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 2008) 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?

Research Questions

Performance:
Q1: Are living shorelines effective in reducing shoreline erosion?

Impacts:
Q2: Do living shorelines alter SAV habitat and/or distributions?

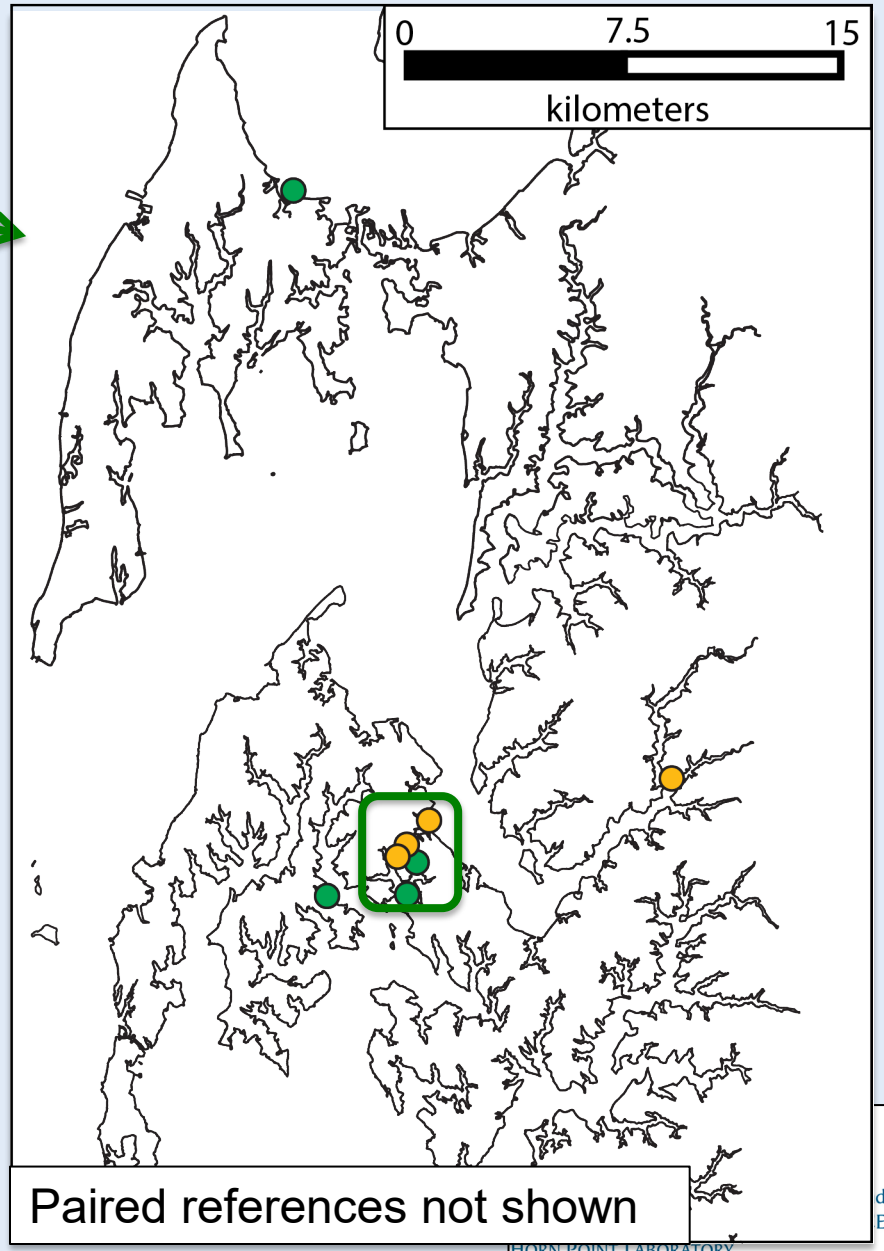
Co-benefits:
Q3: What are potential trade-offs in ecosystem services (sediment and nutrient accretion)?



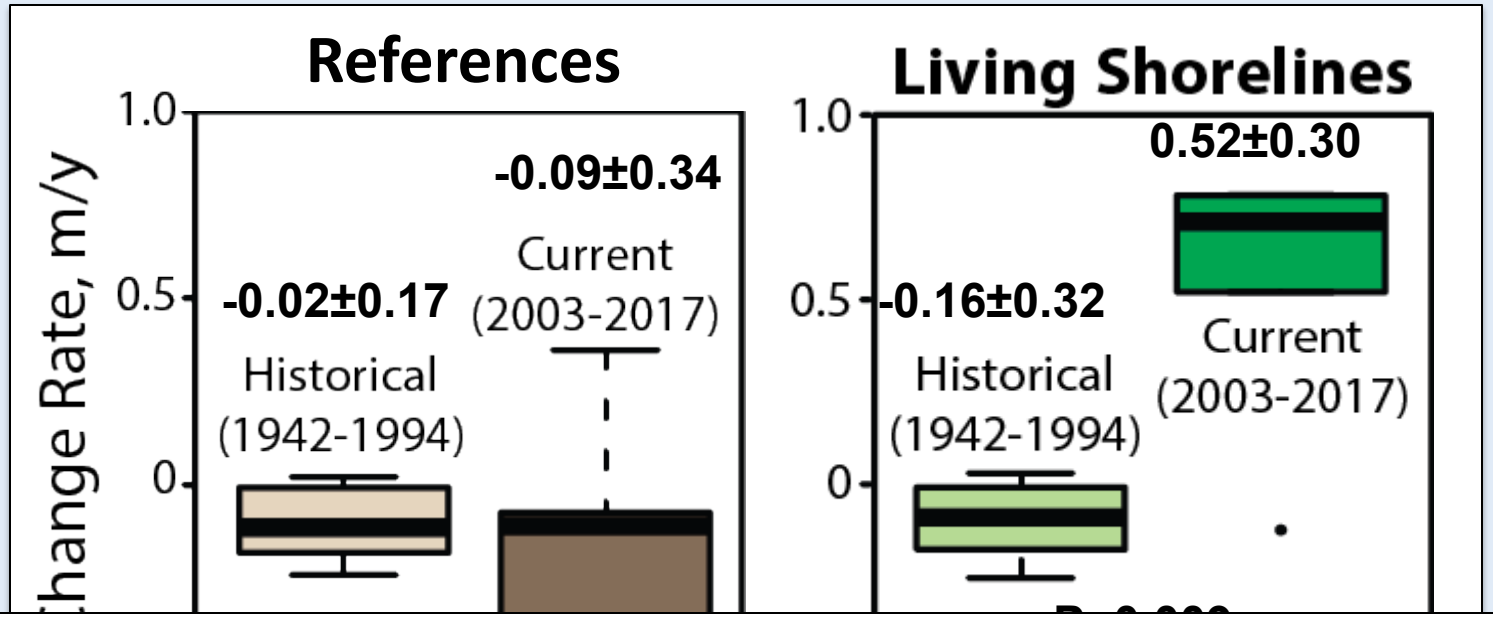

Study Sites

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

- Installed 2004-2008
- 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)



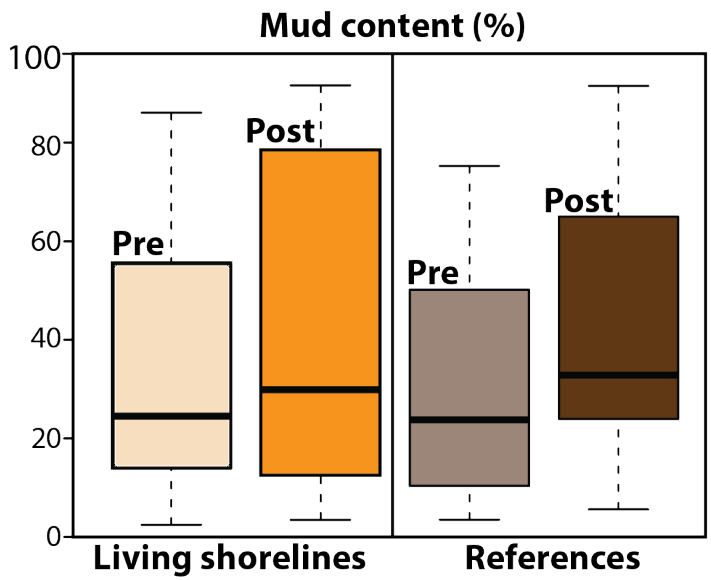
Performance: erosion rates before and after installation

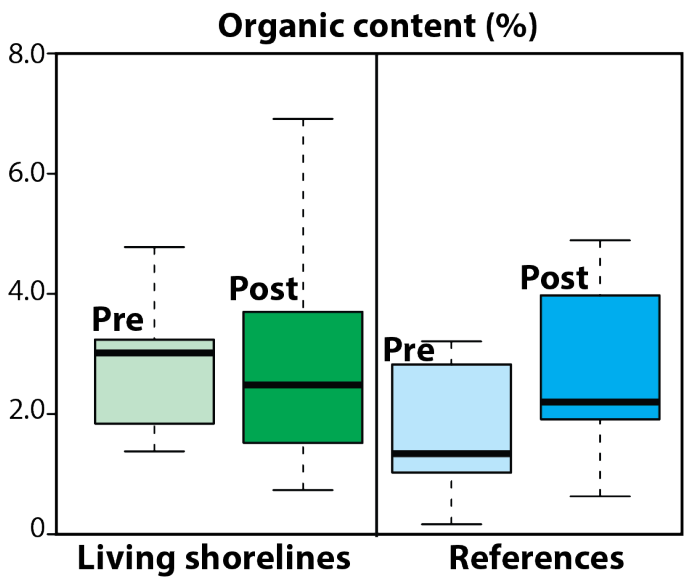


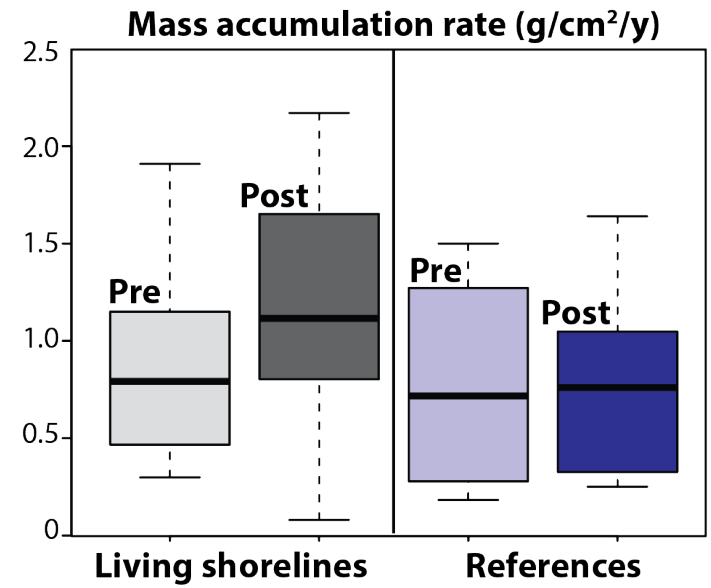
Net accretion occurs at living shorelines due to installation, while **erosion continues at or above historical rates at reference** sites

- **Negative** change = erosion (shoreline moves landward); **Positive** change = accretion (shoreline moves seaward)
- Trend of increasing erosion at reference shorelines but not statistically significant ($p>0.10$)
- Significant accretion at living shorelines from installation building shoreline seaward (~instantaneous change rather than rate)

Impacts: Do living shorelines alter SAV habitat?







No significant differences

- Pre- versus post-installation
- Living versus reference shorelines

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Changes can be significant at individual sites

Site	Mud at site	Mud at reference	Rate at site	Rate at reference
QL				
OP				
RU				
HG				
SD	NA*		NA*	
EC		NA**		NA**
MG				
MM				

T-tests between pre- and post-installation

Gray = not significant ($p<0.10$)

Red = increase

Blue = decrease

*=not enough data in “after”

**=core not collected

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Changes can be significant at individual sites

Site	Mud at site	Mud at reference	Rate at site	Rate at reference
MG				
MM				

No SAV at either the sites or their references since 1989

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Some significant changes at individual sites

Site	Mud at site	Mud at reference	Rate at site	Rate at reference
RU				
HG				

Sites: both have increasing sedimentation rates, decreasing mud (more sand)
References: both have no change in sedimentation rates, different trends for mud

Conveniently – all are in the same SAV monitoring quad

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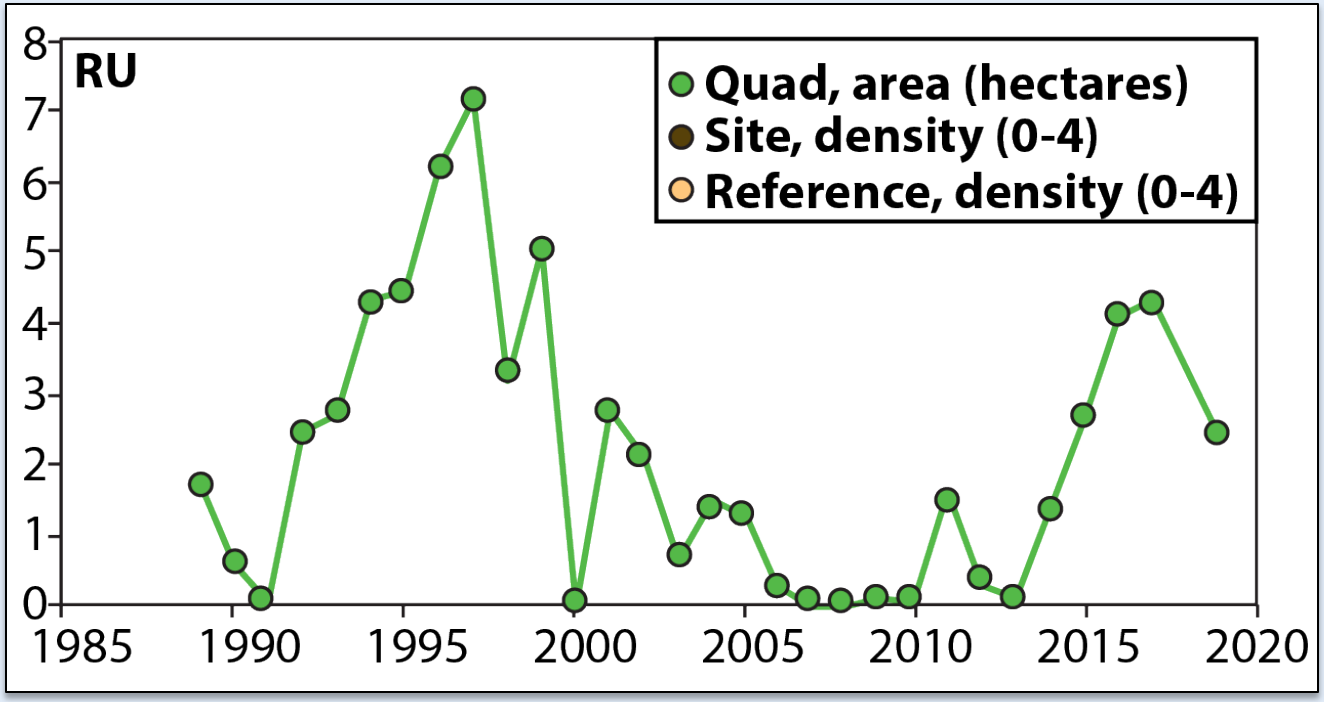
SAV area within the quad – lots of variability!



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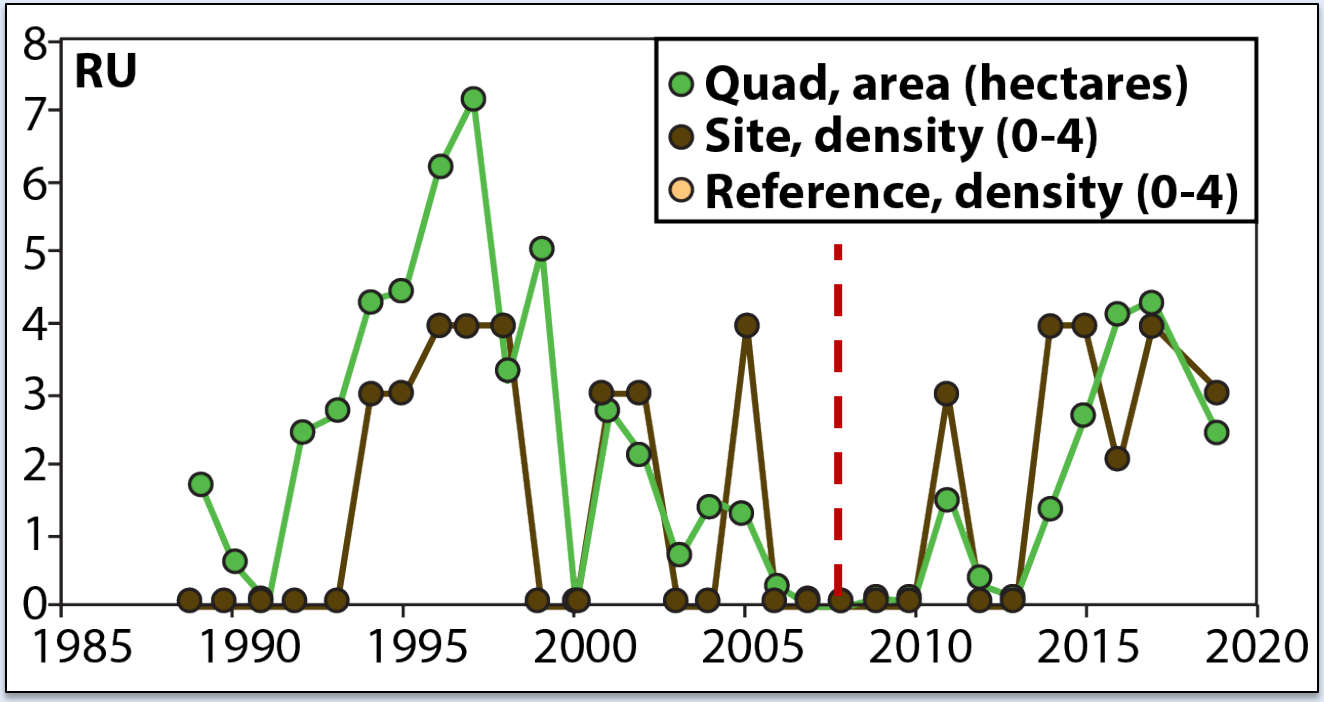
SAV area at the site follows the quad



Install 2008 (red line)

Site: increasing sedimentation rate; decreasing mud (more sand)
Reference: no change in sedimentation rate; decreasing mud (more sand)

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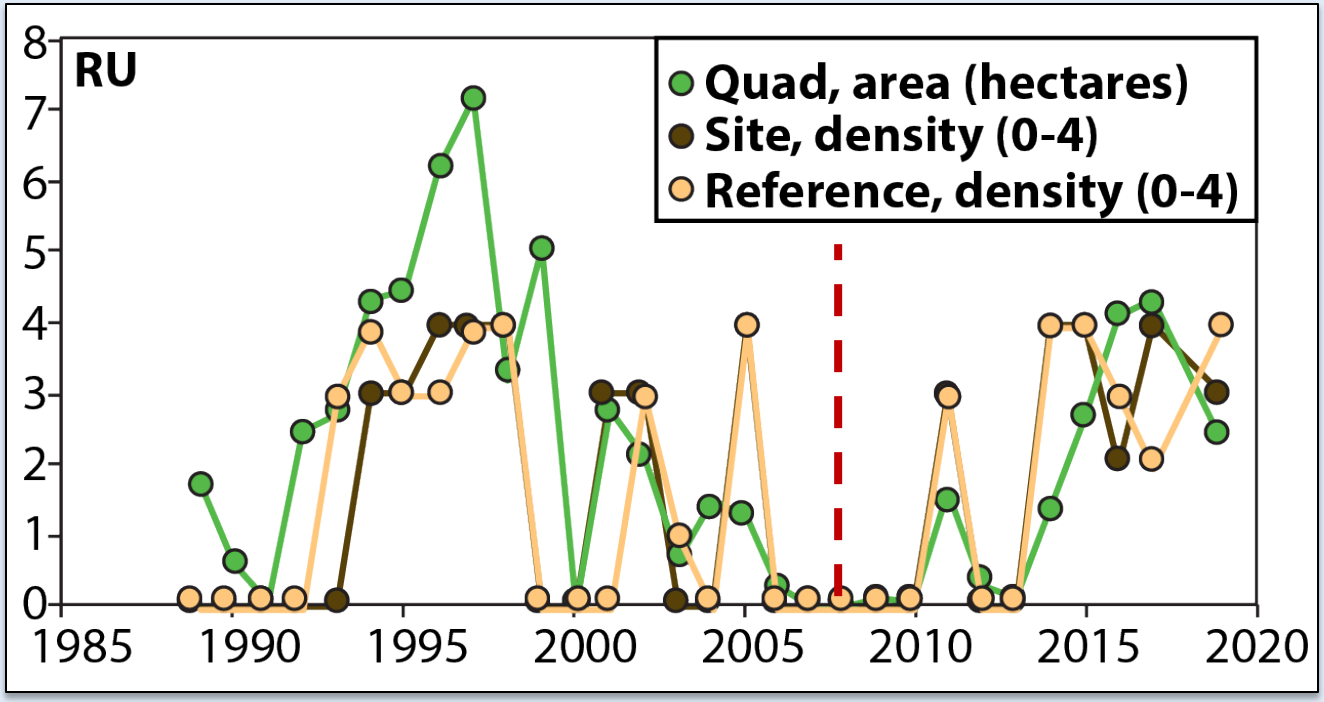
SAV area at the reference site follows general trend



Install 2008 (red line)

Site: increasing sedimentation rate; decreasing mud (more sand)
Reference: no change in sedimentation rate; decreasing mud (more sand)
No difference between SAV at site and reference site; both follow quad

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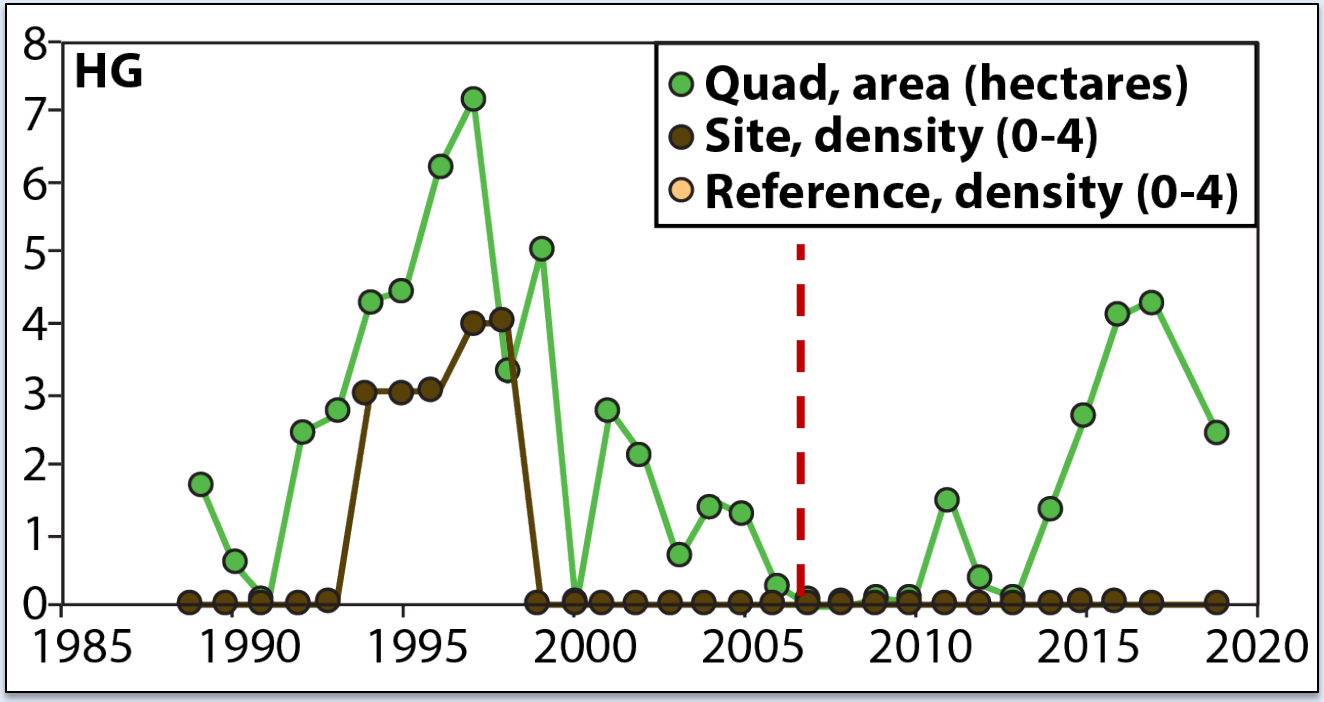
At a nearby site (same quad), SAV disappears many years before installation



Install 2007 (red line)

Site: increasing sedimentation rate; decreasing mud (more sand)
Reference: no change in sedimentation rate; increasing mud (less sand)

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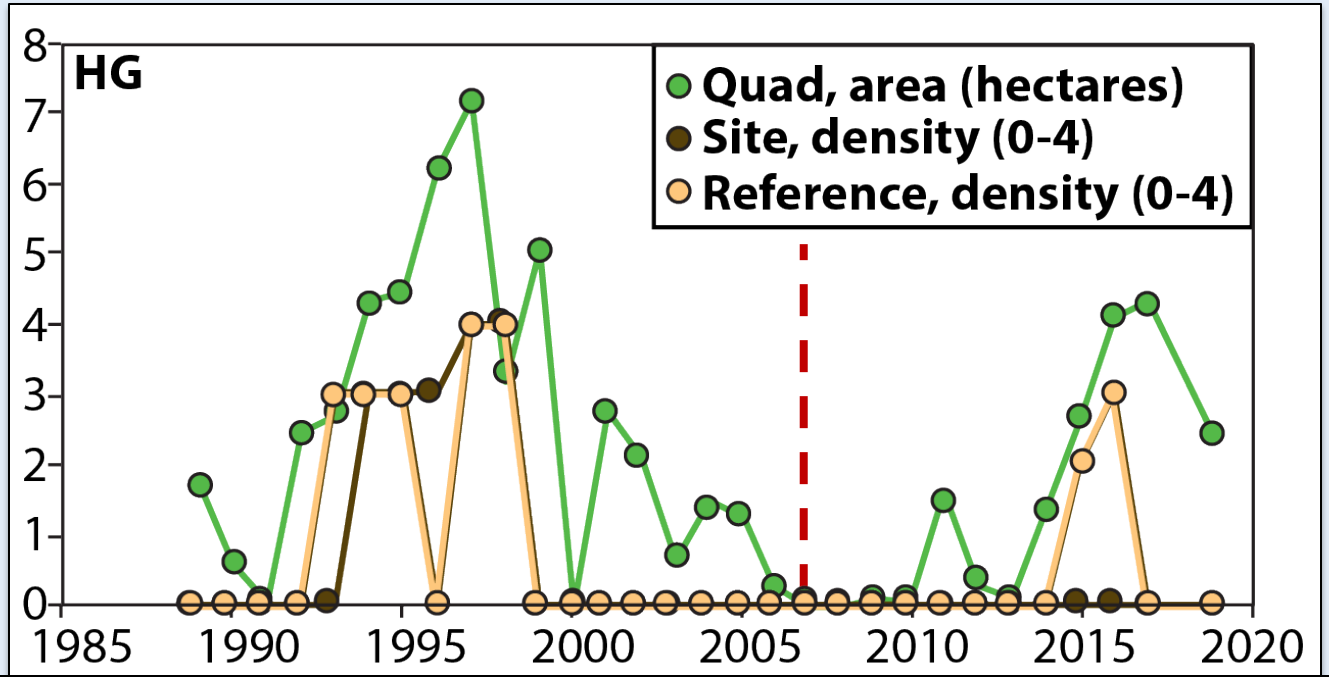
SAV disappears at a different site, same quad



Living shoreline installation **does not appear to influence** SAV distributions, which generally **follow regional trends** except for some sites where **local processes** affect both living and reference shorelines

Reference: no change in sedimentation rate; increasing mud (less sand)
SAV at site and reference follow the same trend, disappearing many years before installation and not returning, not influenced by divergence in mud trends.

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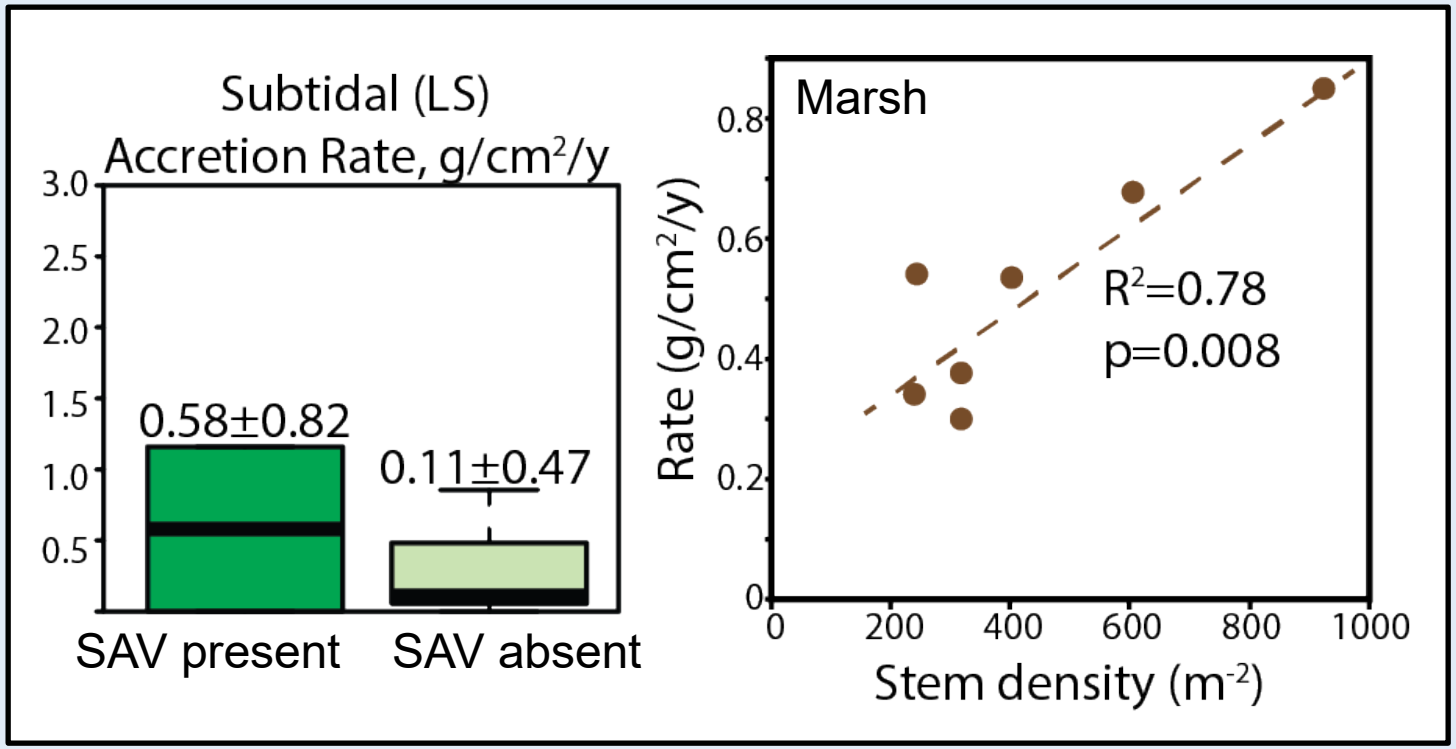
Co-benefits: what controls burial rates in marsh and subtidal? Plants!



Subtidal (LS) = shallow water adjacent to living shorelines; rates tend to be higher at sites with SAV

Marsh accretion rates increase with stem density

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Co-benefits: how do sediment and nutrient burial rates compare

SAV present	Accretion rate g/cm²/y	N burial mg/cm²/y (%)	P burial mg/cm²/y (%)	C burial mg/cm²/y (%)
Living shoreline marsh	0.67	3.0 (0.45)	4.1 (0.62)	31.7 (4.8)
Living shoreline subtidal	0.42	0.19 (0.045)	1.8 (0.43)	1.58 (0.38)
Reference subtidal	**0.15**	**0.18 (0.12)**	**0.55 (0.37)**	**1.5 (1.0)**

SAV absent	Accretion rate g/cm²/y	N burial mg/cm²/y (%)	P burial mg/cm²/y (%)	C burial mg/cm²/y (%)
Living shoreline marsh	0.45	3.6 (0.81)	3.6 (0.80)	41.8 (9.3)
Living shoreline subtidal	0.11	0.10 (0.09)	0.57 (0.52)	0.90 (0.82)
Reference subtidal	**0.53**	**0.92 (0.18)**	**4.7 (0.90)**	**9.4 (1.8)**

Living shorelines **increase** sediment and nutrient storage in the coastal zone due to the addition of marsh habitat that traps sediment

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Summary

Performance: shoreline erosion rates

- Net accretion at living shorelines due to construction
- Continuing erosion at or above historical rates at reference shorelines

Impacts of living shorelines to SAV?

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

Co-benefits: sediment/nutrient burial rates

- SAV and marsh plants effectively trap sediments and associated nutrients
- Net sediment and nutrient storage across the coastal zone is much higher for sites with living shorelines, due to the addition of marsh habitat; SAV presence may also enhance storage to a lesser extent

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Chesapeake Bay Trust

Are living shorelines effective, and what does this mean for me?

- Living shorelines accrete sediment, and therefore protect against erosion compared to shorelines without protection.
- (We know from other studies LS are better habitat than armor, so if a landowner can't tolerate erosion, let's go with LS)
- (SAV beds also trap nutrients and accrete sediments, but not as much)
- You get the most nutrient trapping when both LS and SAV are present, so if your goal is nutrient removal, having both habitat types present is good

What about the trade-off(s), and what does this mean for me?

- SAV is really variable - 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

- Living shoreline installation didn’t change conditions where SAV grows, so probably doesn’t drive SAV changes

- If SAV disappears after living shoreline installation; it wasn’t necessarily tied to the living shoreline

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