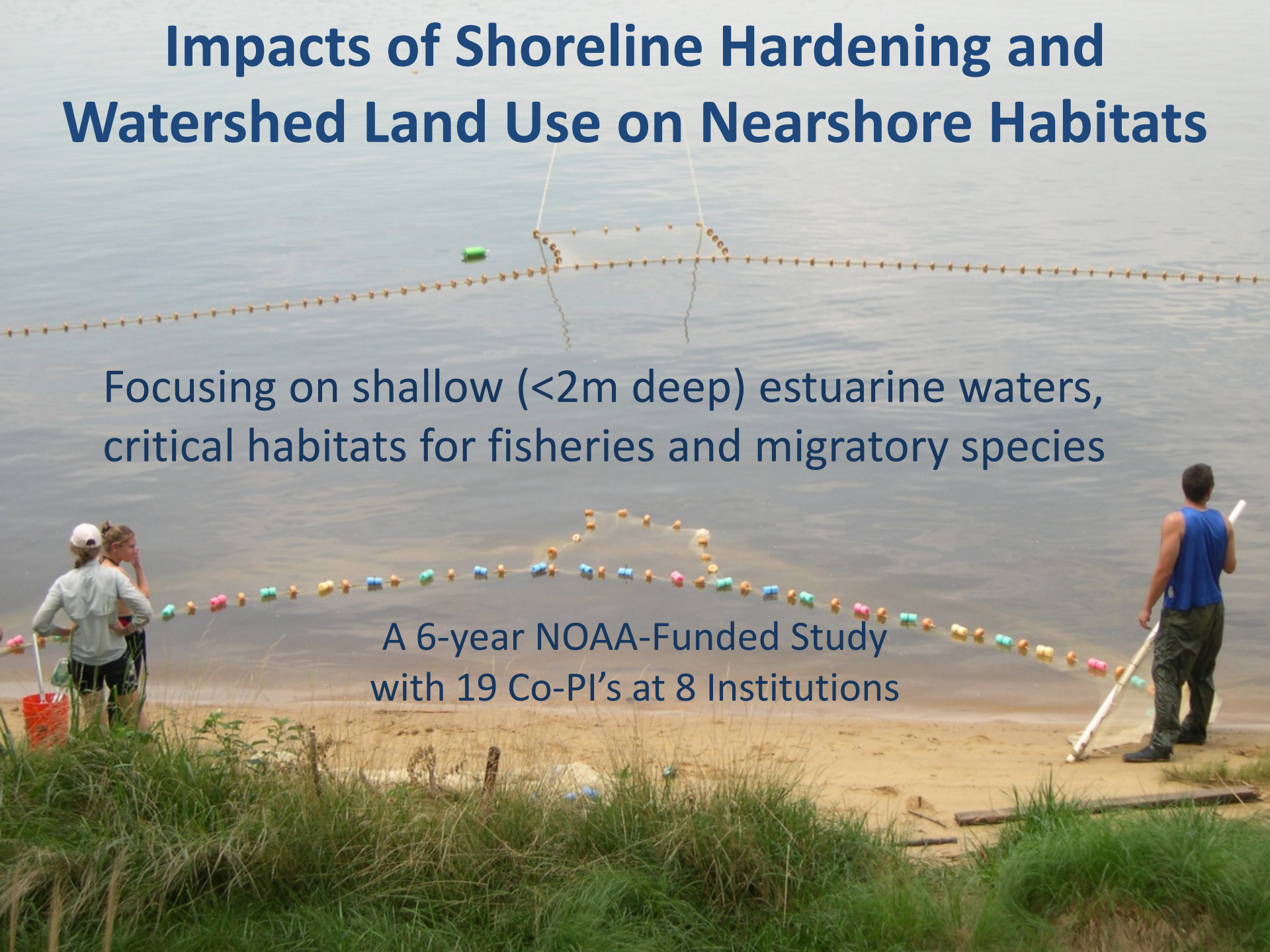
Impacts of Shoreline Hardening and Watershed Land Use on Nearshore Habitats



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:

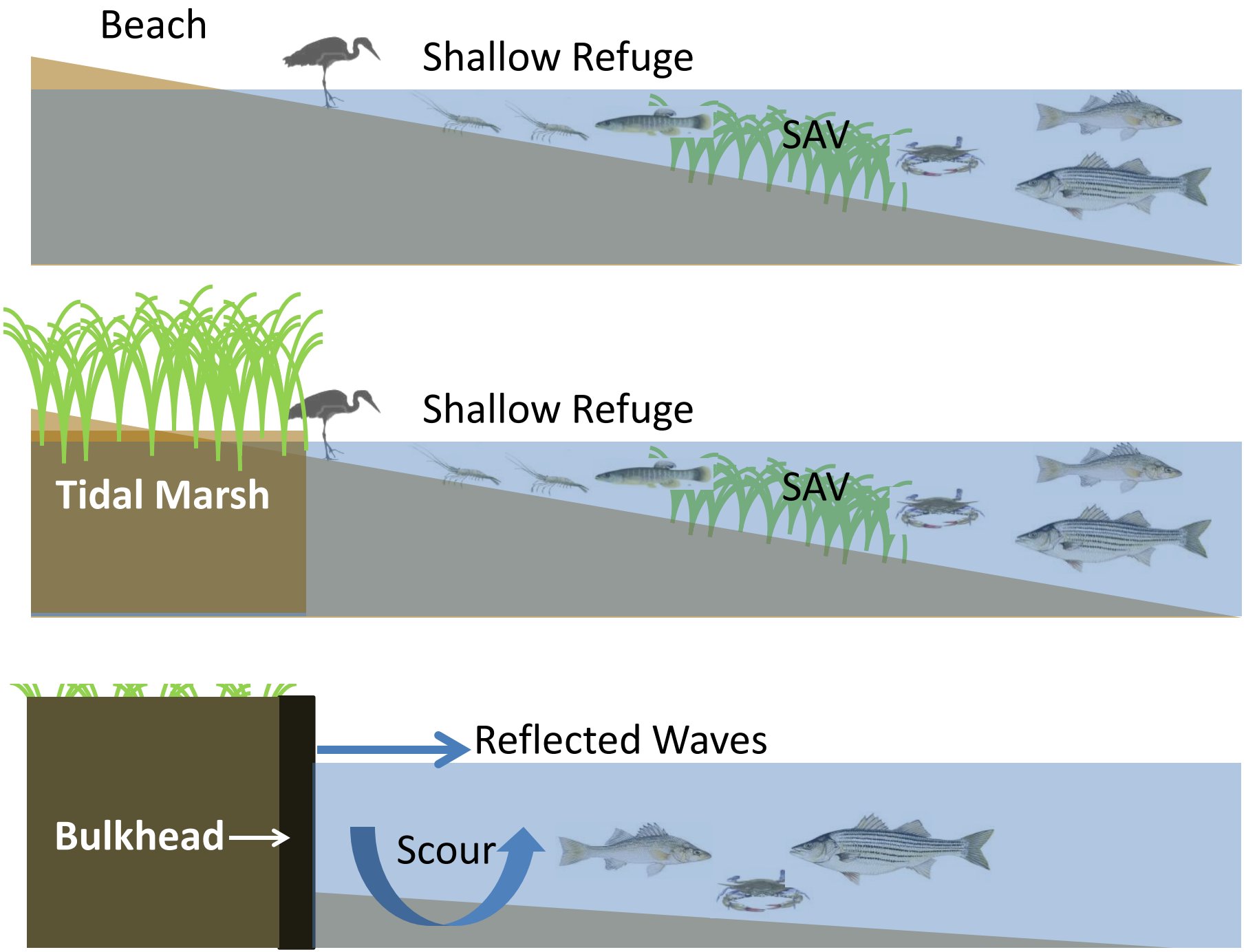
- Karin Kettenring, Utah State
- Michael Erwin, USGS
- Diann Prosser, USGS
- Lee Karrh, MD DNR
- Evamaria Koch, UMCES
- Larry Sanford, UMCES
- Rochelle Seitz, VIMS
- Timothy Targett, UDE
- Denice Wardrop, PSU

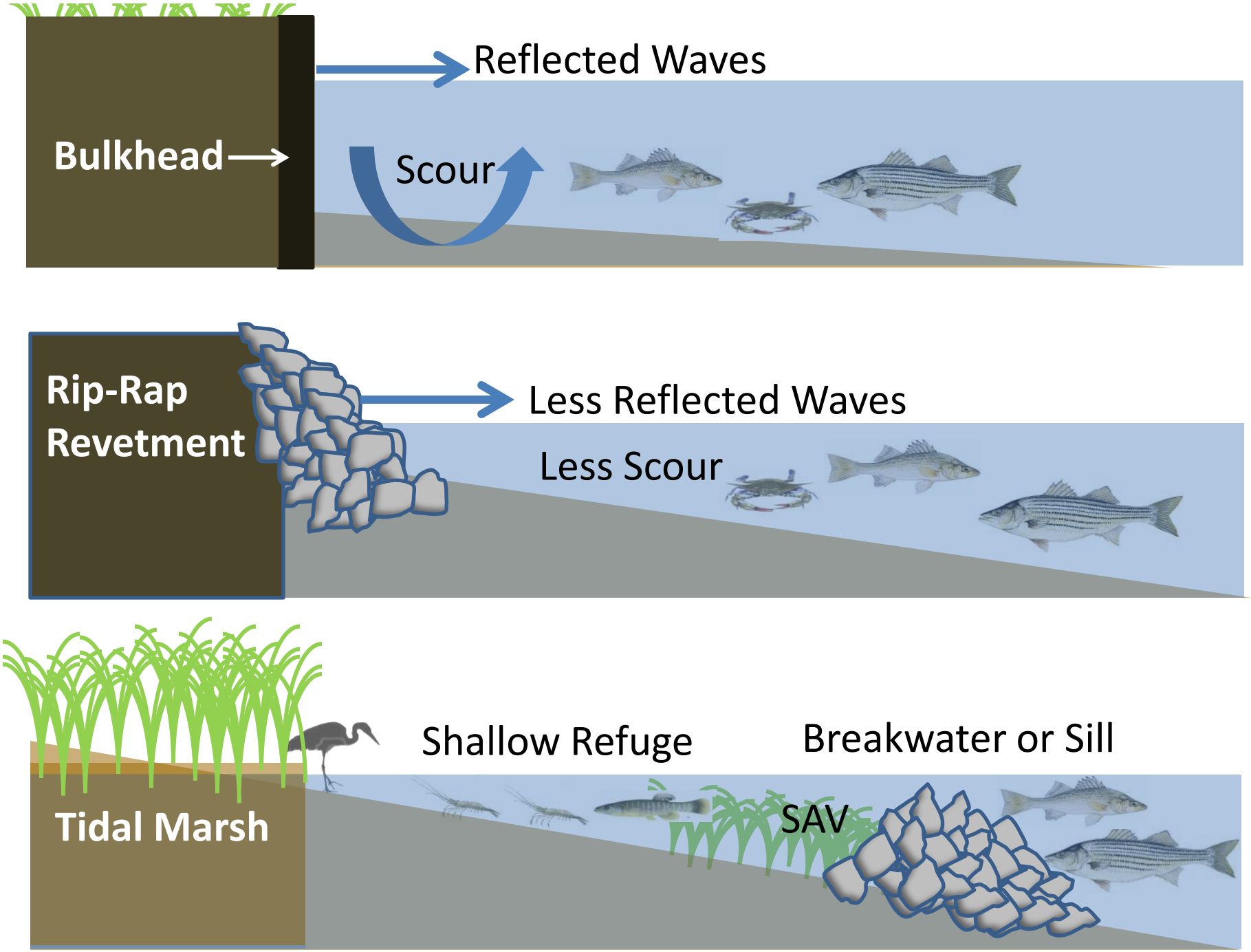
Notable SERC Postdocs:

- 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
Reflected Waves
Bulkhead
Scour


Reflected Waves
Bulkhead
Scour
Rip-Rap
Revetment
Less Reflected Waves
Less Scour
Shallow Refuge
Breakwater or Sill
Tidal Marsh
SAV

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

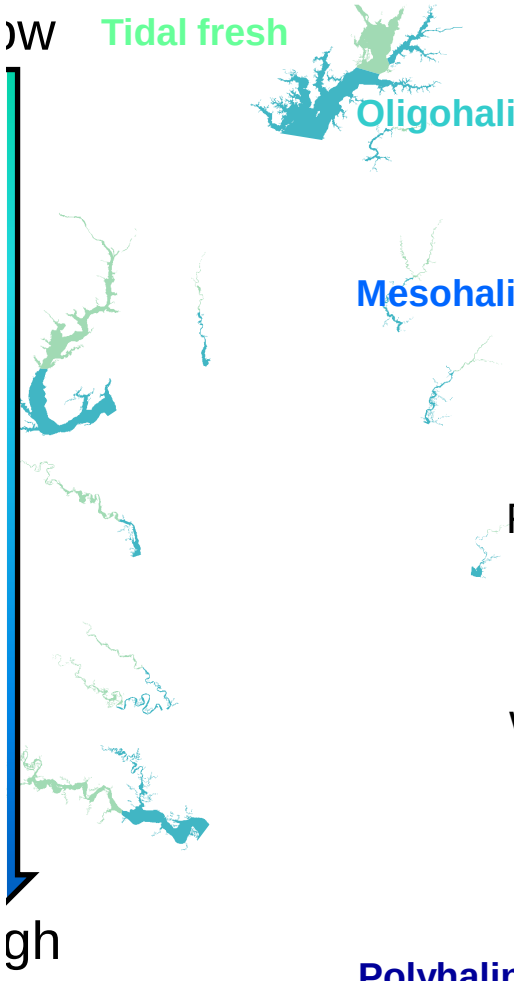
- Total N and chlorophyll increase with % cropland and % developed land.
- Total P increases with % cropland.
- Eutrophication seems most intense in summer and early fall.
- Water quality in subestuaries may differ from adjacent waters due to local watershed inputs and effects of water depth.

Submerged Aquatic Vegetation (SAV)

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

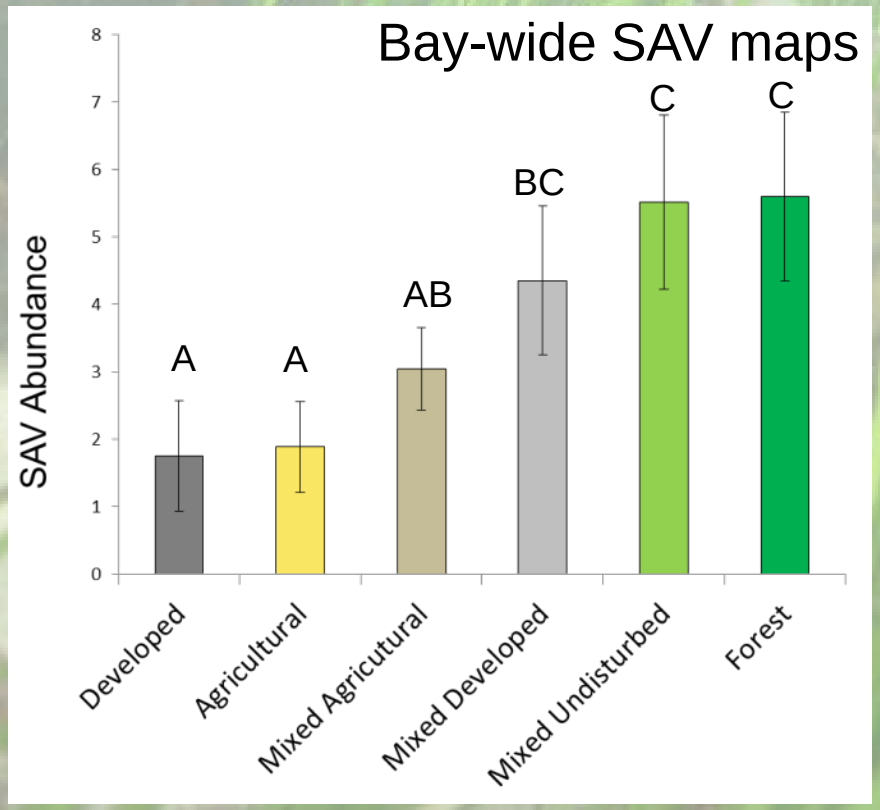
Lee Karrh, Brooke Landry, Becky Golden (MD-DNR)

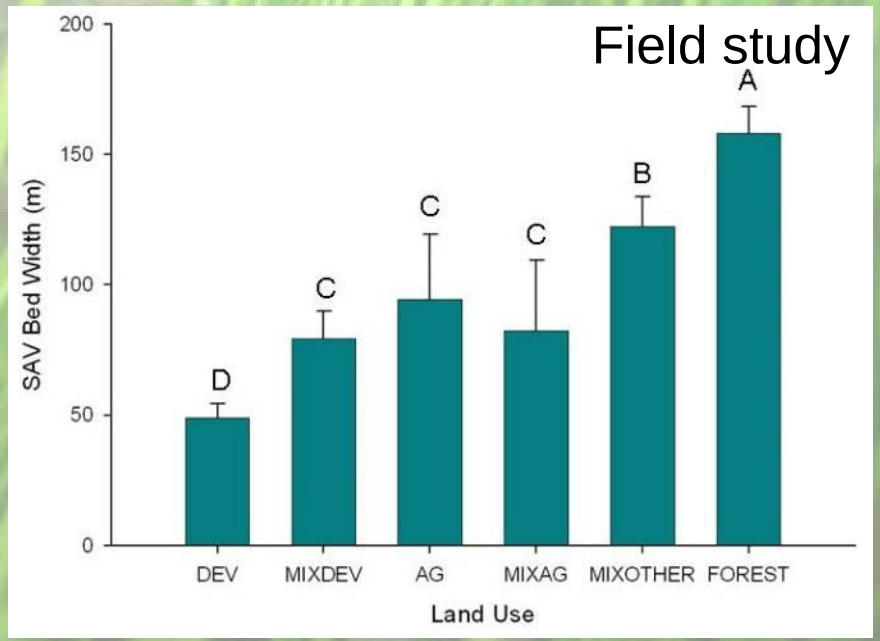
Eva Koch, Larry Sanford (UMCES-HPL)


ow
Tidal fresh
Oligohali
Mesohali
gh
Polyhalir

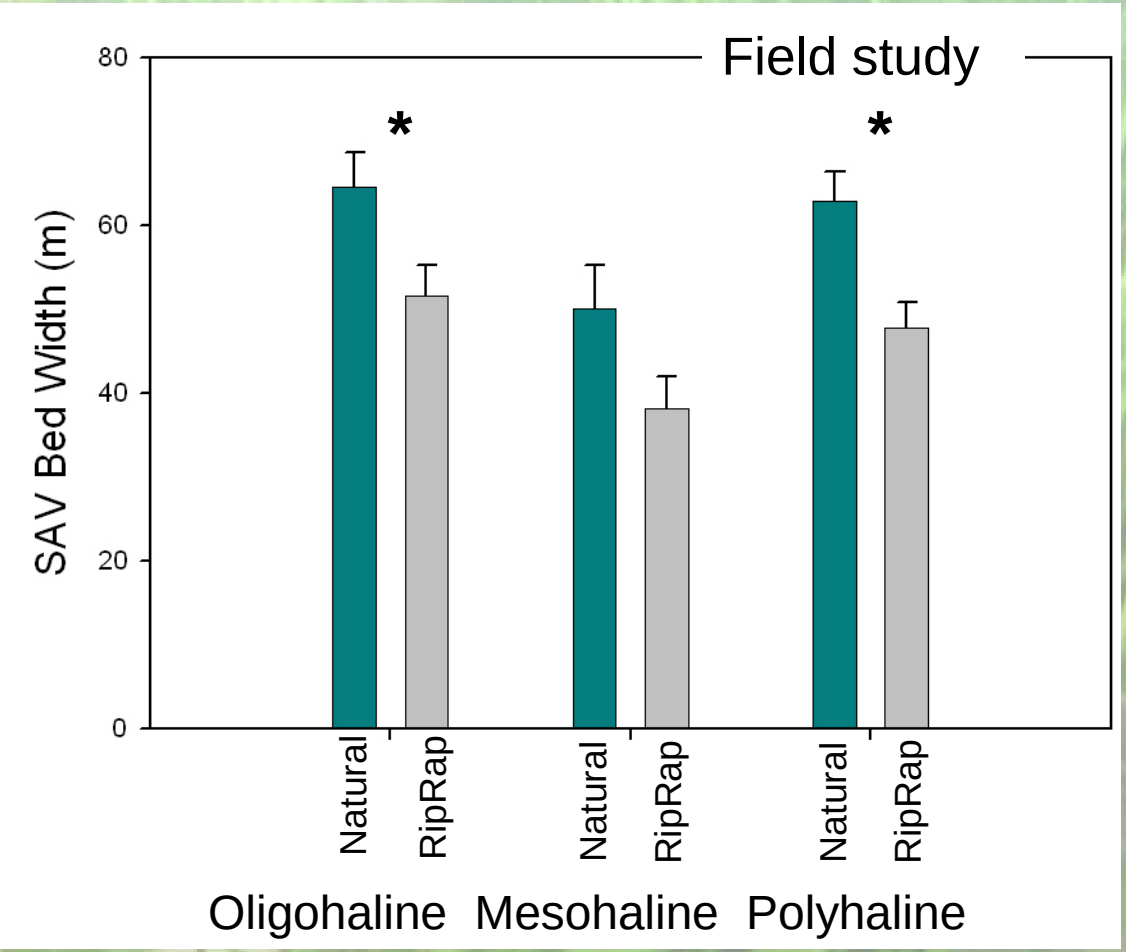
Local watershed land use affects subestuary SAV abundance

- Lower abundance in watersheds dominated by agriculture or developed land

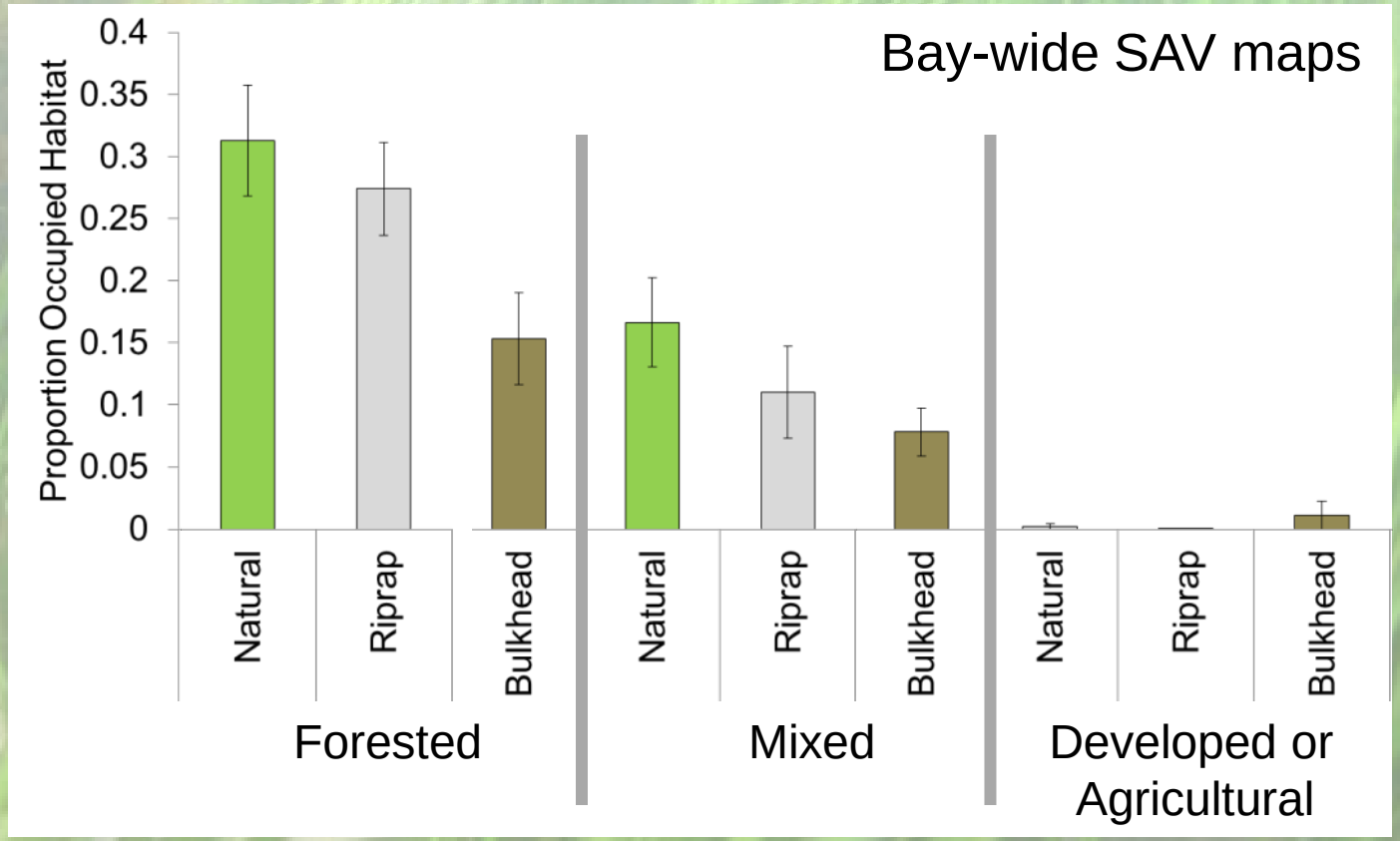




Shoreline hardening can reduce SAV abundance



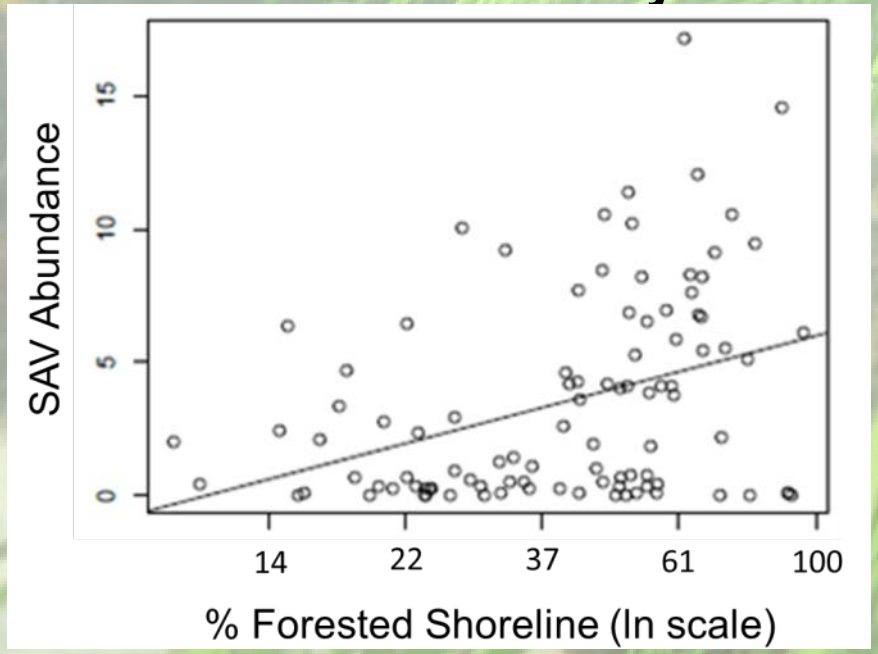
Shoreline hardening has more impact on SAV in subestuaries with healthy watersheds

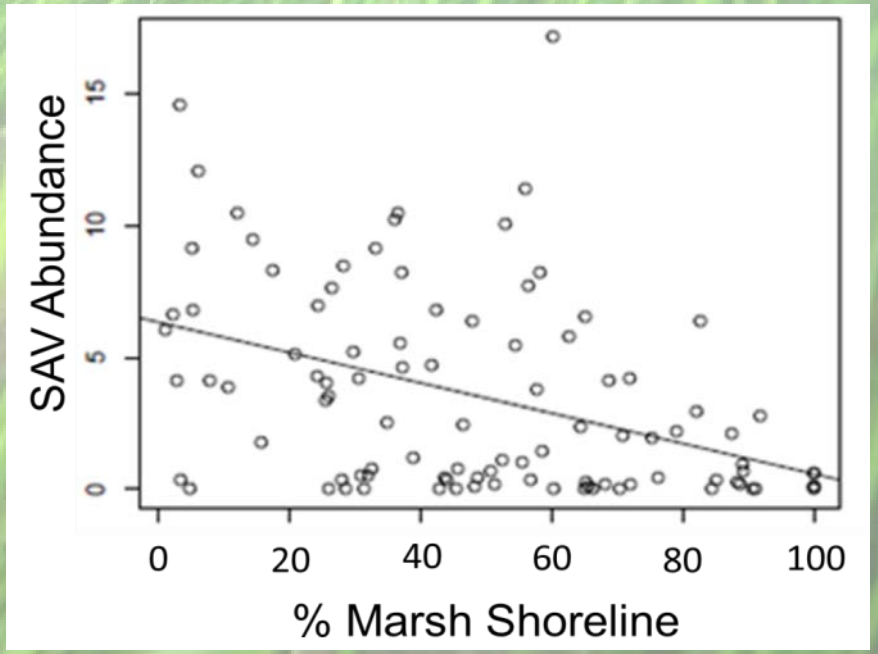


- Shoreline effects are weaker where development or agriculture already limit SAV

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

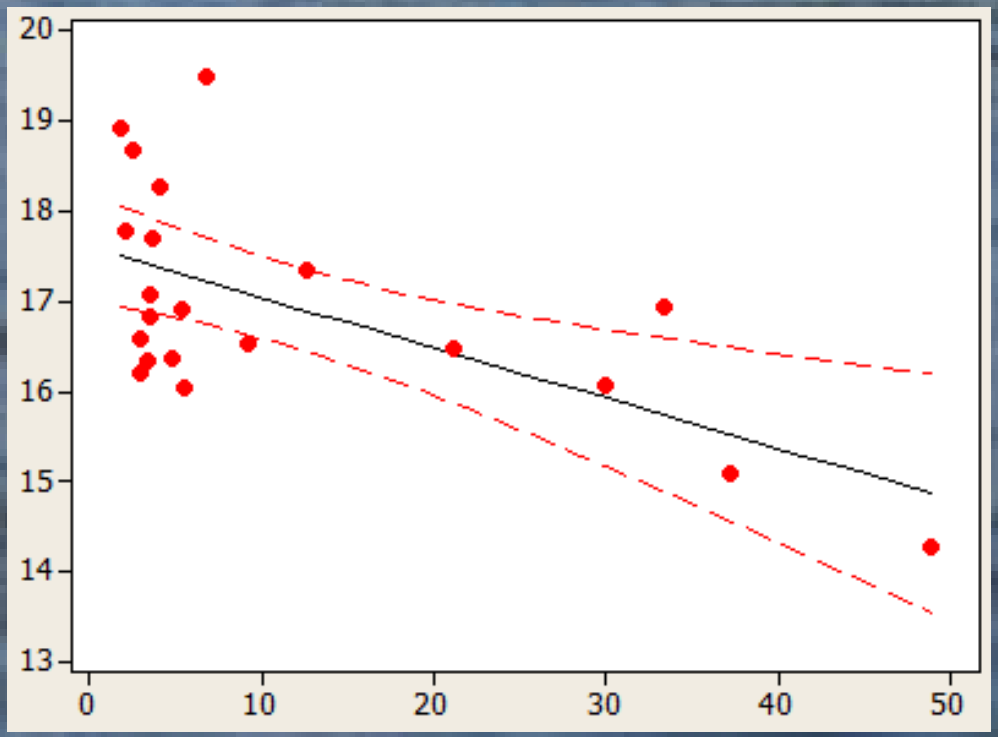
Birds
(Prosser)

Fish, crabs, shrimp
(Breitburg, Targett, Kornis)

Benthos
(Seitz)

IWCI *decreases* with percent **bulkhead** in subestuary

(2010-2014 summer surveys)

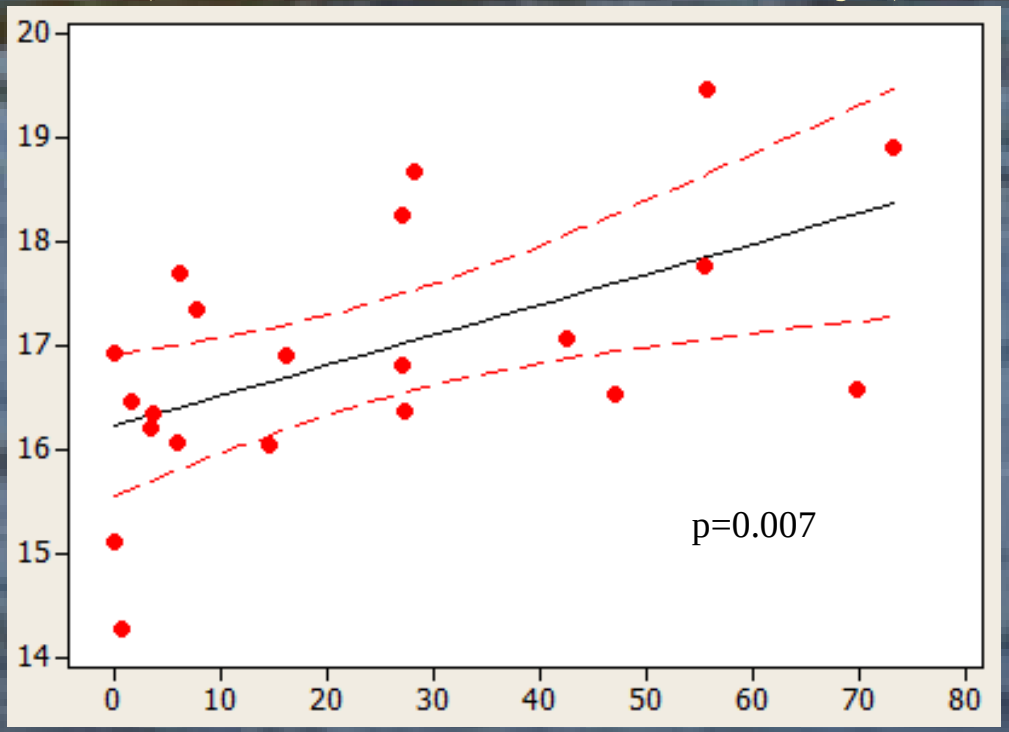


"Birds Boycott Bulkhead"

USGS

IWCI *increases* with percent **native wetlands** in subestuary

(2010-2014 summer surveys)

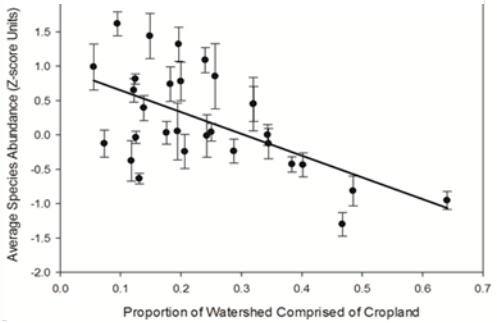


"Waterbirds are Wild for Wetlands"

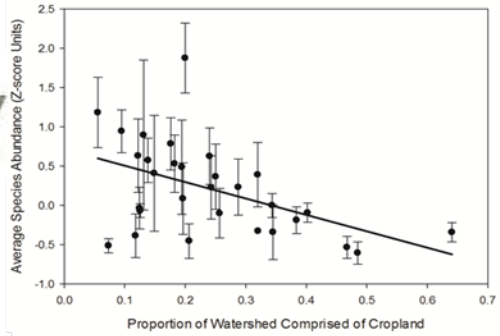
USGS

% watershed cropland

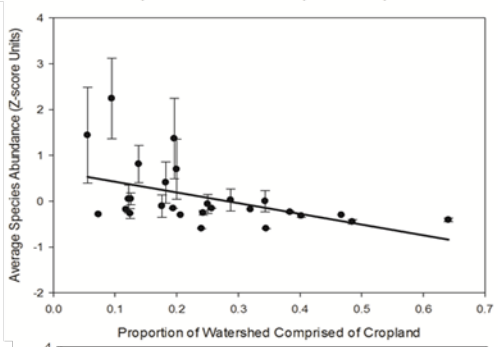
Blue Crab



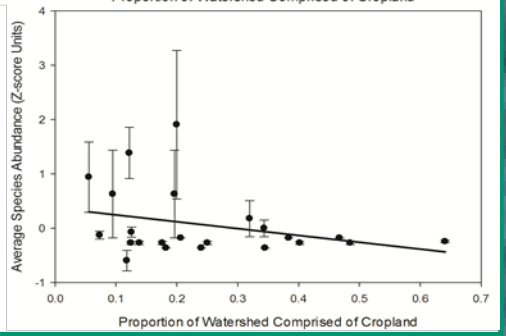
Spot



Atlantic Croaker

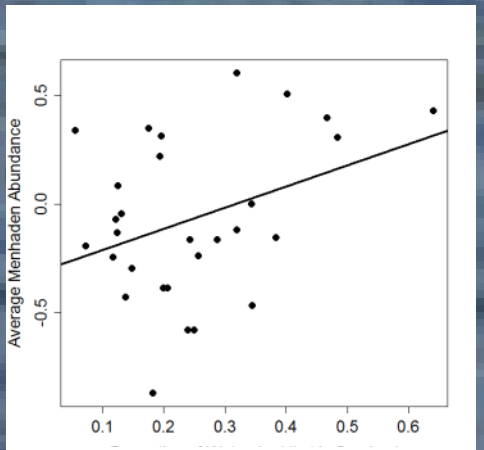


Silver Perch

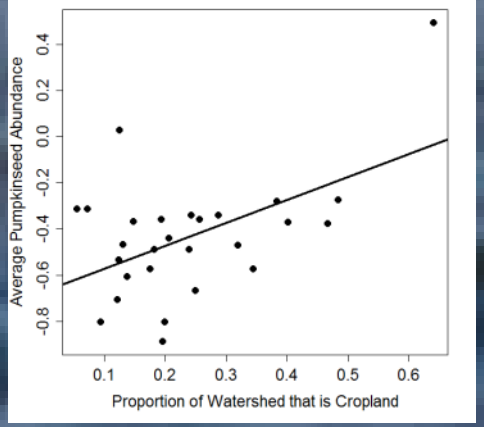


High % **agriculture in watershed** associated with decreases in several benthivore/ piscivore species and increases in 2 planktivorous fishes

Atlantic Menhaden



Juvenile Centrarchids

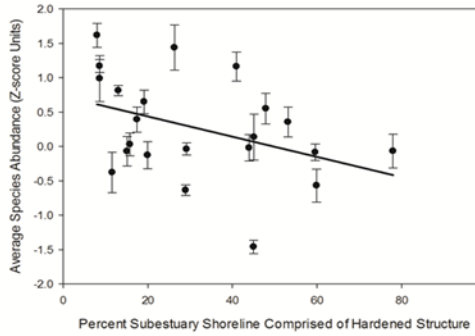


Smithsonian Institution

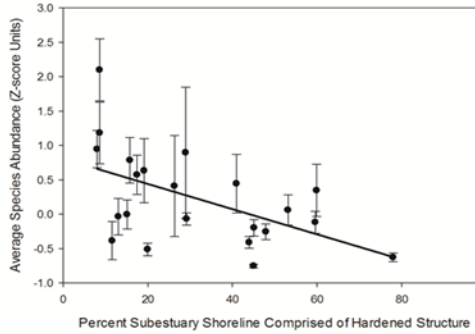
Increasing % **hardened shoreline** in subestuaries is associated with decreased abundances of many nearshore fish species and blue crab; only juvenile centrarchids seem to be favored

% hardened shoreline

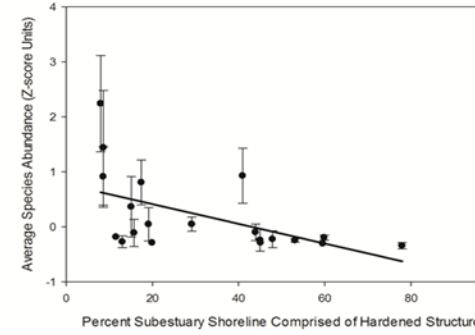
Blue Crab



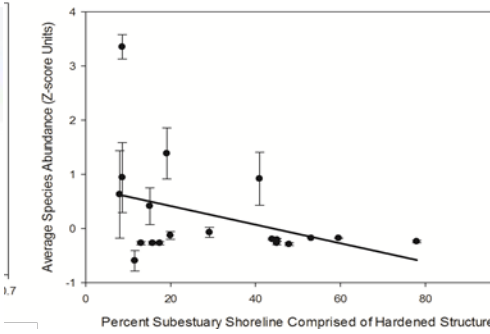
Spot



Atlantic Croaker



Silver Perch

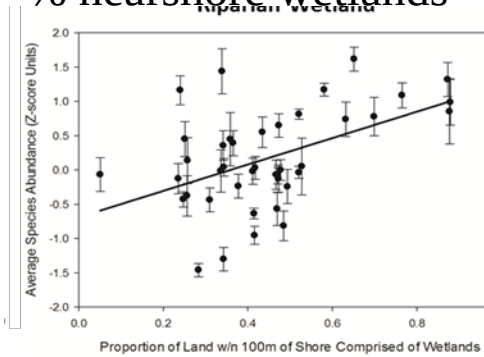


Smithsonian Institution

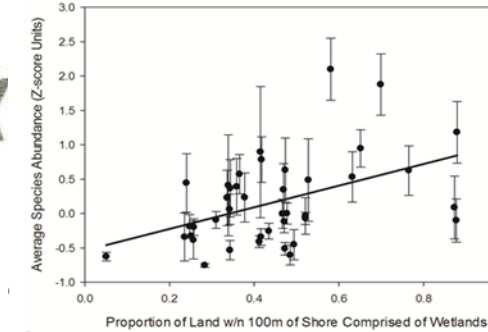
Abundance of fishes & blue crab increases with increasing nearshore **wetlands** in the subwatershed

% nearshore wetlands

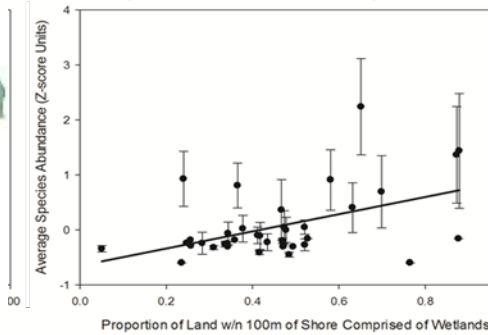
Blue Crab



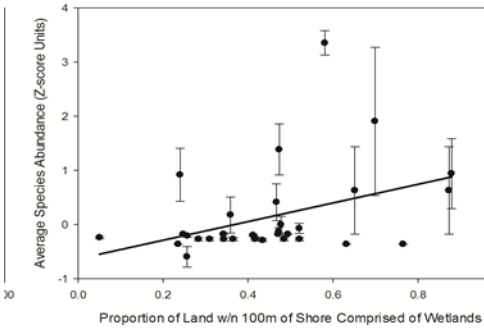
Spot



Atlantic Croaker



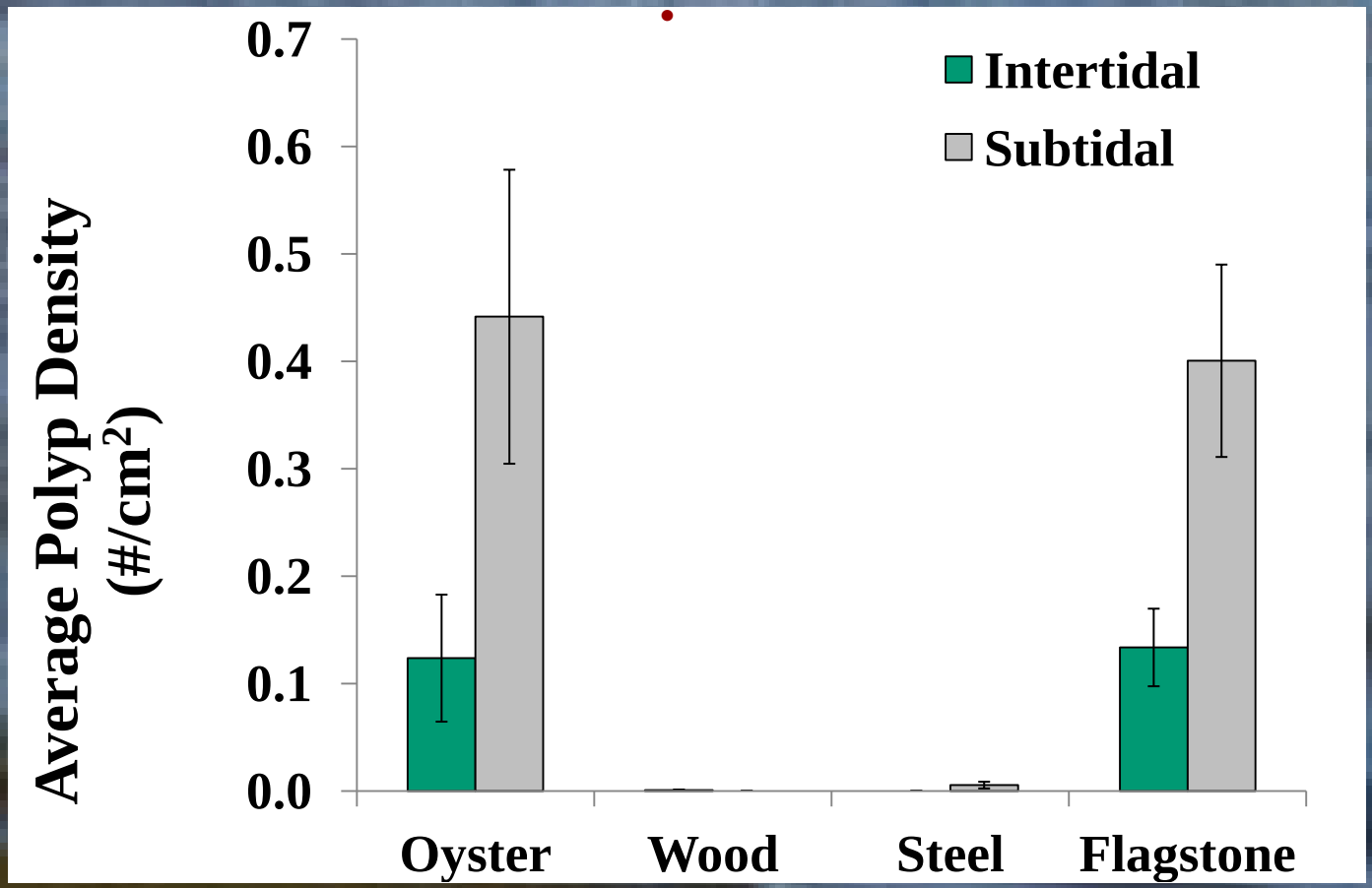
Silver Perch

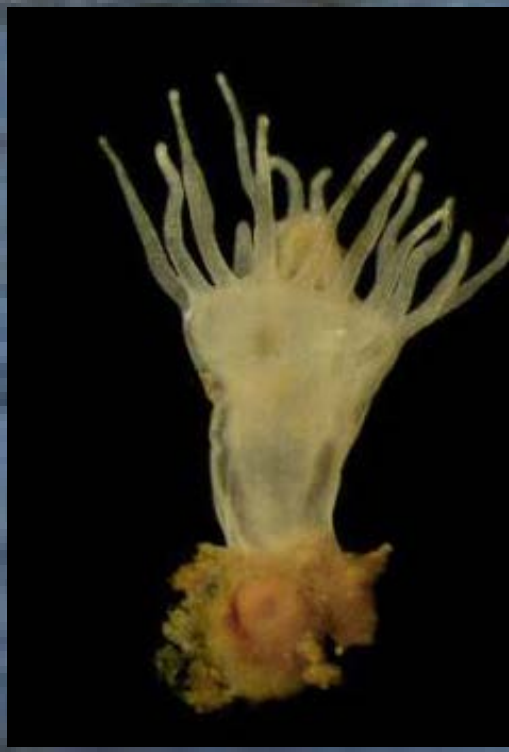


Smithsonian Institution

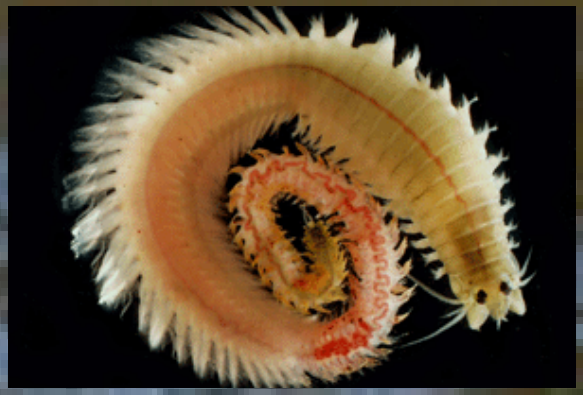
Shoreline hardening: using rock can increase habitat for the overwintering sessile stages of the sea nettle.

(Breitburg lab)



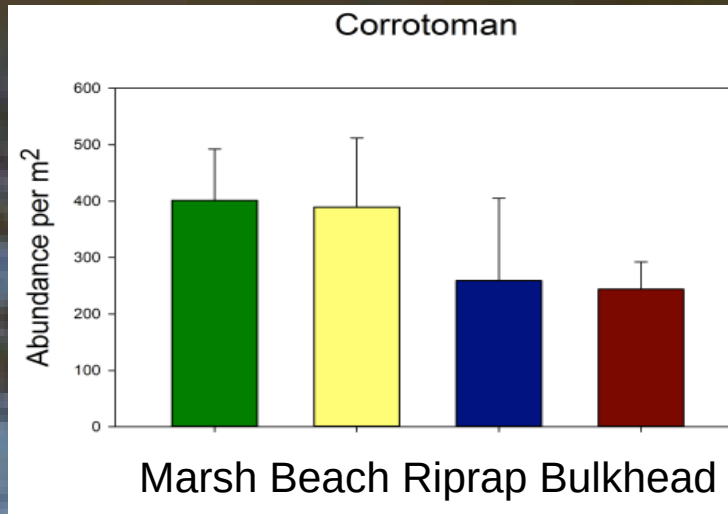


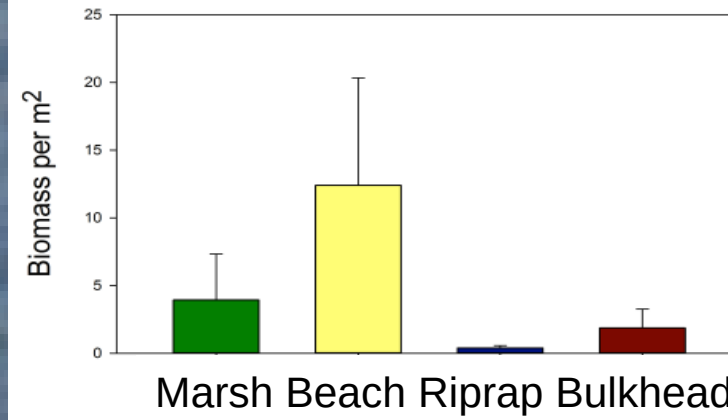
Smithsonian Institution

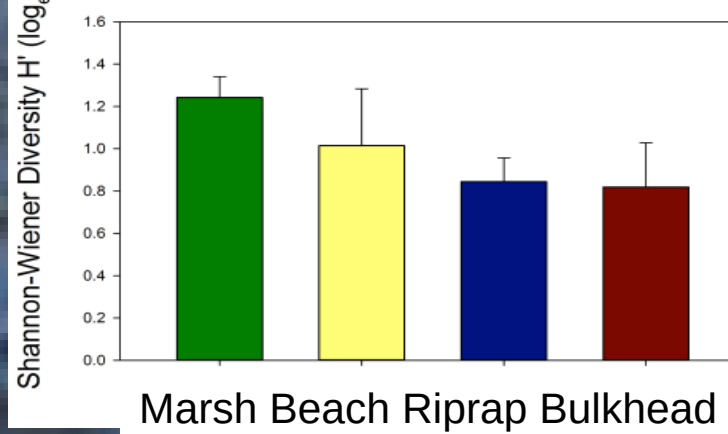


Natural shoreline habitats have higher abundance, biomass, and diversity of benthic invertebrates than developed habitats

(e.g.,Corrotoman River)

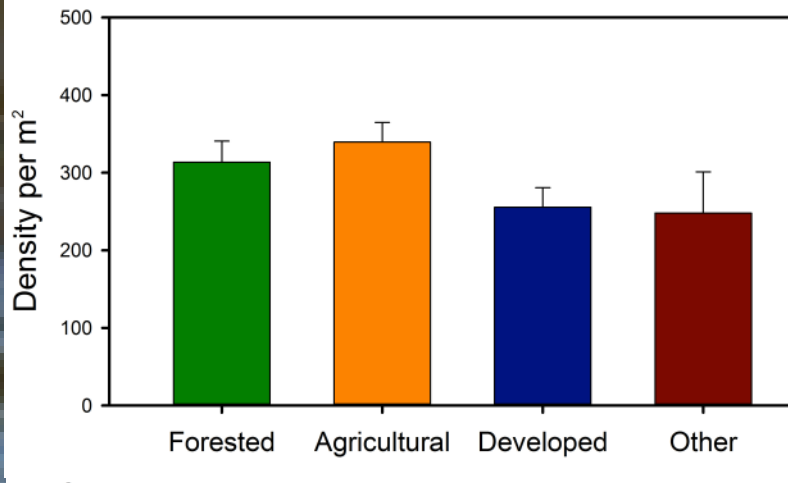


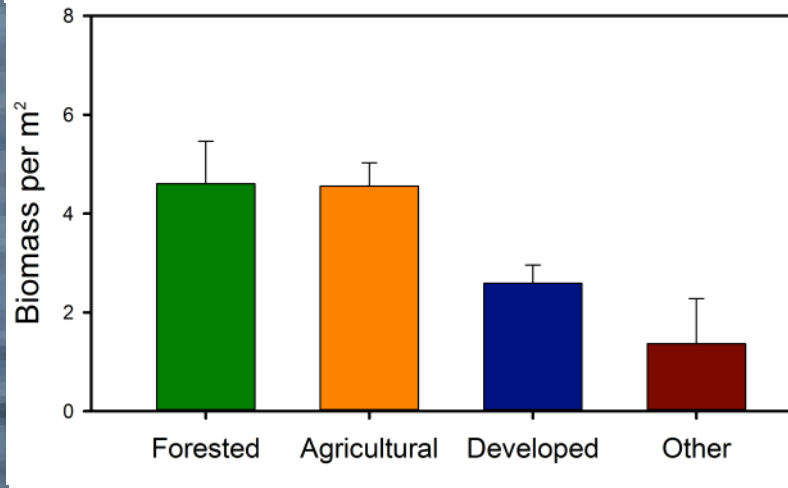


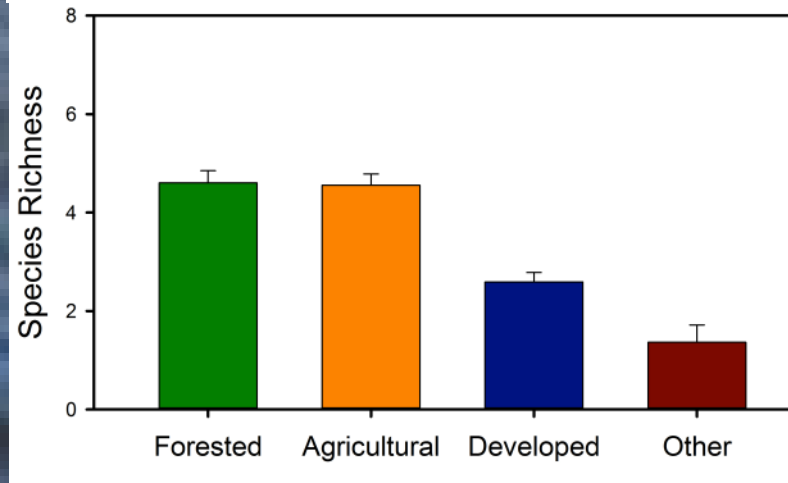


VIMS | William & Mary
Virginia Institute of Marine Science
1940-2015 75 Years

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

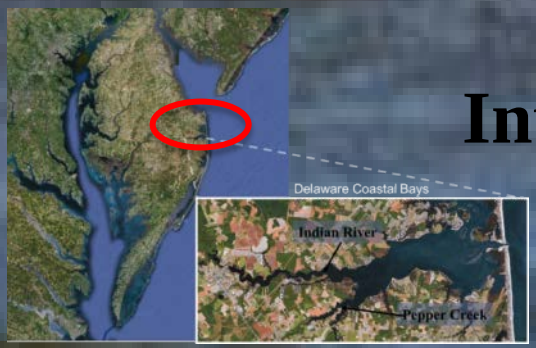






Riprap-sill structure provides higher habitat quality for shore zone estuarine fishes (and blue crabs) than does riprap revetment

Greater fish abundance along riprap-sill shoreline than riprap revetment

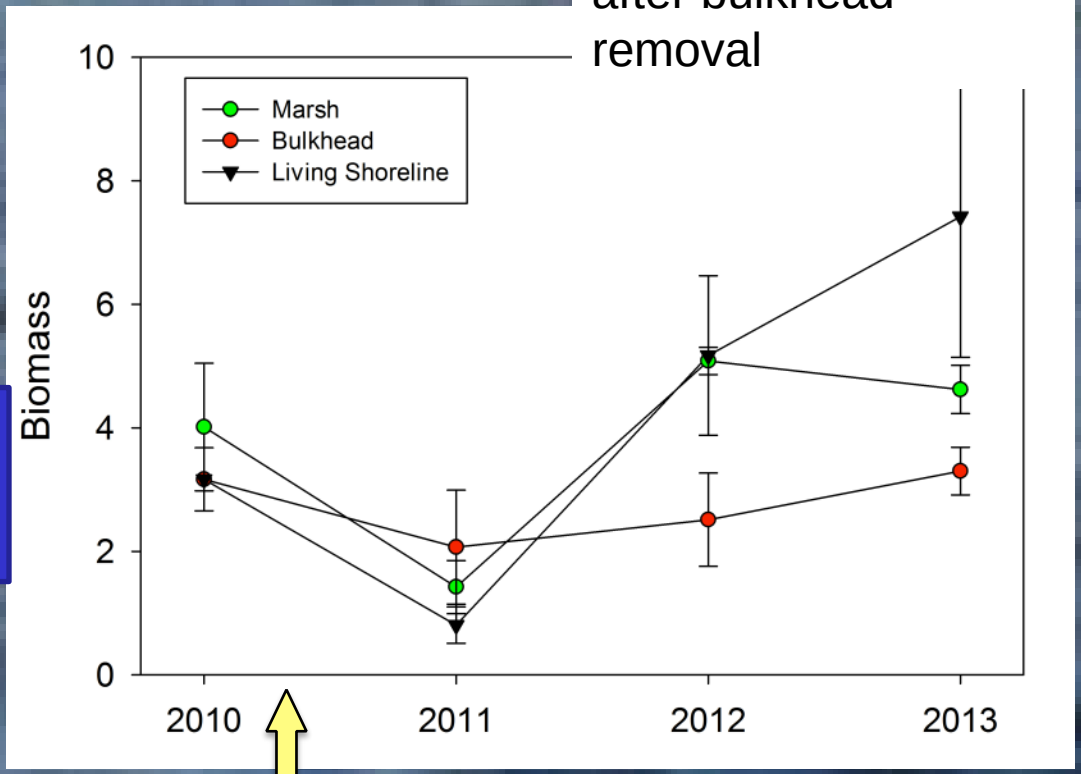


Intensive Sampling in Delaware Coastal Bays

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

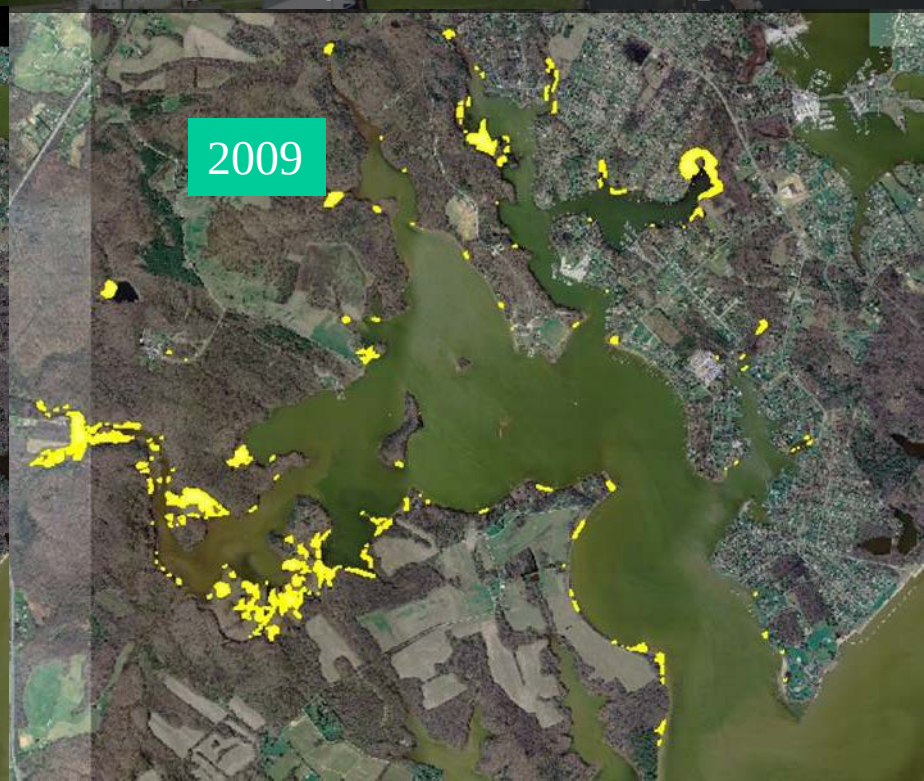
Note: More Fine sediment in 2011

Macrofauna

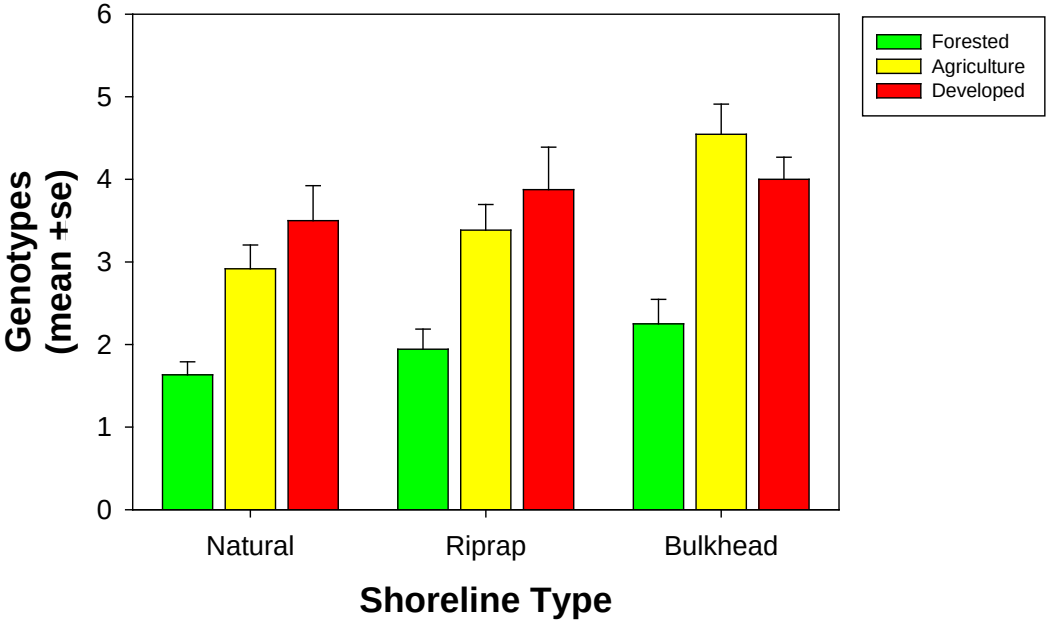
Both **shoreline hardening** and **watershed land use** affect economically and ecologically important species in Chesapeake Bay & Delaware Coastal Bays, **but design of shoreline protection can reduce negative effects**

Understanding and Controlling the Invasion of Tidal Wetlands by Phragmites australis

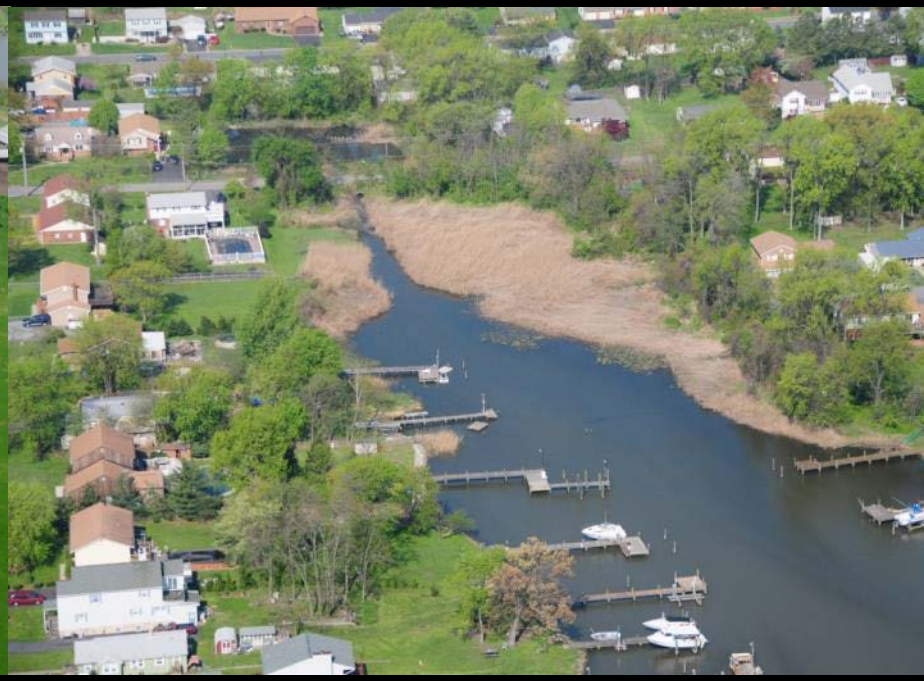
- In many parts of the C. Bay, it is too late for restoration.
- Only individual sites can be managed when restoration goals can be met
- BUT there has not been a Bay-wide effort to quantify the scale of the problem

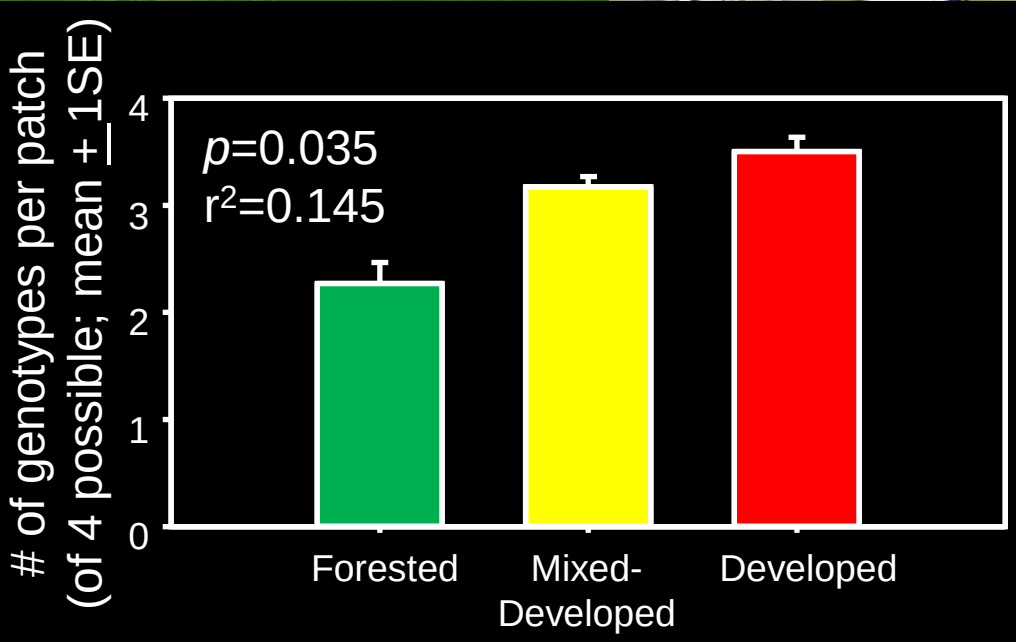


Shoreline type and genetic diversity



Land use and genetic diversity

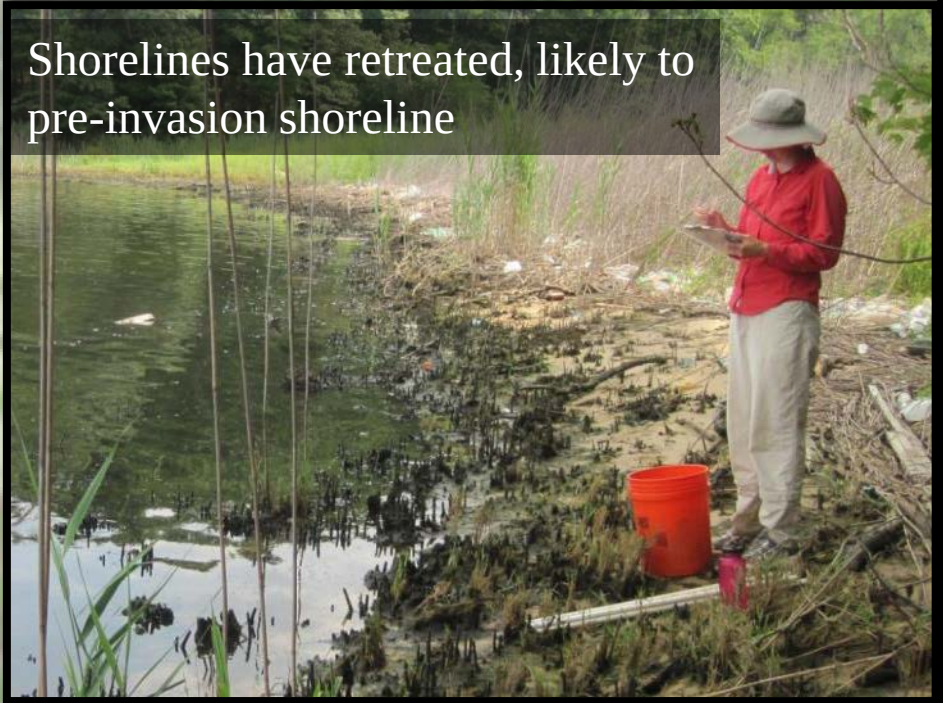




Recovery has been significant in some sites regardless of land use

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