Blue Carbon Sequestration and Eelgrass Habitat Restoration

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Blue Carbon in Eelgrass Meadows in the PNW

- Initial Optimism and Enthusiasm (2010 - 2018
- Data Collection and Syntheses (2018 – 2022)
- Fact Driven Estimates (current)

Global Biogeochemical Cycles

RESEARCH ARTICLE
10.1029/2019GB006345

Special Section:
Carbon cycling in tidal wetlands and estuaries of the contiguous United States

A Synthesis of Blue Carbon Stocks, Sources, and Accumulation Rates in Eelgrass (*Zostera marina*) Meadows in the Northeast Pacific

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Key Points:
- Sediment carbon content varied both within and among Northeast Pacific eelgrass meadows, yet there was no clear latitudinal trend
- Carbon in eelgrass meadow sediments appears to be derived largely from noneelgrass sources
- Northeast Pacific carbon stocks and accumulation rates are comparable to other *Z. marina* meadows but lower than global seagrass values

Supporting Information:
- Supporting Information S1

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Abstract There is increasing urgency to implement climate change mitigation strategies that enhance greenhouse gas removal from the atmosphere and reduce carbon dioxide (CO_2) emissions. Recently, coastal "blue carbon" habitats—mangroves, salt marshes, and seagrass meadows—have received attention for their ability to capture CO_2 and store organic carbon (OC), primarily in their sediments. Across habitat types and regions, however, information about the sequestration rates and sources of carbon to local sediments remains sparse. Here we compiled recently obtained estimates of sediment OC stocks and sequestration rates from 139 cores collected from temperate seagrass (*Zostera marina*) meadows in Alaska, British Columbia, Washington, and Oregon. Across all cores sediment OC content averaged 0.75%. Organic carbon stocks in the top 25 cm and 1 m of the sediment averaged 1,846 and 7,168 g OC m^{-2}, respectively. Carbon sequestration rates ranged from 4.6 to 93.0 g OC m^{-2} yr^{-1} and averaged 24.8 g OC m^{-2} yr^{-1}. Isotopic data from this region suggest that OC in the sediments is largely from noneelgrass sources. In general, these values are comparable to those from other temperate *Z. marina* meadows, but significantly lower than previously reported values for seagrasses globally. These results further highlight the need for local and species-level quantification of blue carbon parameters. While temperate eelgrass meadows may not sequester and store as much carbon as seagrass meadows elsewhere, climate policy incentives should still be implemented to protect existing sediment carbon stocks and the other critical ecosystem services associated with eelgrass habitats.

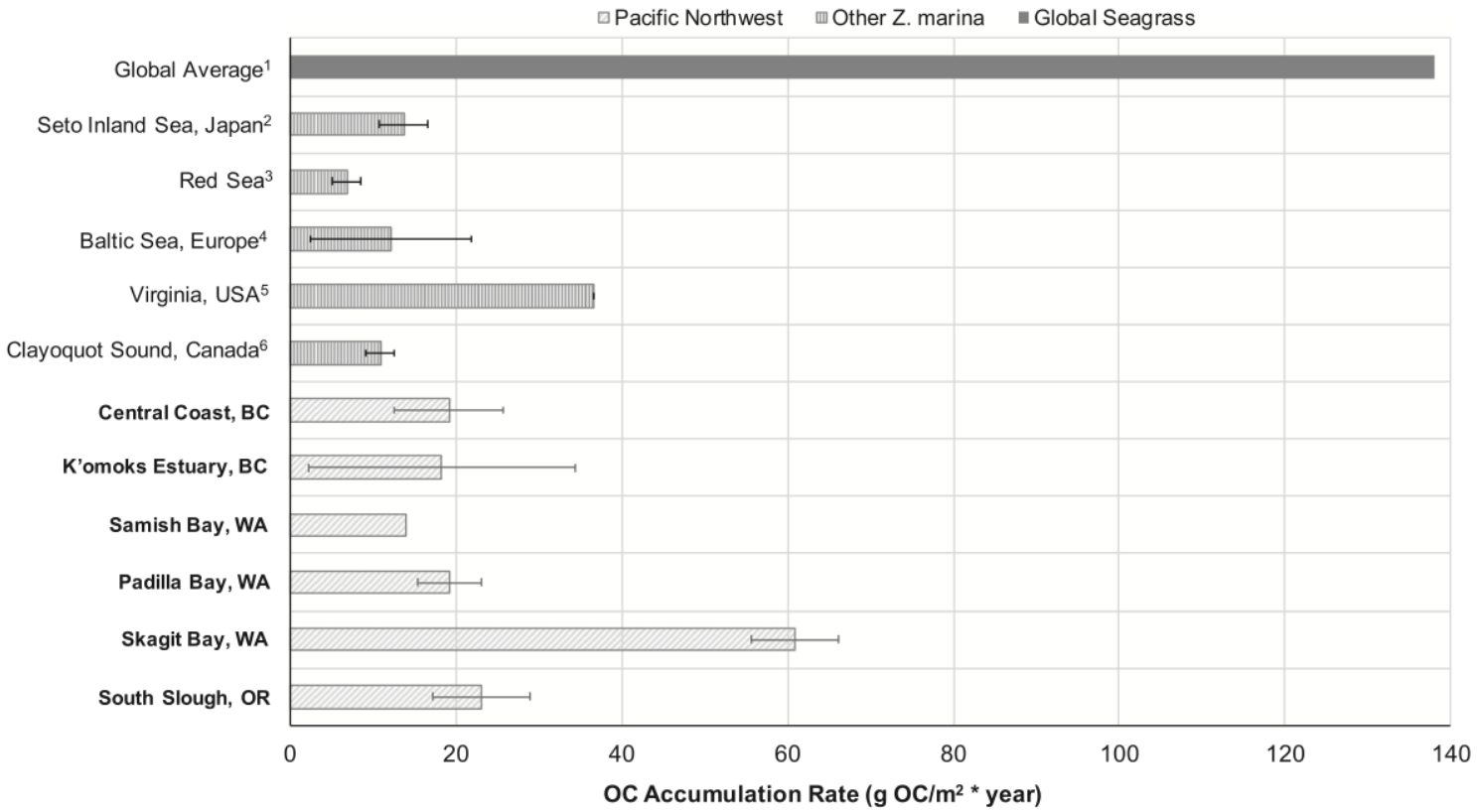
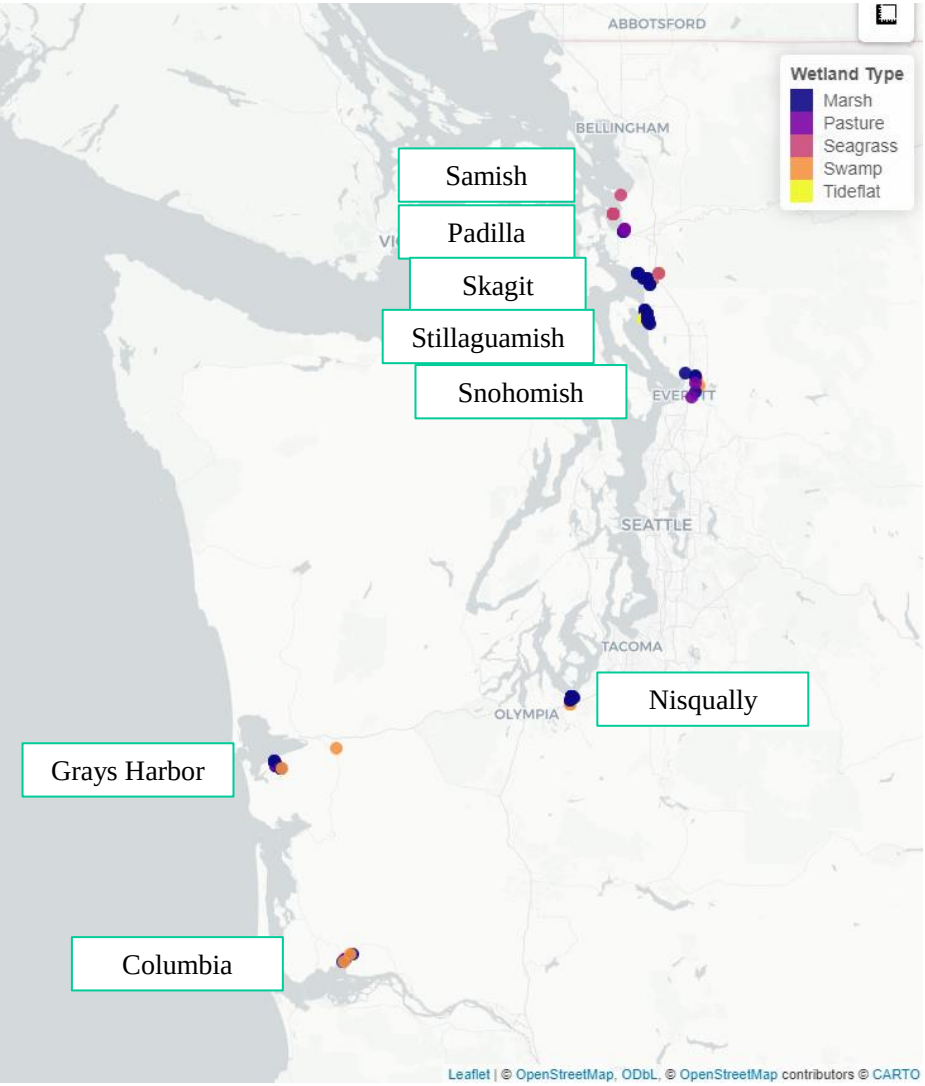


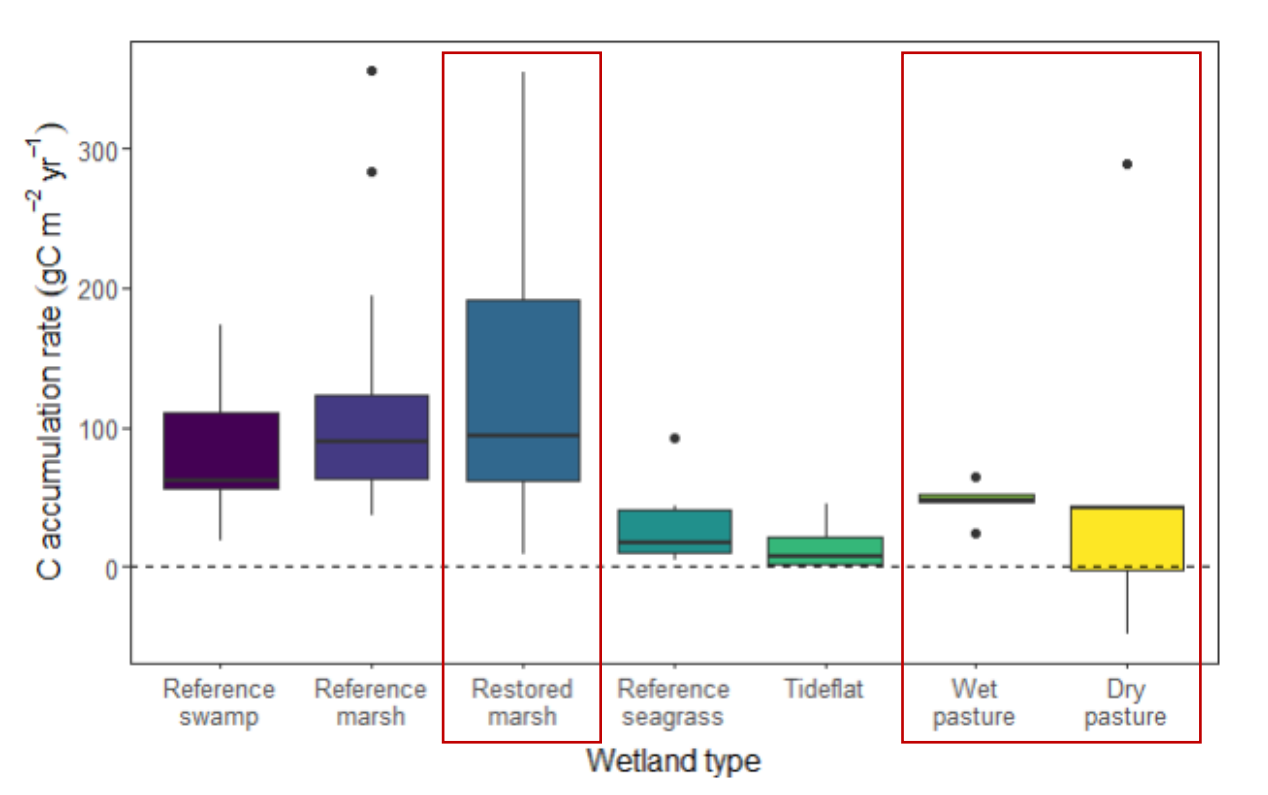
Figure 5. Organic carbon accumulation rates from *Z. marina* meadows in some of the Pacific northwest regions from this study (light grey, diagonal hatched bars), compared with accumulation rates from other published studies in *Z. marina* meadows (medium grey, vertical hatched bars) and a published average for seagrasses globally (dark grey bar). Error bars denote standard error. Sources for OC accumulation rate values are as follows: 1 = McLeod et al. (2011), 2 = Miyajima et al. (2015), 3 = Serrano et al. (2018), 4 = Jankowska et al. (2016), 5 = Greiner et al. (2013), 6 = Postlethwaite et al. (2018).

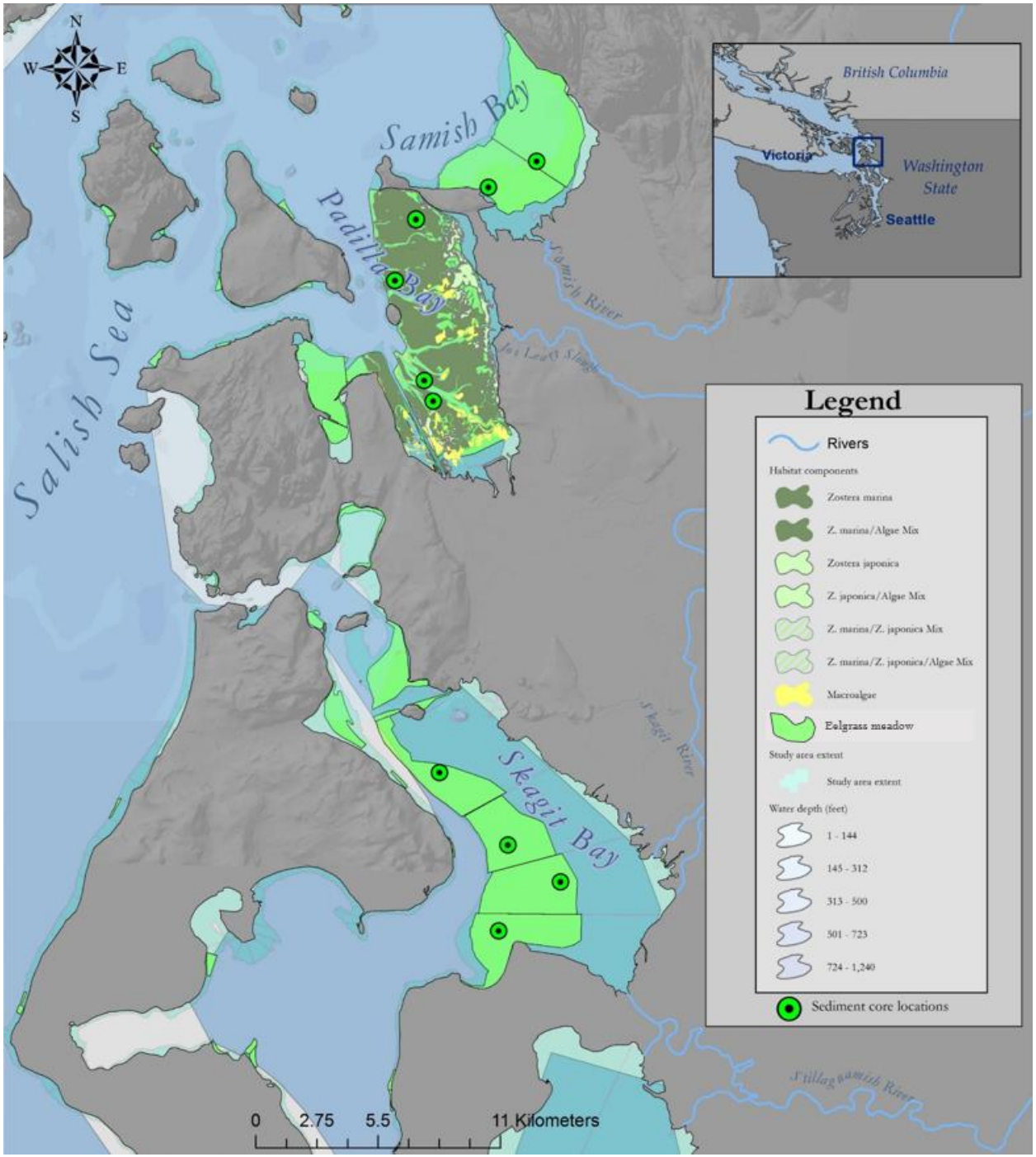


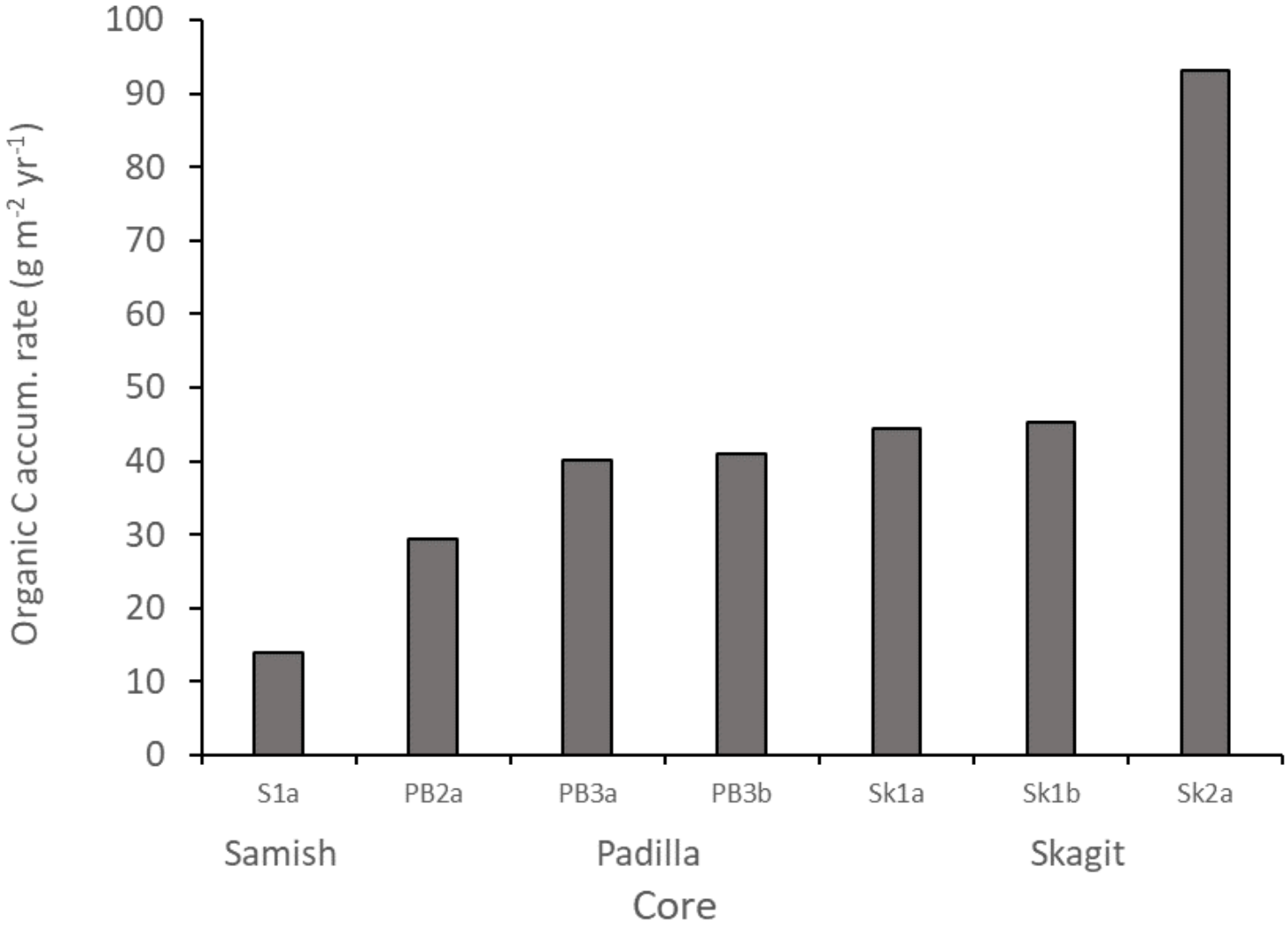
Soil carbon accumulation rates in WA	
Estuaries	8
Sites	53
Cores	105

Tidal marsh	32
Tidal swamp	10
Seagrass	3
Unvegetated tideflat	4
Nontidal pasture	7

Results – WA carbon accumulation rates by wetland type




N
W
E
S
Samish Bay
Padilla Bay
Salish Sea
Samish River
Joe Leach Slough
Skagit River
Skagit Bay
Stillaguamish River
British Columbia
Victoria
Washington State
Seattle
Legend
Rivers
Habitat components
Zostera marina
Z. marina/Algae Mix
Zostera japonica
Z. japonica/Algae Mix
Z. marina/Z. japonica Mix
Z. marina/Z. japonica/Algae Mix
Macroalgae
Eelgrass meadow
Study area extent
Study area extent
Water depth (feet)
1 - 144
145 - 312
313 - 500
501 - 723
724 - 1,240
Sediment core locations
0
2.75
5.5
11 Kilometers


Organic C accum. rate (g m-2 yr-1)
100
90
80
70
60
50
40
30
20
10
0
S1a
PB2a
PB3a
PB3b
Sk1a
Sk1b
Sk2a
Samish
Padilla
Skagit
Core

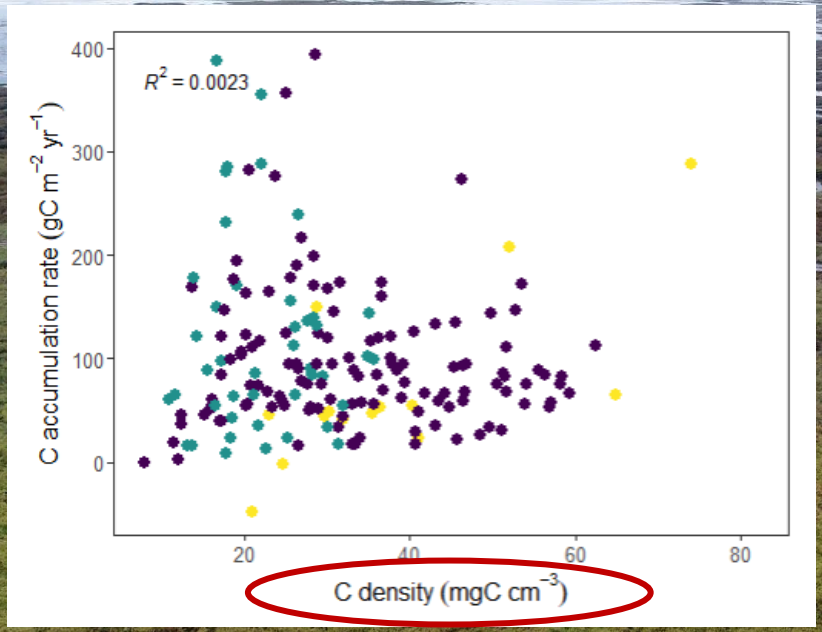
Carbon Accumulation Rate
(g C/cm^2/year)

Carbon Density
(g C/cm^3)

X

Accumulation Rate
(cm/year)

Results – Accretion is more predictive of carbon accumulation rate



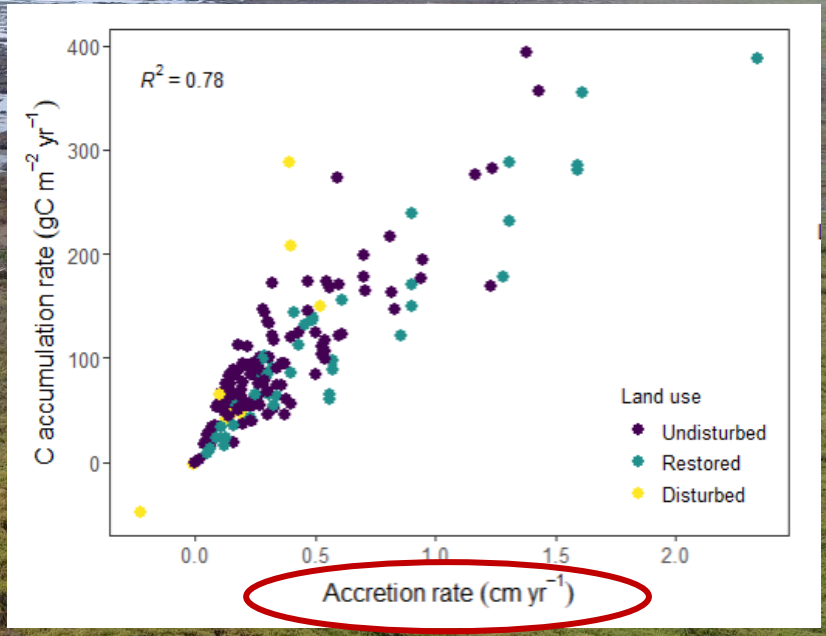
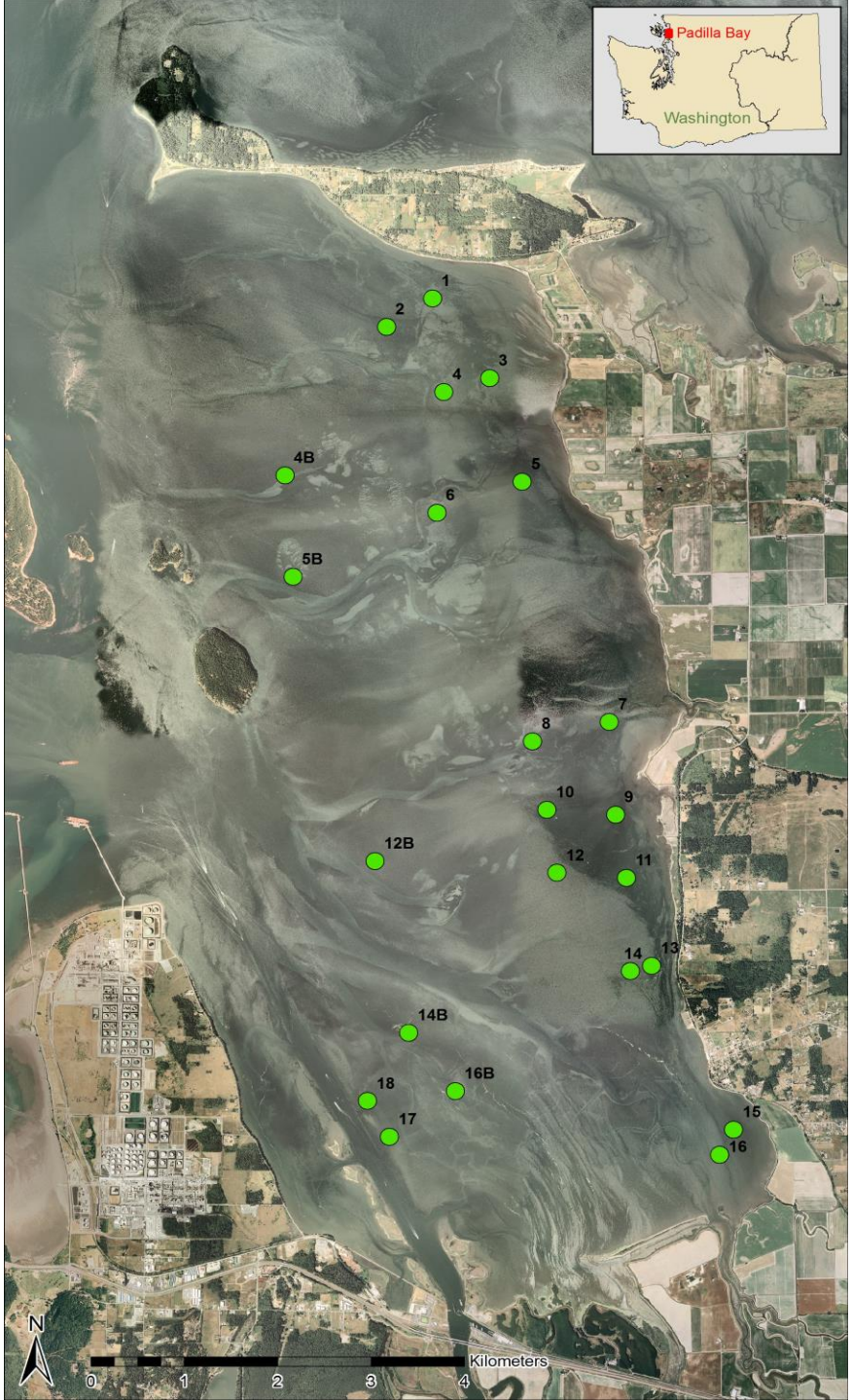
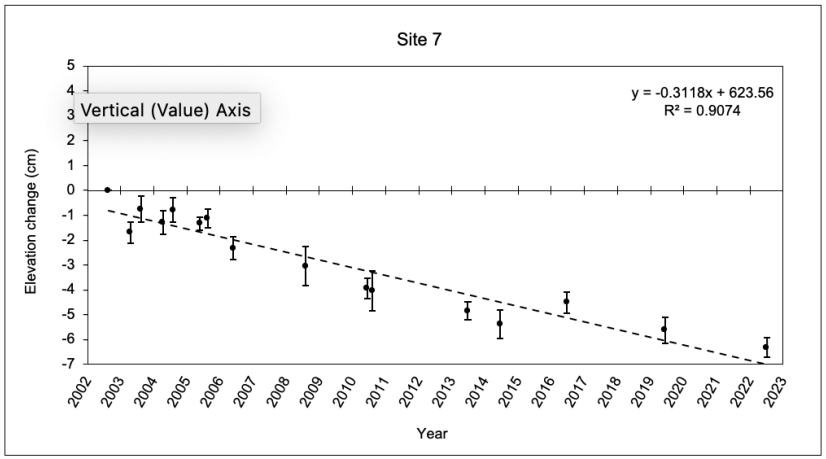
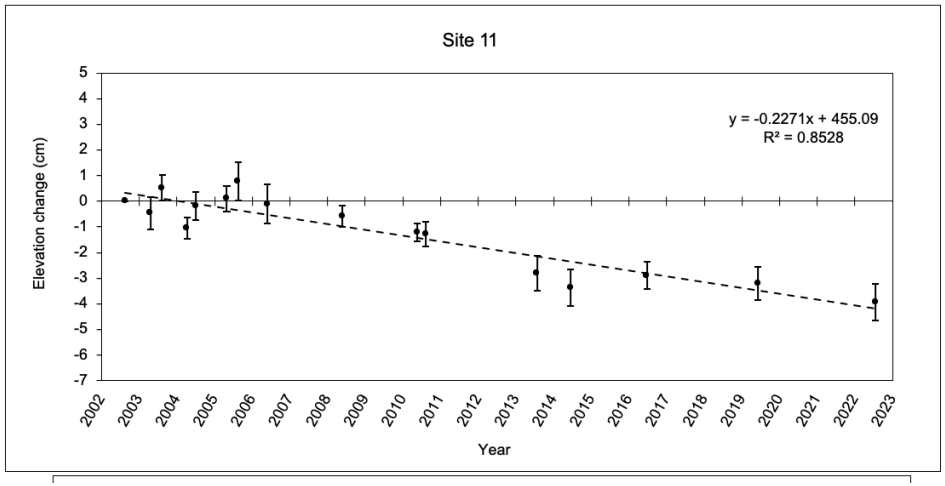
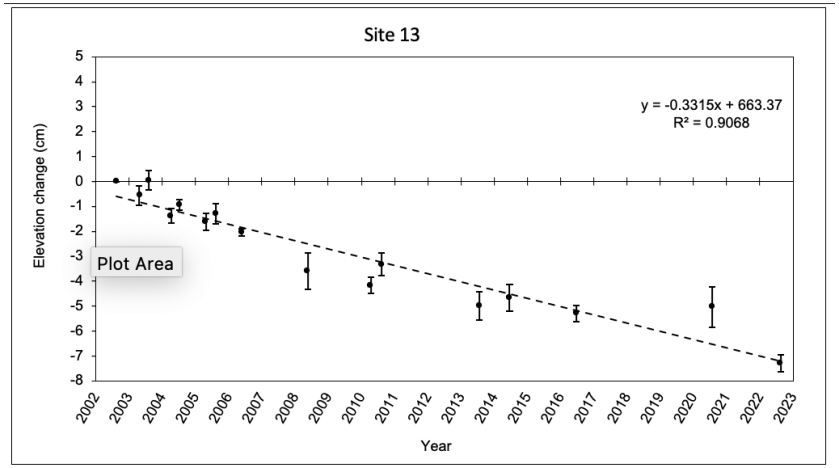


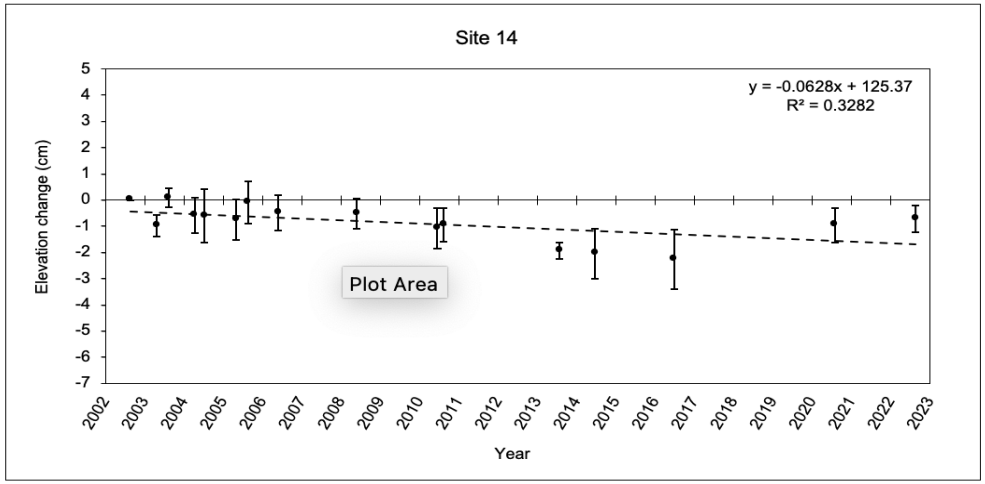
Photo: Micrometeorology Lab, UBC


Padilla Bay
Washington
1
2
3
4
4B
5
6
5B
7
8
9
10
11
12
12B
13
14
14B
16B
18
17
15
16
N
0
1
2
3
4
Kilometers

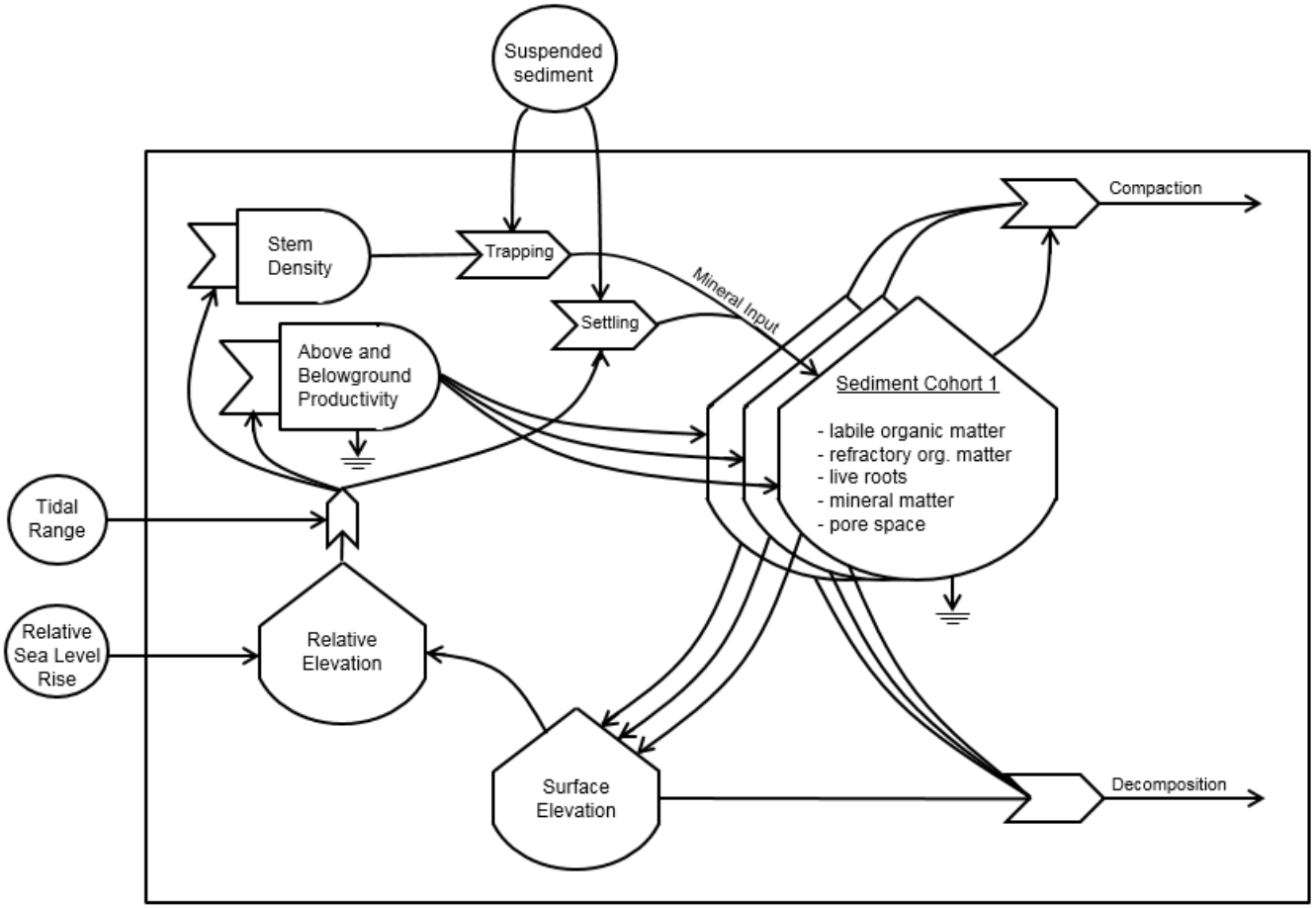

Site 7
y = -0.3118x + 623.56
R² = 0.9074
Vertical (Value) Axis
Elevation change (cm)
Year


Site 11
y = -0.2271x + 455.09
R² = 0.8528
Elevation change (cm)
Year


Site 13
y = -0.3315x + 663.37
R² = 0.9068
Plot Area
Elevation change (cm)
Year


Site 14
y = -0.0628x + 125.37
R² = 0.3282
Plot Area
Elevation change (cm)
Year

Why aren’t accretion rate high in PNW?

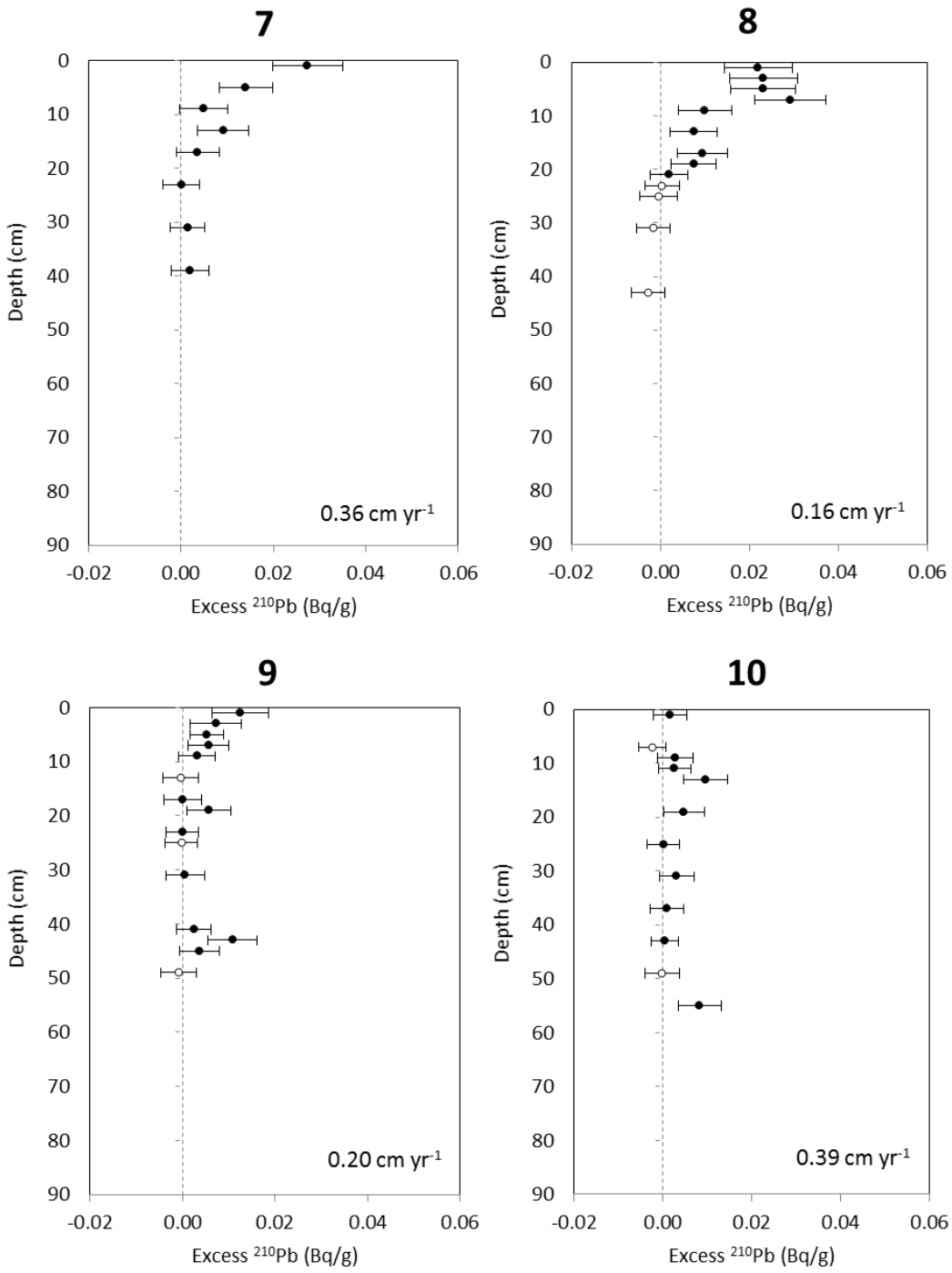

Suspended sediment
Stem Density
Trapping
Settling
Mineral Input
Compaction
Above and Belowground Productivity
Sediment Cohort 1
- labile organic matter
- refractory org. matter
- live roots
- mineral matter
- pore space
Tidal Range
Relative Sea Level Rise
Relative Elevation
Surface Elevation
Decomposition

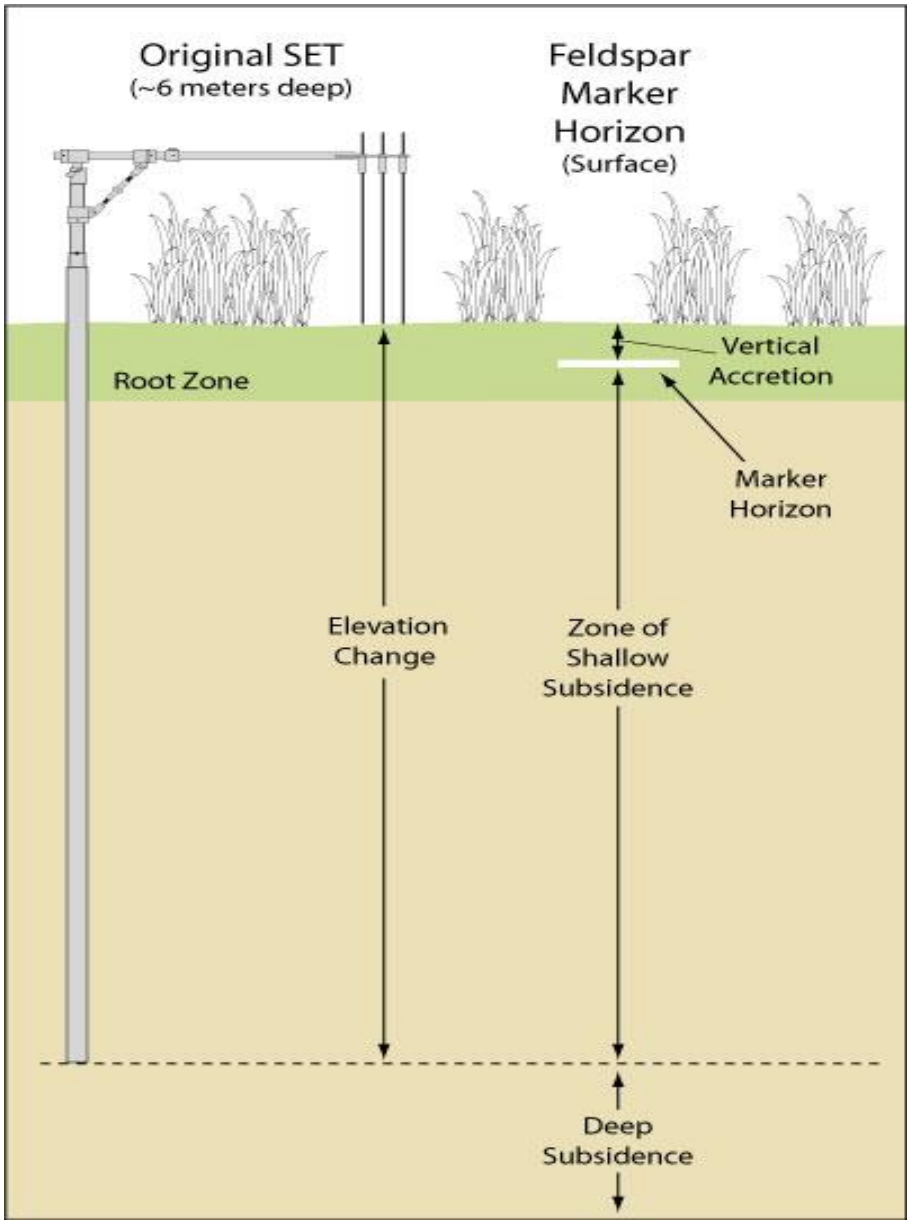
Methodological Restraints

- Horizon Markers
- Cores
- SETs

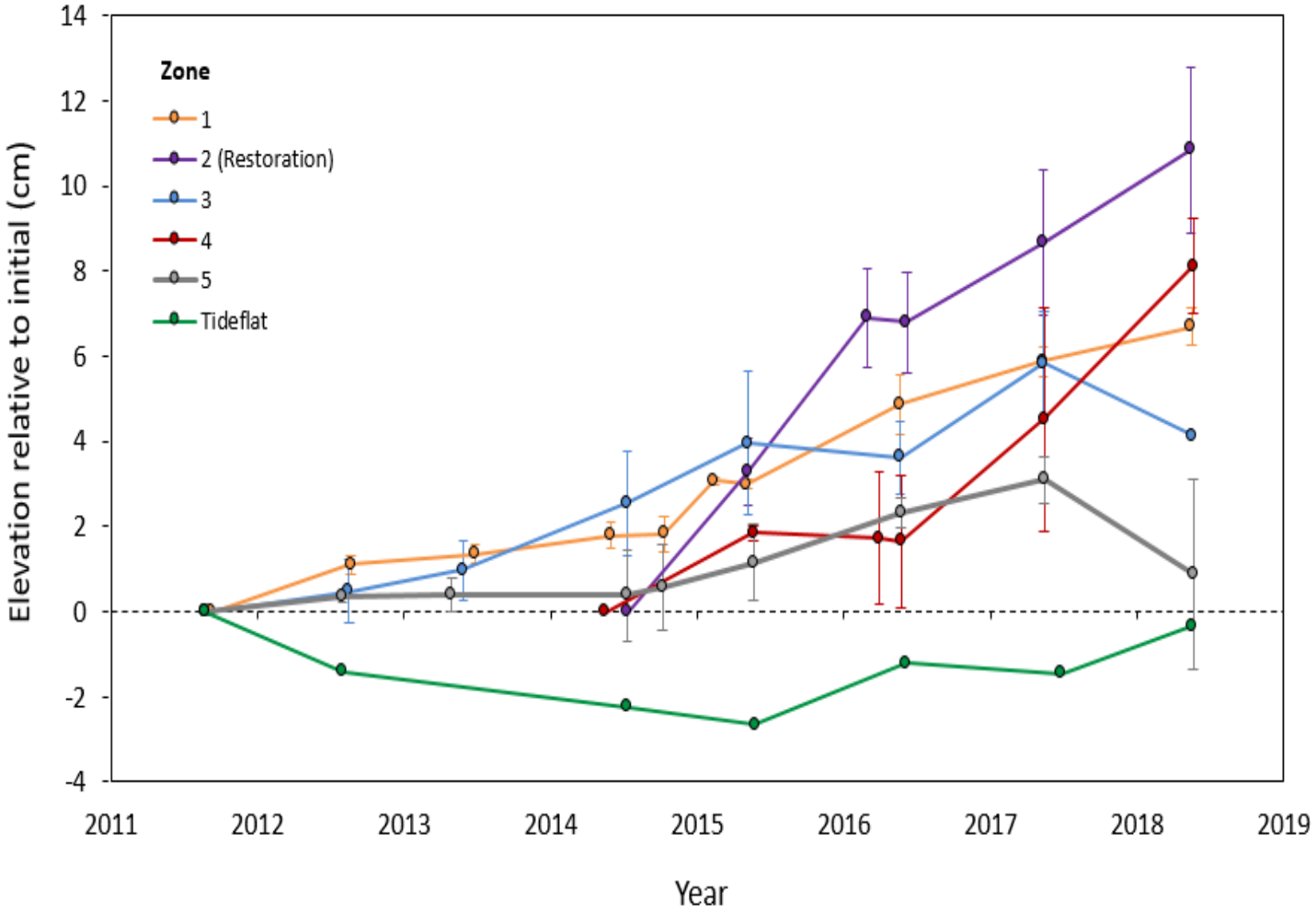
Laboratory Methods

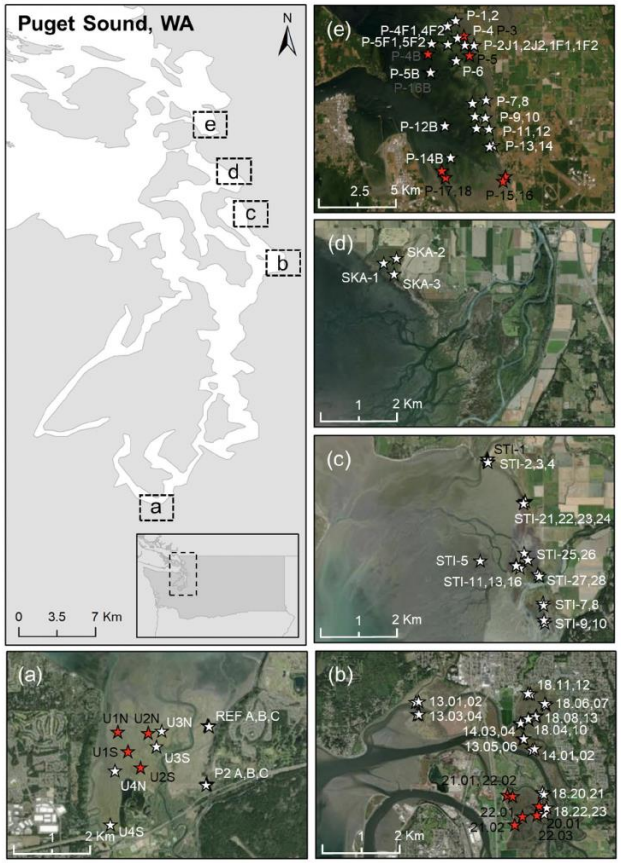
- Cores sliced into 2cm sections
- Bulk Density
- LOI % O.M. and Mineral Matter by Weight
- Carbon by ratio
- Accretion by ^{210}Pb


7
8
9
10
Depth (cm)
0
10
20
30
40
50
60
70
80
90
-0.02
0.00
0.02
0.04
0.06
Excess ^{210}Pb (Bq/g)
0.36 cm yr^{-1}
0.16 cm yr^{-1}
0.20 cm yr^{-1}
0.39 cm yr^{-1}



Shallow subsidence = Vertical accretion - elevation change


Zone
1
2 (Restoration)
3
4
5
Tideflat
Elevation relative to initial (cm)
14
12
10
8
6
4
2
0
-2
-4
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year



- First SETs establish in 2002 @ Padilla Bay, WA
- Currently there are over 100 SET deployed on the USA side of the Salish Sea (and another 100 in Canada).
- Padilla Bay, Nisqually, Stillaguamish, Snohomish, Skagit
- Reference and restored marshes
- These deltaic estuaries comprise 75% of current estuarine habitat

Other Caveats

Take Home Messages