Long-term impacts of living shorelines to SAV habitats in Chesapeake Bay

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Restoration Research Questions:

How does impacting SAV compare to the benefit of creating intertidal wetland?

Under what conditions...is an SAV impact tolerable? How can indirect impacts...on SAV loss be better predicted?

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Addressing shoreline erosion with living shorelines

1. Chesapeake Bay focus but ubiquitous problem; in the Bay,
    - 33% of the shoreline is eroding; 70% of the Maryland portion
    - 85% of the shoreline is privately owned

2. Past efforts focused on “hard” approaches like breakwaters and rip rap
    - ~25% of the Bay’s shoreline already hardened, more than 50% in some areas, with generally negative ecosystem impacts

3. Recent push (including Maryland laws in 2003) for living shorelines as an alternative. These have habitat benefits (e.g. fish, wildfowl) – but, how do they impact adjacent ecosystems, especially SAV? And, what are the trade-offs in ecosystem services?

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Research Questions

Q1: Does living shoreline installation impact existing SAV beds?
SAV trends adjacent to living shorelines and reference shorelines should be similar in the years before installation but may diverge (less SAV at living shorelines) after installation.

Q2: Are living shorelines effective?
Shoreline erosion rates should be lower after living shoreline installation.

Q3: What are potential trade-offs in ecosystem services (sediment and nutrient accretion)?
Both plant communities trap sediment and associated nutrients, and so net accretion should be highest when SAV is present adjacent to living shorelines and lowest when SAV is absent adjacent to natural shorelines.

Not discussed today:
Q4: Is SAV habitat altered by living shoreline installation?

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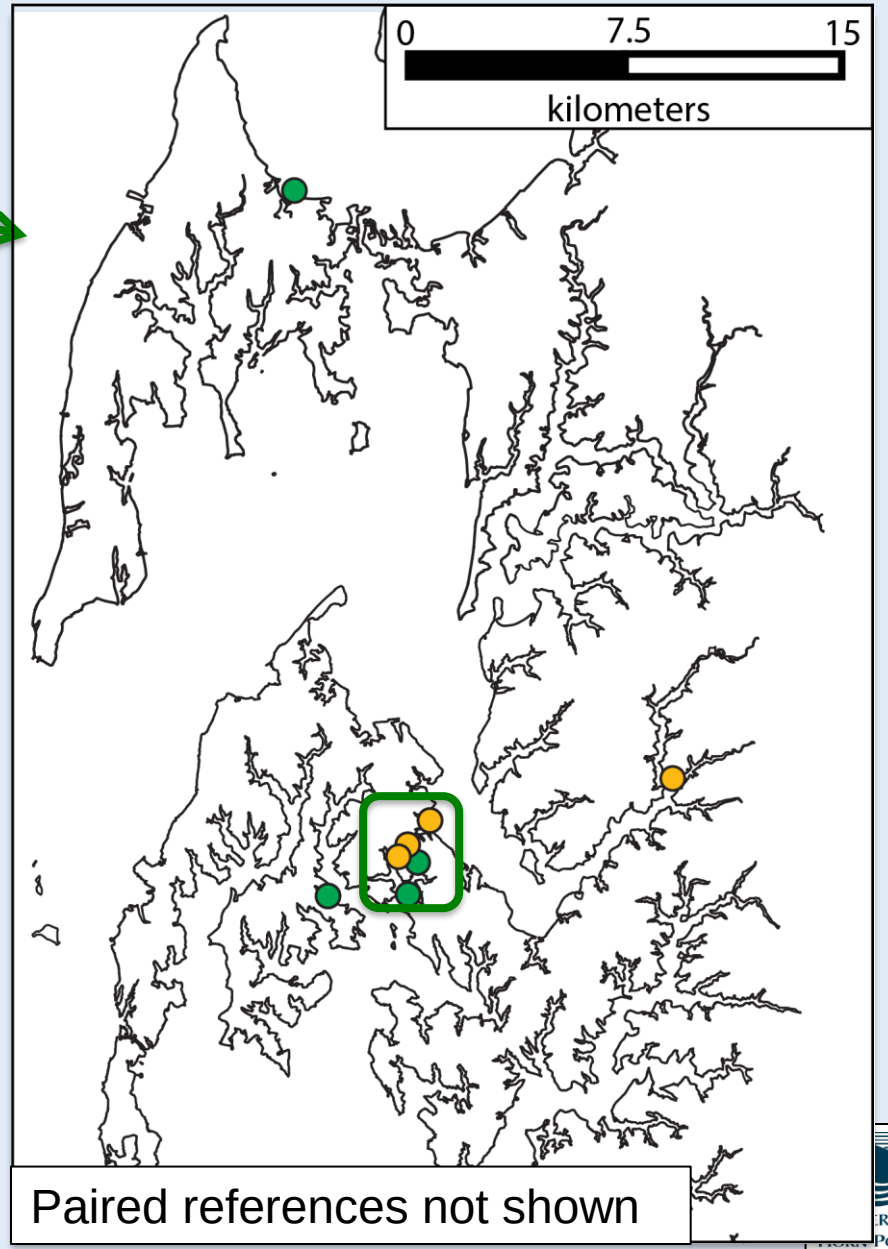
Study Sites



8 sites with paired reference sites (natural shorelines, typically within ~0.5 km, similar physical setting) in the mesohaline portion of Chesapeake:

- Weighted-bed density of SAV from 1978-2005 (GIS analysis of VIMS aerial data)
- 4 sites with persistent, dense SAV before installation (green)
- 4 sites without SAV before installation (yellow)

Paired references not shown

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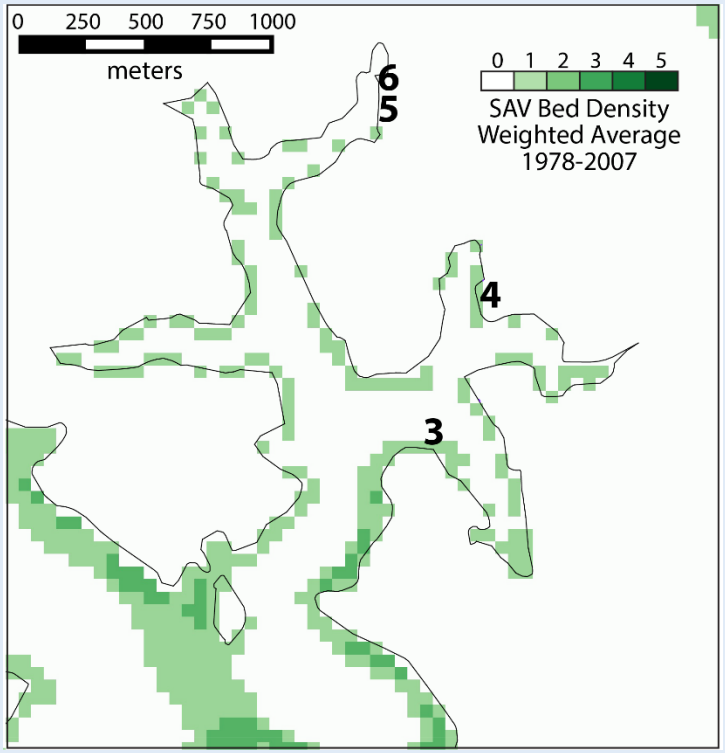
Sites (continued)

Site (#)	Install Year	SAV before?	Length, feet (meters)
QL (1)	2005	yes	600 (182.9)
OP (2)	2006	yes	440 (134.1)
RU (3)	2008	yes	1330 (405.4)
HG (4)	2007	yes	1860 (566.9)
SD (5)	2007	no	770 (234.7)
EC (6)	2005	no	550 (167.6)
MG (7)	2004	no	1500 (457.2)
MM (8)	2008	no	615 (187.5)



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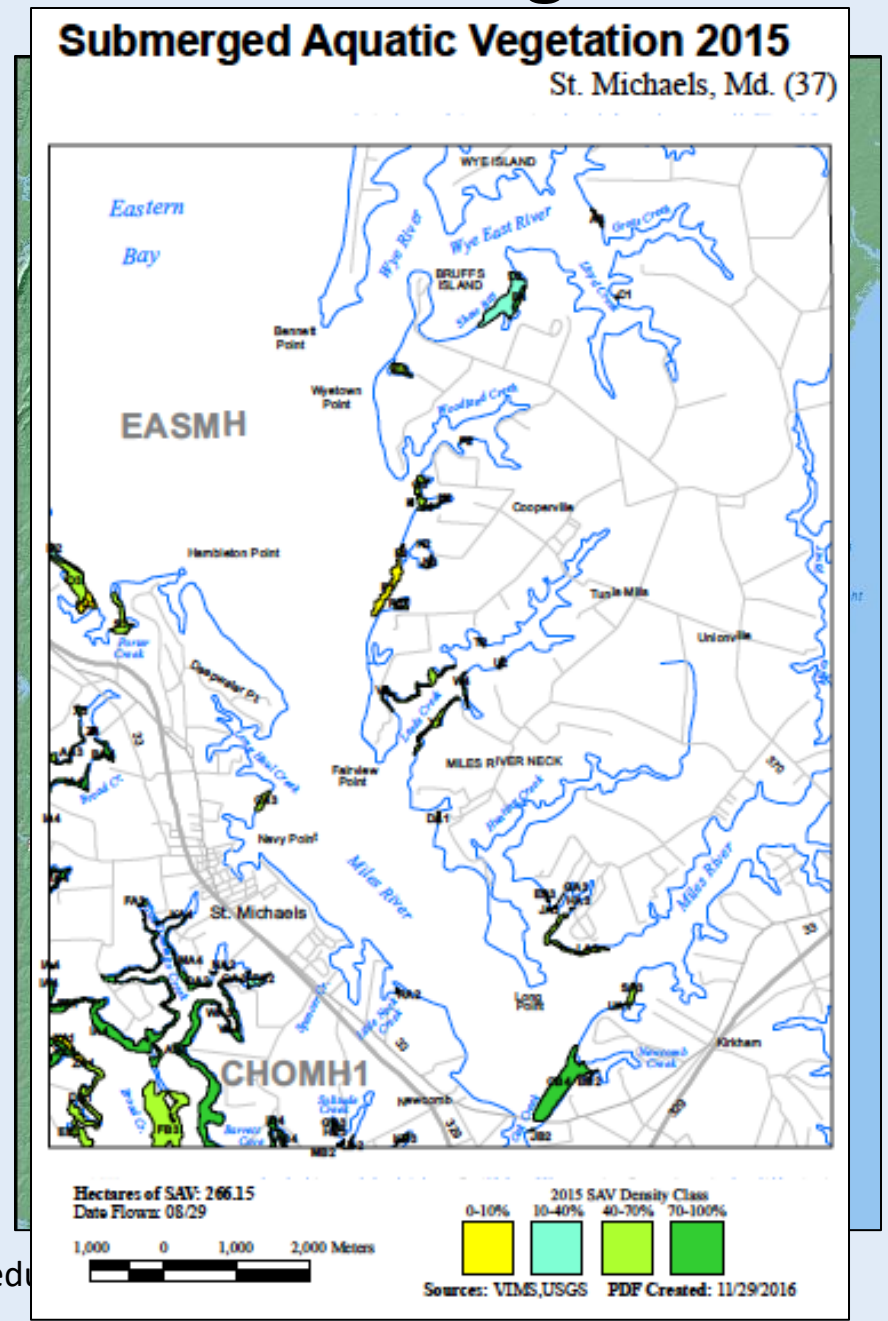
Q1: Does living shoreline installation impact SAV?



Aerial photography from VIMS 1978, 1984-present w/ground surveys

Segments (large areas) and quads (smaller areas)

Delineate density classes: 0-10%, 10-40%, 40-70%, 70-100%

Photographs, GIS data on VIMS SAV website (http://web.vims.edu/bio/sav)

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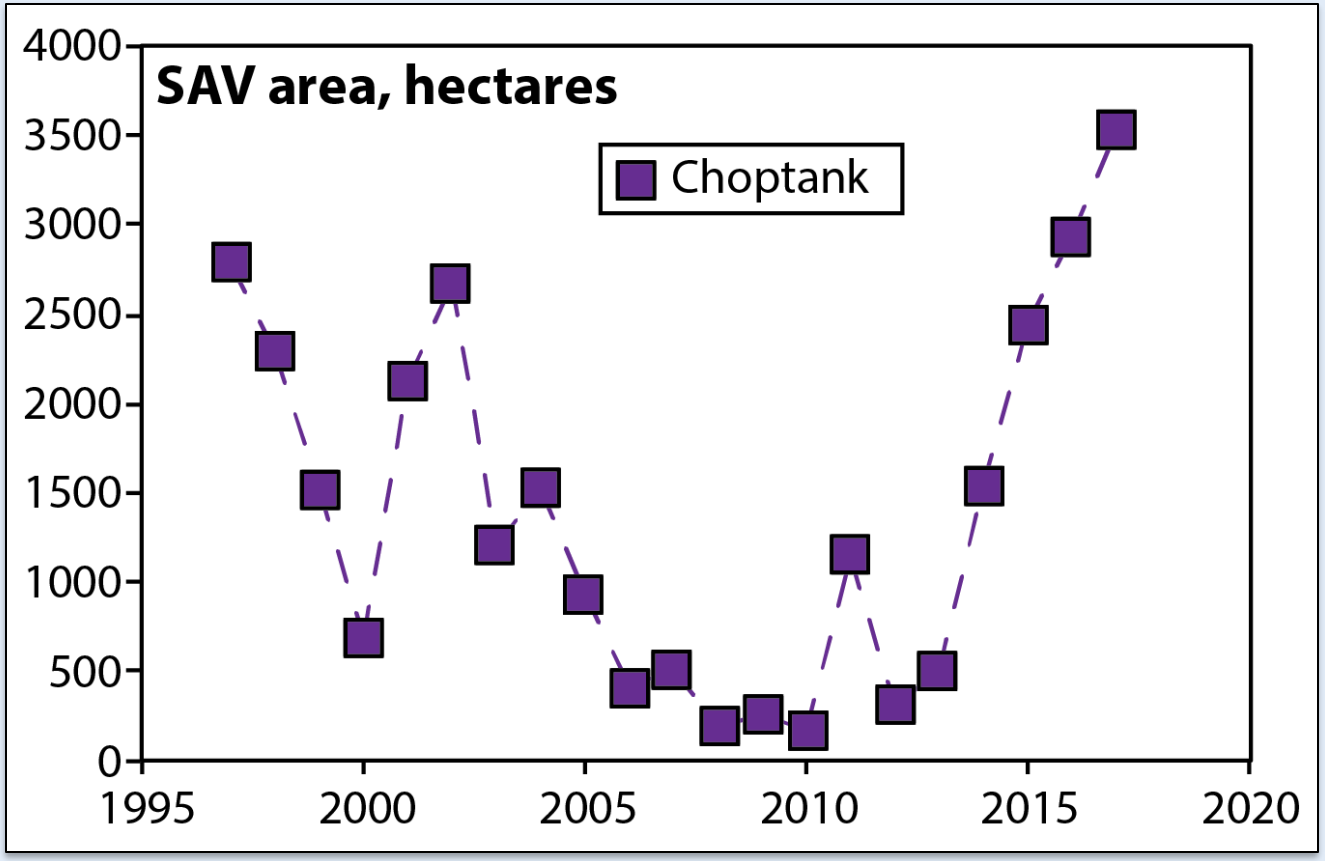
SAV area within a segment is highly variable



- Area high at start of window (1997), decreases to 2000, recovery to 2002
- Decline after 2002, sustained low areas from 2005-2012, except for 2011
- Resurgence from 2012 to 2017

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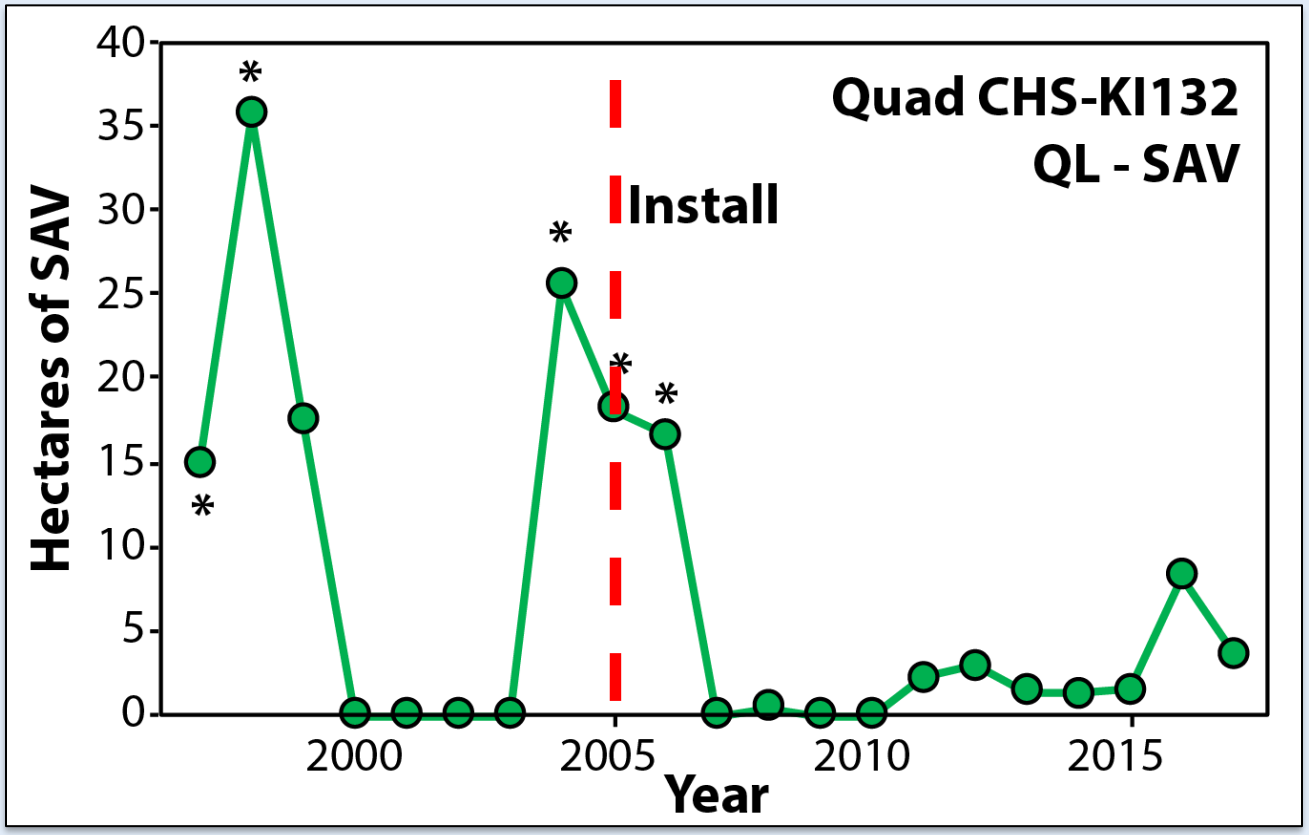
SAV area within a quad and presence at a site also vary



SAV generally present at this site if there is ~15 or more hectares of SAV within the quad – indirect evidence of "enough" water clarity and/or seed bank

And/or: SAV disappears from site after living shoreline installation; not present at the site even if it is present in the quad

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Year	SAV, quad (ha)	SAV, site	SAV, reference
1997	15.03	4	0
1998	35.60	3	3
1999	17.42	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2007	0	0	0
2008	0.52	0	0
2009	0	0	0
2010	0	0	0
2011	2.31	0	0
2012	3	0	0
2013	1.43	0	0
2014	1.26	0	0
2015	1.53	0	0
2016	8.30	0	0
2017	3.62	0	0

SAV distributions at all shorelines appear to follow trends in larger area, with no obvious impact of living shoreline installation.

Categories for SAV in quad (ha):

- 0 = Absent
- 0-9 = Low
- 9-18 = Medium
- 18-27 = High
- 27-36 = Very high

- 1 = Low
- 2 = Medium
- 3 = High
- 4 = Very high

- 2005 install
- SAV disappears from site and nearby reference at same time
- SAV persists in quad at lower levels
- No obvious relationship to living shoreline install

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Q2: Are living shorelines effective in reducing erosion?

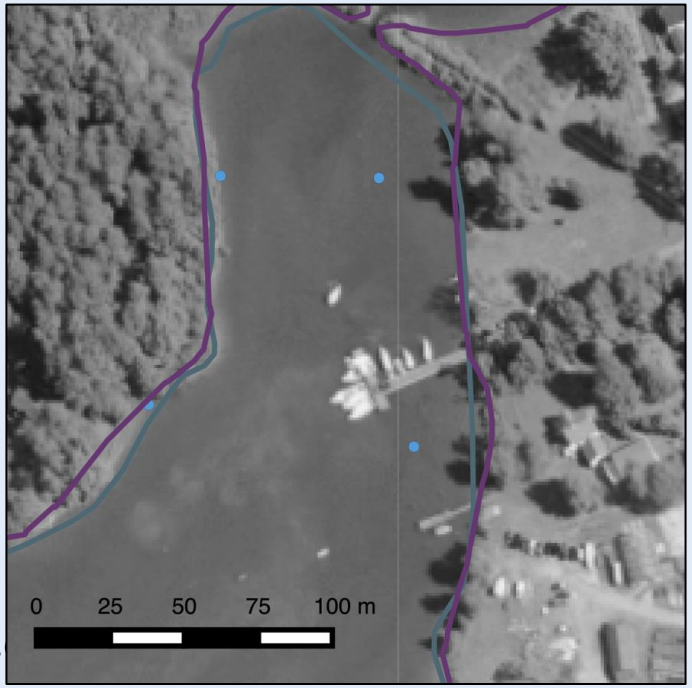
GIS analysis:

- Historical: difference of 1942-1994 MGS shoreline surveys perpendicular to site

- Current: georeferenced aerial photos from VIMS; digitized shorelines in 2003 (before any living shorelines installed) and 2017 (first field survey)

Feb 2007 Google Earth

Living shoreline
Natural shoreline



July 2003 VIMS
Purple = 1994 shoreline
Blue = 1942 shoreline

MGS = Maryland Geological Survey
VIMS = Virginia Institute of Marine Science
Thank you Dave Wilcox and JJ Orth (VIMS)!

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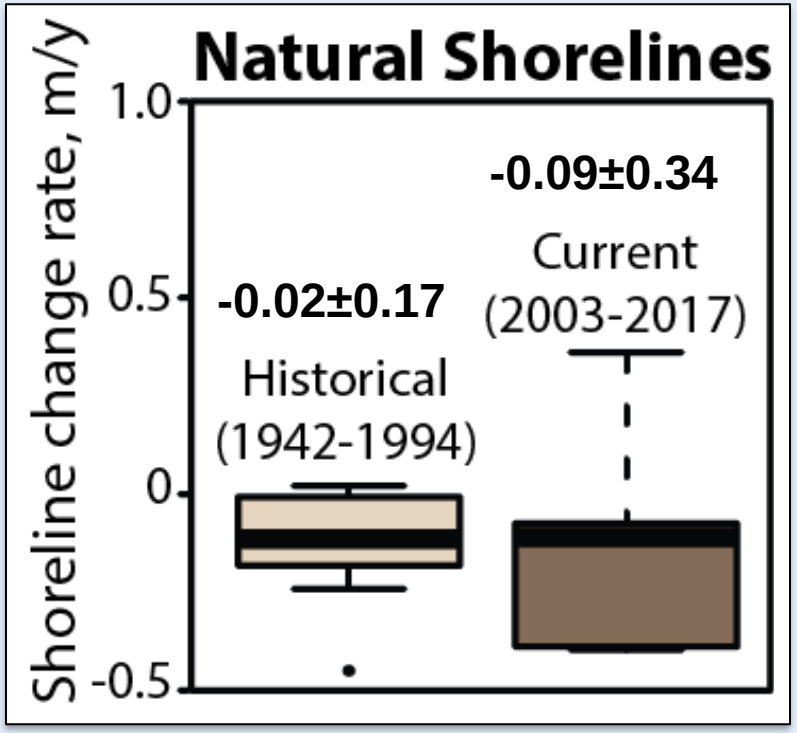
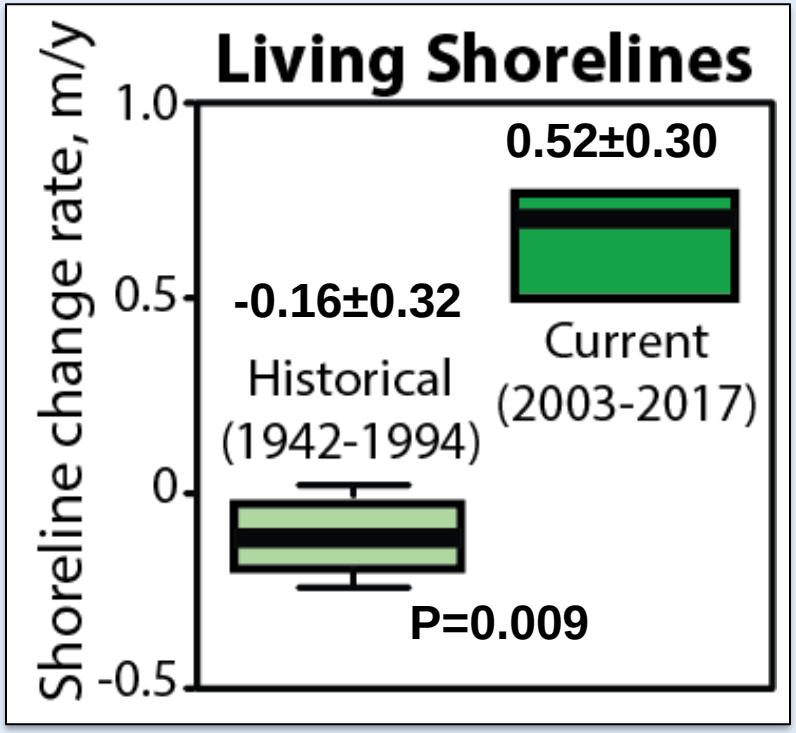
Erosion continues at natural shorelines; net accretion at living shorelines





Trend of increasing erosion at natural shorelines but not statistically significant (p>0.10)

Significant accretion at living shorelines from installation (instantaneous change rather than rate)

Negative change = erosion (shoreline moves landward)
Positive change = accretion (shoreline moves seaward)

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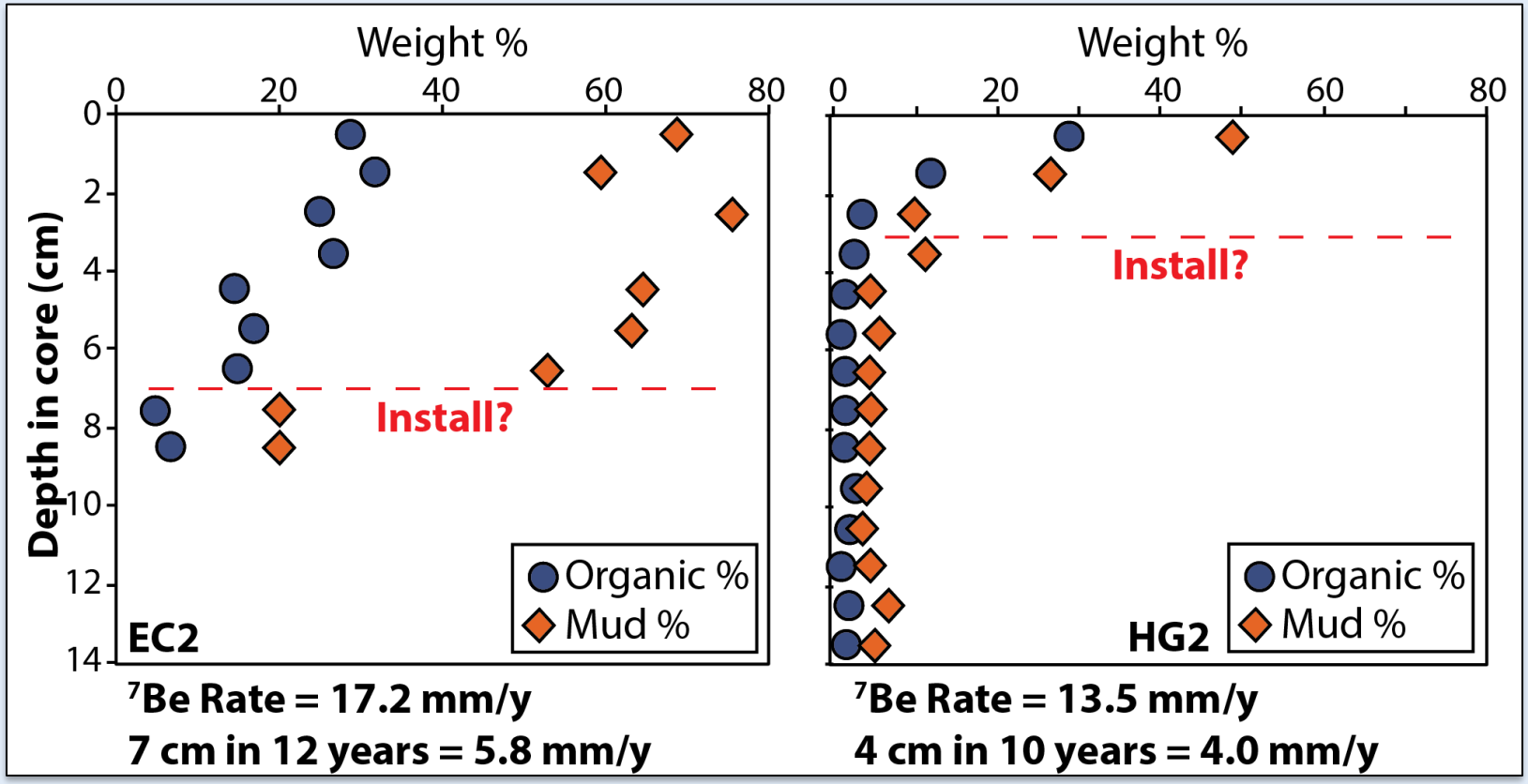
Q3: What are potential trade-offs in ecosystem services (sediment and nutrient accretion)?



- Vertical sediment profiles in the marsh of two living shoreline sites
- Change in sediment character (mud/organic content) likely from sand layer during installation (below line) overlain by marsh accretion (above line)
- ^{7}Be (half-life 53.3 days) rates are ~2-3 times higher than estimate from install horizon – seasonal bias, recent acceleration, delay in first few years?

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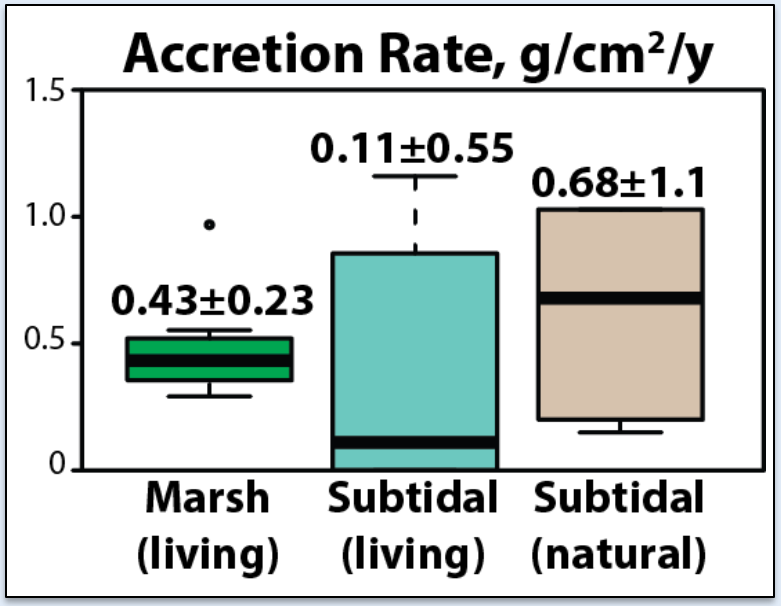
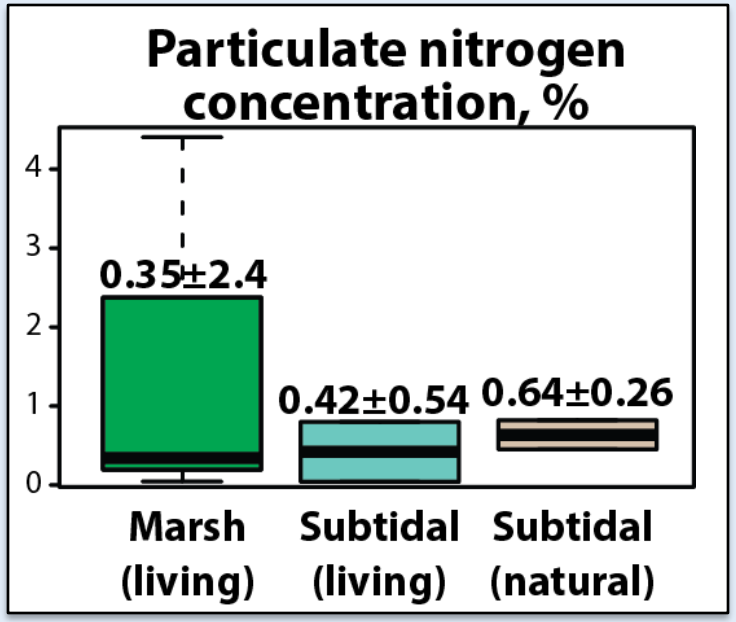
Highest accretion in the subtidal next to natural shorelines

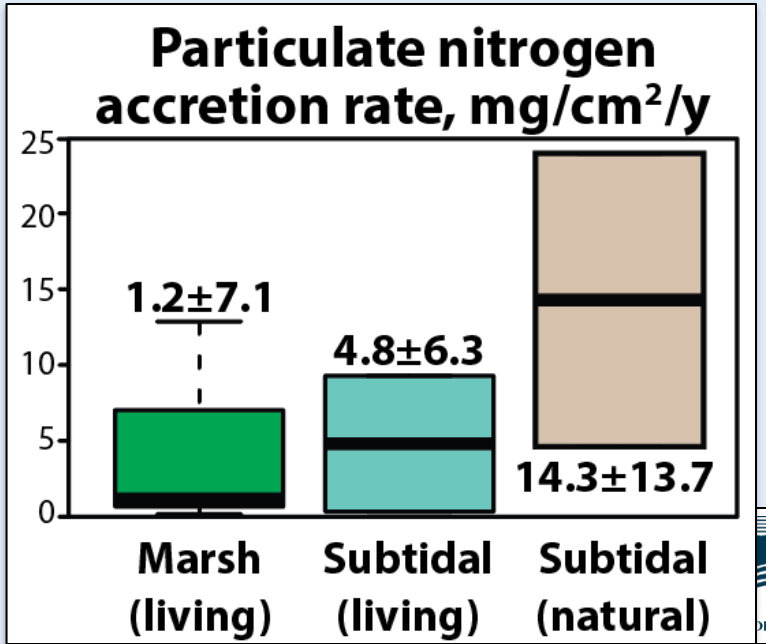




Median accretion rate for marsh + subtidal living shorelines ~ rate at natural shorelines; coincidence?

Very limited particulate nitrogen concentration data; marsh value especially variable

Particulate nitrogen accretion rates calculated for sites, then averaged



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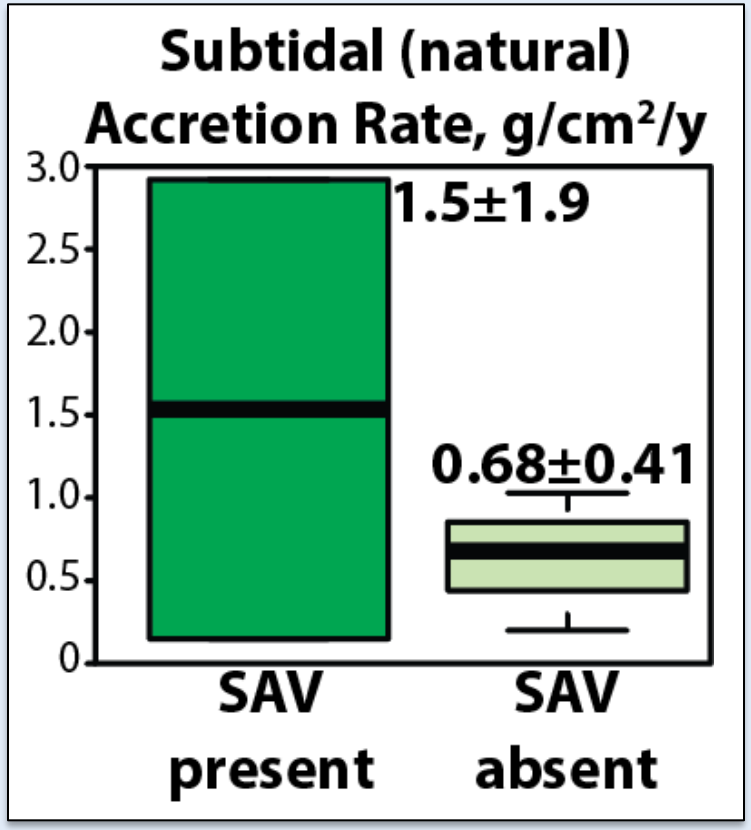
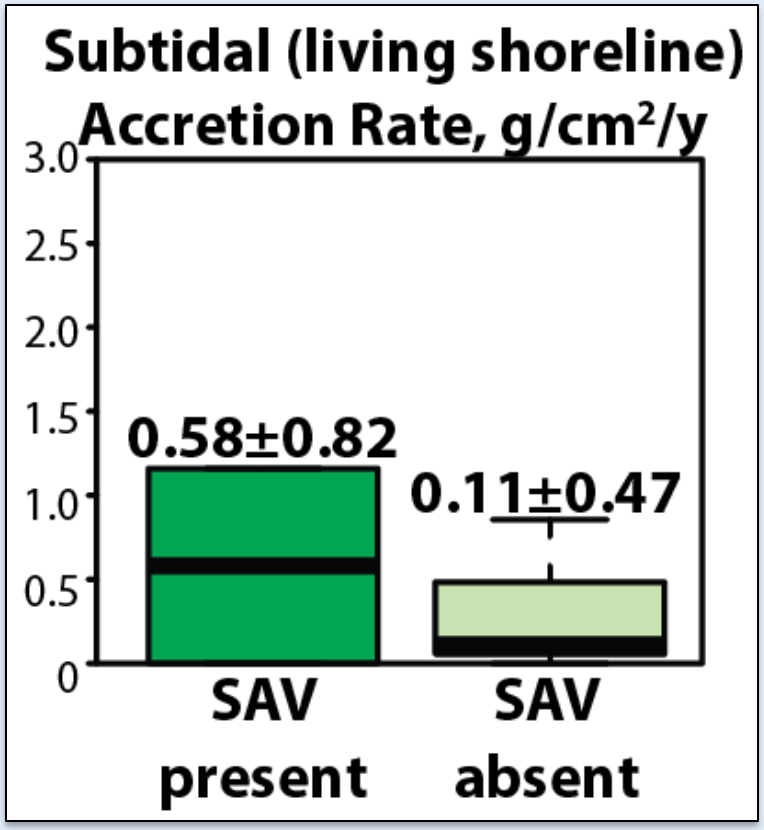
SAV is effective at trapping sediments





- Accretion rates are higher when SAV is present for both shoreline types
- Indicates SAV is effective at trapping sediments, though differences are not significant (variability, number of sites)

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Accretion is highest with both SAV and living shorelines

Average accretion rate, g/cm²/y	SAV present	SAV absent
Natural subtidal	1.5±1.9	0.64±0.42
Living shoreline subtidal	0.58±0.82	0.32±0.46
Living shoreline marsh	0.60±0.33	0.41±0.11

Average particulate nitrogen concentration, % (very limited data)	
Natural subtidal	0.64±0.26
Living shoreline subtidal	0.42±0.54
Living shoreline marsh	1.6±2.4

Particulate nitrogen accretion rate, mg/cm²/y	SAV present	SAV absent
Natural subtidal	9.8	4.2
Living shoreline subtidal	2.4	1.3
Living shoreline marsh	9.6	6.6

WINNER! Living shoreline with SAV = 12.0 mg/cm²/y

Second Place: natural shoreline with SAV

Third Place: living shoreline without SAV = 7.9 mg/cm²/y

Loser: natural shoreline without SAV

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Summary

Q1: Does living shoreline installation impact existing SAV beds?

- SAV distributions at all shorelines appear to follow trends in larger area.
  - ➢ No obvious qualitative impact of living shoreline installation

Q2: Are living shorelines effective in reducing erosion?

- There is net accretion (shoreline moves seaward) at living shorelines from installation, but continuing erosion (shoreline moves landward) at or above historical rates at natural shorelines.

Q3: What are potential trade-offs in ecosystem services (sediment and nutrient accretion)?

- Subtidal accretion rates are highest next to natural shorelines where SAV is present, which likely reflects increased sediment supply from shoreline erosion and trapping by SAV
- Net nitrogen accretion rates appear to be highest for sites with both living shorelines and SAV, and lowest for natural shorelines without SAV
  - ➢ Living shorelines enhance net sediment and nitrogen accretion via the added component of accretion in the marshes of living shorelines, especially in the absence of SAV.

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Jana Davis
Chesapeake Bay Trust

What does this mean for me?

- SAV is really variable; comes and goes
- SAV might disappear at a site at which a living shoreline was built, but if so, it likely disappeared in the region as a whole also
- So don’t be alarmed if SAV disappears after living shoreline installation; it wasn’t necessarily tied to the living shoreline

What does this mean for me?

- Living shorelines have two elements that trap sediment and nutrients: the marsh platform and the subtidal below.

- SAV beds not in front of living shorelines are also associated with trapped nutrients and accreting sediments

- You get the most nutrient trapping when both are present, so if your goal is nutrient removal, having both habitat types present is good

What does this mean for me?

What do I take from this if I am a practitioner:

- Both living shorelines and SAV are good from a nutrient and sediment removal perspective (and we know habitat). Considering designing to encourage SAV below the site
- Natural shoreline has nutrient reducing value too; don't use shoreline protection unless you have to

What do I take from this if I am a regulator:

- Diversity of vegetative habitats is good for critters – we knew that already. It also appears good for nutrient and sediment removal
- I'd be careful to not attribute SAV loss to living shorelines – it's possible any loss is due to larger patterns in the region
- Because both living shorelines and SAV have similar nutrient/sediment reducing value, I'd be balanced: In areas with lots of wetland but little SAV, perhaps don't encourage covering up the last SAV sprig with a living shoreline. In areas with lots of SAV but no wetland, consider allowing living shorelines