The Need to Create Direction in Shoreline Protection: using data to drive change

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Our current path:

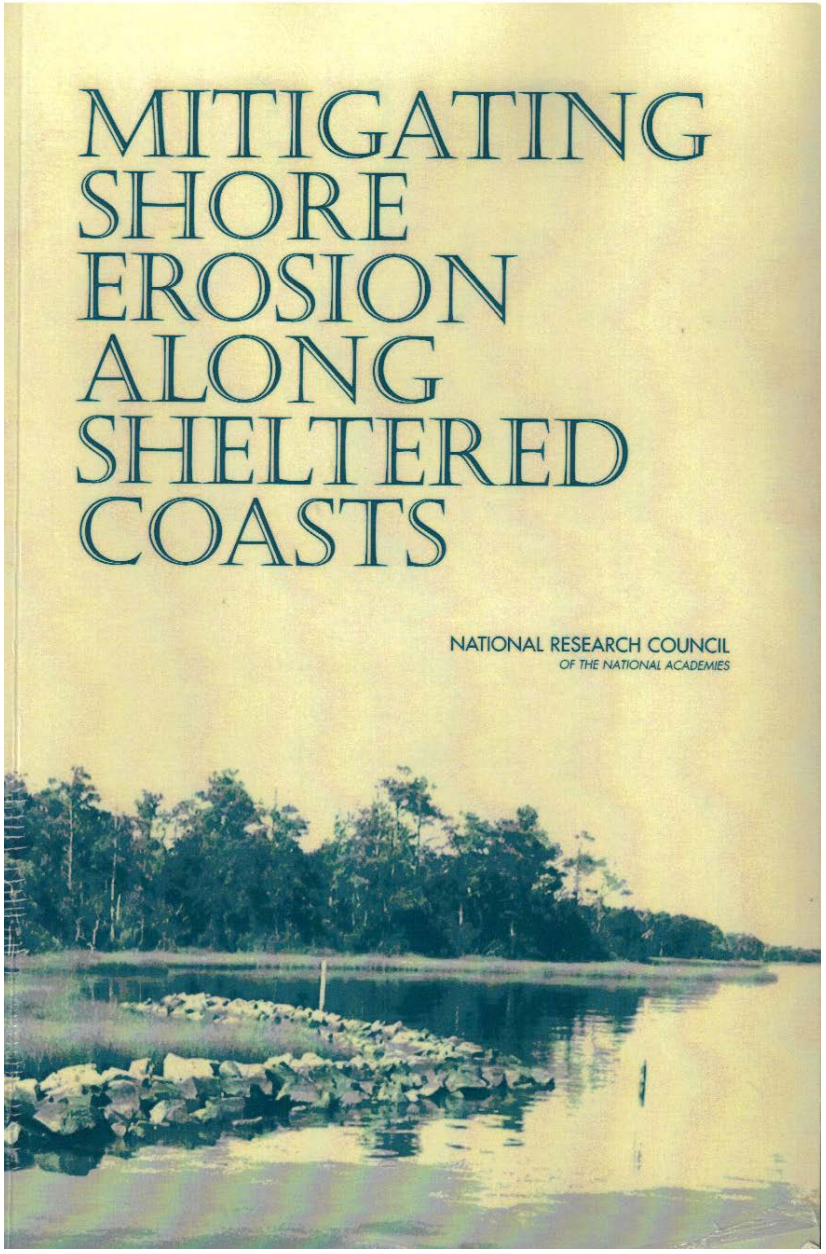
a journey through the unknown

“…26% of Maryland's 6,600 km of shoreline is already hardened (does not include tidal creeks)” Nash (2008)

Our lab uses marshes and submersed aquatic vegetation (SAV) as habitat indicators

The learning process: consequences of hardening

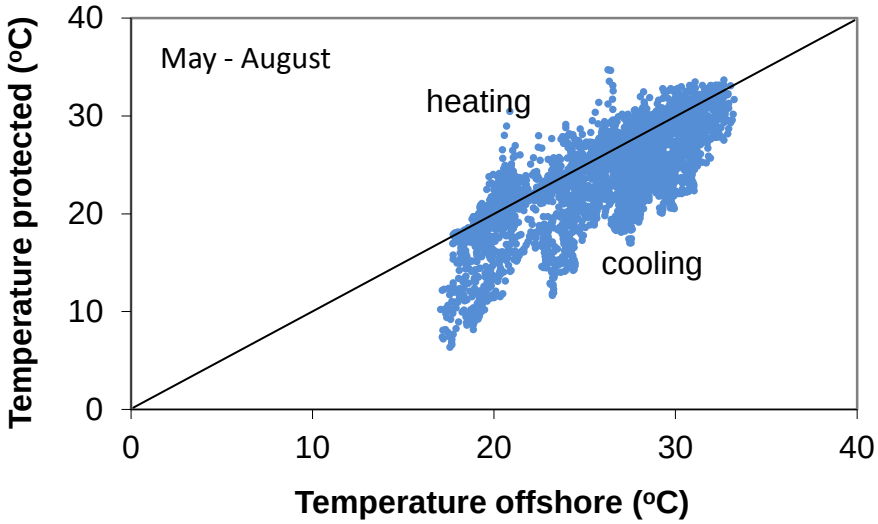
- National Research Council (2007) report
- 4 case studies:
  - performance of groins and sills
  - effect of living shorelines on water temperature
  - effect of rip rap on submersed aquatic vegetation (SAV)
  - effect of breakwaters on SAV habitat

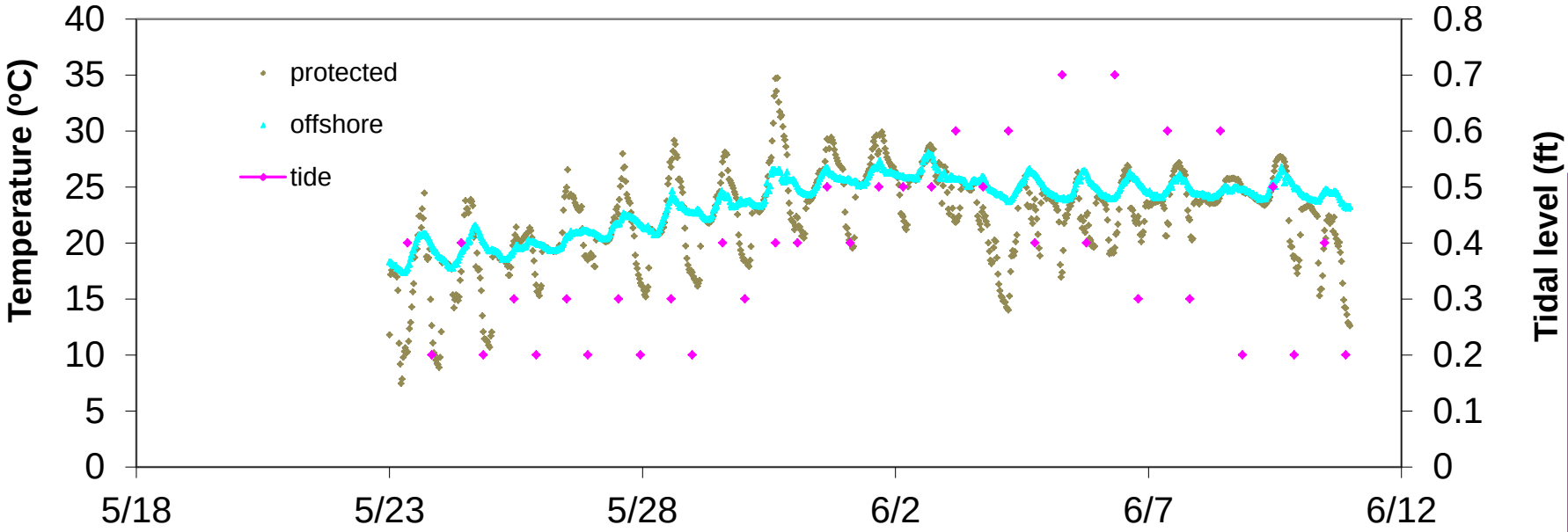


Hardening of shorelines leads to a "trade-off in ecosystem services"

As ecosystem services of the original (eroding) shoreline are lost (e.g. habitat provided by fallen trees; sand source), new ecosystem services may be gained (e.g. substrate for new species).

Effect of living shorelines on water temperature





Effect of living shorelines on water temperature

May 2-August 23, 2006

Site	Mouth Area (m^2)	# Days >30C protected	# Days >30C offshore	Difference (%)
Wye	0.821	67	43	155%
Patterson	0.347	62	36	172%
Severn (biolog)	0.00	50	36	138%
Londontowne	0.00	50	28	178%

Evaluation of performance of sills and groins (6 to 14 yrs post-construction)

Burke, Koch and Stevenson (2005)

Erosion control
Marsh health, presence of SAV
State of structure

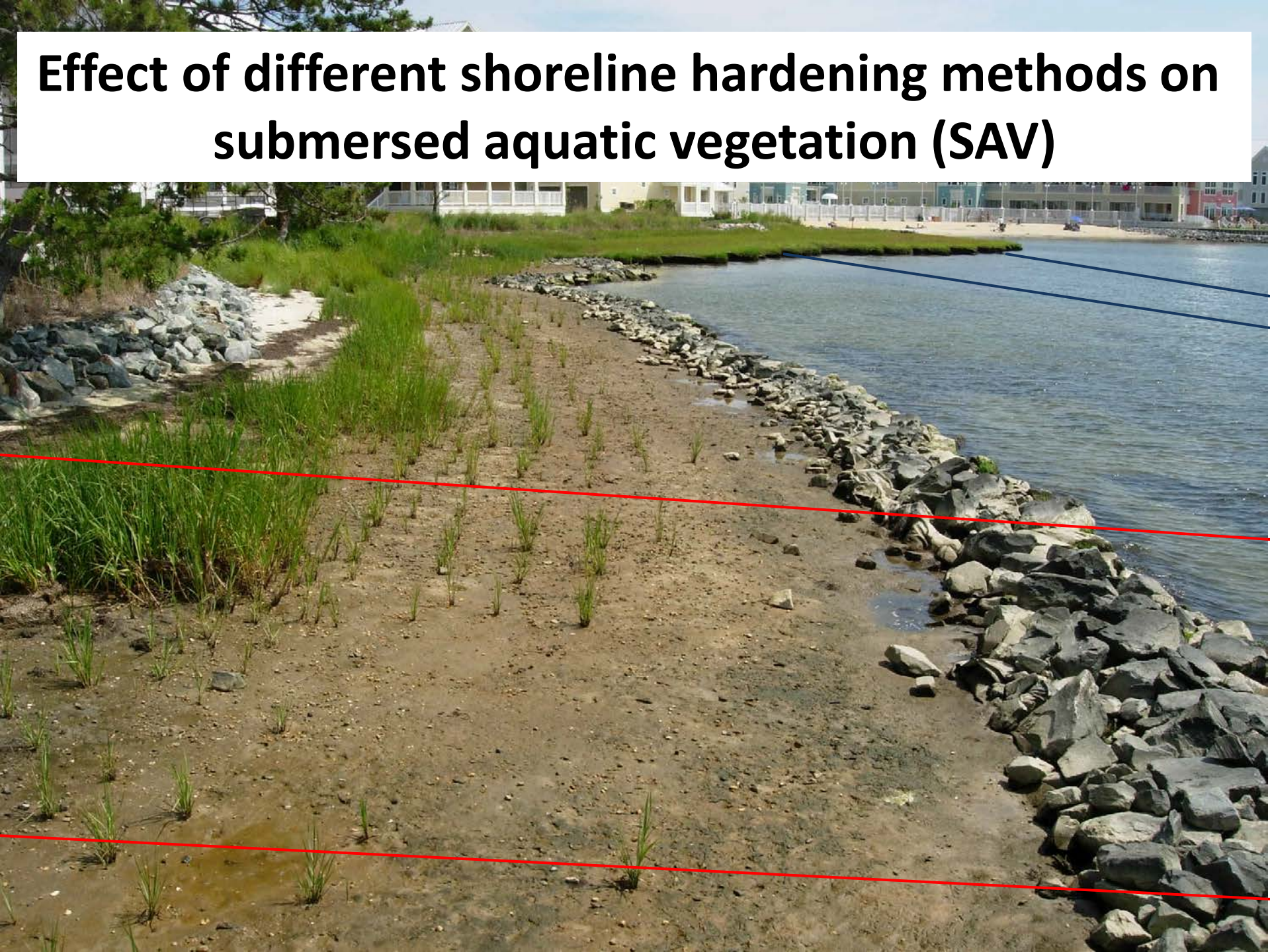
Parameters recorded:

- land survey of the bank
- elevations of structure
- transects through the marsh and near shore environment
- plant species characteristics, wildlife usage and other biological conditions of the marsh habitat and submerged aquatic vegetation (SAV)
- wave period and heights
- fetch
- sediment characteristics in marsh and nearshore
- depth profiles (slope of nearshore)
- water column nutrient concentration
- epiphytes

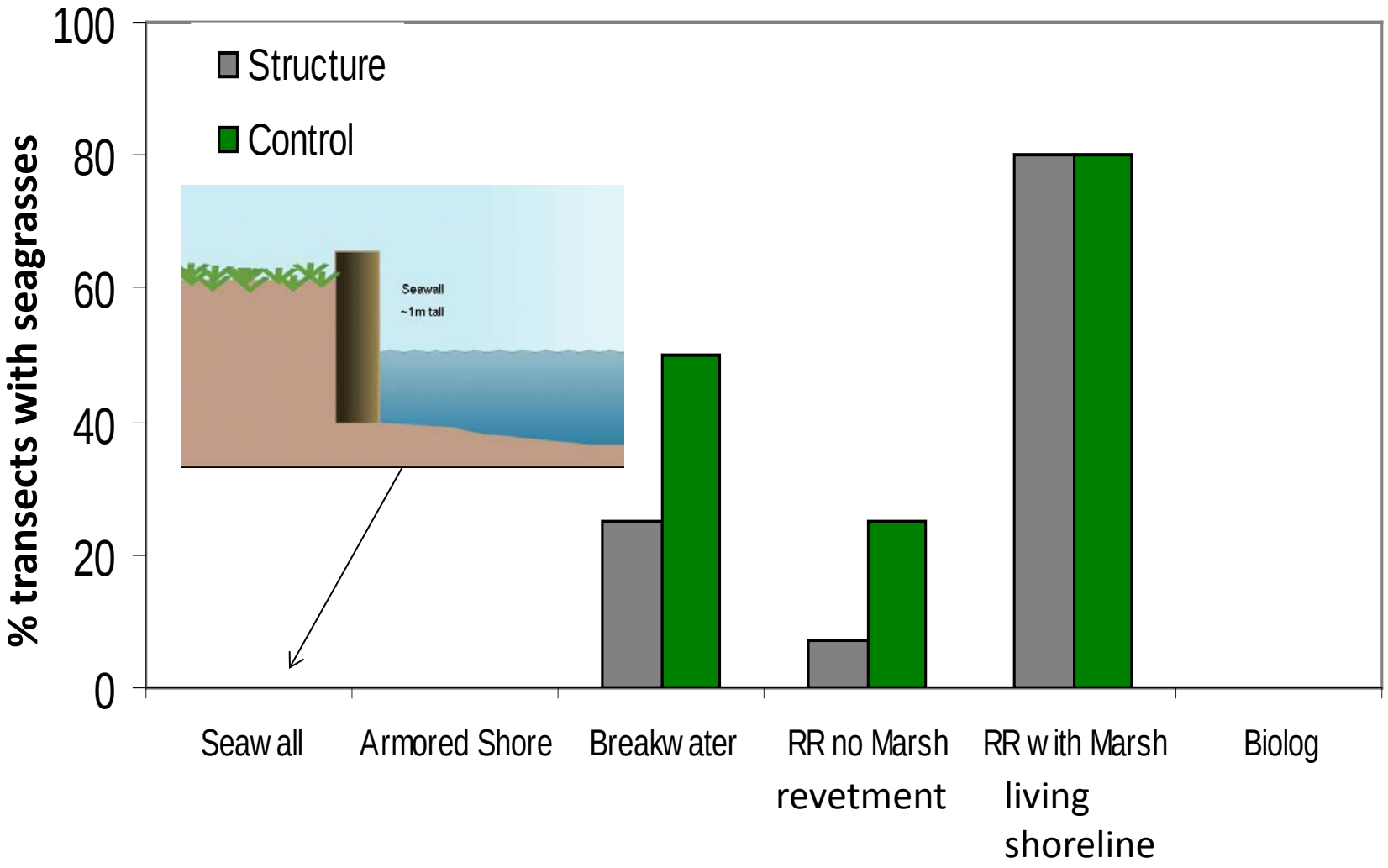
Parameters we wish we had recorded:

- boat wakes
- long shore transport
- shading – angle of sun, trees etc

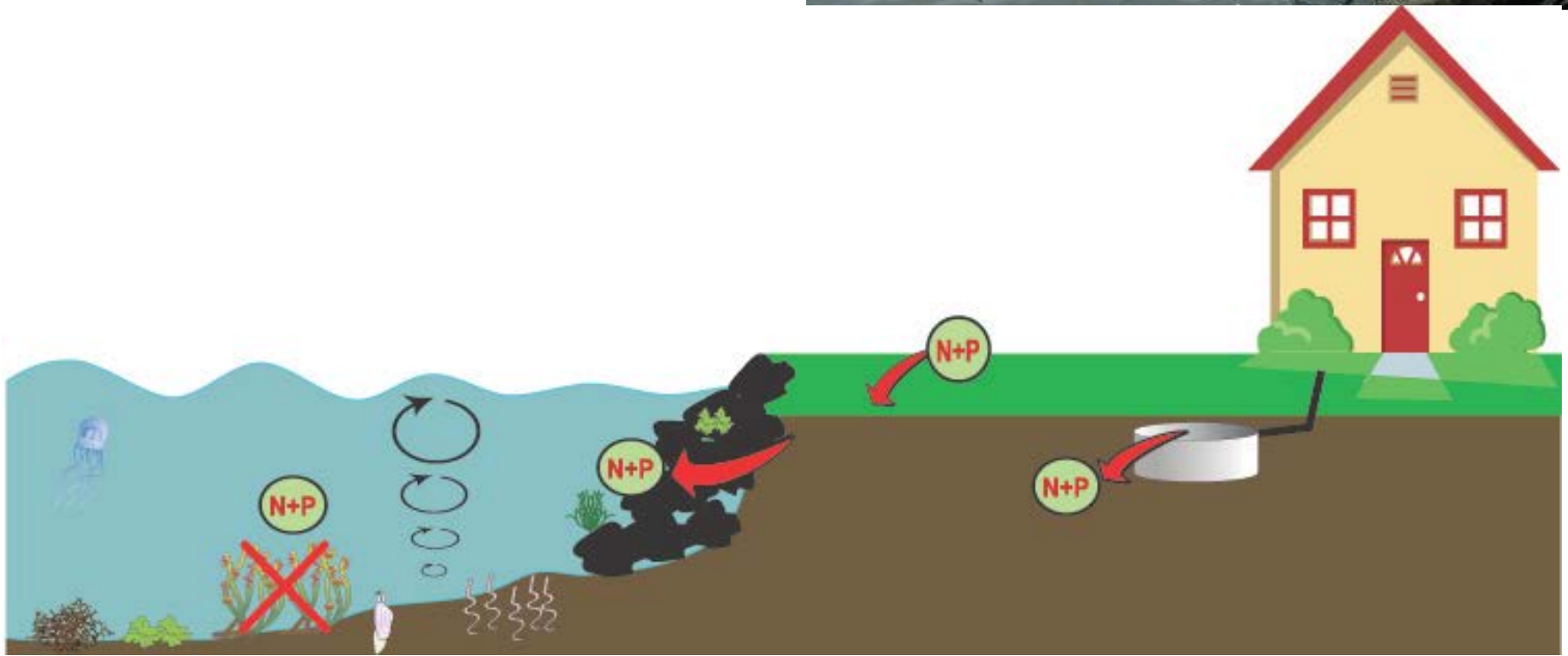
Effect of different shoreline hardening methods on submersed aquatic vegetation (SAV)

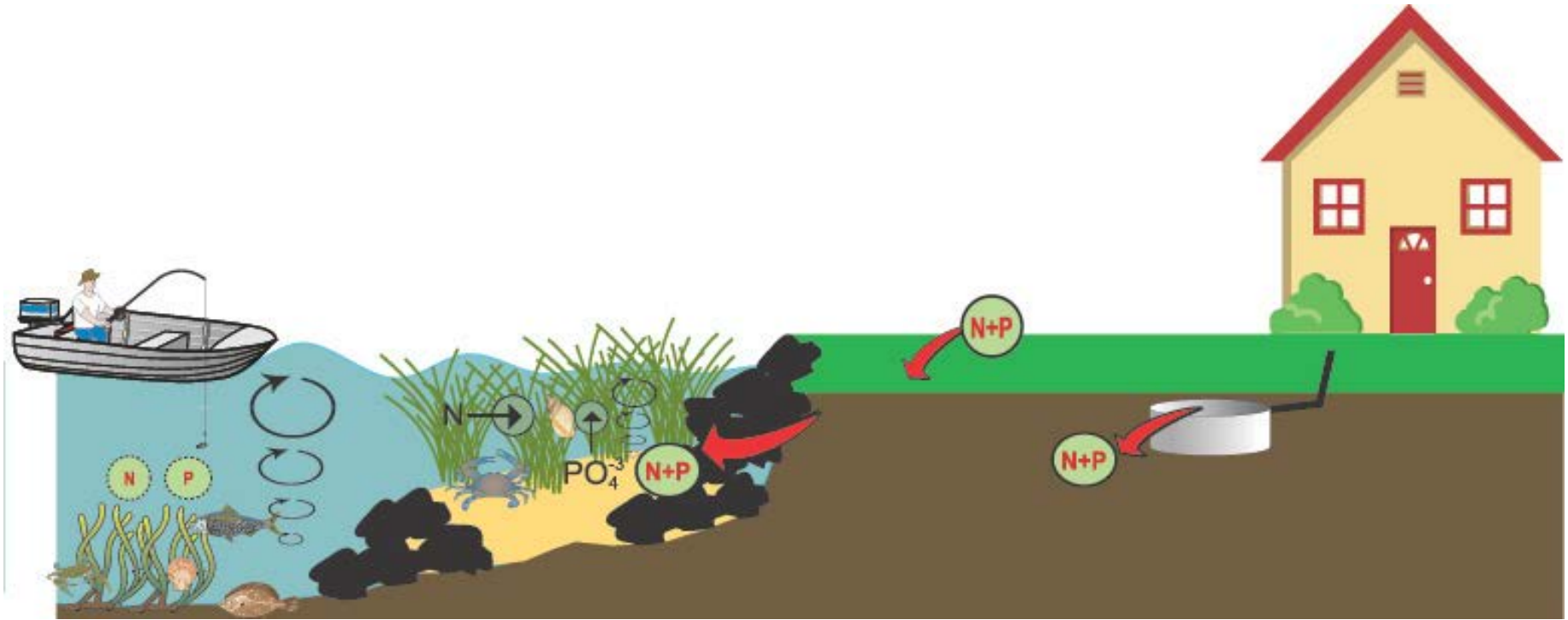


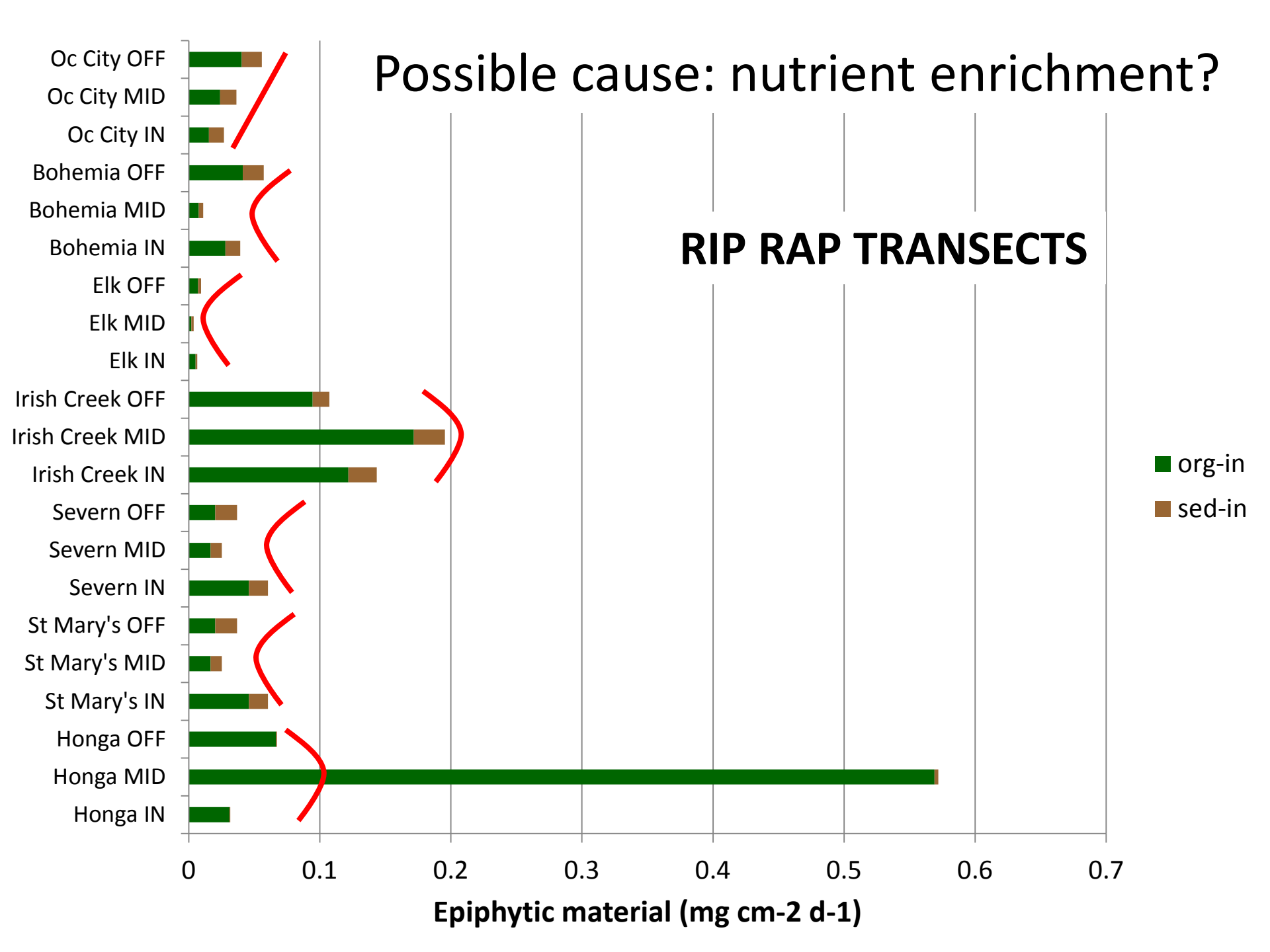
Maryland Coastal Bays (*Zostera marina* and *Ruppia maritima*)



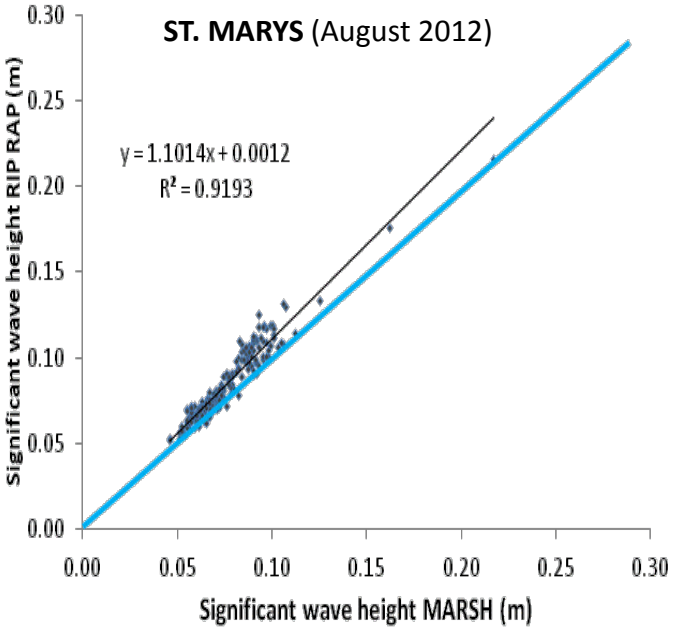
Possible cause:
nutrient enrichment?



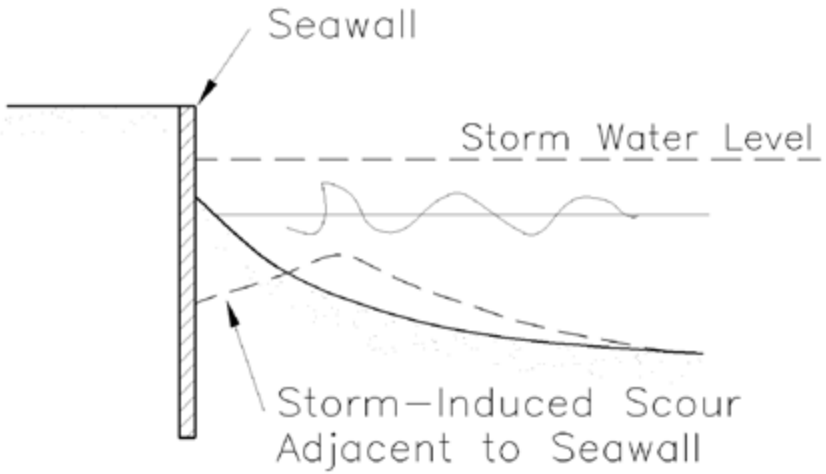

N+P
N
P
N
PO_4^{-3}
N+P
N+P


Possible cause: nutrient enrichment?
RIP RAP TRANSECTS
Oc City OFF
Oc City MID
Oc City IN
Bohemia OFF
Bohemia MID
Bohemia IN
Elk OFF
Elk MID
Elk IN
Irish Creek OFF
Irish Creek MID
Irish Creek IN
Severn OFF
Severn MID
Severn IN
St Mary's OFF
St Mary's MID
St Mary's IN
Honga OFF
Honga MID
Honga IN
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Epiphytic material (mg cm-2 d-1)
org-in
sed-in

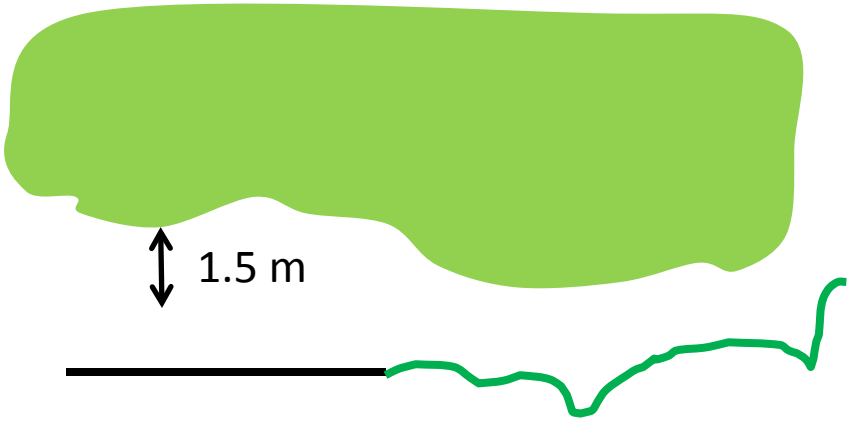
Possible cause: wave reflection?



Reflected waves may be pushing SAV bed offshore and resuspending sediments



Storm–Induced Scour Adjacent to Seawalls

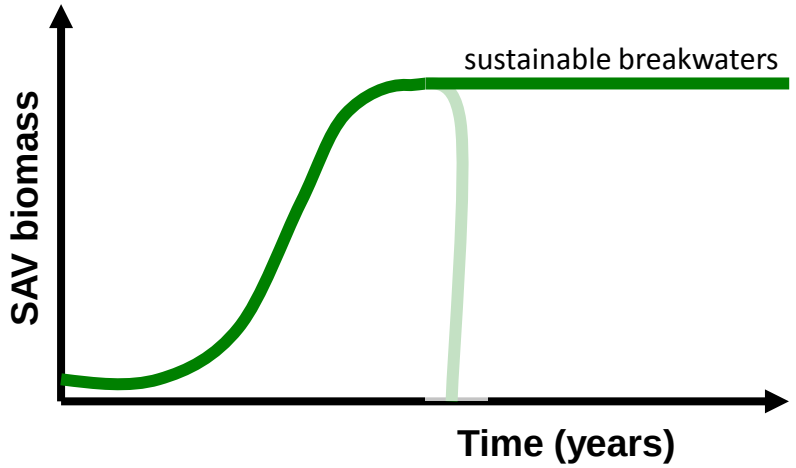


NOAA Project

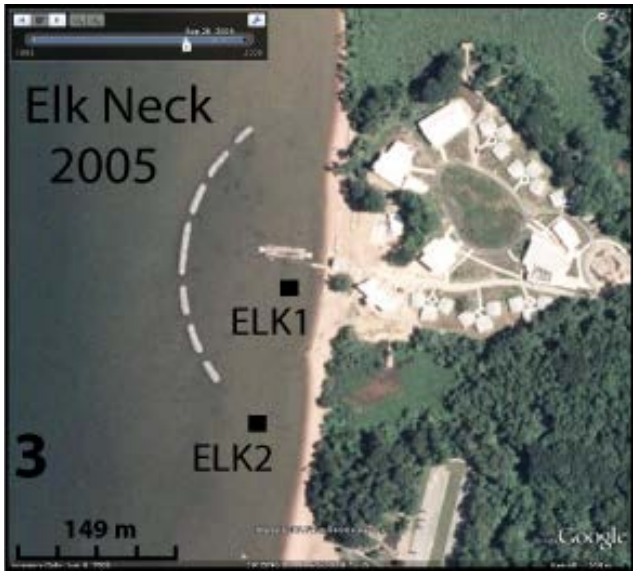
Multiple stressors in coastal areas

with Lee Karrh and other colleagues in MD & VA

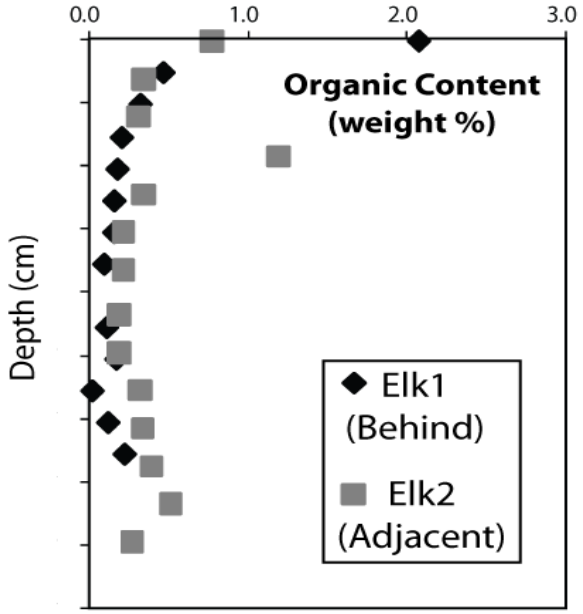
Effect of breakwaters on SAV

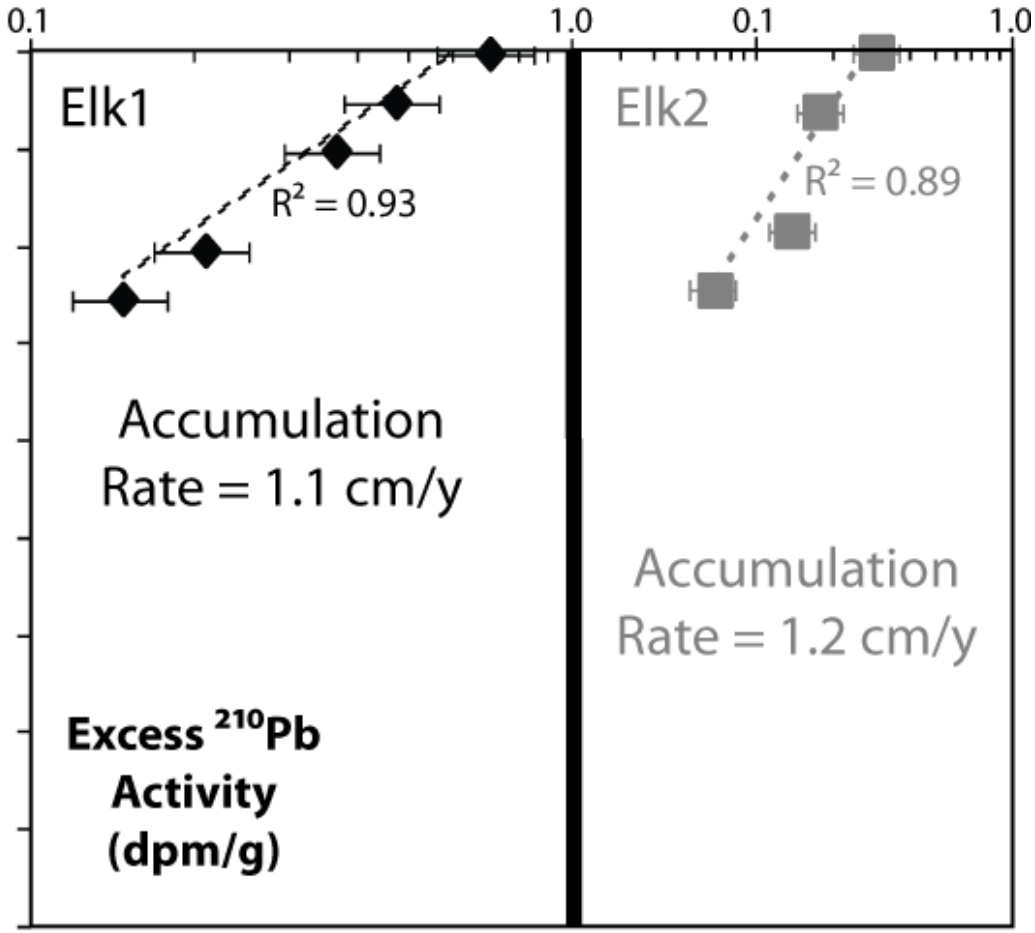



Studied 24 breakwaters (1 to 19 yrs old)
throughout Chesapeake Bay

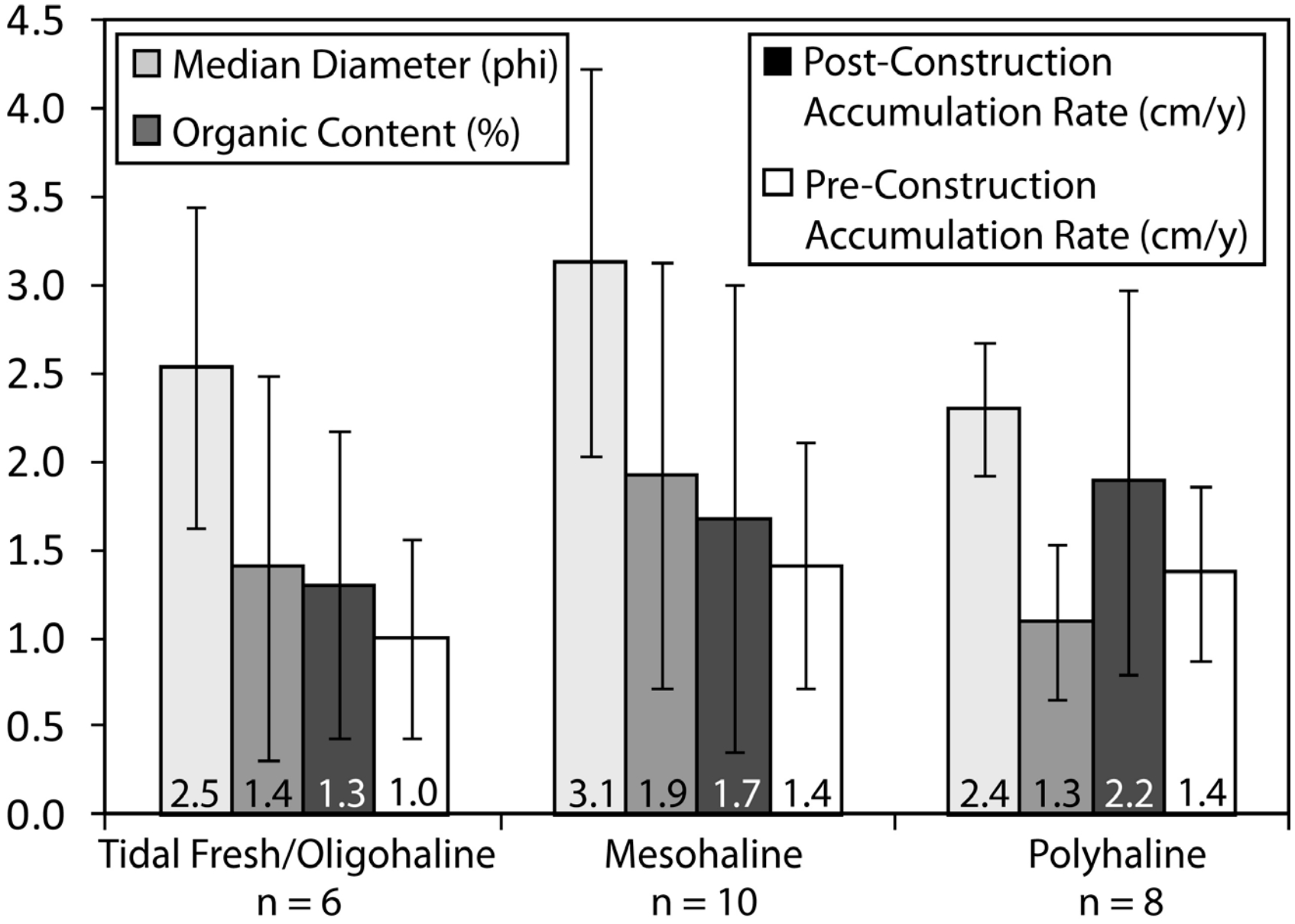

Elk Neck
2005
ELK1
ELK2
3
149 m
Google

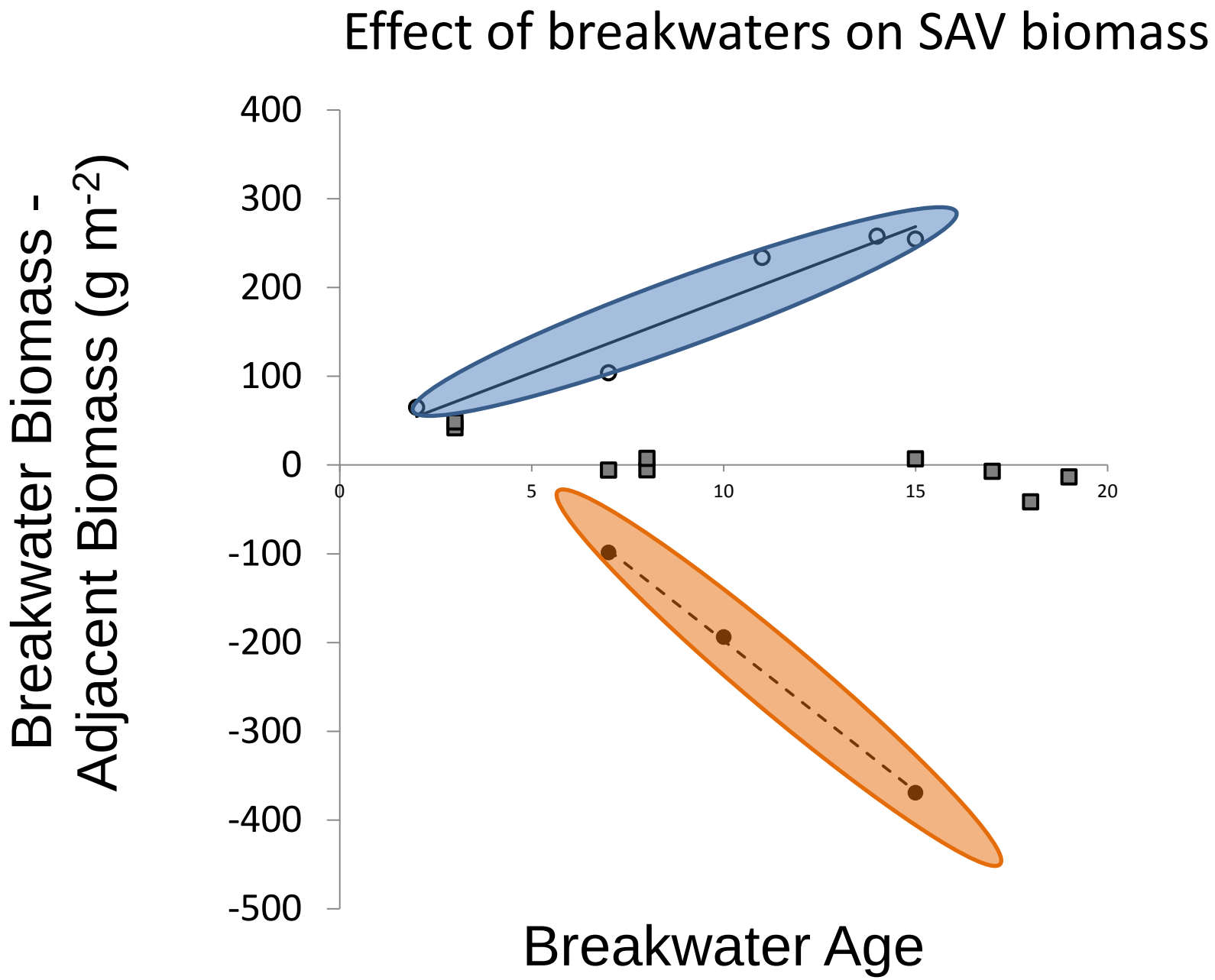
4 years old

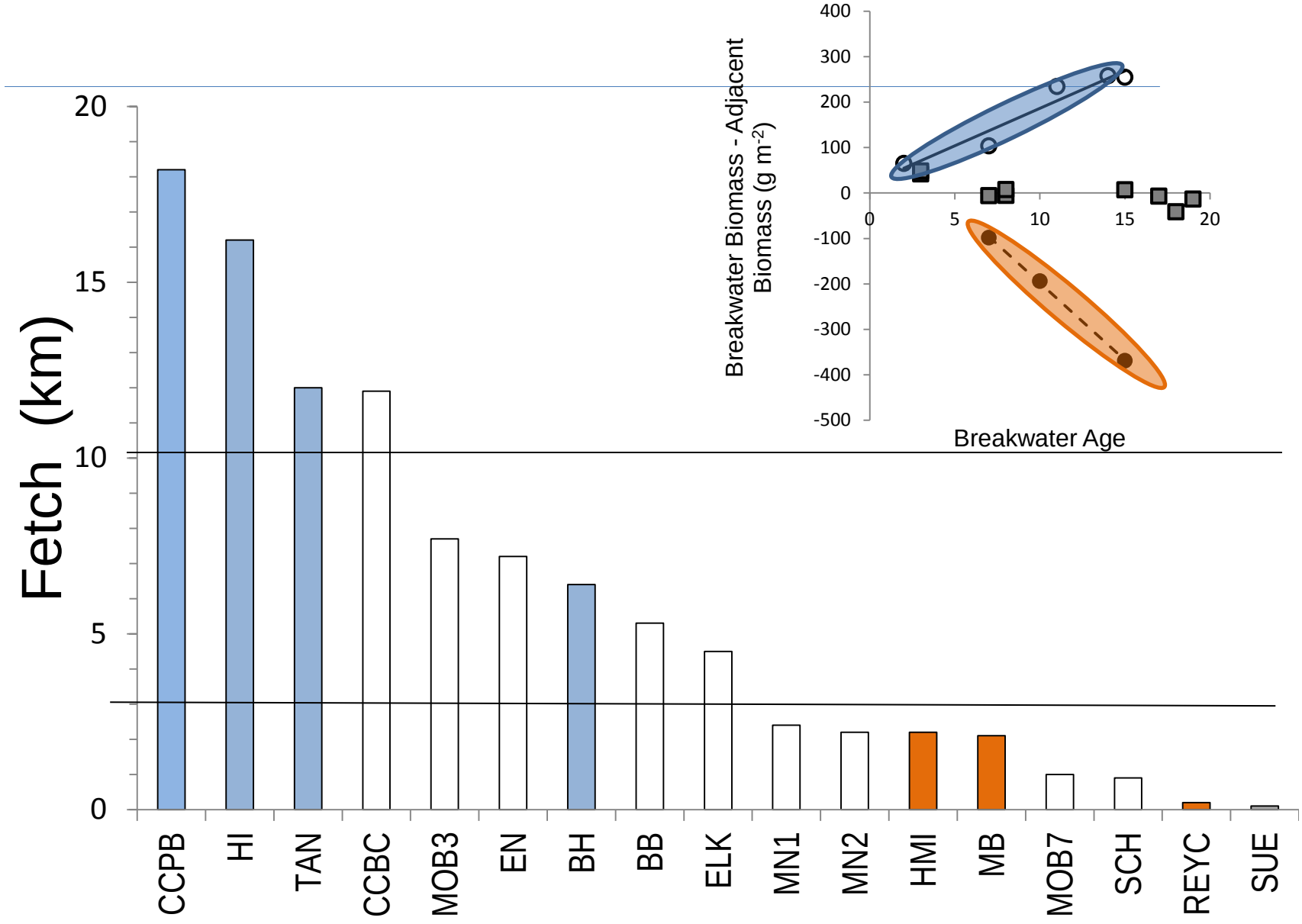

0.0
1.0
2.0
3.0
Organic Content
(weight %)
Depth (cm)
Elk1
(Behind)
Elk2
(Adjacent)

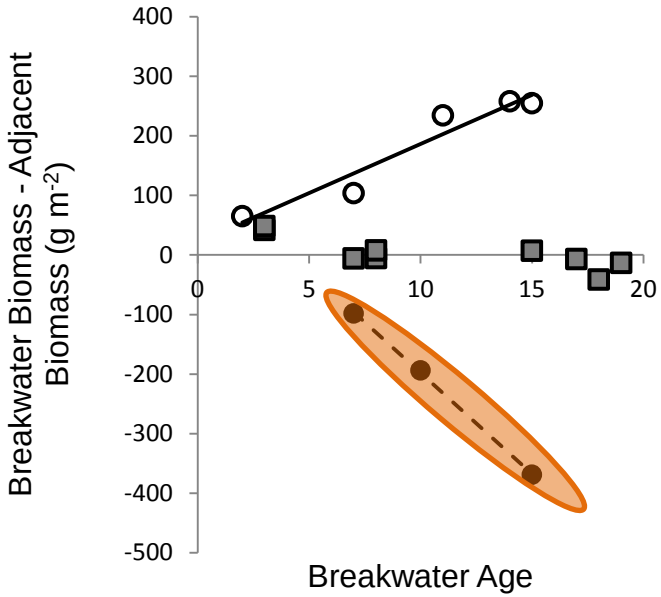

0.1
1.0
0.1
1.0
Elk1
$R^2 = 0.93$
Accumulation
Rate = 1.1 cm/y
Excess ^{210}Pb
Activity
(dpm/g)
Elk2
$R^2 = 0.89$
Accumulation
Rate = 1.2 cm/y

Effect of breakwaters on sedimentation rates




Effect of breakwaters on SAV biomass
Breakwater Biomass - Adjacent Biomass (g m-2)
400
300
200
100
0
-100
-200
-300
-400
-500
0
5
10
15
20
Breakwater Age


Fetch (km)
20
15
10
5
0
CCPB
HI
TAN
CCBC
MOB3
EN
BH
BB
ELK
MN1
MN2
HMI
MB
MOB7
SCH
REYC
SUE
Breakwater Biomass - Adjacent Biomass (g m-2)
400
300
200
100
0
-100
-200
-300
-400
-500
0
5
10
15
20
Breakwater Age


Breakwater Biomass - Adjacent Biomass (g m-2)
400
300
200
100
0
-100
-200
-300
-400
-500
0
5
10
15
20
Breakwater Age


NH4+
fine sediment
sediment organic matter

Shoreline hardening can reduce nearshore turbidity

Casson Point, Little Choptank

Calm day

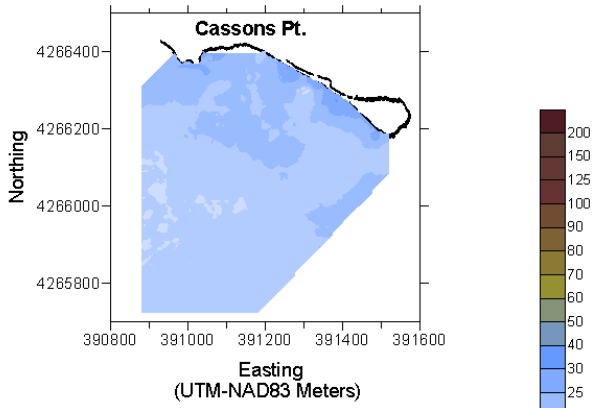
Windy day

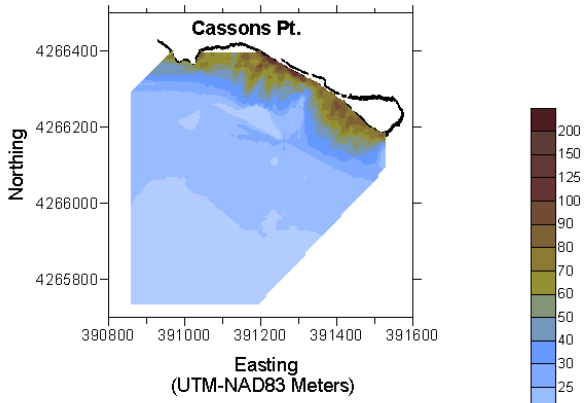
Eroding shore

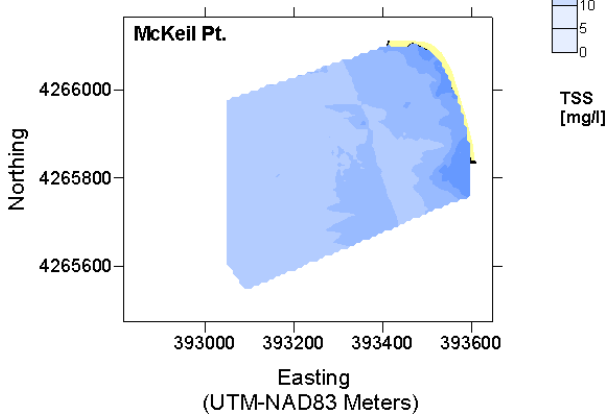
Hardened shore

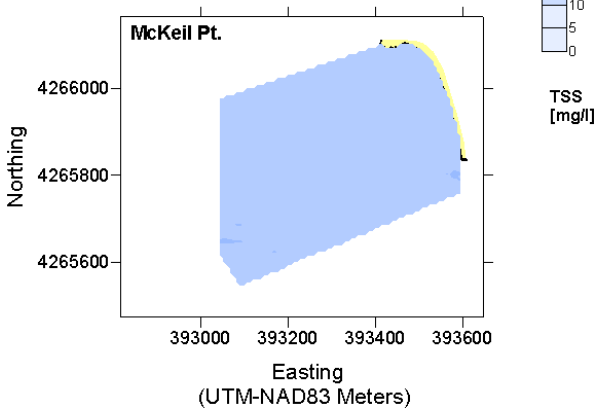
CTD Survey: SGLC3S1: June 20, 2006

CTD Survey: SGLC3S3 June 22, 2006









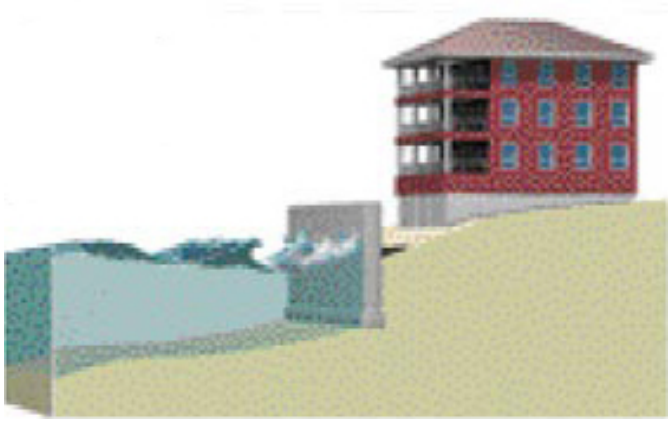
But the wrong type of shoreline protection can increase nearshore turbidity

Next step: Engineering shorelines for habitat creation

- green bulkheads
- breakwaters for SAV habitat creation

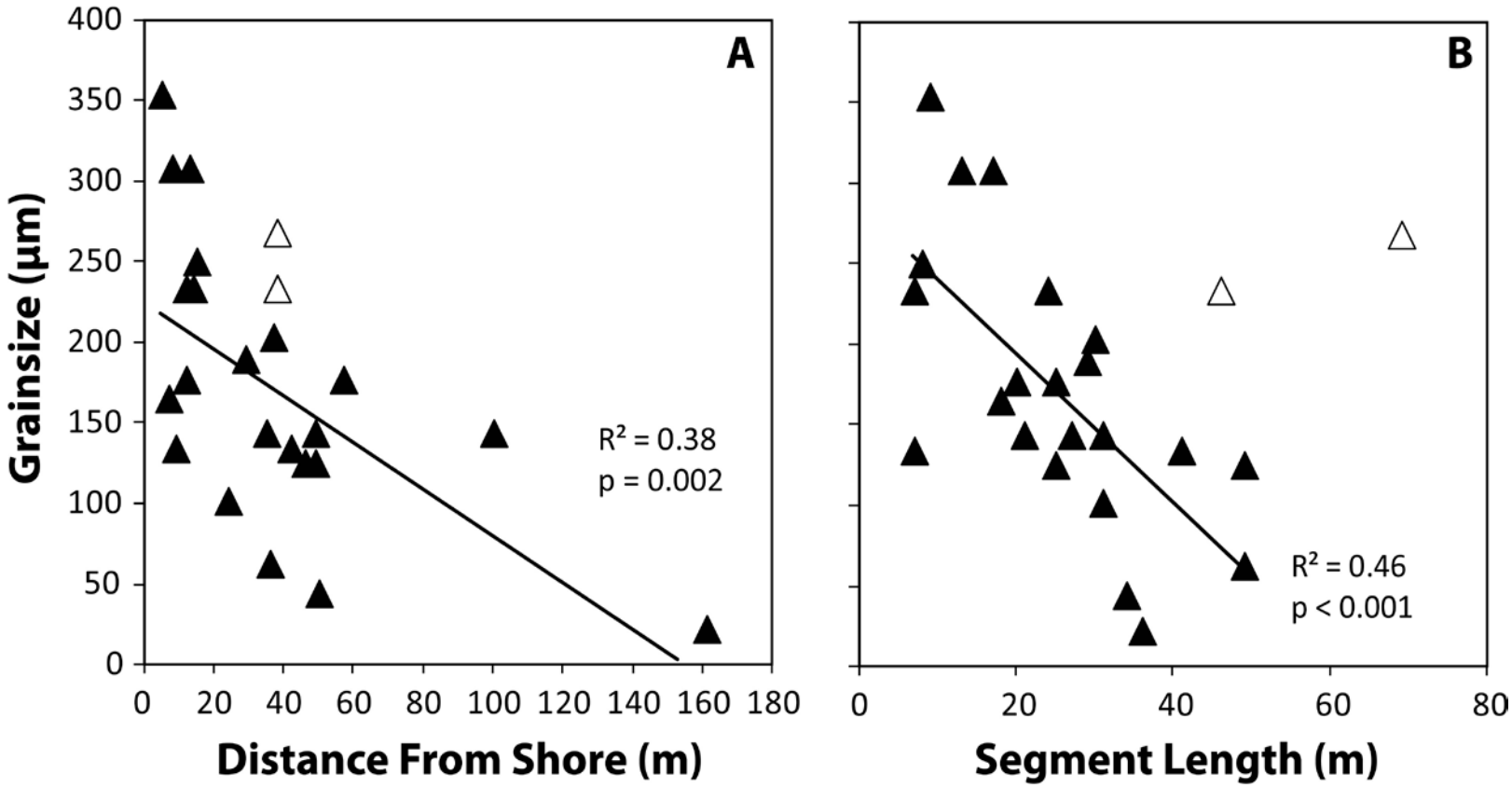
Living shorelines beyond “sill + marsh”

Ocean City
"bulkhead greening" project
using "Peruvian flutes"



Seagrass *Zostera marina*
Macroalgae
Scallops

Breakwater construction for SAV conservation and/or restoration



Breakwaters for SAV habitat creation

Breakwaters can sustain SAV populations as long as some habitat requirements are met:

- **Water quality** – regional water quality needs to be good enough to support SAV growth
- **Water depth** – deep enough so SAV can remain submersed at low tide
- **Sediment** – needs to remain sandy (<35% silt+clay) with low organic matter (<5 to 8% organic matter) over time. Sedimentation rates >9mm/yr are also beneficial but no infilling (habitat becomes intertidal)
- **Fetch** – breakwaters are most beneficial to SAV in long fetch areas (> 10 km)

Breakwaters for SAV habitat creation

Shoreline characteristics also need to be considered:

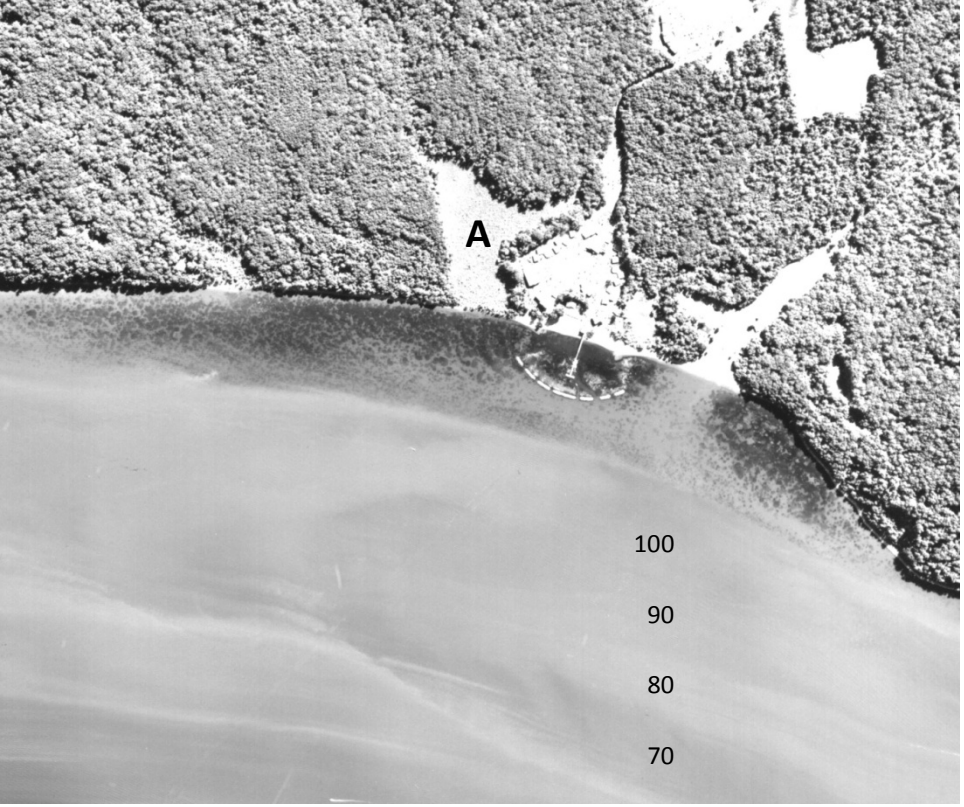
- **Eroding Marshes** – a layer of sand* needs to be added to cover the marsh peat in the sub-tidal (*>2cm, Wicks et al. 2009)

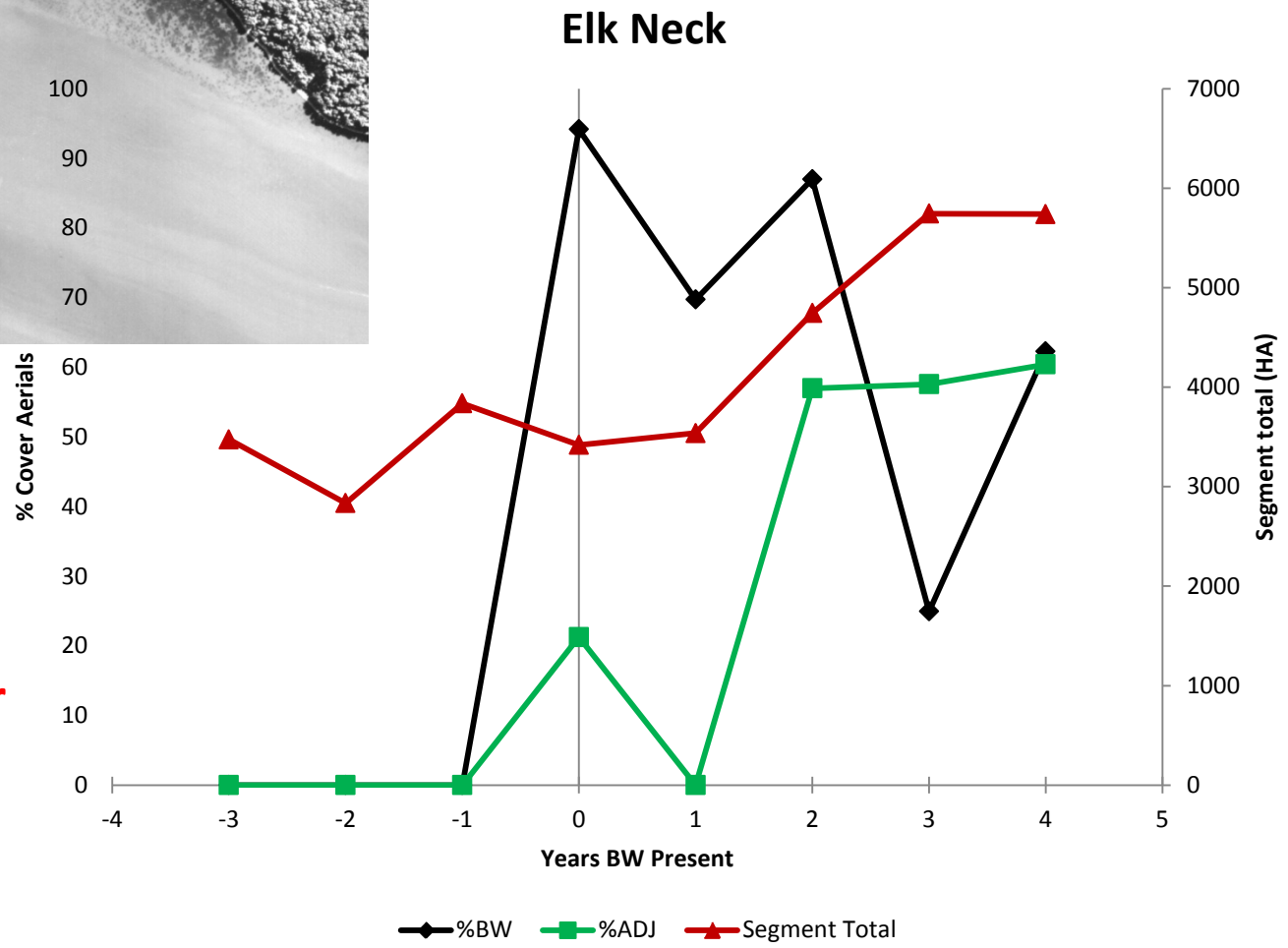
- **Sandy Beach** – breakwater beneficial to SAV especially when fetch > 10 km

- **Cliffs** – base of cliff needs to be stabilized to reduce sediment input and shoaling breakwater-protected area

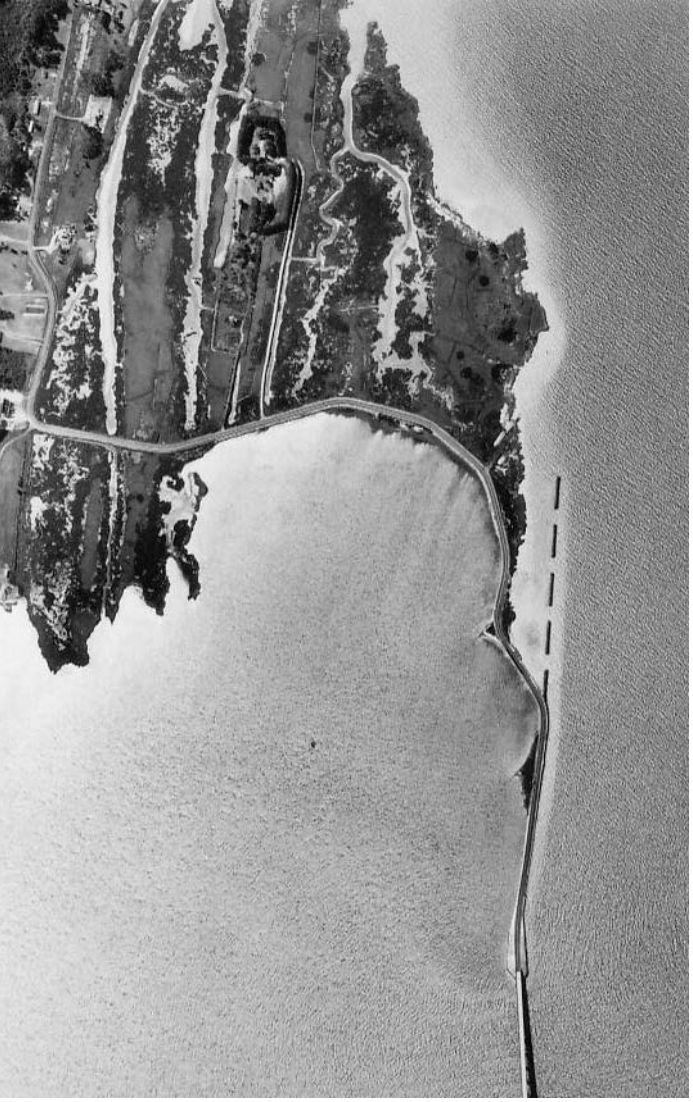
How long do we need to monitor a site to determine if it was successful?

20 years!

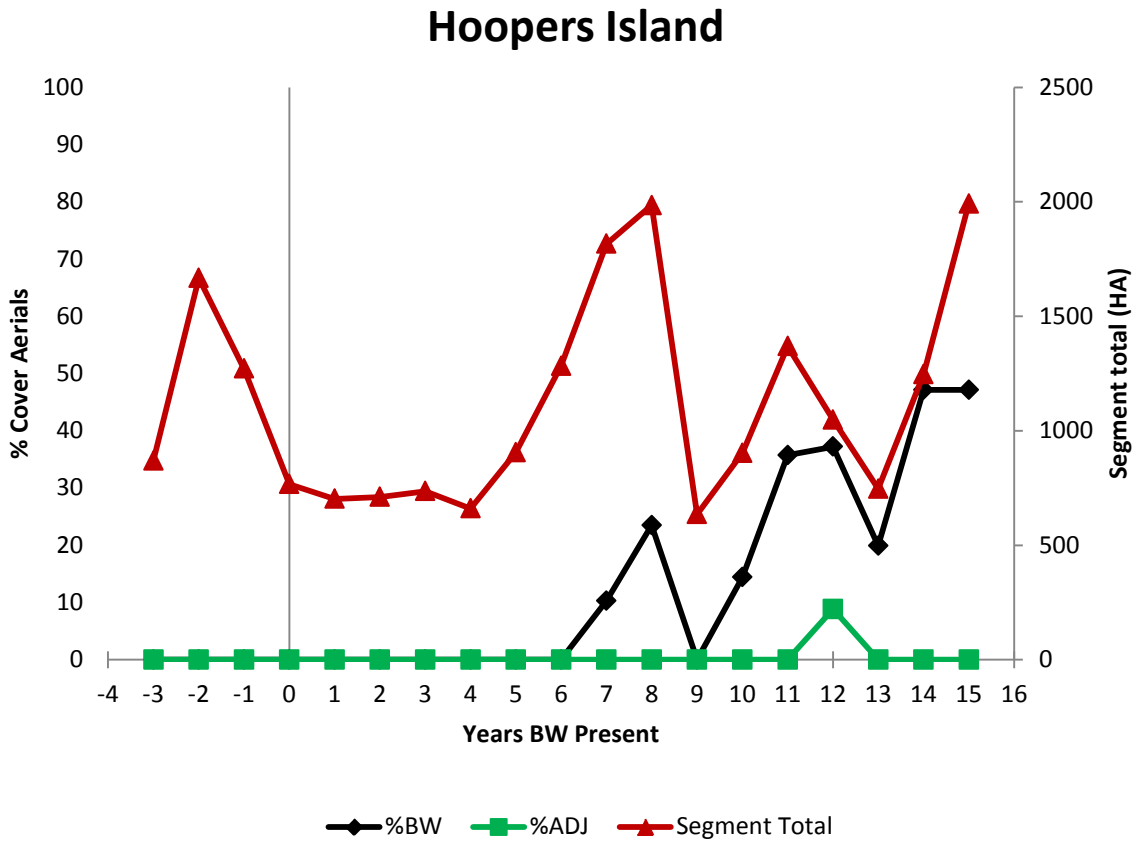


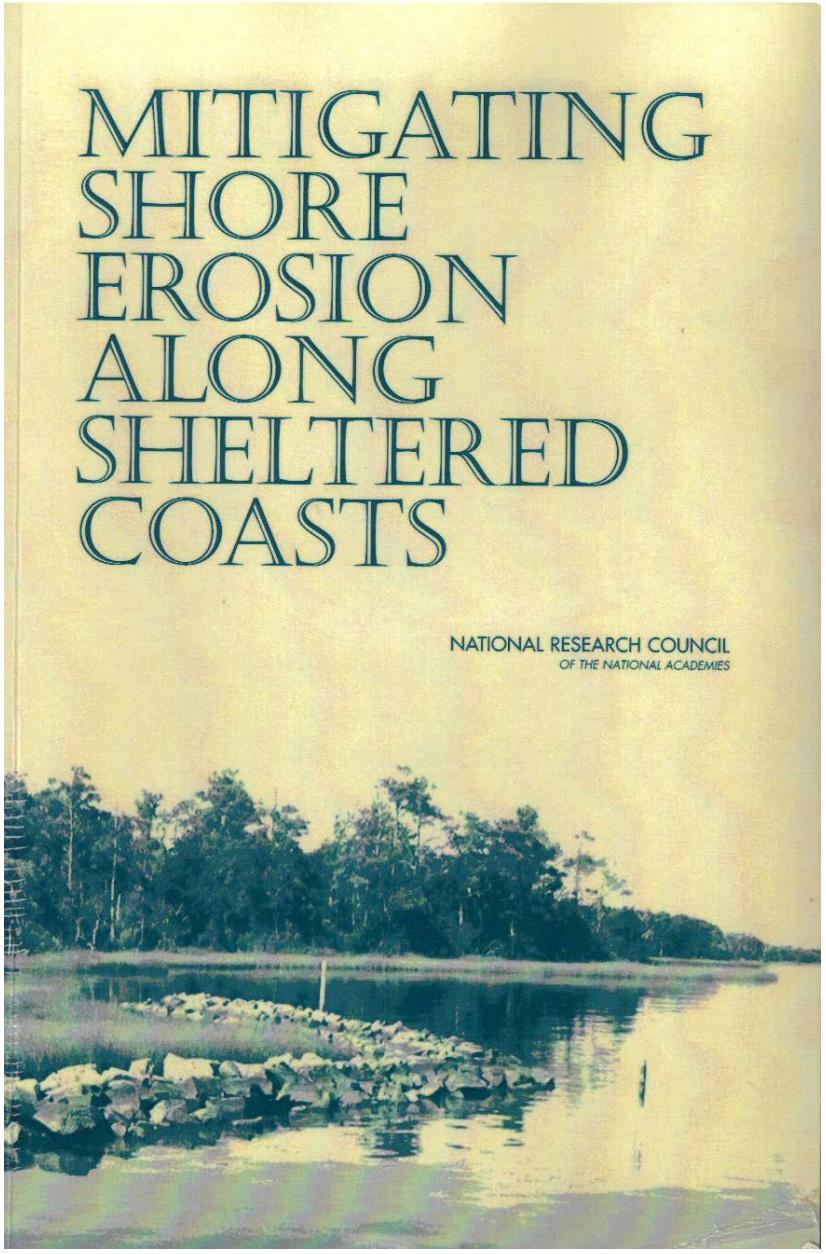


Area where lots of fine particles are available – SAV crashed in 3rd yr after construction.



Area with sediments unsuitable for SAV (compacted peat) – breakwaters can keep suitable sediments in place = beneficial for SAV. Sustainable SAV beds **11 yrs post-construction**.

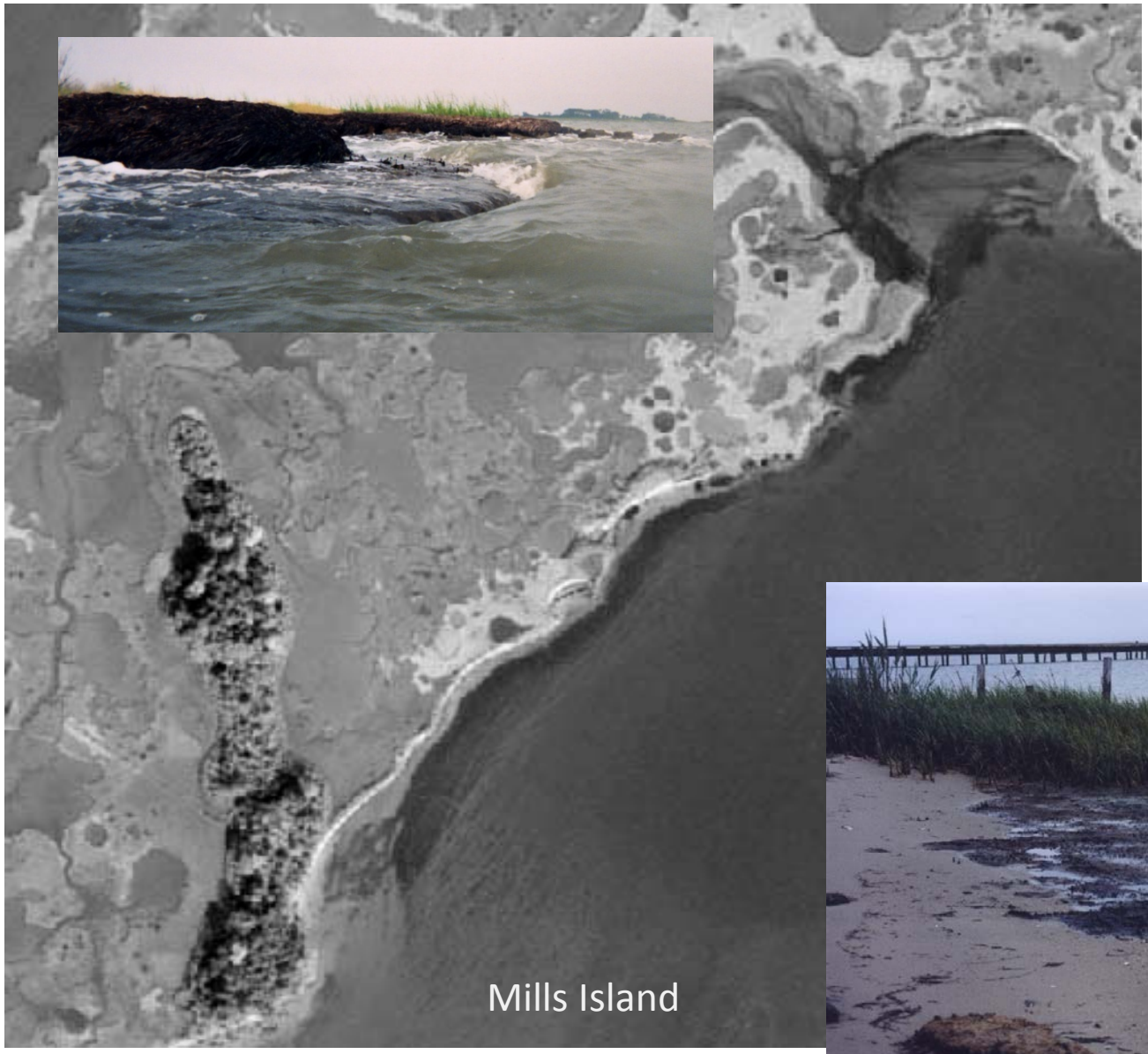




Cumulative effects of shoreline hardening are rarely assessed

Development of regional shoreline management plans should occur at the state and local level in partnership with the federal government.

Hardening of some areas can be detrimental to an entire region



How much sand is needed?

The future of our shorelines and coasts …

… depends on engineers and ecologists working together.

US Army Corps of Engineers

NOAA

Sea Grant
Maryland

CHESAPEAKE BAY TRUST

MARYLAND COASTAL BAYS PROGRAM

Consequences of hardening:

- shoreline hardening leads to a trade off in ecosystem services
- the effectiveness of coastal structures (reducing erosion while providing habitat) depends on local conditions such as slope of the shore, boat traffic and sediment type
- living shorelines alter the water temperatures making them more extreme (warmer and colder). What is the role of the material (rock x biolog) in water heating/cooling?
- living shorelines (sill + marsh) have less of a detrimental effect on SAV than rip rap without marsh. Is this a nutrient effect or a wave reflection effect?
- breakwaters can be detrimental to SAV when they trap fine and organic particles over time but can be beneficial in high fetch areas.