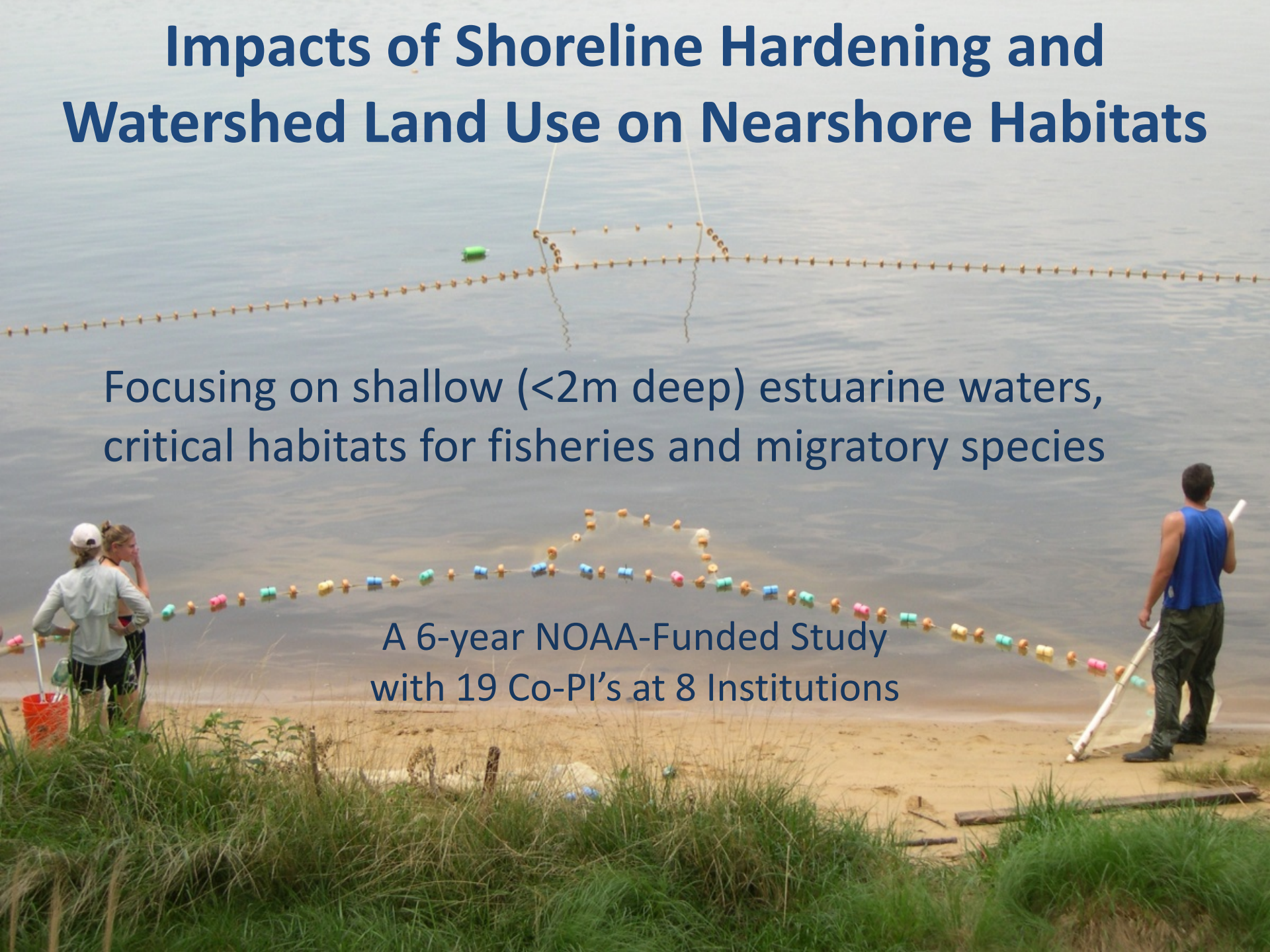


Impacts of Shoreline Hardening and Watershed Land Use on Nearshore Habitats



Focusing on shallow (<2m deep) estuarine waters, critical habitats for fisheries and migratory species

A 6-year NOAA-Funded Study
with 19 Co-PI's at 8 Institutions

19 Principal Investigators, 8 Institutions, led by the Smithsonian Environmental Research Center (SERC)

From SERC:

- Thomas Jordan (lead)
- Denise Breitburg
- Charles Gallegos
- Eric Johnson
- Xuyong Li
- Melissa McCormick
- Patrick Neale
- Gerhardt Riedel
- Donald Weller
- Dennis Whigham

From other institutions:

- Karin Kettenring, Utah State
- Michael Erwin, USGS
- Diann Prosser, USGS
- Lee Karrh, MD DNR
- Evamaria Koch, UMCES
- Larry Sanford, UMCES
- Rochelle Seitz, VIMS
- Timothy Targett, UDE
- Denice Wardrop, PSU

Notable SERC Postdocs:

- Matt Kornis
- Chris Patrick

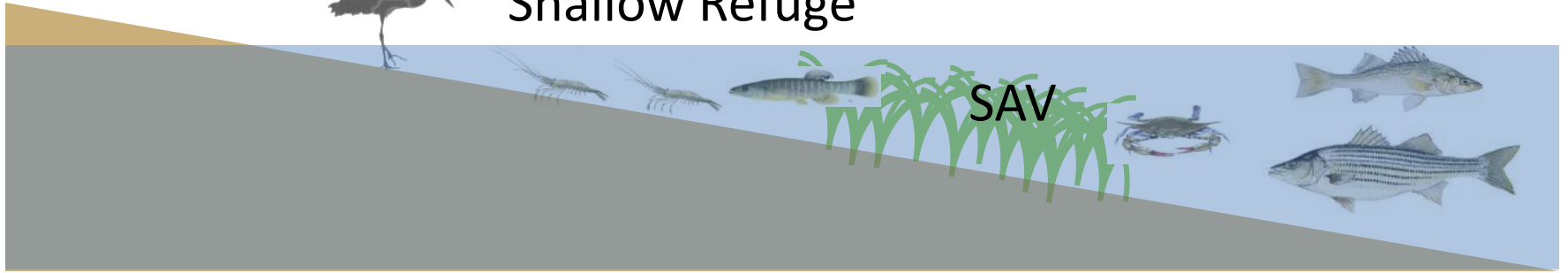
Land use effects compounded with stressors at the intertidal zone

- Watershed inputs of nutrients, sediments, and toxic substances
- Shoreline alterations: Bulkhead, riprap revetments, and “living shorelines”
- Spread of invasive reed *Phragmites*

Beach



Shallow Refuge



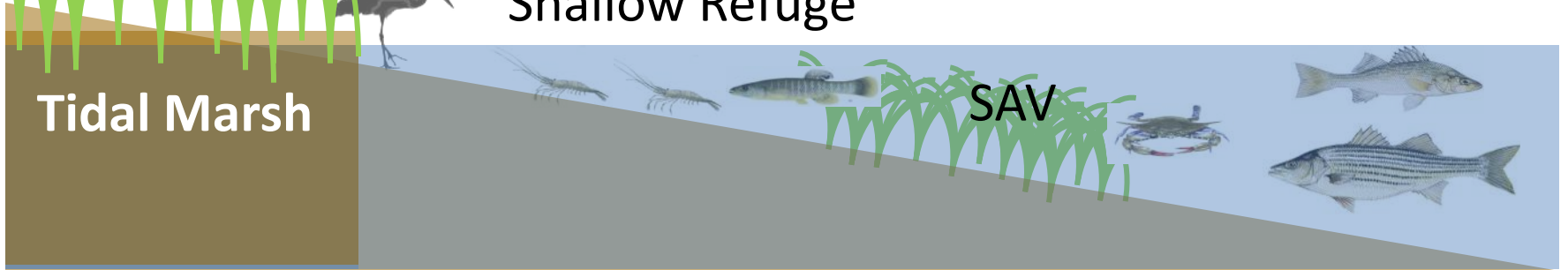
SAV



Tidal Marsh



Shallow Refuge



SAV



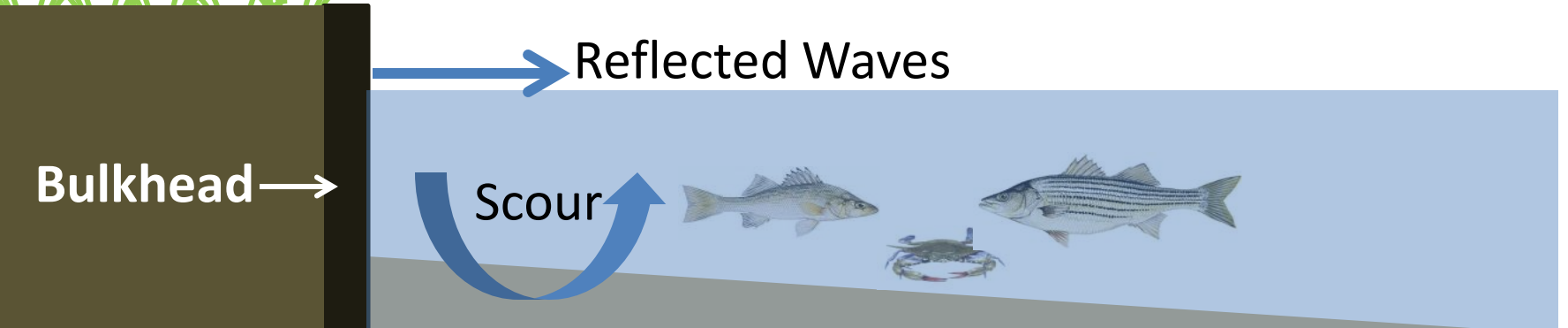
Bulkhead

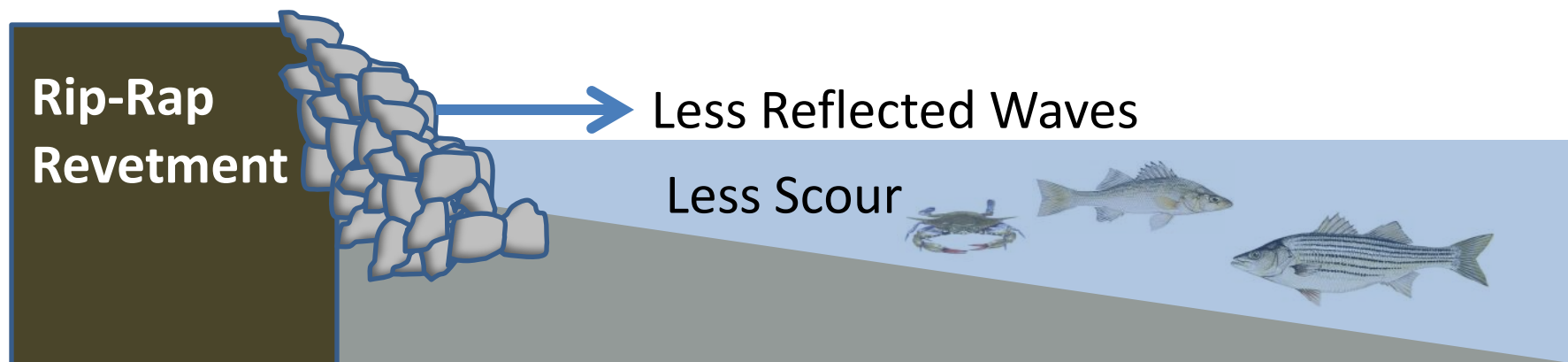
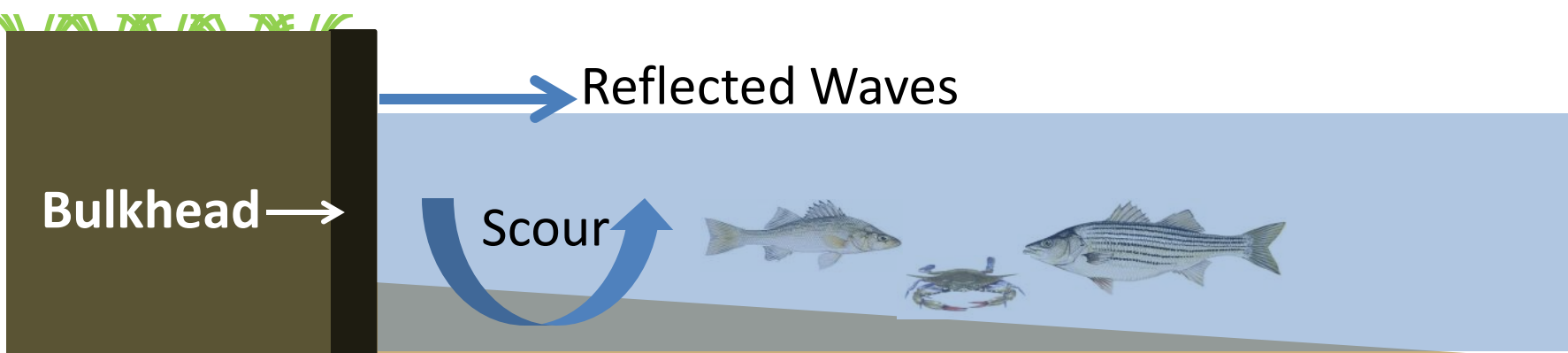


Reflected Waves



Scour





Compare shoreline types...



Natural Marsh



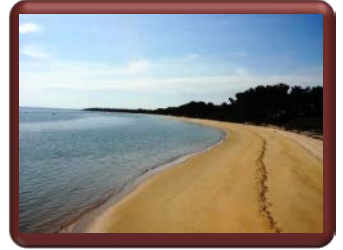
Phragmites
Marsh



Rip-Rap



Bulkhead



Beach

...in bays and sub-estuaries with watersheds that have differing land use



Forested



Residential Development



Agricultural

Our study sites
include Chesapeake
Bay sub-estuaries
and Coastal Bays.

142 systems identified

- 128 in Chesapeake Bay
- 14 in Coastal & Inland Bays



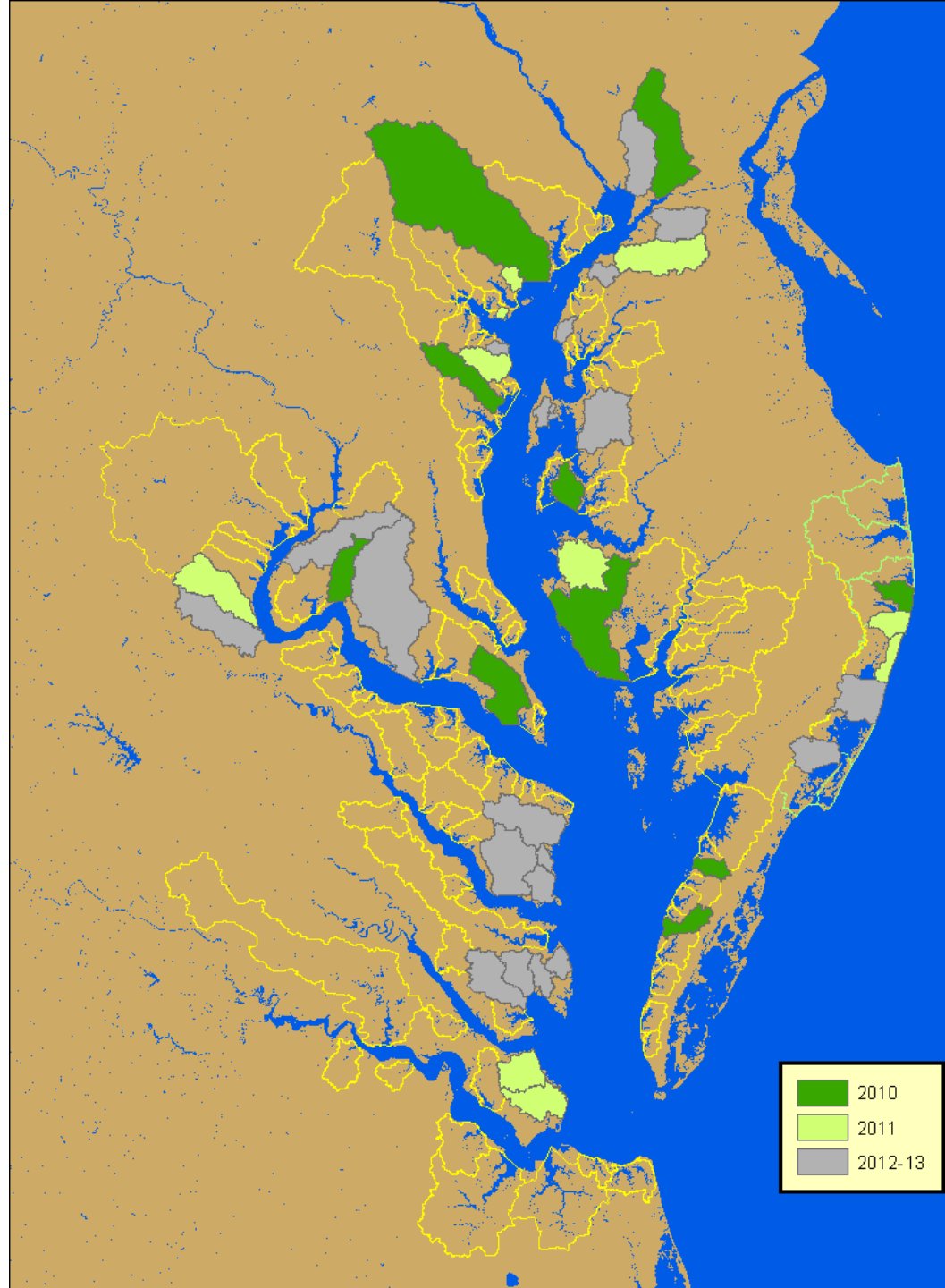
Our study sites include Chesapeake Bay sub-estuaries and Coastal Bays.

142 systems identified

- 128 in Chesapeake Bay
- 14 in Coastal & Inland Bays

47 systems sampled

Many more modeled



Nutrients and Chlorophyll: Summary

- Total N and chlorophyll increase with % cropland and % developed land.
- Total P increases with % cropland.
- Eutrophication seems most intense in summer and early fall.
- Water quality in subestuaries may differ from adjacent waters due to local watershed inputs and effects of water depth.



Submerged Aquatic Vegetation (SAV)

**Don Weller, Chris Patrick, Chuck Gallegos,
Meghan Williams (SERC)**

**Lee Karrh, Brooke Landry, Becky Golden
(MD-DNR)**

Eva Koch, Larry Sanford (UMCES-HPL)

W

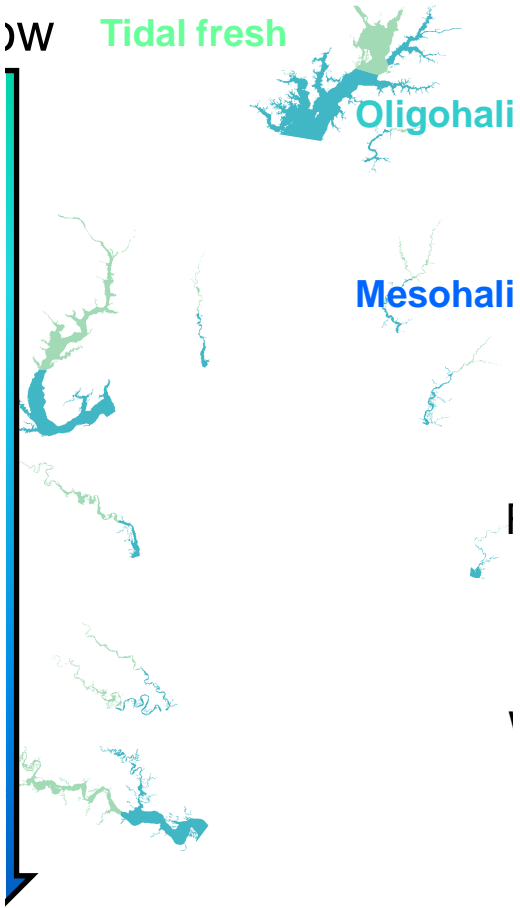
Tidal fresh

Oligohali

Mesohali

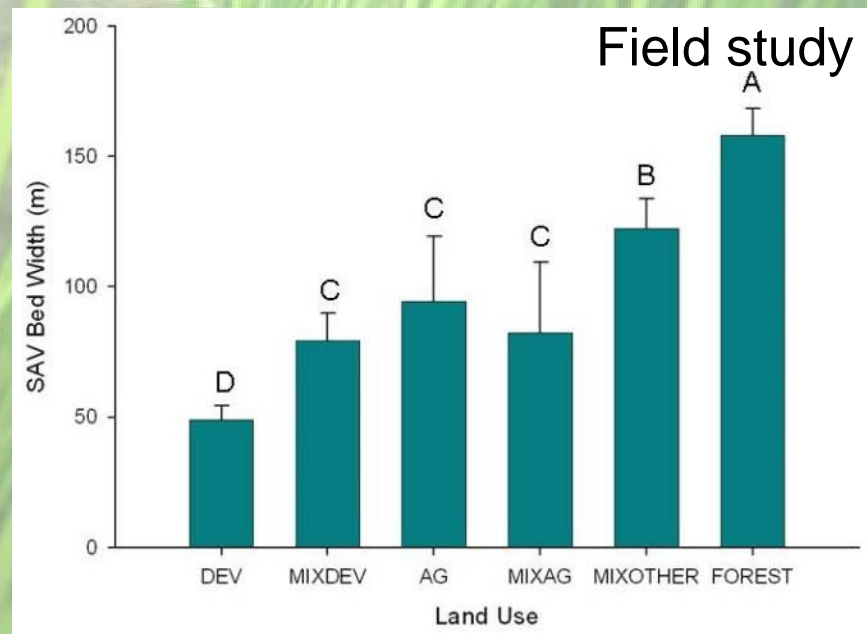
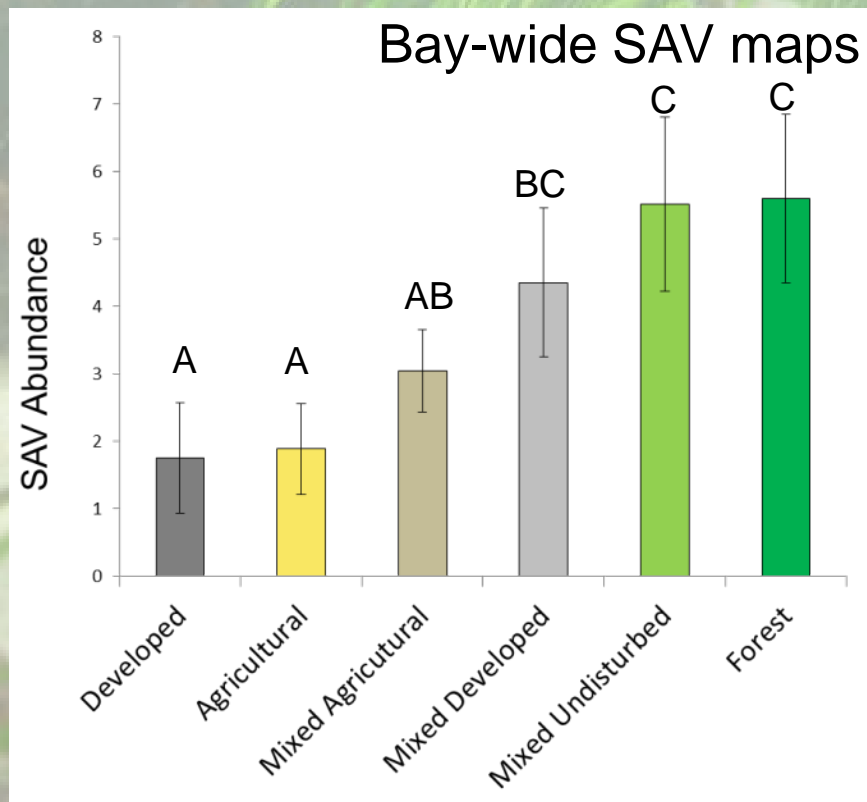
gh

Polyhalir

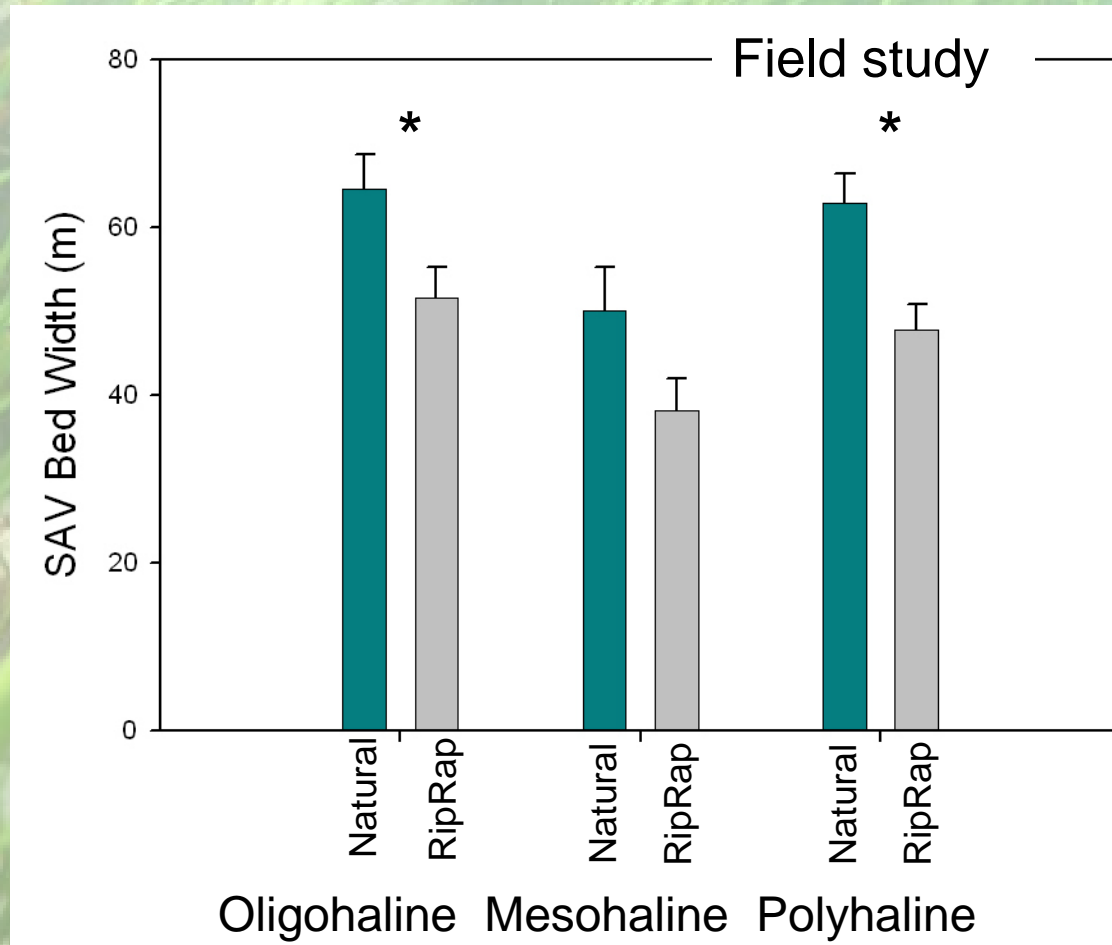


Local watershed land use affects subestuary SAV abundance

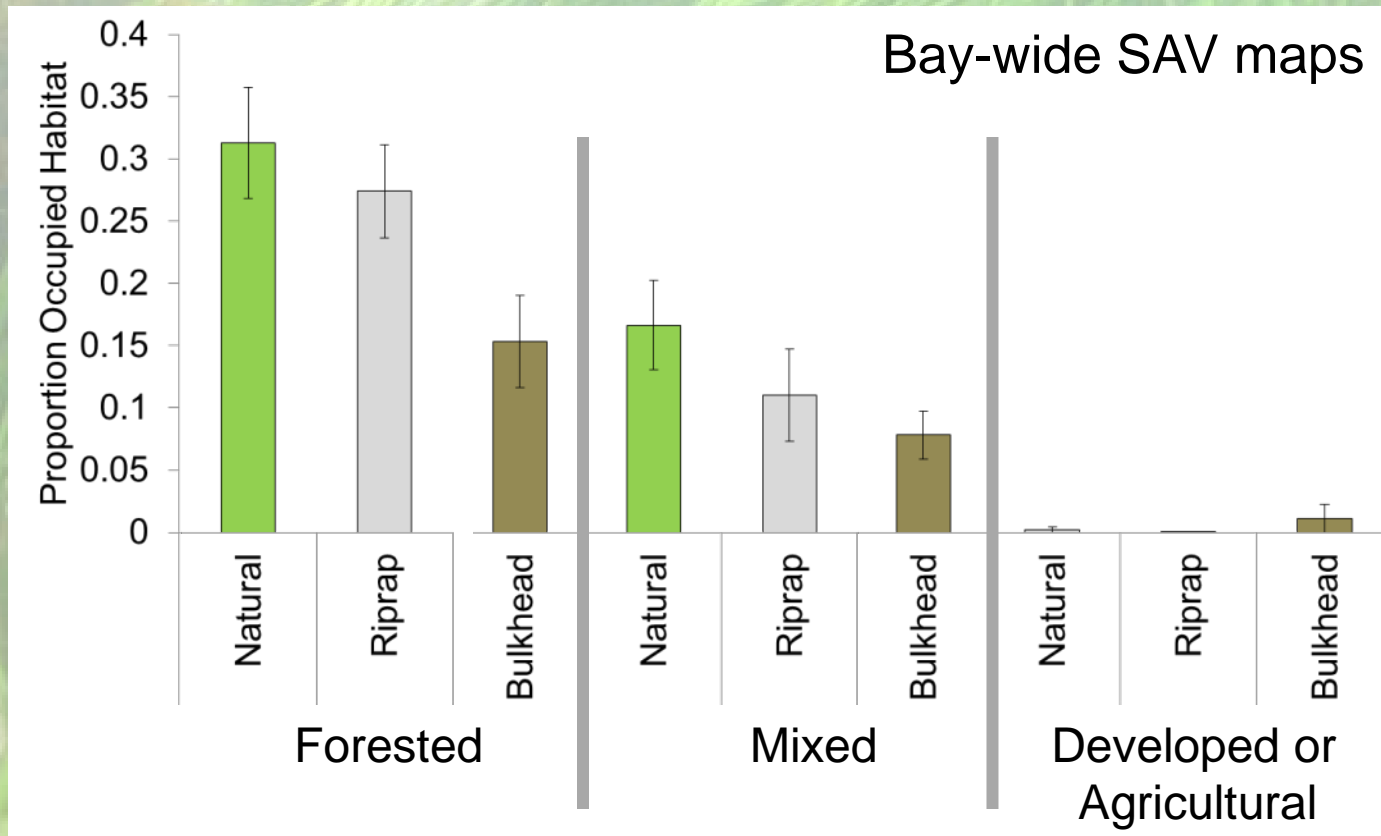
- Lower abundance in watersheds dominated by agriculture or developed land



Shoreline hardening can reduce SAV abundance



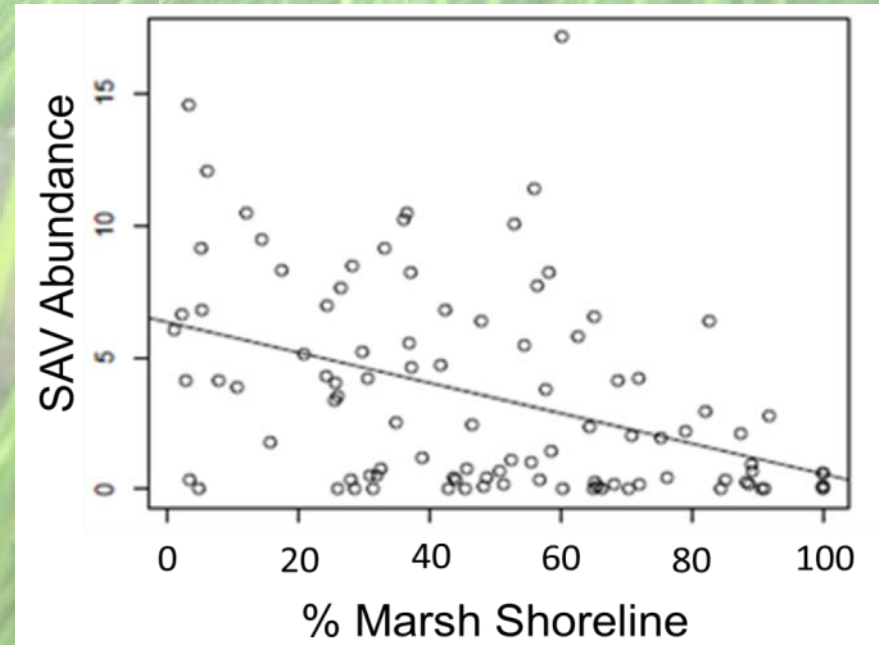
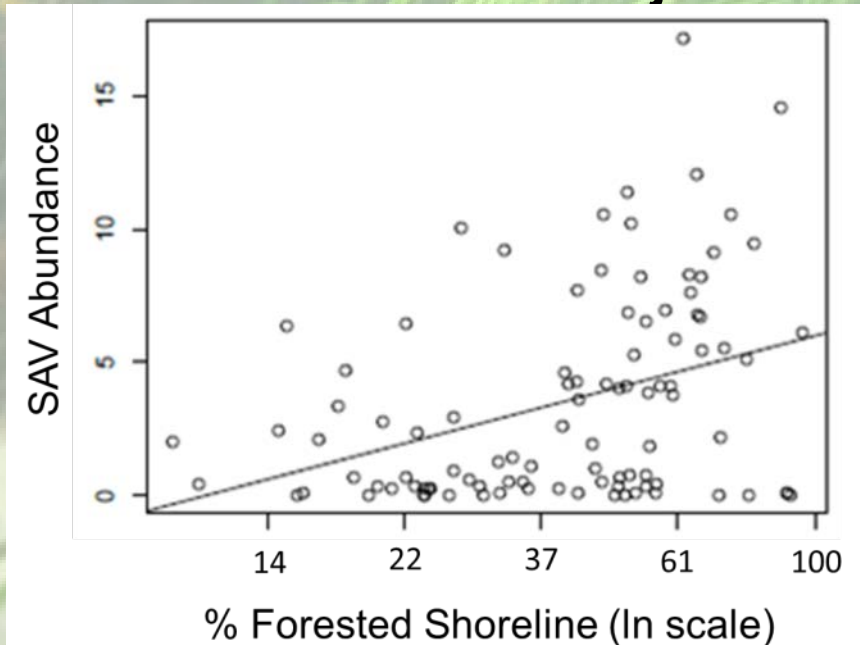
Shoreline hardening has more impact on SAV in subestuaries with healthy watersheds



- Shoreline effects are weaker where development or agriculture already limit SAV

Natural shorelines are not all created equal

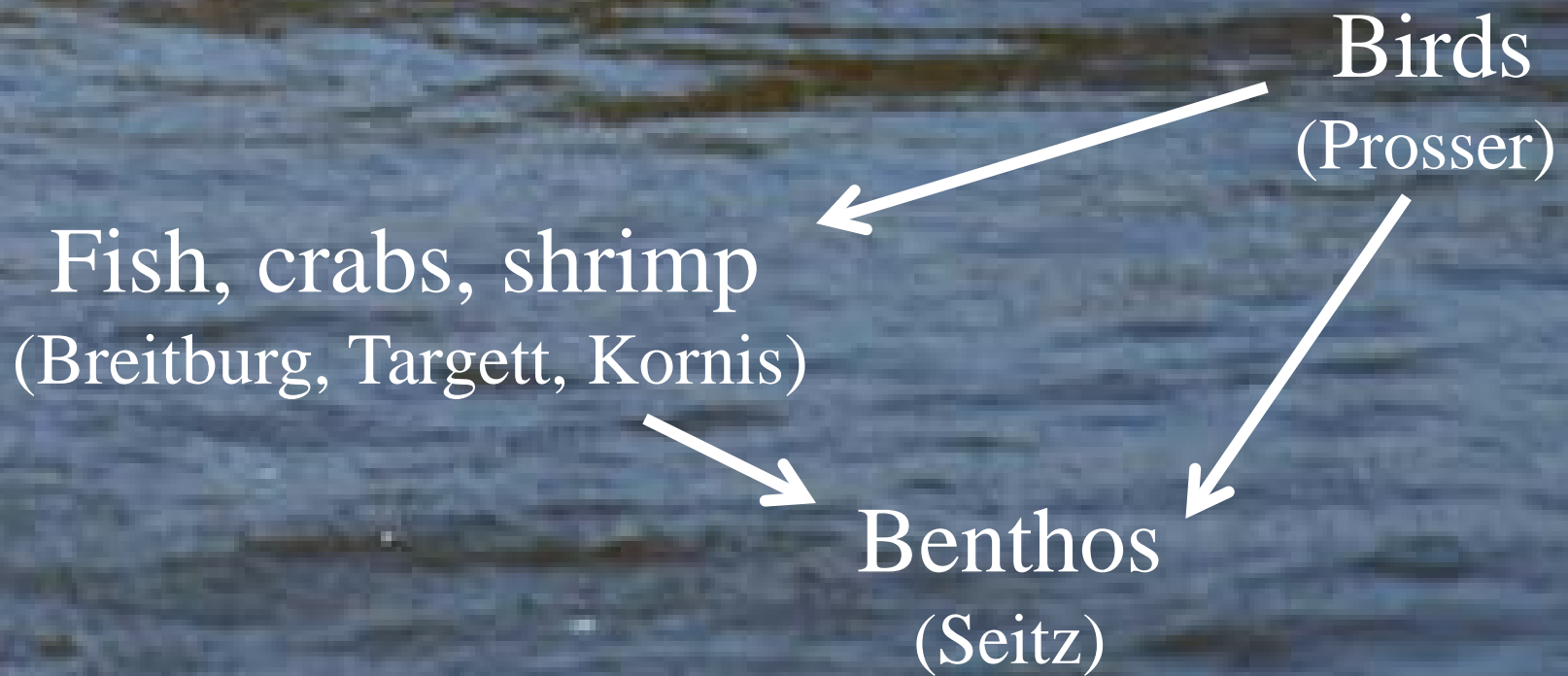
- Forested shorelines are positively related to adjacent SAV abundance



- Shoreline marsh has a negative effect, possibly by promoting muddy sediments



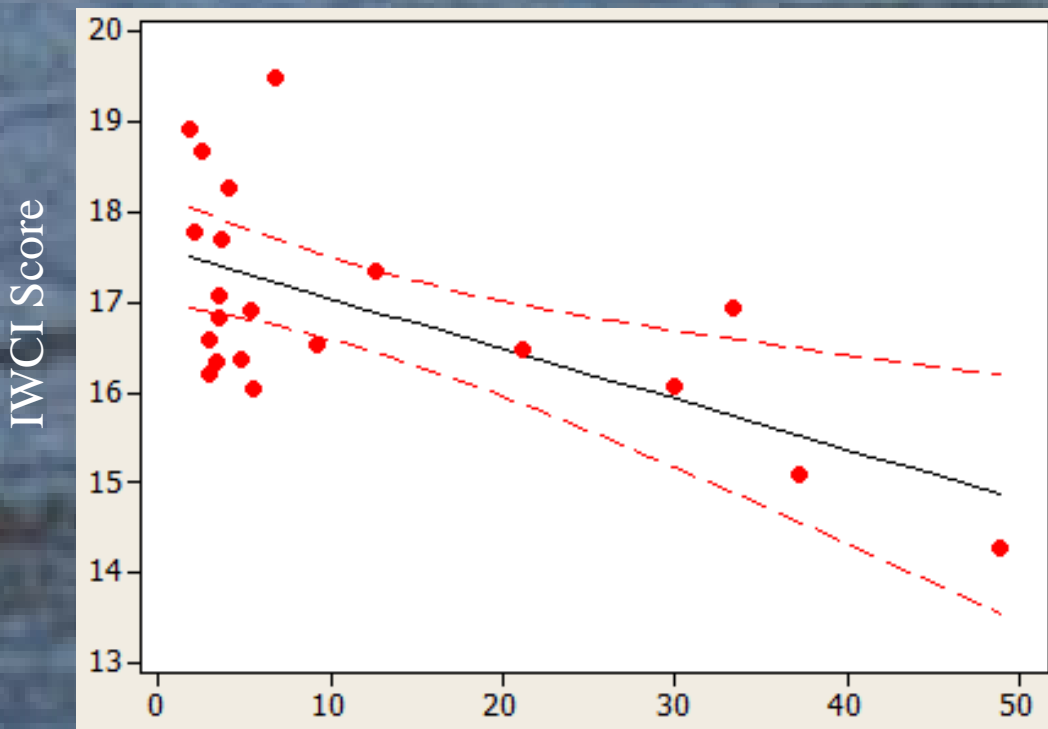
Macrofauna





IWCI *decreases* with percent bulkhead in subestuary

(2010-2014 summer surveys)



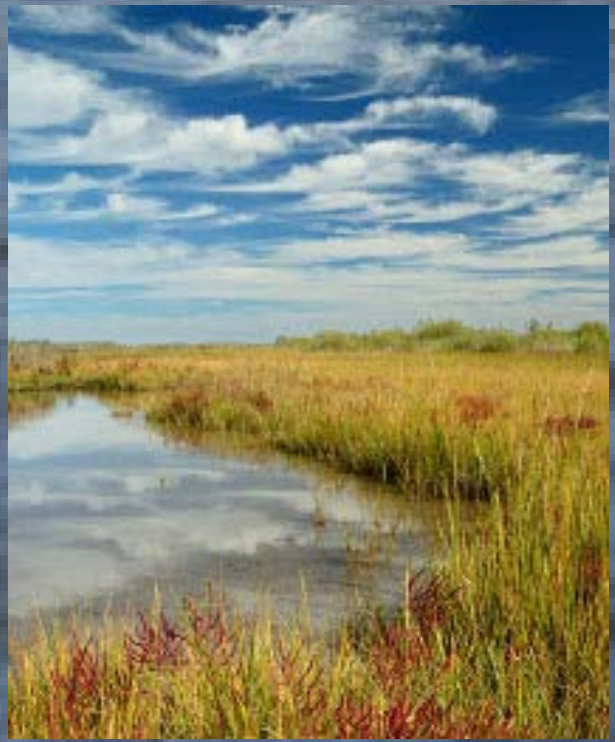
“Birds Boycott Bulkhead”

Percent Bulkhead

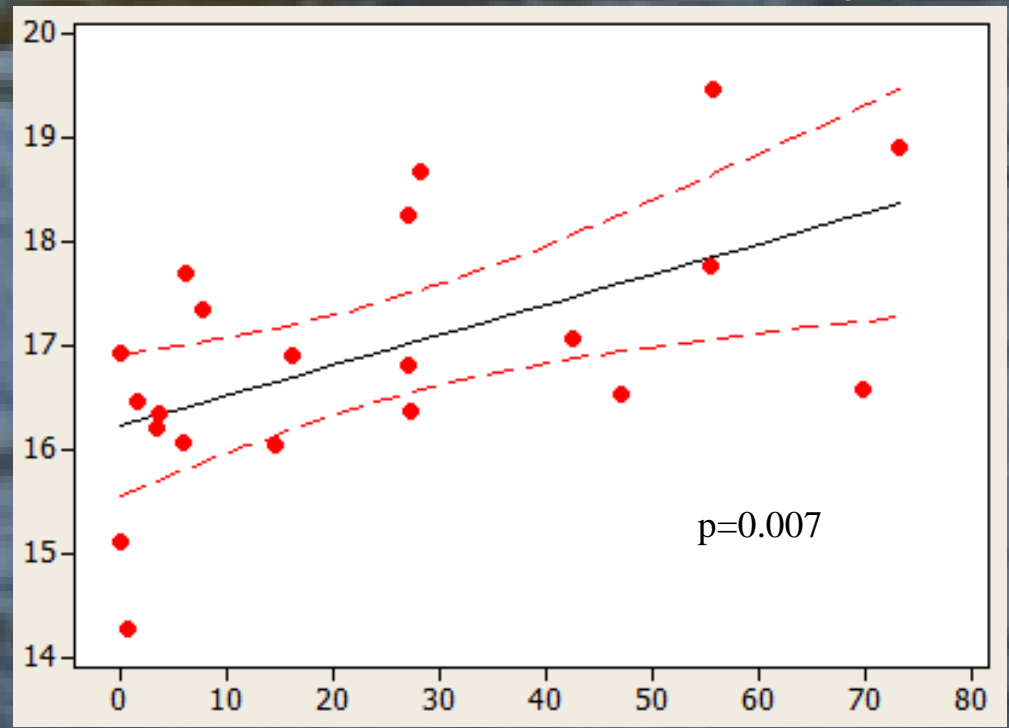


IWCI *increases* with percent native wetlands in subestuary

(2010-2014 summer surveys)



IWCI Score



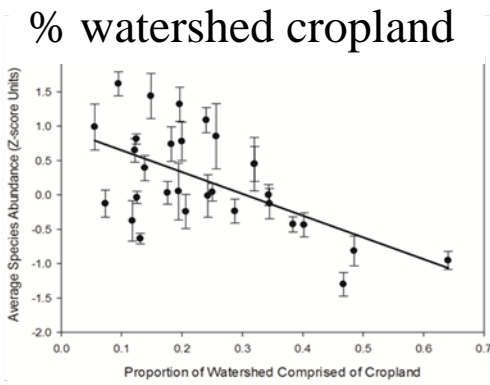
Percent Natural Marsh

“Waterbirds are Wild for Wetlands”

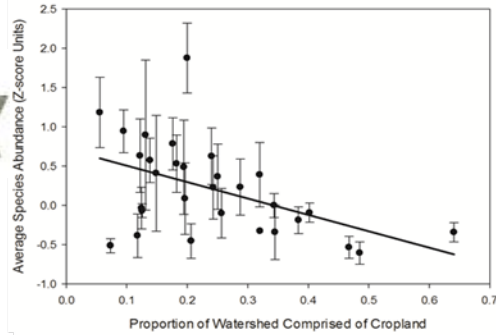




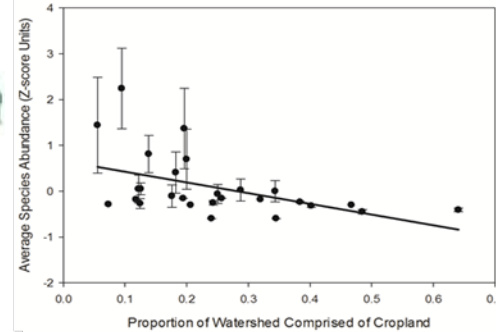
Blue Crab



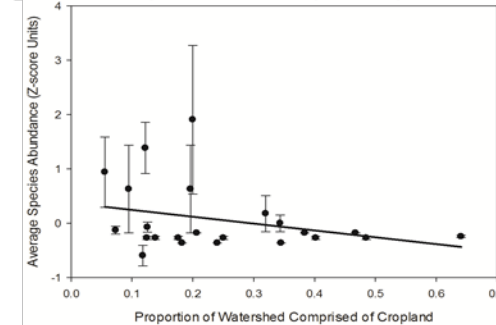
Spot



Atlantic Croaker



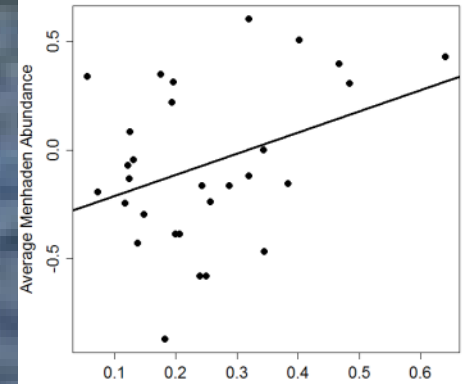
Silver Perch



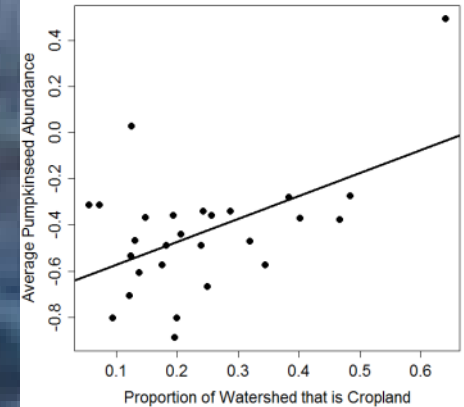
High % agriculture in watershed associated with decreases in several benthivore/ piscivore species and increases in 2 planktivorous fishes



Atlantic Menhaden



Juvenile Centrarchids

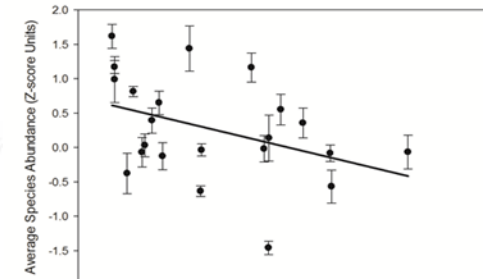


Increasing %
hardened shoreline
in subestuaries is
associated with decreased
abundances of many
nearshore fish species and
blue crab; only juvenile
centrarchids seem to be
favored

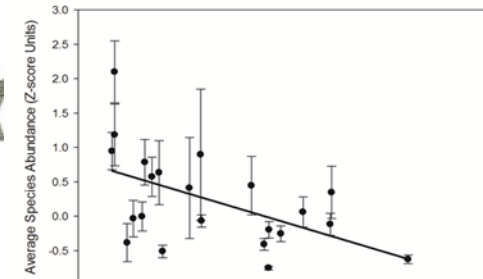


Blue Crab

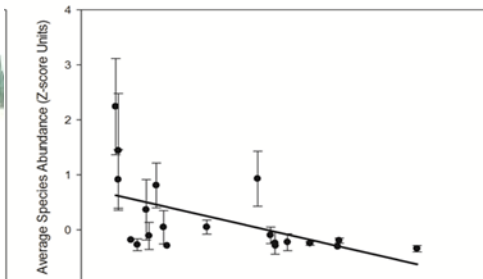
% hardened shoreline



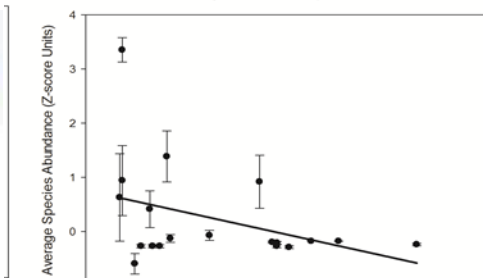
Spot



Atlantic Croaker



Silver Perch

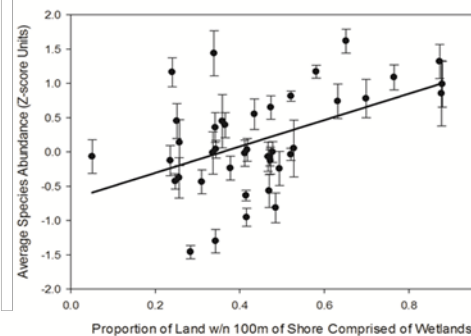


Abundance of fishes & blue crab increases with increasing nearshore wetlands in the subwatershed

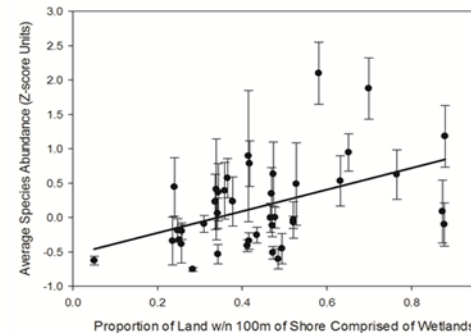


Blue Crab

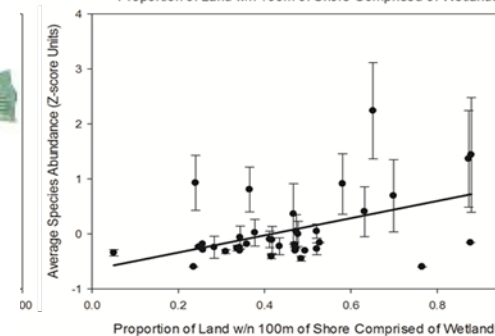
% nearshore wetlands



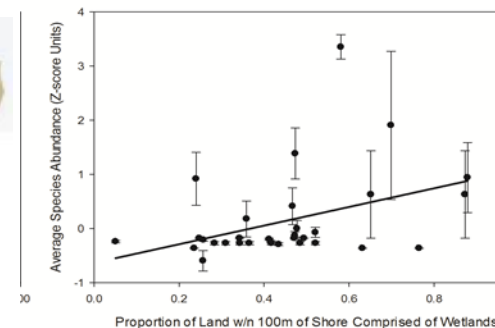
Spot



Atlantic Croaker

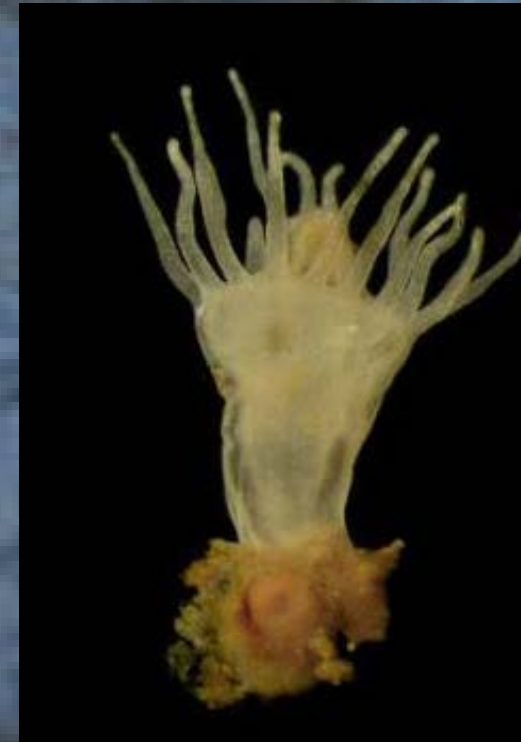
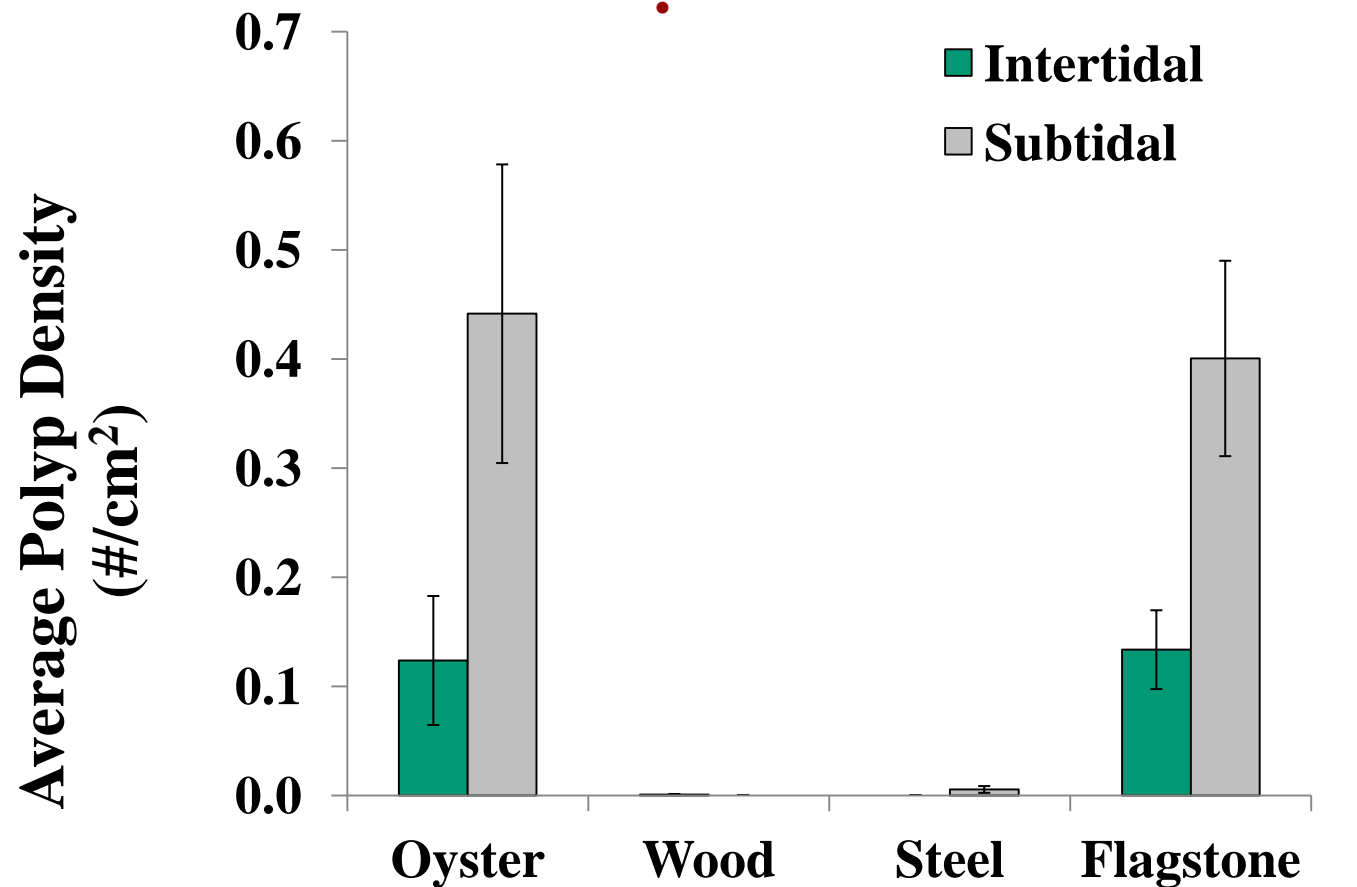


Silver Perch



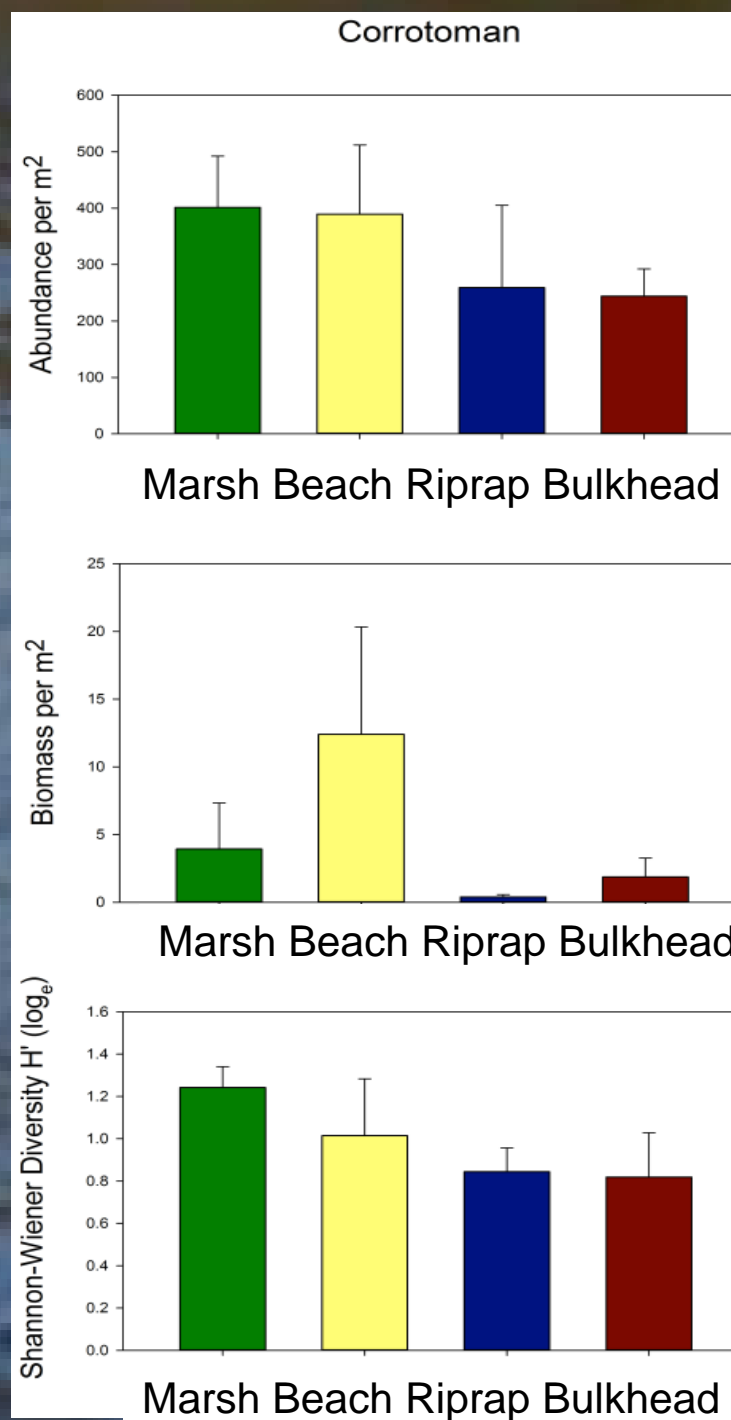
Shoreline hardening: using rock can increase habitat for the overwintering sessile stages of the sea nettle.

(Breitburg lab)



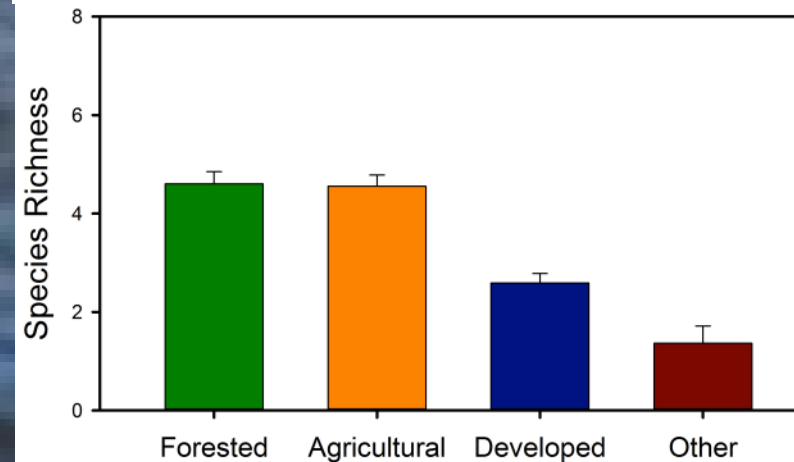
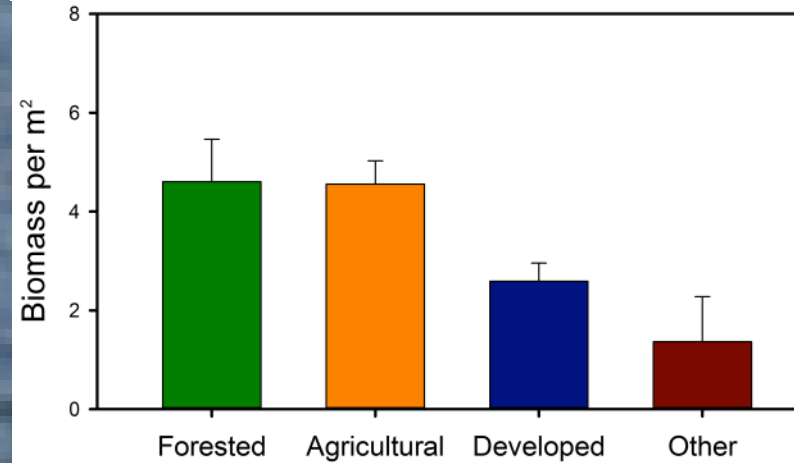
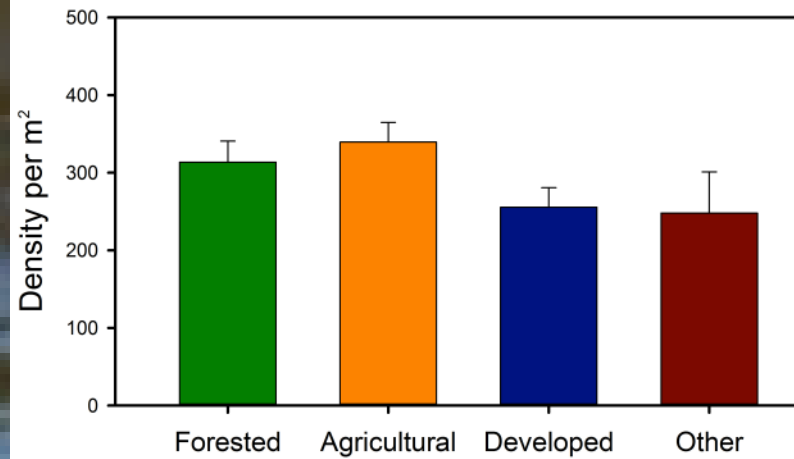


Natural shoreline habitats have higher abundance, biomass, and diversity of benthic invertebrates than developed habitats (e.g., Corrotoman River)





Developed and mixed-developed watersheds have reduced benthic density, biomass, & richness



Riprap-sill structure provides higher habitat quality for shore zone estuarine fishes (and blue crabs) than does riprap revetment



Greater fish abundance along riprap-sill shoreline than riprap revetment



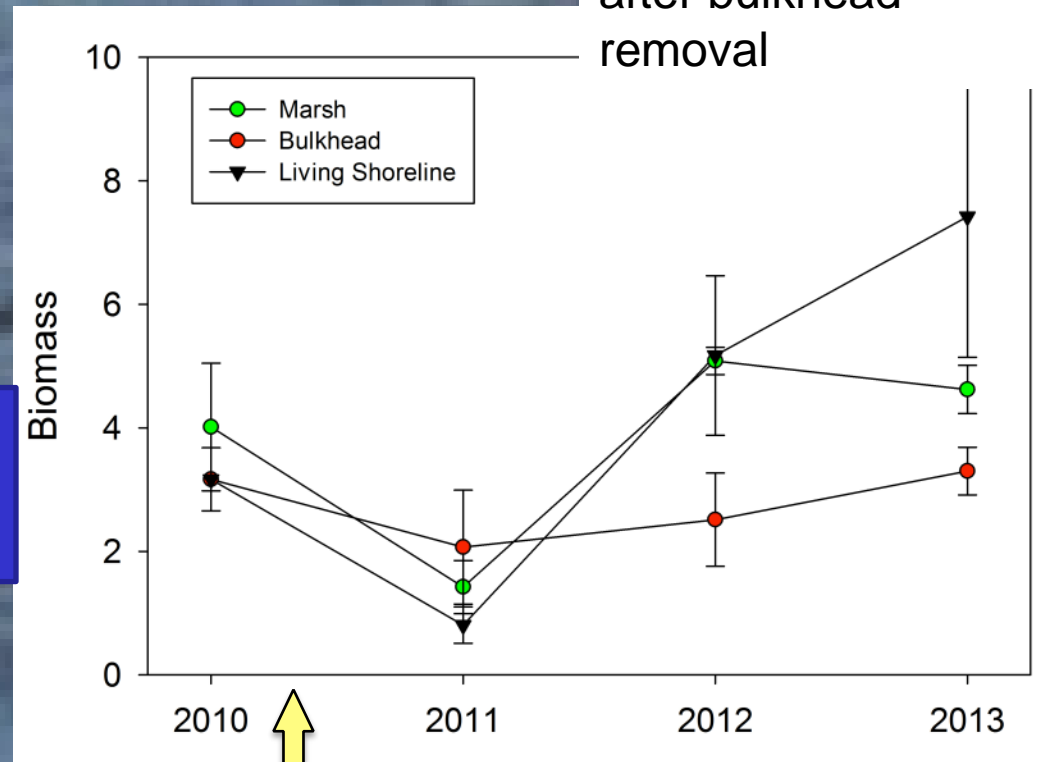
Intensive Sampling in Delaware Coastal Bays

Living Shorelines increase benthic biomass over long term (BACI study) (Seitz lab)



Biomass
ANOVA:
P = 0.001

Windy Hill, Corsica
River, Maryland,
after bulkhead
removal



Living shoreline created

Note: More
Fine sediment in 2011



Macrofauna

Both shoreline hardening and watershed land use affect economically and ecologically important species in Chesapeake Bay & Delaware Coastal Bays, but design of shoreline protection can reduce negative effects

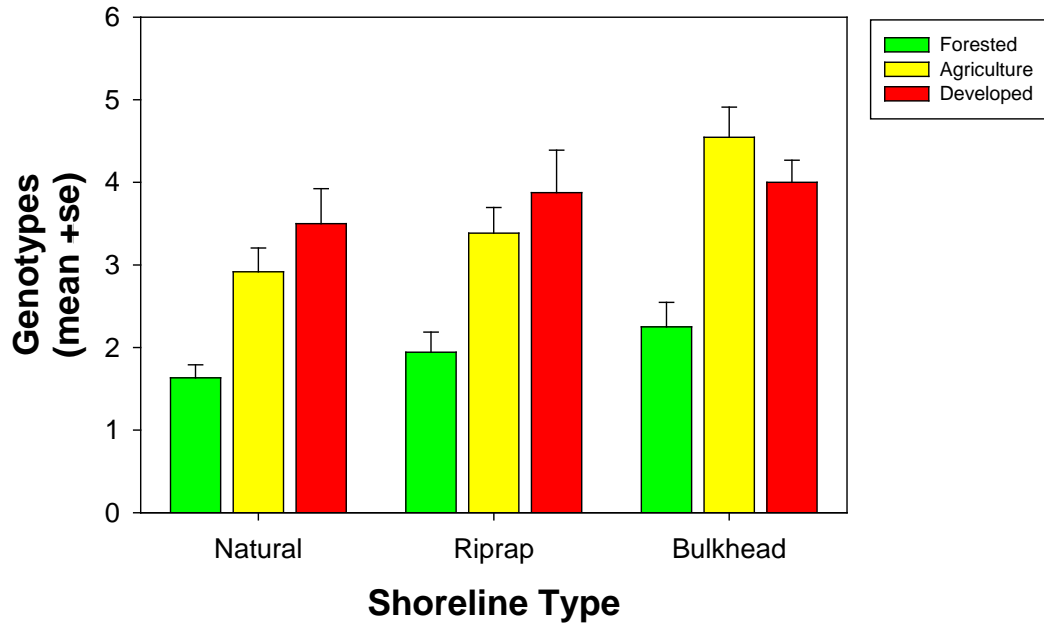
Understanding and Controlling the Invasion of Tidal Wetlands by *Phragmites australis*

- In many parts of the C. Bay, it is too late for restoration.
- Only individual sites can be managed when restoration goals can be met
- BUT there has not been a Bay-wide effort to quantify the scale of the problem

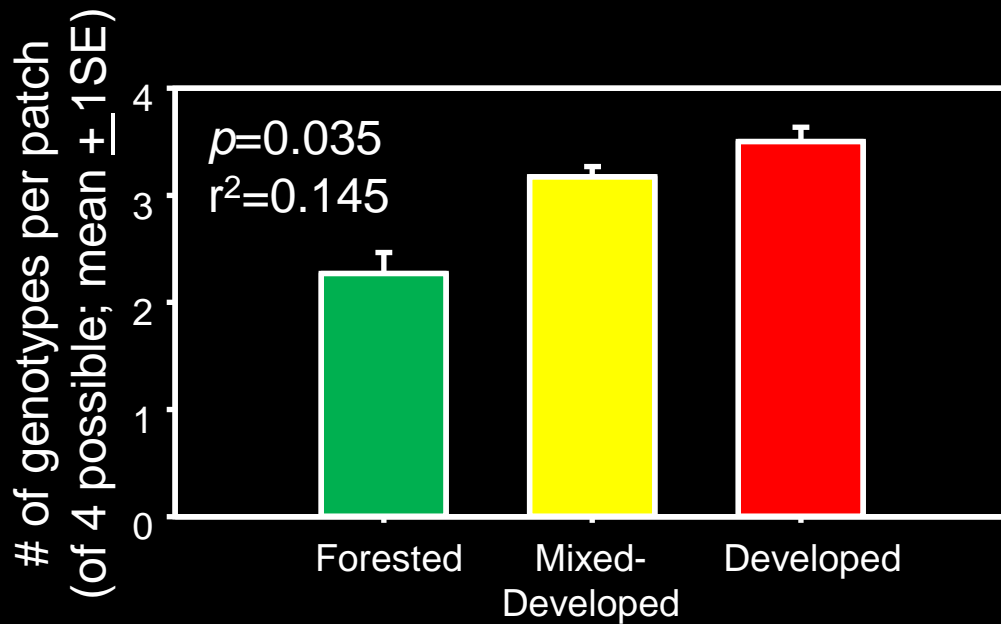
1970

2009

Shoreline type and genetic diversity



Land use and genetic diversity



Recovery has been significant in some sites regardless of land use



Recovery has not occurred and the sites are breaking up



Shorelines have retreated, likely to pre-invasion shoreline



- Seed bank is independent of canopy composition
- Seeds mix on the tides
- Ample propagules for passive revegetation



Compare shoreline types...



Natural Marsh



Phragmites
Marsh



Rip-Rap



Bulkhead



Beach

...in bays and sub-estuaries with watersheds that have differing land use



Forested



Residential Development



Agricultural