

Designing Sustainable Coastal Habitats



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Climate Change and Chesapeake Bay Habitats

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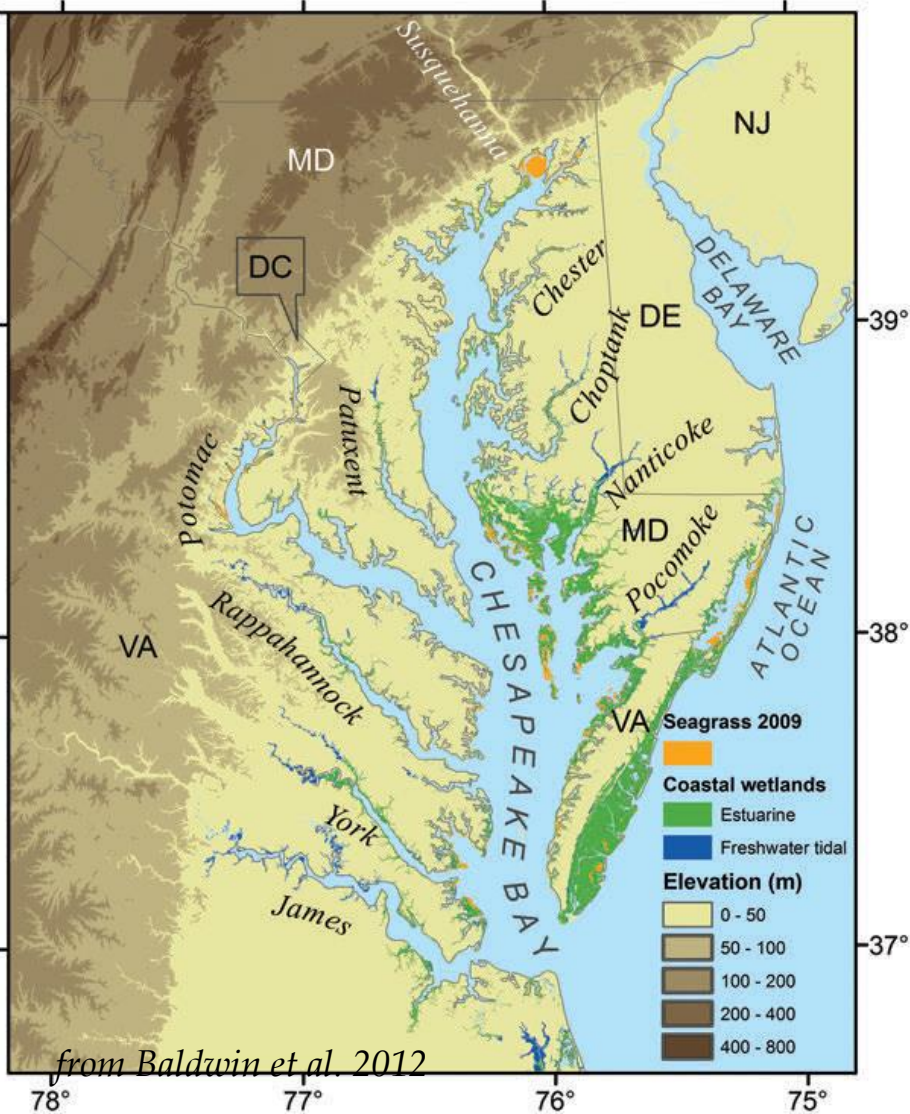
STAC Chesapeake Bay Forage Base
Workshop

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Existing coastal wetlands – Chesapeake Bay



Total Bay Coastal Wetlands
 ~595,000 ha

NON-TIDAL COASTAL WETLANDS

State	Coastal (ha)	%
VA	260,627	64
MD	136,558	90

Havens, regional assessment

TIDAL FRESHWATER WETLANDS

State	(ha)
Delaware	823
Maryland	10,345
Virginia	16,000
North Carolina	1,200
South Carolina	26,115
Georgia	19,040

After: Mitsch & Gosselink 2000

BRACKISH & SALT MARSH

Salt Marsh	27,438
Brackish marsh	123,651

SAV (2012) ~ 19,500 ha

Two principal drivers of bay habitat persistence, human use and climate, are constantly changing

Human Use



Climate Change



Climate Change can affect coastal wetlands through multiple ways

Temperatures can change plant growth and assemblages

Storms can physically remove SAV beds and marsh plants

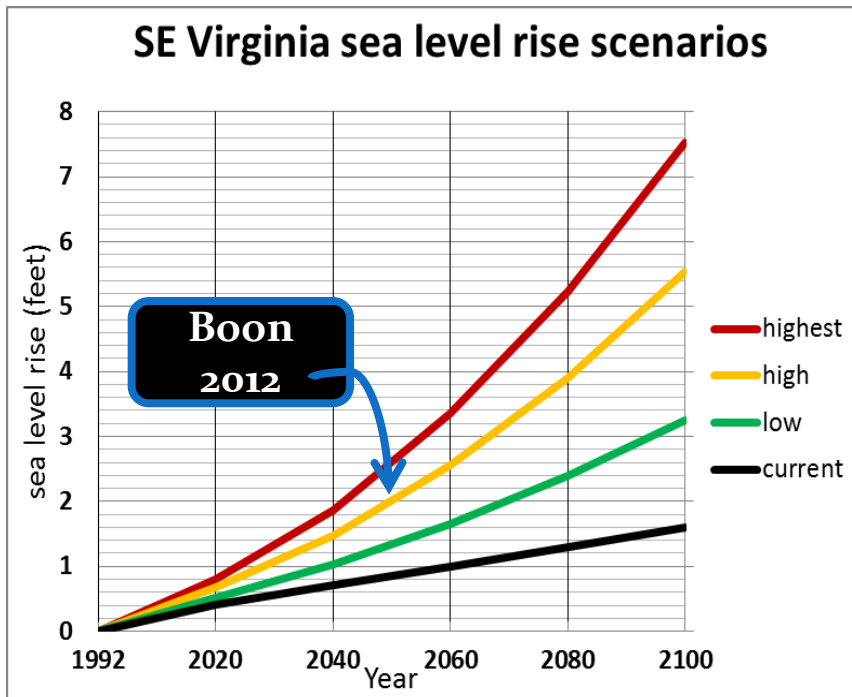


Changing weather patterns can affect local salinity

Runoff can add to turbidity and nutrient levels

Sea level rise can increase water depth & reduce available habitat

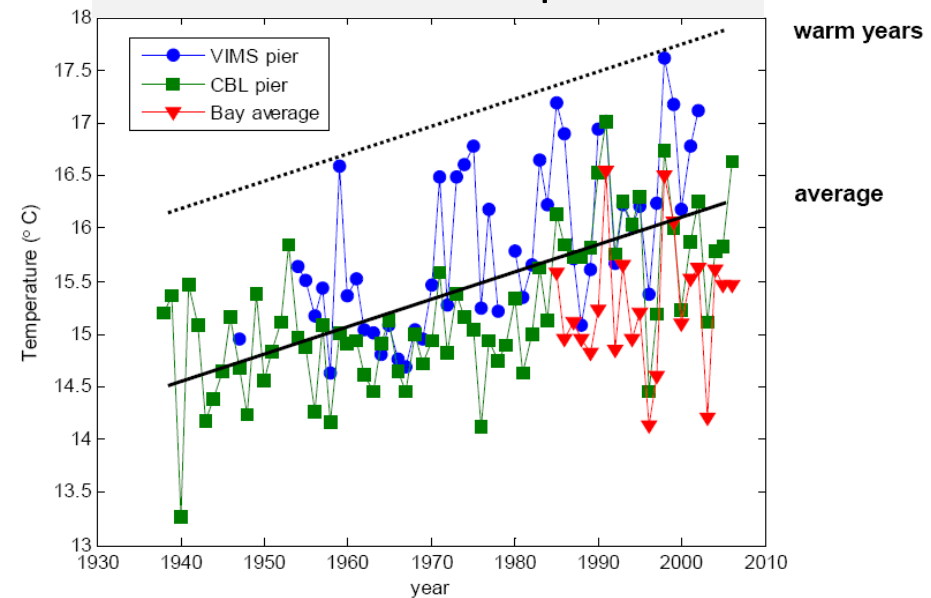
Shoreline protection can prevent landward migration



- SE VA Average Rate is 4.42 mm/yr & accelerating (~3.4 mm/yr baywide)
- **SE VA is likely to see a 2–3 ft rise by 2050**



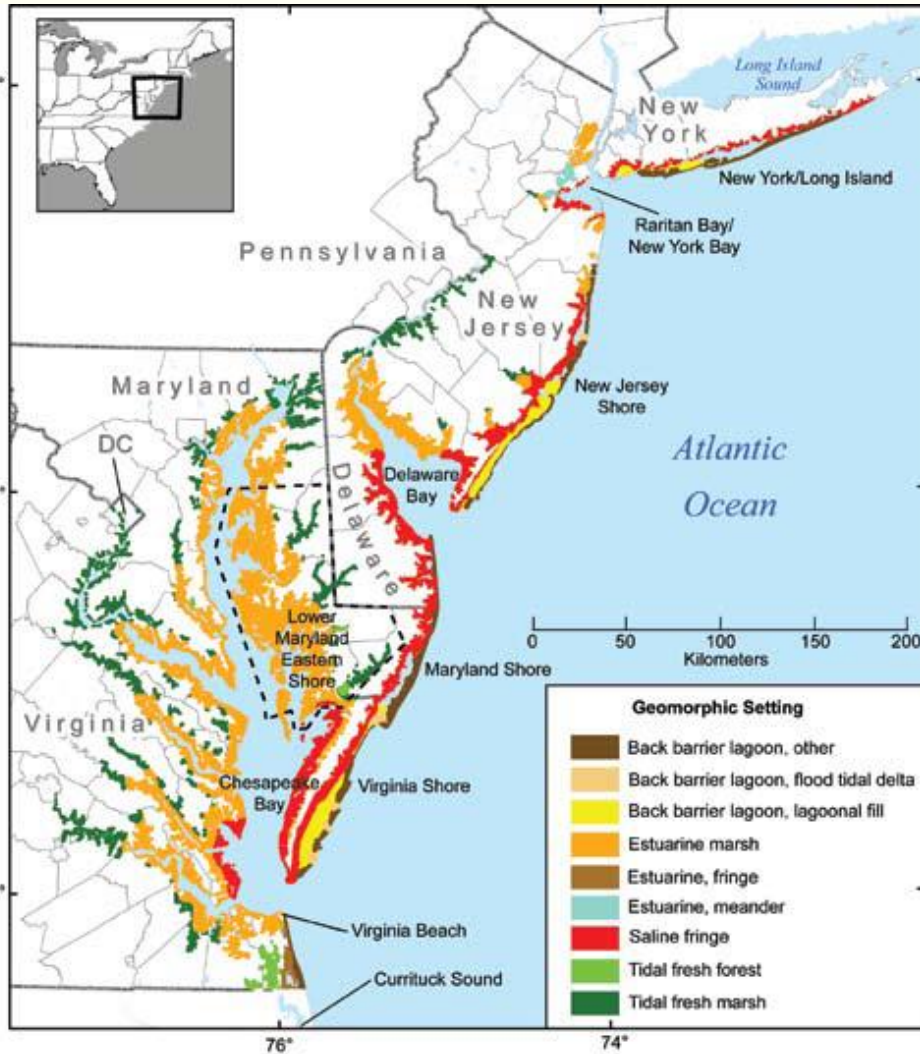
Surface Water Temperature



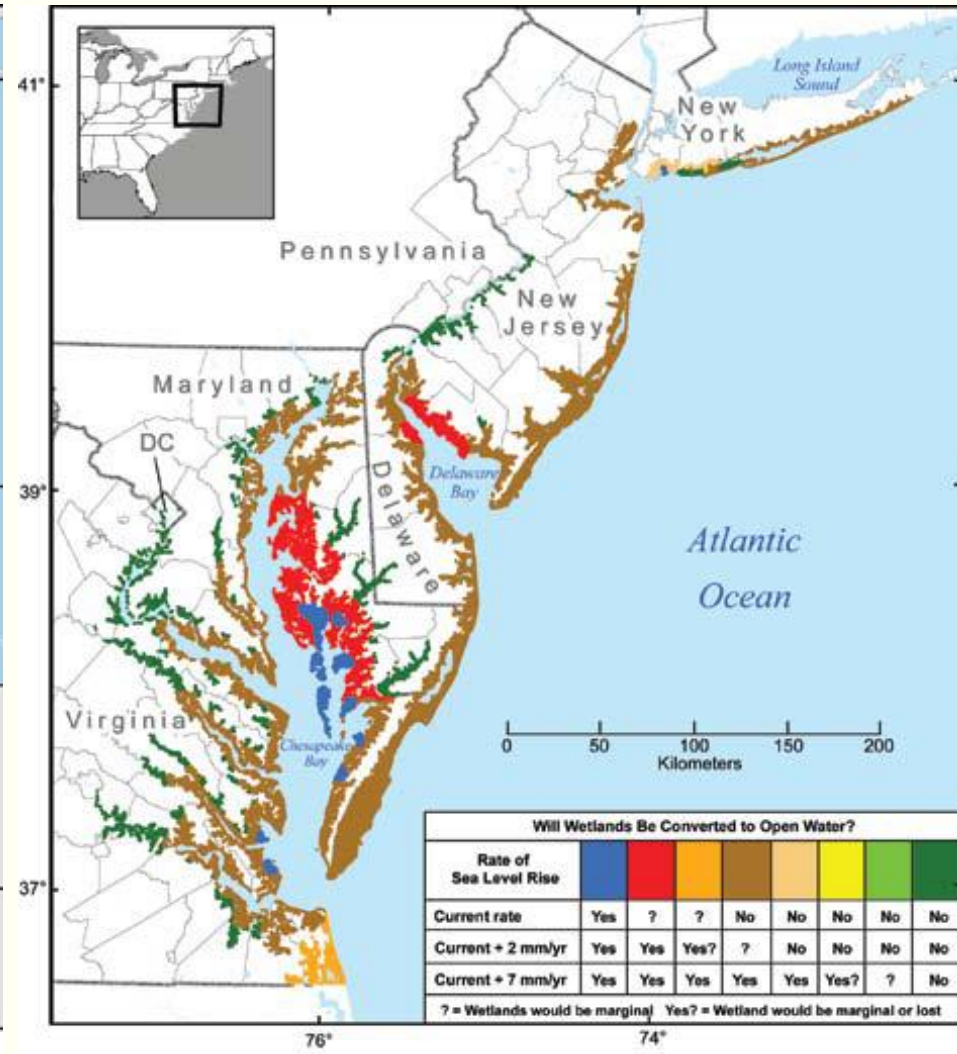
- Both mean and max annual temps have increased by more than 1°C (1.8°F) over the past 5-6 decades
- Seasonal warming occurring ~3 weeks earlier than in the 1960s
- **Expected increase of 2 – 6° C by 2100**

Tidal wetlands and Sea level rise

Geomorphic settings of mid-Atlantic tidal wetlands



Conversion of tidal wetlands to open water



Geomorphic settings have differing hydrodynamics, sediment sources, & vegetative communities
 Wetland response to sea level rise expected to vary with geomorphic setting
 CCSP 2009; Cahoon et al. 2009; data source: Reed et al., 2008; map source: Titus et al., 2008

The Problem with Shoreline Hardening



Map source: D. Bilkovic

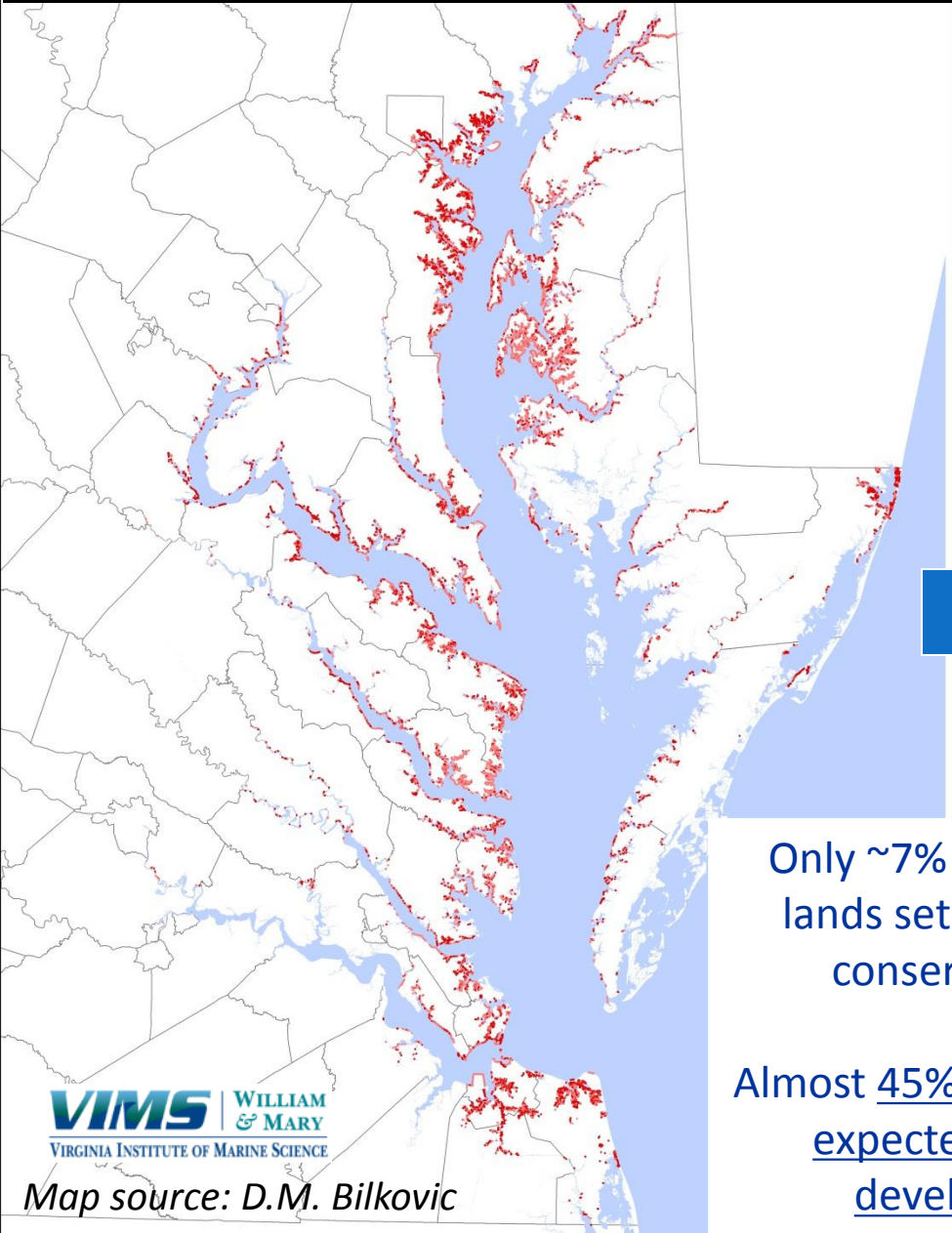
- Habitat loss & fragmentation – forest, wetlands (Peterson and Lowe 2009; Dugan et al 2011)
- Sediment supply & transport altered, increased scouring, turbidity (Bozek and Burdick 2005, NRC 2007)
- Increase in invasive spp (Chambers et al 1999)
- Decrease fish & benthos, marsh bird diversity, terrapin presence (Peterson et al 2000, Chapman 2003, King et al 2005, Bilkovic et al 2006, Seitz et al 2006, Bilkovic & Roggero 2008, Morley et al 2012, Isdell et al in press)
- Prevents natural migration of habitats with SLR
- Evidence of Low Thresholds (e.g. >5% riprap–no increase in SAV (Patrick et al 2014)

Chesapeake Bay
18% of tidal shoreline hardened
VA: 11% MD: 28%
32% riparian land developed
~5 km² of artificial substrate introduced (*intertidal impacted*)

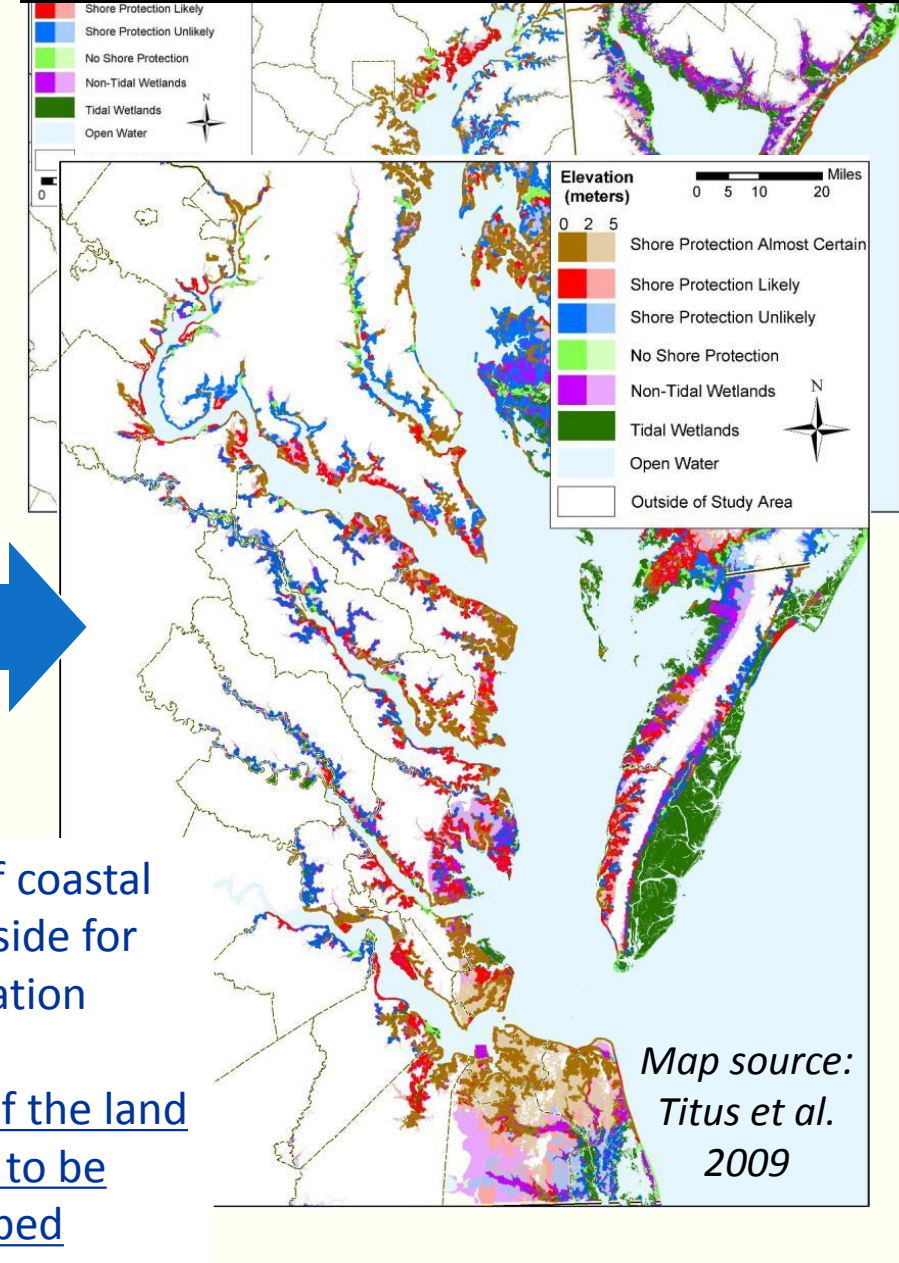


Coastal Development: Status and Future Trends

Current shoreline hardening – Bulkhead/Riprap



Future shore protection

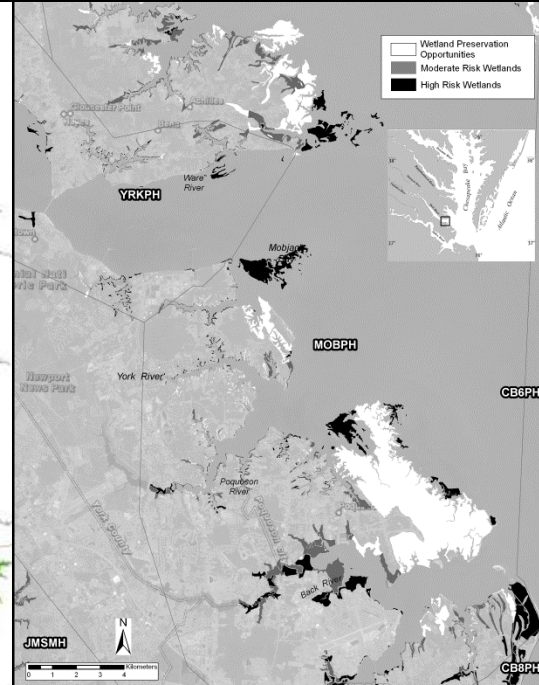
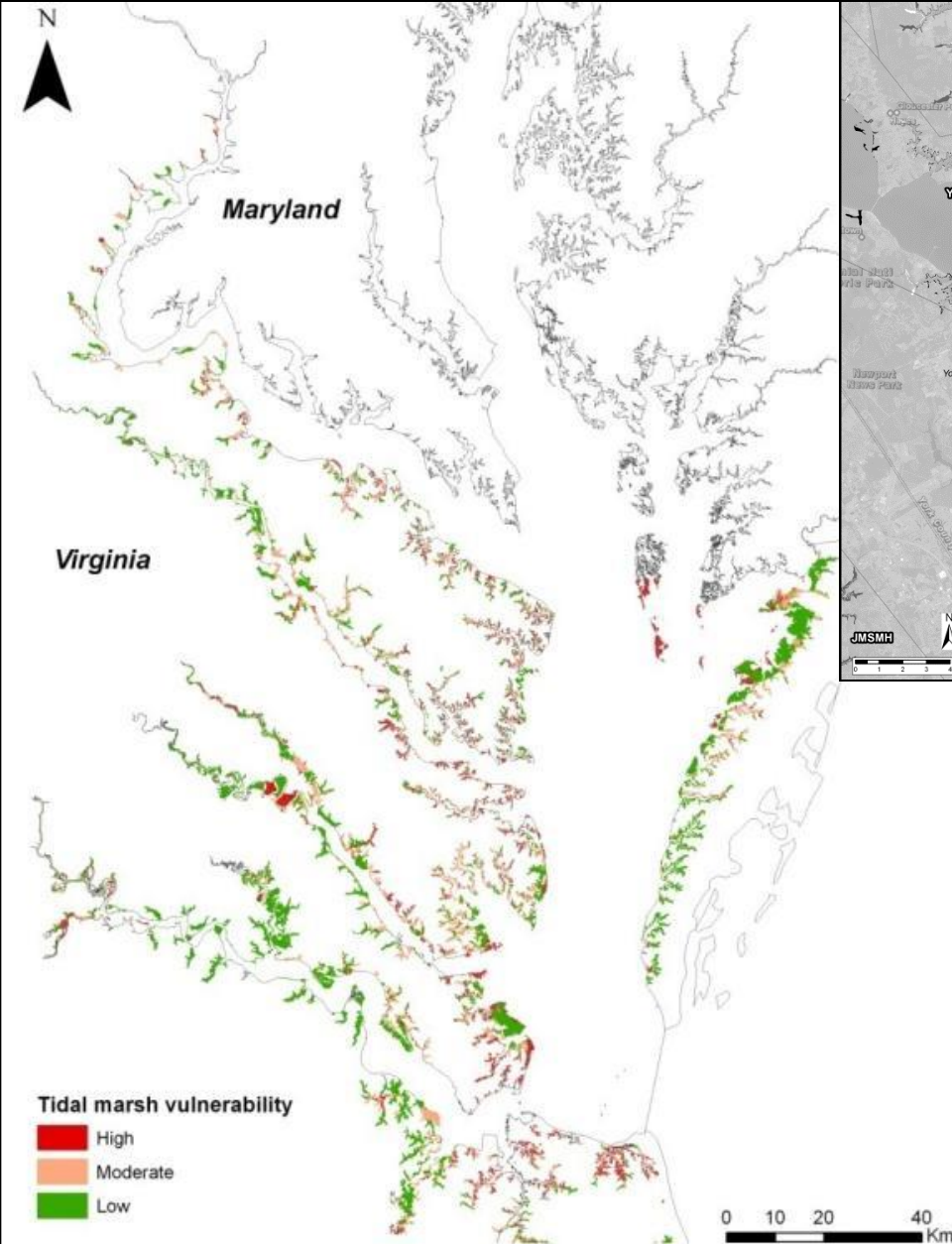


Only ~7% of coastal lands set aside for conservation

Almost 45% of the land expected to be developed

Map source: Titus et al. 2009

Tidal Marshes – SLR & barriers to migration



Tidal marshes in the meso-polyhaline reaches at highest risk due to land development & SLR



Nearly 40% of Virginia marshes are vulnerable to SLR due to adjacent development



High Risk Marsh



Low Risk Marsh

Continuum of shoreline protection approaches

Estuarine & coastal shorelines



Eastern Shore: The Virginia Coast Reserve



Tabbs Creek, VA



Minimally-Moderately altered

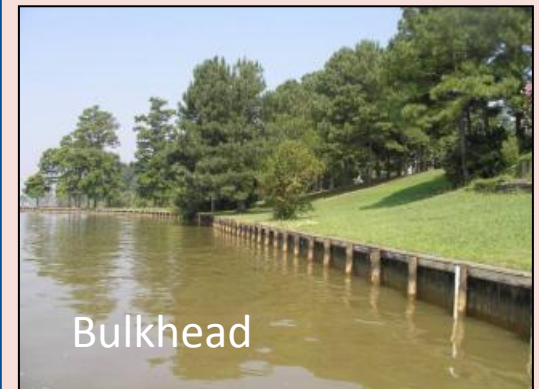


Created marsh

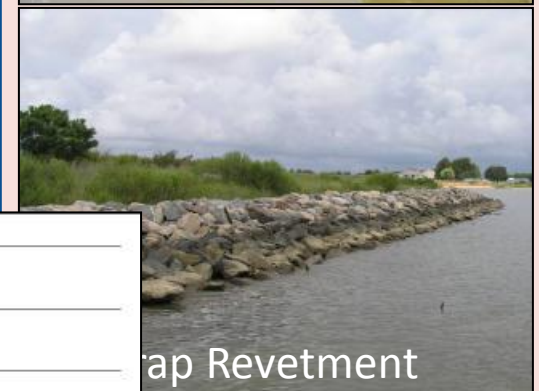


Oyster-sill

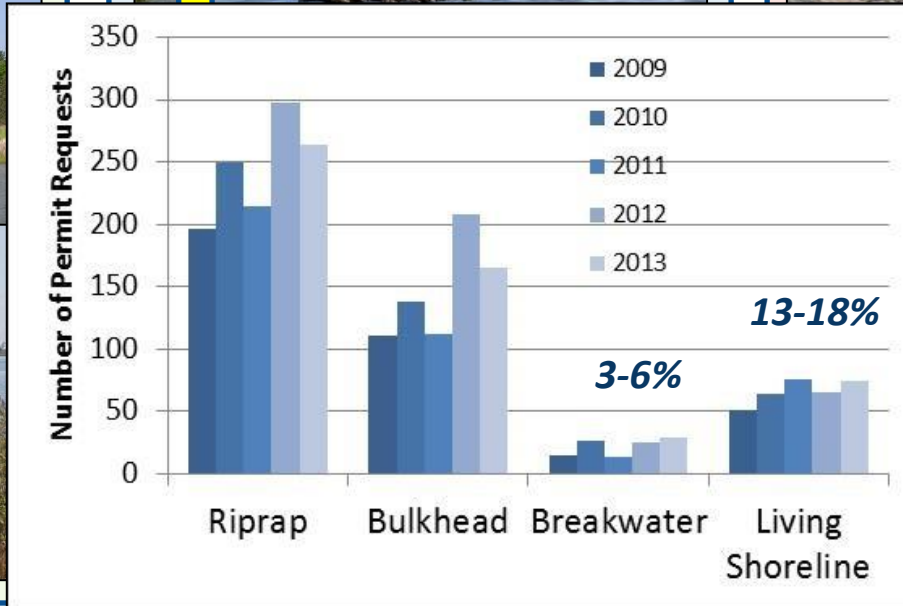
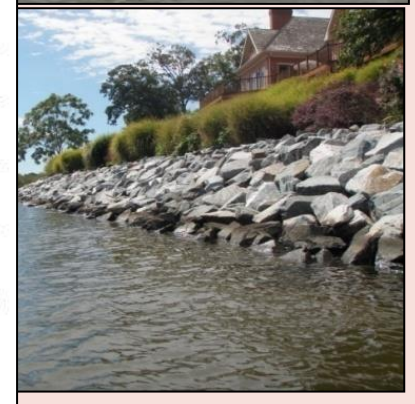
Highly altered



Bulkhead



Riprap Revetment



Nekton assemblages & productivity in living shorelines depend on availability of suitable habitat

Nekton assemblages less diverse at armored shorelines than natural marshes & nekton utilization increases when armored shorelines are converted to living shorelines (diversity & density)



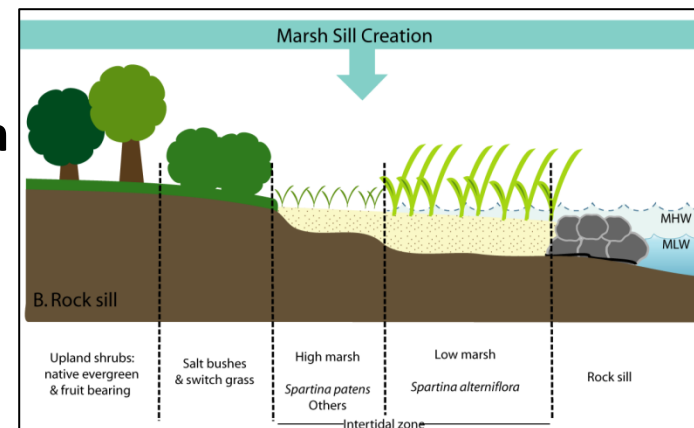
Assumed energy transfer to higher trophic levels not yet verified

- The role that living shorelines may play as fish and shellfish nursery habitat has not yet been measured. We need to demonstrate enhanced growth and protection from predation compared to other habitats



Persistent aquatic environment seaward from marsh edge may be essential

- *Sediment accretion landward of living shoreline structures may limit suitable habitat over time*



Ribbed Mussels and Marshes



Ecosystem Engineers

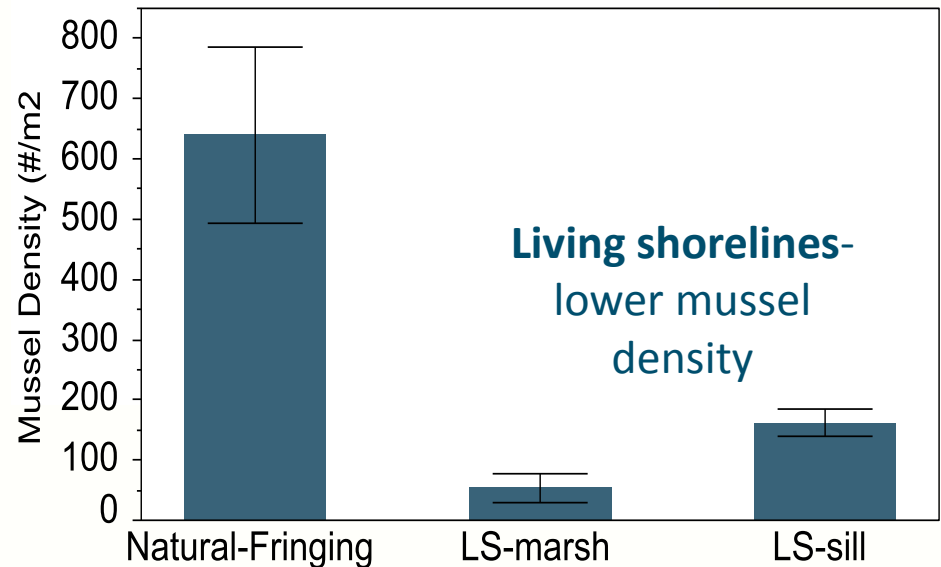
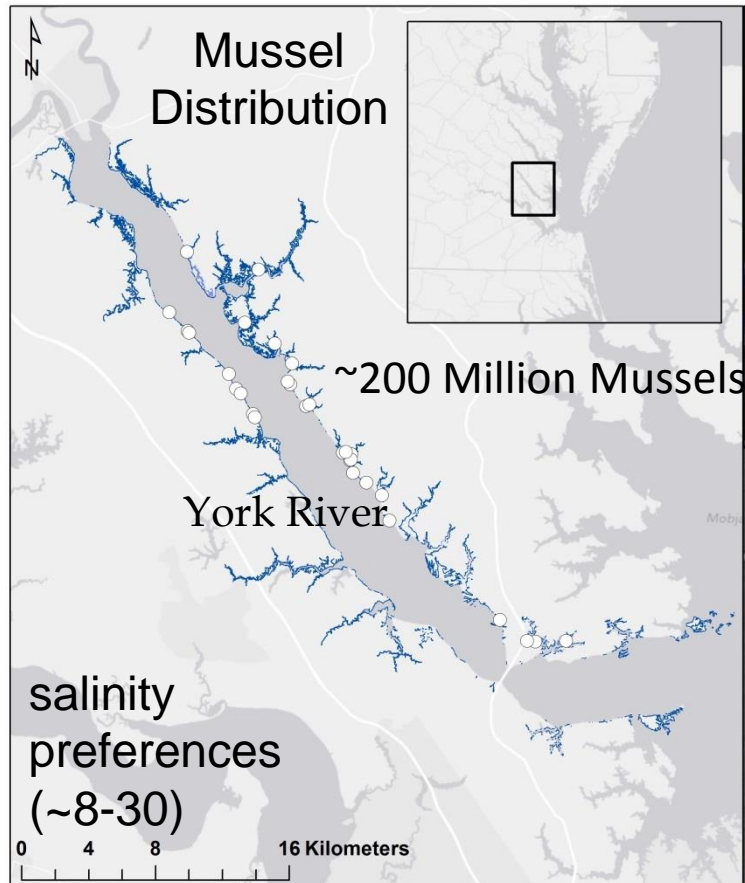
Filter water

Accrete sediment, Stabilize shore

Promote marsh plant growth

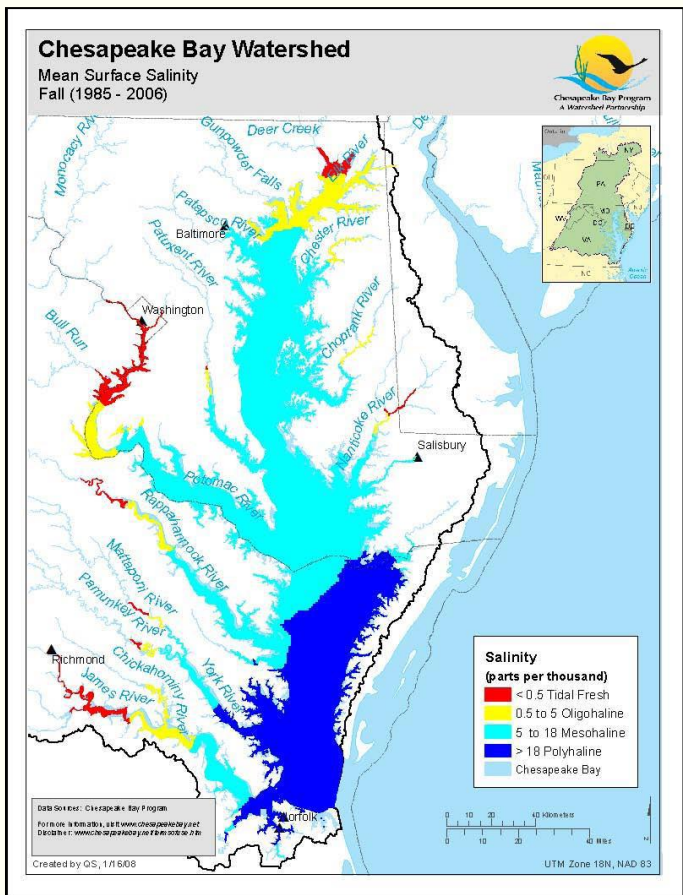
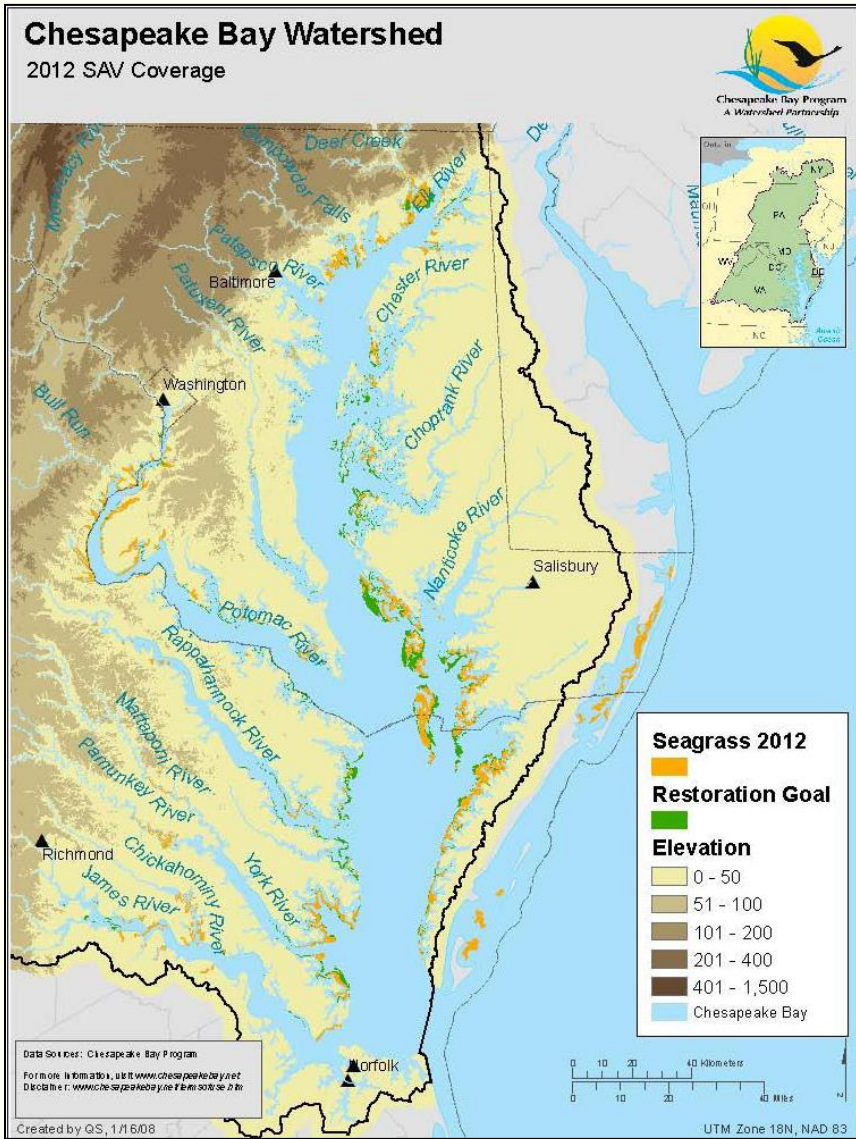
Enhance nutrient dynamics

Important Prey item



Submerged Aquatic Vegetation

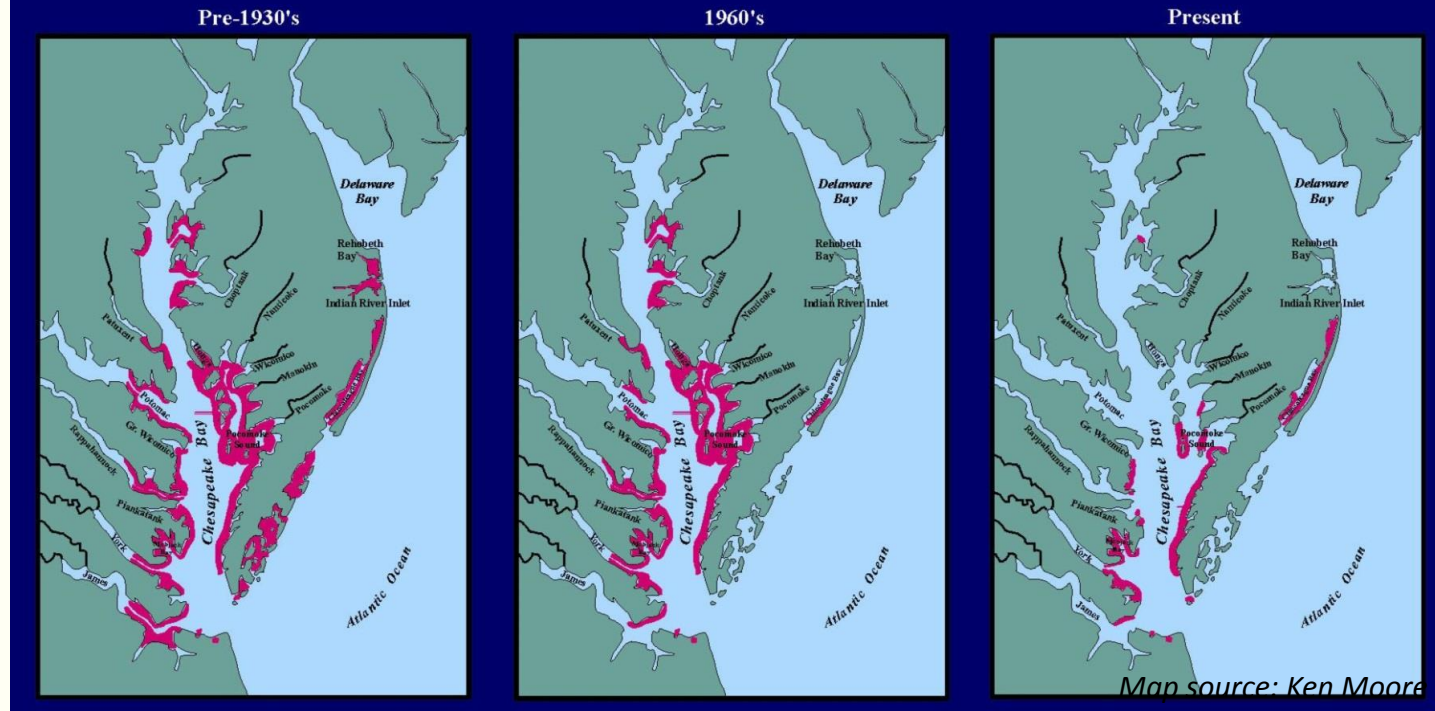
~ 20 SAV species are commonly found throughout Chesapeake Bay



SAV communities can be grouped by salinity tolerances

- *Zostera marina* – eelgrass (Polyhaline)
- *Ruppia maritima* – widgeongrass (Meso)

Eelgrass Distribution in Chesapeake Bay & Coastal Bays



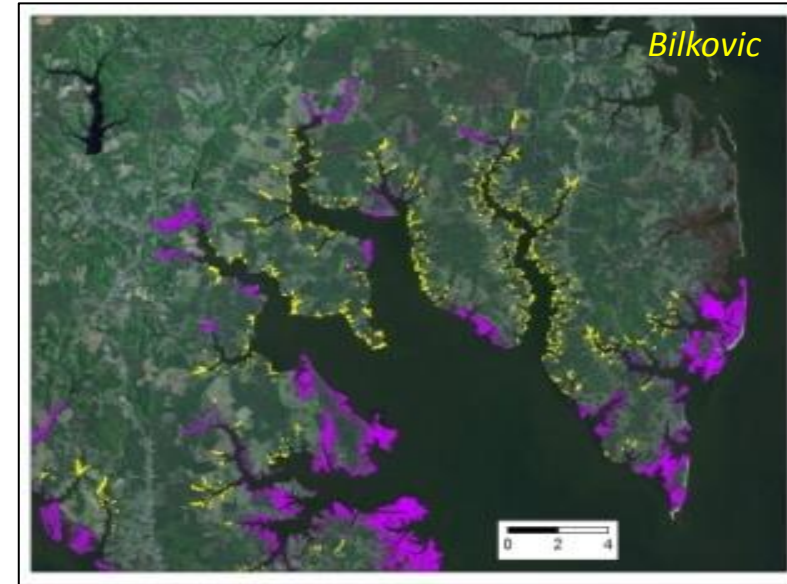
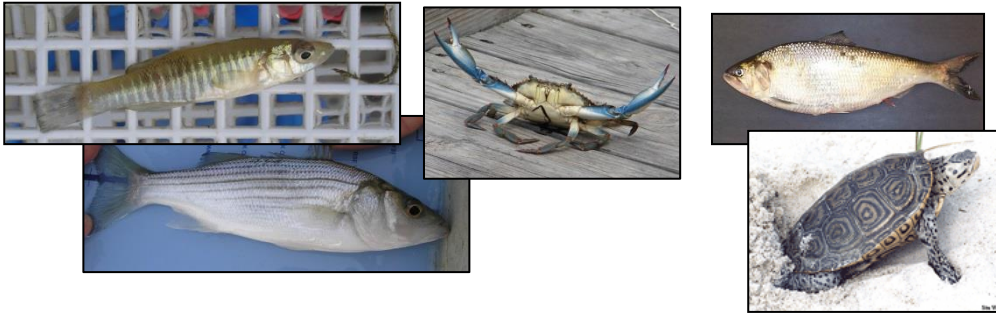
Stresses related to climate change that affect eelgrass survival include:

- Increased frequency and duration of high summer water temps , $> 30^{\circ}\text{C}$ (86°F)
-Massive baywide decline observed during 2005 from $>30^{\circ}\text{C}$
- Increased rainfall = \uparrow runoff of sediments and nutrients = \downarrow light availability
- Light requirements of eelgrass increase with increasing temps
- Increased storm intensity and frequency
- Increased water level/shl hardening = declines in habitat area

BUT, $\uparrow\text{CO}_2$ with warmer waters may increase high temp tolerance leading to enriched growth, shoot survival and propagation (Tom Arnold, Dickerson; Richard Zimmerman, ODU)

Recommendations and Research Needs

- **More detailed data on sediment processes & Shallow water bathymetry**
- **Landscape-level influences on bay habitat resilience** - Better understanding of the extent that landscape setting moderates habitat connectivity, functionality, and species distribution



Fragmentation patterns of marshes
Dispersed wetlands (yellow) tend to occur in areas of developed land use

- **Align implementation & monitoring of habitat restoration activities with living resource objectives.**

Thank You!
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