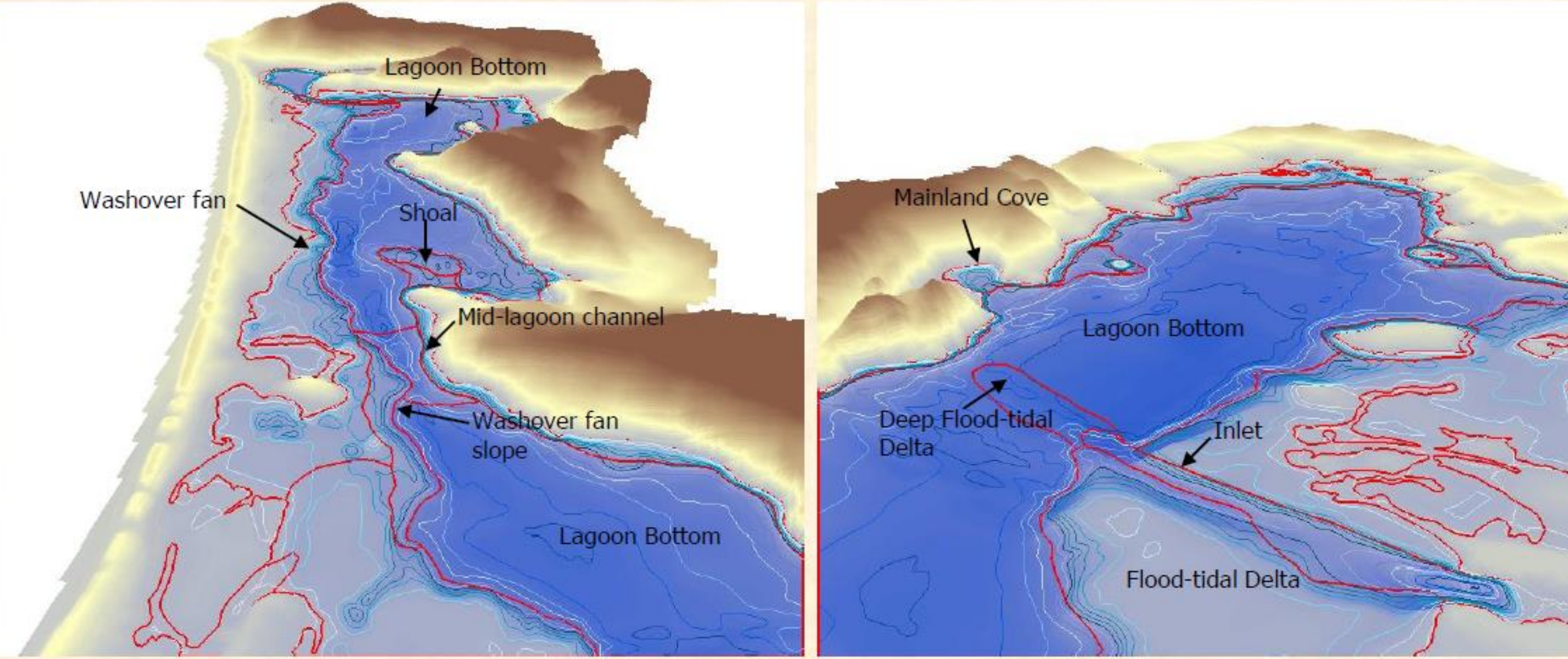


Figure 4. Frequency distribution of carbon stored in *the upper meter* of selected marsh soils from the Atlantic and Gulf coastal regions of the United States. Individual estimates are shown in Table 2.



Depth cm	SOC %	Horizon	Bulk Density g/cm^3	SOC pool kg/m^2
25	34	fibric	0.1	8.5
50	42	hemic	0.08	8.4
75	43	hemic	0.08	8.6
100	39	hemic	0.07	6.8
Total				**32.3**

Hussein et al. 2004



Shallow Subtidal Landscape Units

Sampling locations by landscape unit

	Ninigret		Point Judith		Quonochontaug		Total
Landscape unit	**n**	**Area (%)**	**n**	**Area (%)**	**n**	**Area (%)**	**N**
Flood-tidal Delta Flat	4	7	4	19	3	18	11
Flood-tidal Delta Slope	-	1	2	2	-	1	2
Washover Fan Flat	3	15	-	0	3	6	6
Washover Fan Slope	3	3	-	0	-	1	3
Submerged Mainland Beach	3	8	5	7	4	9	12
Mainland Cove	3	2	3	6	-	3	6
Lagoon Bottom	5	43	3	41	4	52	12
Total	21	79	17	75	14	99	**52**

Average Soil Organic Carbon Pools in the upper meter of Coastal Lagoons

Landscape Unit	Rhode Island Millar et al. 2014 kg/m^2	Maryland Balduff, 2007 kg/m^2
Flood-Tidal Delta	6.2	3.6
Lagoon Bottom	12.5	12.3
Mainland Cove*	22.2	20.8
Submerged Beach	10.3	8.8
Washover Fan	6.4	2.5

* Mainland Cove was averaged between those with buried organic horizons and those without

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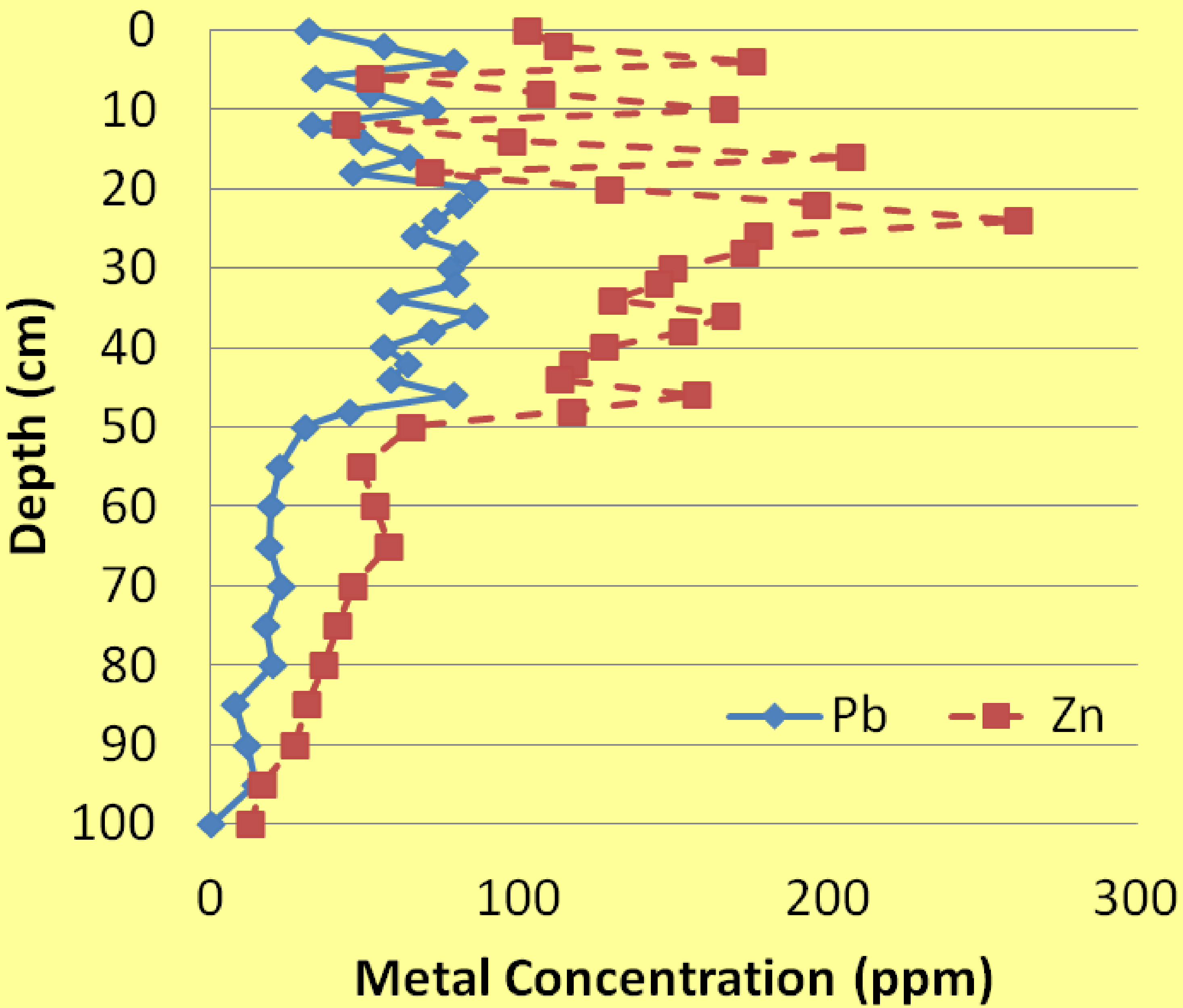
* Other than the mainland cove units, these values are on the low end of salt marsh carbon pools.

Average SOC pools in forests vs shallow subtidal wetlands

Soil Classification (subgroup)	n	Mean SOC (kg m^2)	CV (%)	Reference
Typic Udipsamments	20	11	15	Davis et al., 2004
Typic Dystrudepts	29	14	29	Davis et al., 2004
Aeric Endoaquepts	20	19	31	Davis et al., 2004
Aeric Endoaquepts	29	25	39	Ricker et al., 2013
Typic Haplosaprists	30	59	20	Davis et al., 2004
Fluventic Psammowassents	9	5	43	Millar et al., 2014
Sulfic Psammowassents	5	6	82	Millar et al., 2014
Typic Fluviwassents	5	11	50	Millar et al., 2014
Haplic Sulfiwassents	10	12	43	Millar et al., 2014
Typic Sulfiwassents	5	14	42	Millar et al., 2014
Fluventic Sulfiwassents	5	20	28	Millar et al., 2014
Thapto-Histic Sulfiwassents	3	49	35	Millar et al., 2014



28 of the vibracore samples we sampled in 2.5 increments for the upper 50 cm and 5 cm increments from 50 to 100 cm for total Zn and Pb analyses

Concentrations above background levels were considered soil materials deposited after widespread use of internal combustion engines (approximately 1900)

We used these depths to estimate SOC sequestration rates

Average SOC sequestration rate for the 5 most common soil-landscape units

Landscape Unit	Number of Observations	Mean SOC Sequestration Rate Mg $ha^{-1}yr^{-1}$	Standard Error
Flood-tidal Delta Flat	5	0.45ab*	0.06
Lagoon Bottom	8	0.68b	0.11
Mainland Cove	3	1.45c	0.02
Submerged Mainland Beach	6	0.23a	0.06
Washover Fan Flat	5	0.18a	0.04

Average SOC sequestration rates for southern New England forests: 0.5 to 0.8 Mg ha^{-1} yr^{-1}

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SOC sequestration rate for a Mid-Atlantic salt marsh: 0.84 Mg ha^{-1} yr^{-1} (Hussein et al 2004)

Average SOC sequestration rates for southern New England forests: 0.5 to 0.8 Mg ha^{-1} yr^{-1}

MESSAGE

- The subtidal component of the estuary is often as larger or larger than the salt marsh component. As such, it is important to develop an understanding of the carbon pools and sequestration rates of both ecosystems for any blue carbon inventory.
- Blue carbon inventories are only accurate if you use a coastal zone soil survey (otherwise marshes and those areas permanently under water just a black box for carbon accounting.
- The shallow subtidal component of the estuary can be stratified by either landscape unit (i.e. lagoon bottom, mainland cove) or by soil type.

MESSAGE

•SOC Pools and sequestration rates of subaqueous soils were similar to their forested (subaerial) counterpart. Salt marsh sequestration rates are typically at the upper end of these rates.

• More studies need to be completed examining SOC in the intertidal and subtidal components of the estuary for blue carbon inventories.

NOAA Coastal Blue Carbon Partnerships

Science

Policy

Management

Since 2012, NOAA has partnered on more than 50 blue carbon efforts