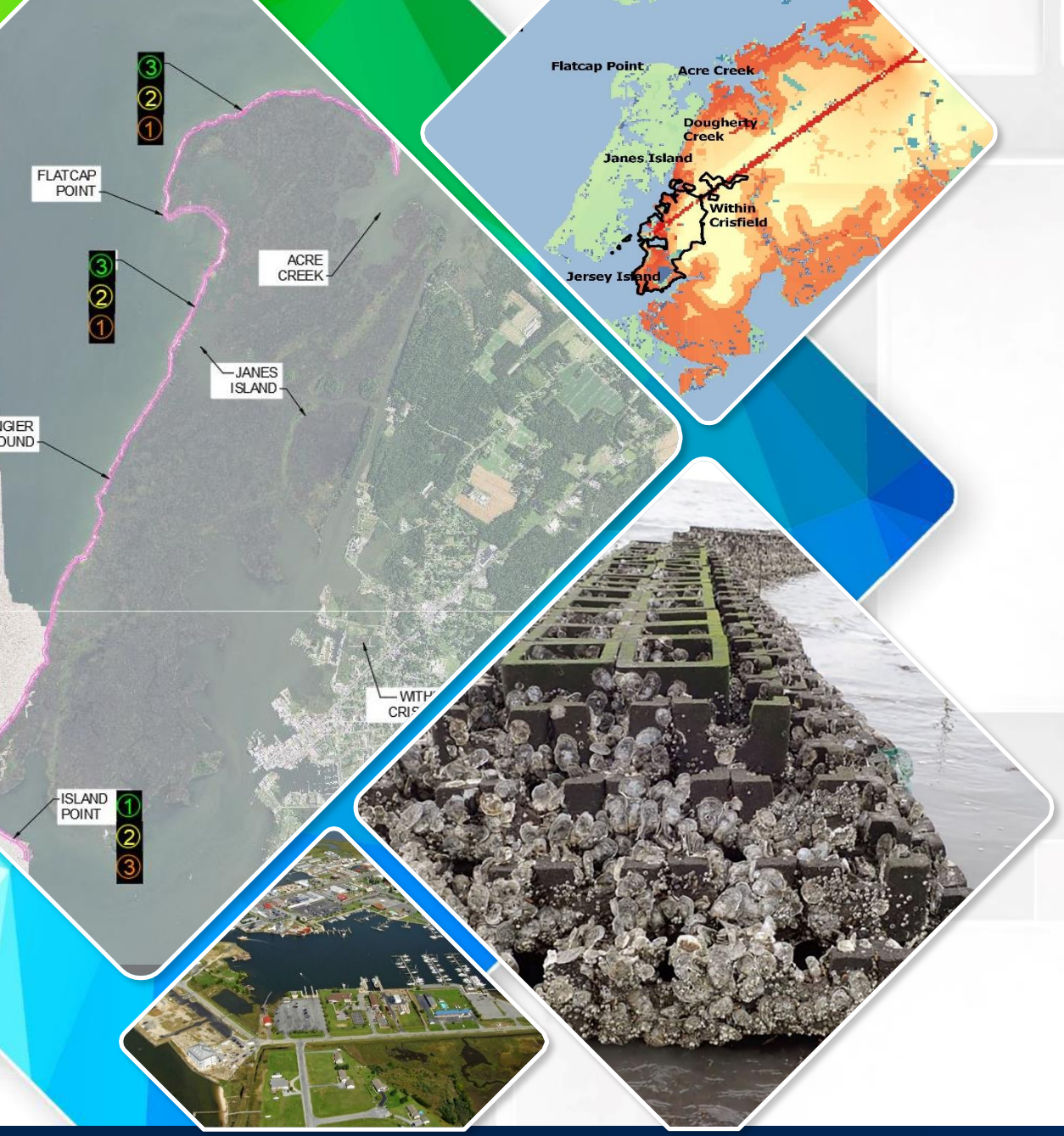
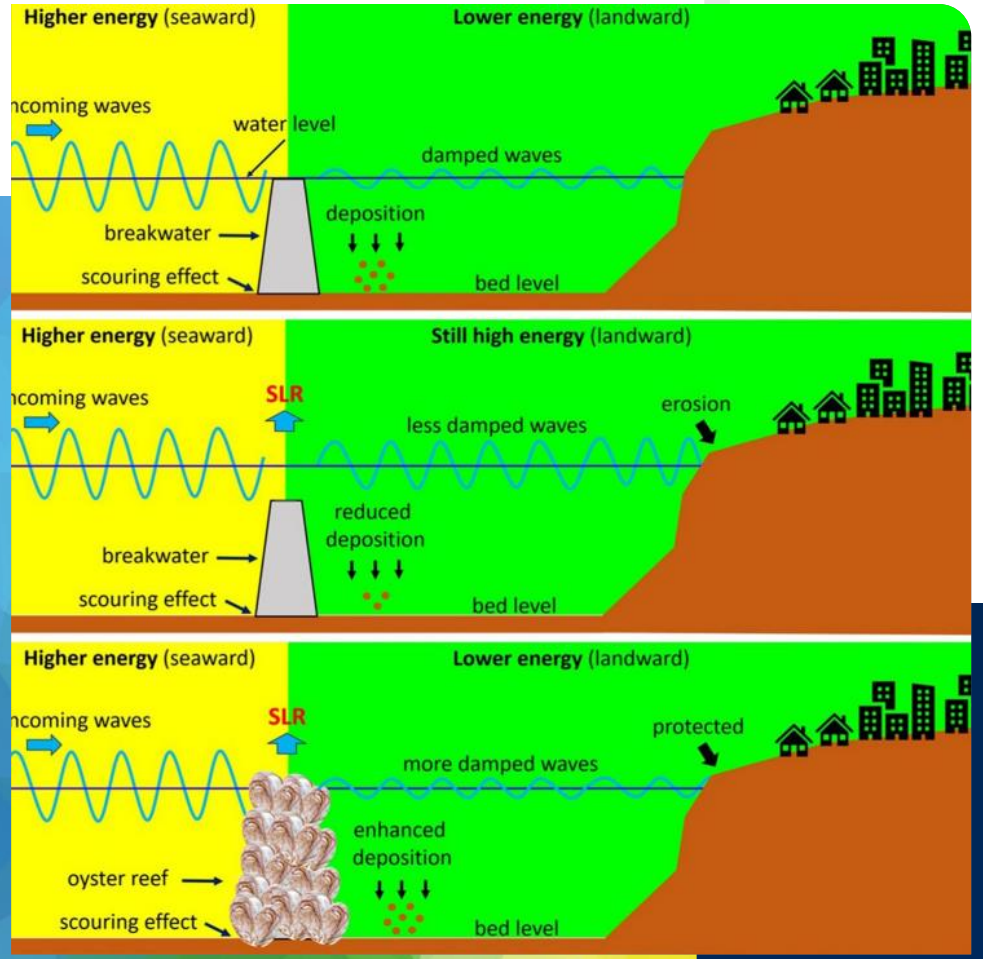


Oyster Reefs as Nature's Breakwater: Quantifying Climate-Resilient Adaptation Performance

Celso Ferreira, Vamsi Krishna Sridharan, Donna Bilkovic, Andrew Scheld, and Julie Reichert-Nguyen

December 14, 2023



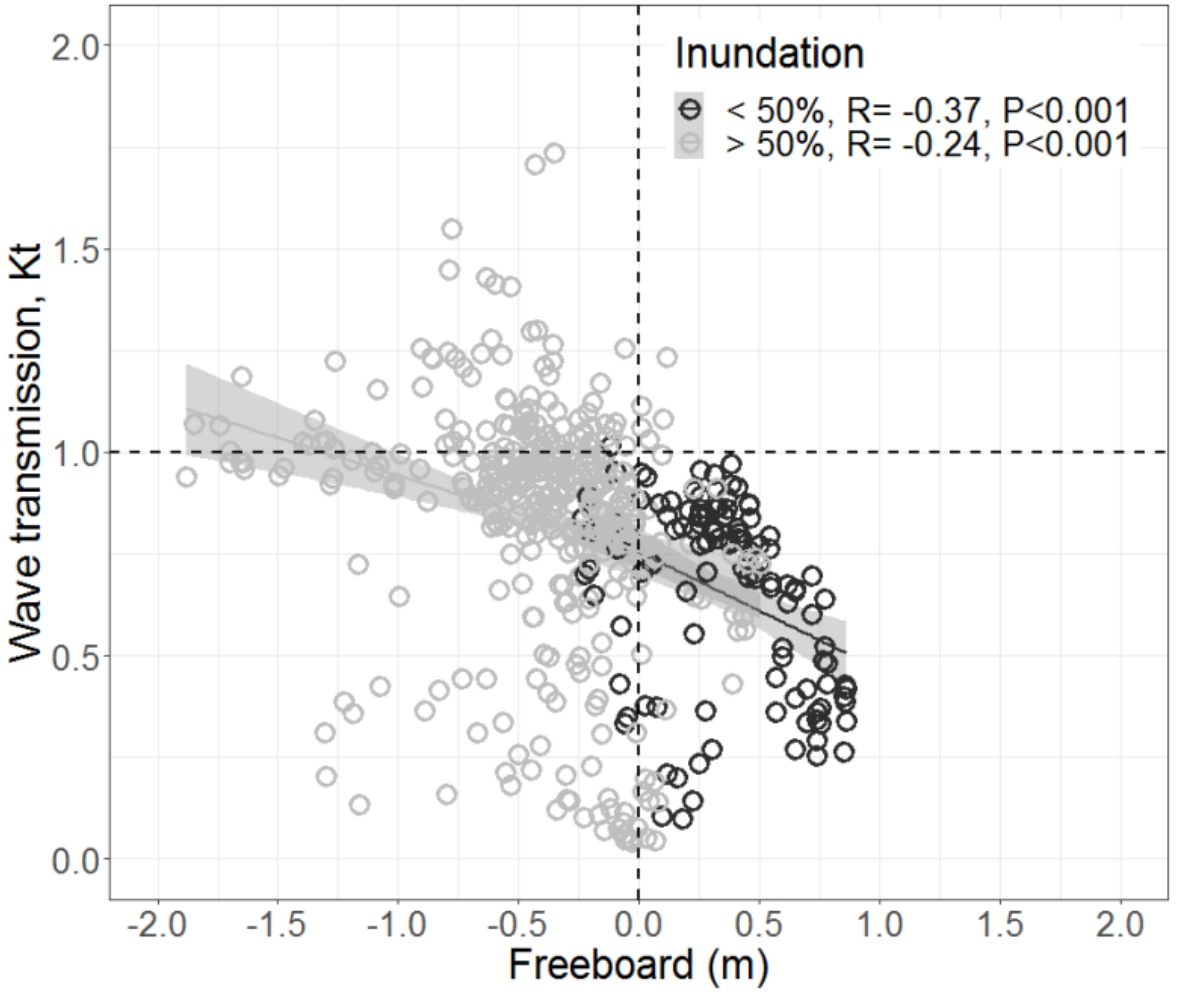
Vona and Nardin 2023 (JGR)

The need for quantifying performance of nature-based shorelines under sea level rise and changing climate

CBP Climate Science Need: Better understanding of the resilience effectiveness of natural infrastructure (e.g., living shorelines, marshes, forest buffers, oyster reefs) strategies to maintain/enhance ecosystem services to climate change impacts.

Technical knowledge gaps

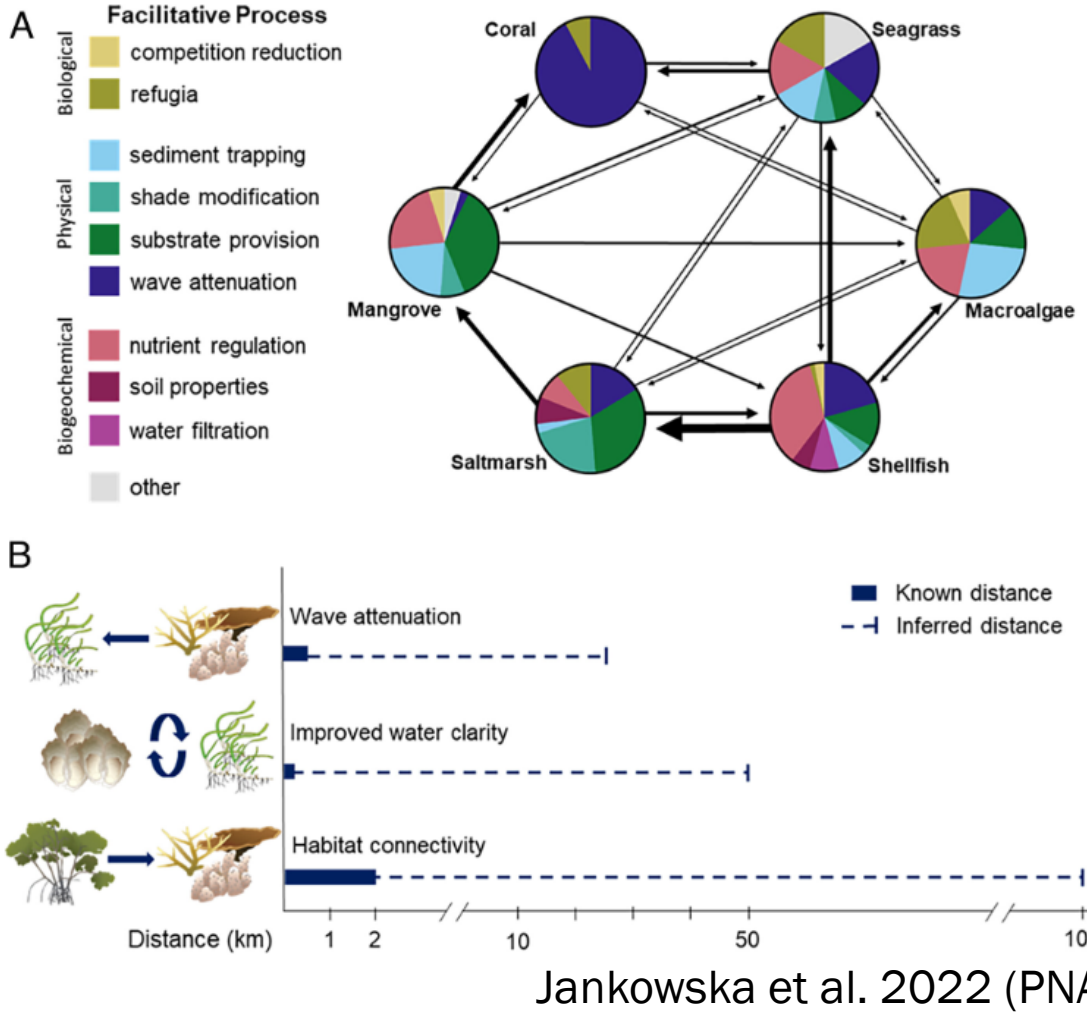
- Few technical studies looking at variety of engineering parameters
- Based on localized experiments
- Primarily focused on wave attenuation and marsh recovery
- Gaps include storm surge protection, erosion control, biodiversity recruitment, performance in medium-to-high wave energy environments, etc.



Morris et al. 2021 (VIMS)

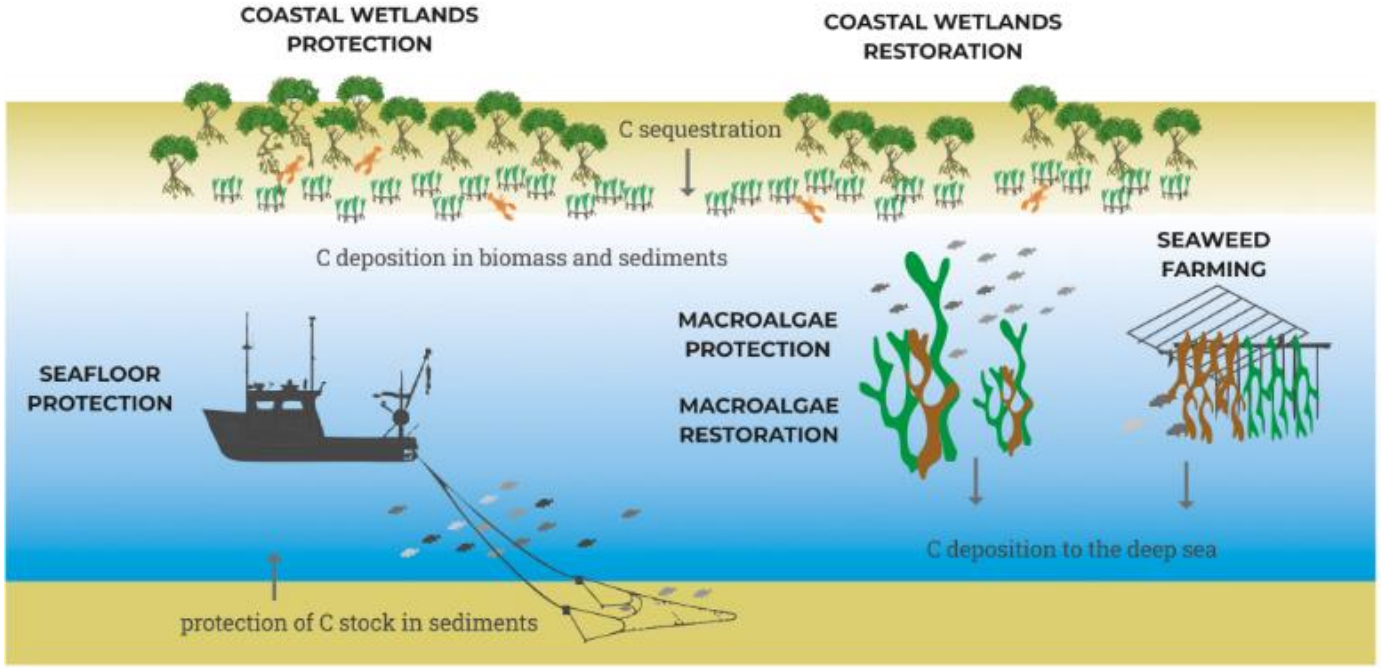
Lack of quantification of value-added co-benefits

Natural system perspective



Jankowska et al. 2022 (PNAS)

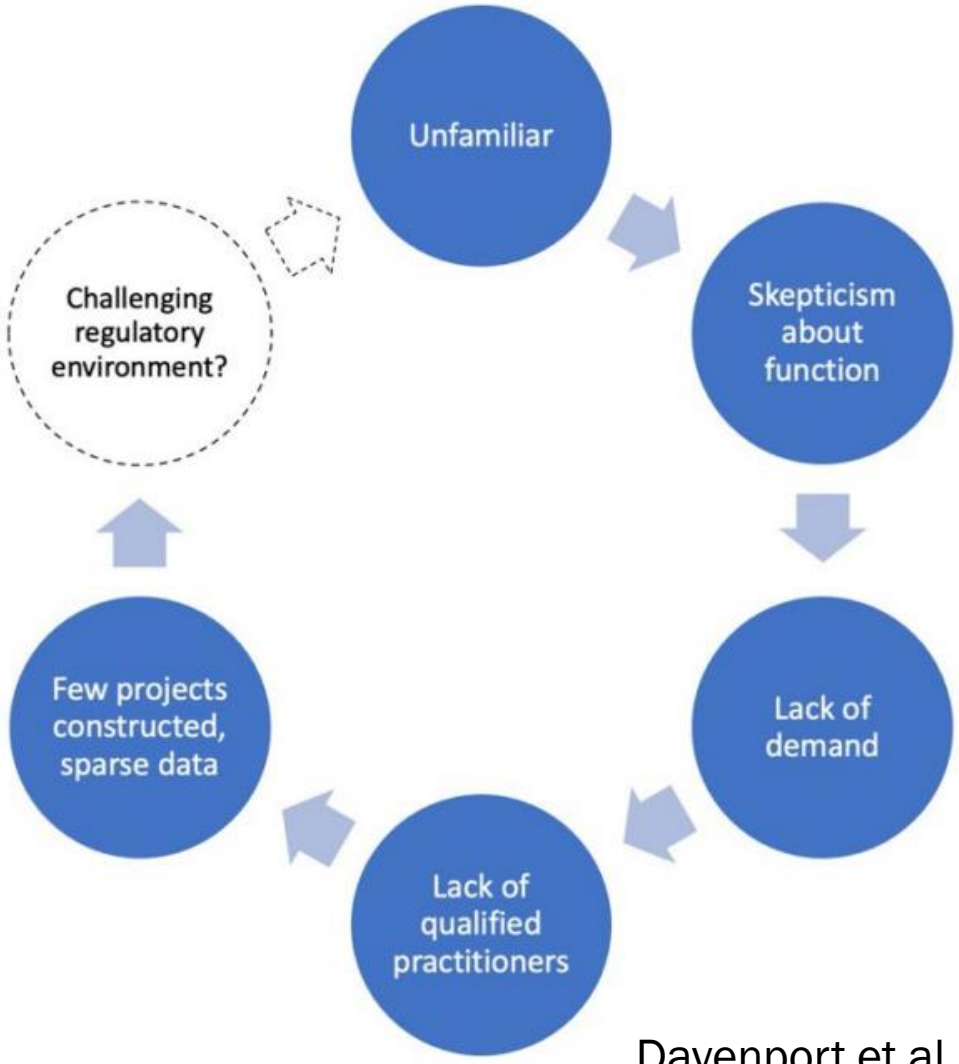
Ecosphere perspective



Vozzo et al. 2023 (PNAS)

Regulatory and legal barriers

- “Living shoreline still aren’t used very widely because few landowners and marine contractor know about them, […], and regulators are more comfortable writing permits for bulkheads.” – Malijenovsky 2014 (CoastalReview)
- “There’s a lot of things you have to look at; and so the challenge is creating a one-size-fits-all general permit that will allow something to go in numerous small properties across the state and not result in any unanticipated result” – Davis, NC DCM



Davenport et al. 2022 (TNC)


VA Eastern Shore
The Nature Conservancy


Choptank River, MD
University of Maryland

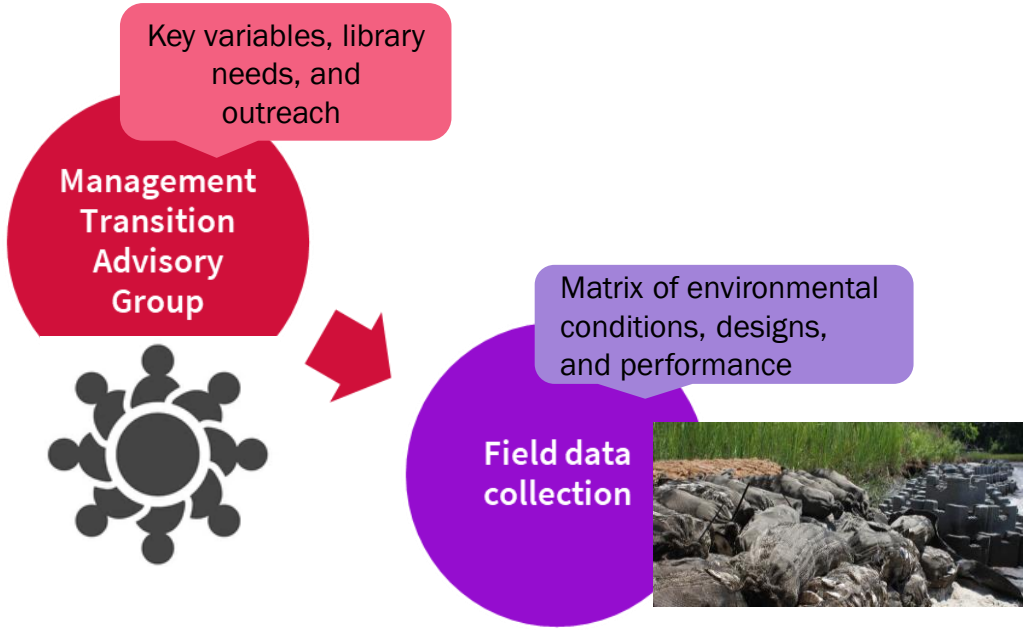
Our approach


Elizabeth River, VA
Chesapeake Bay Foundation


Hog Island, VA
Middle Peninsula Planning District Commission

Key elements of project

Key elements of project



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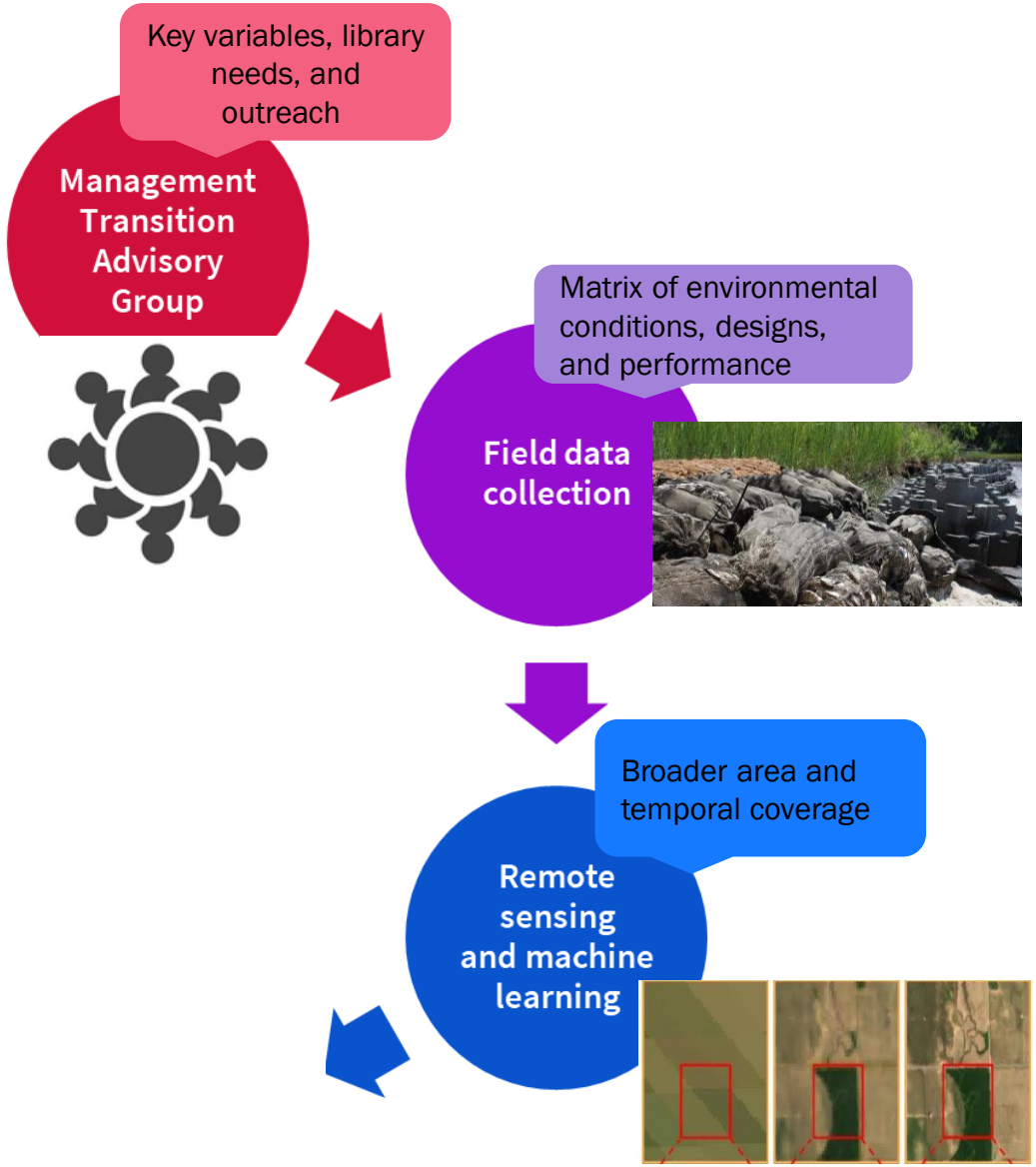

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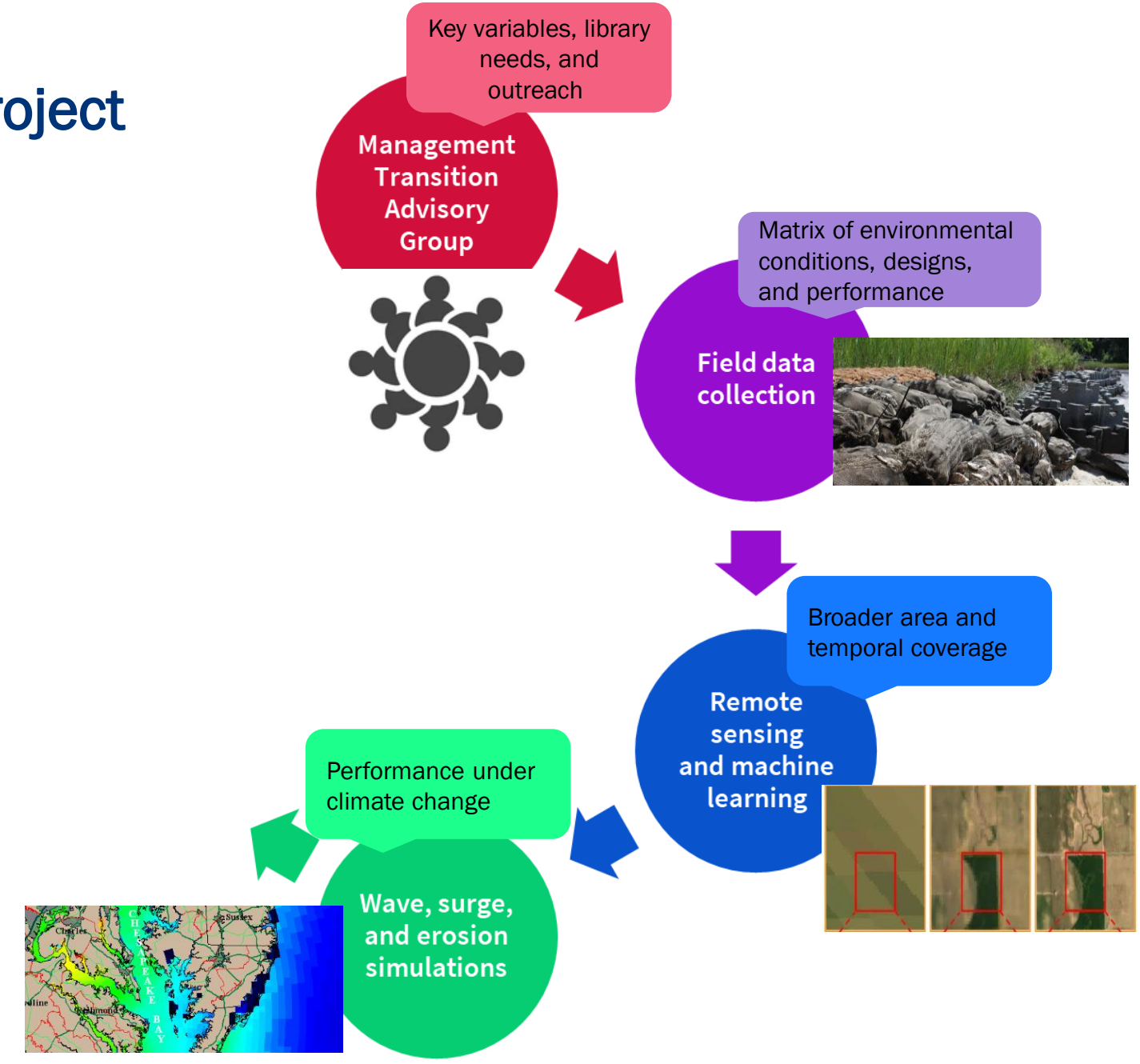

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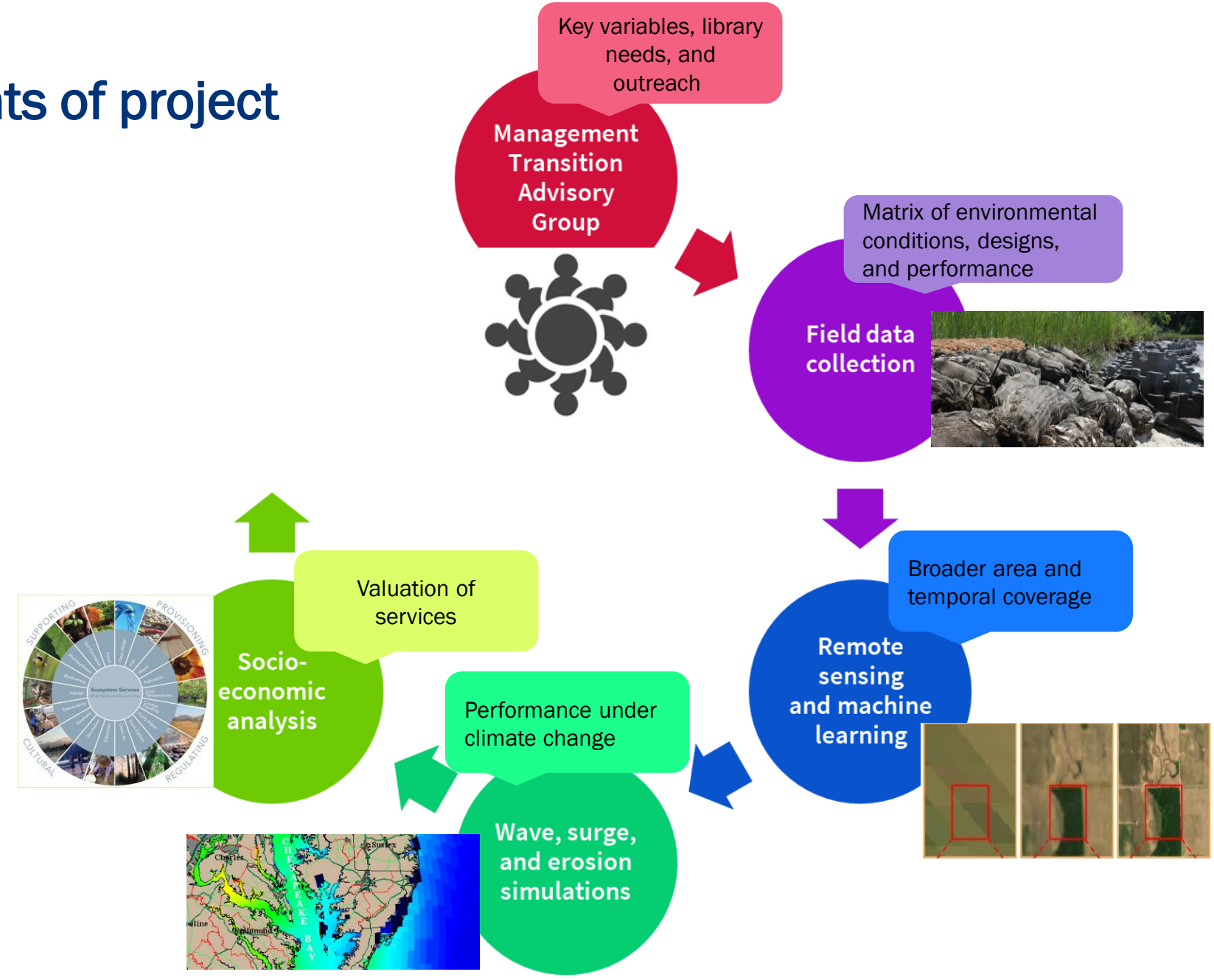

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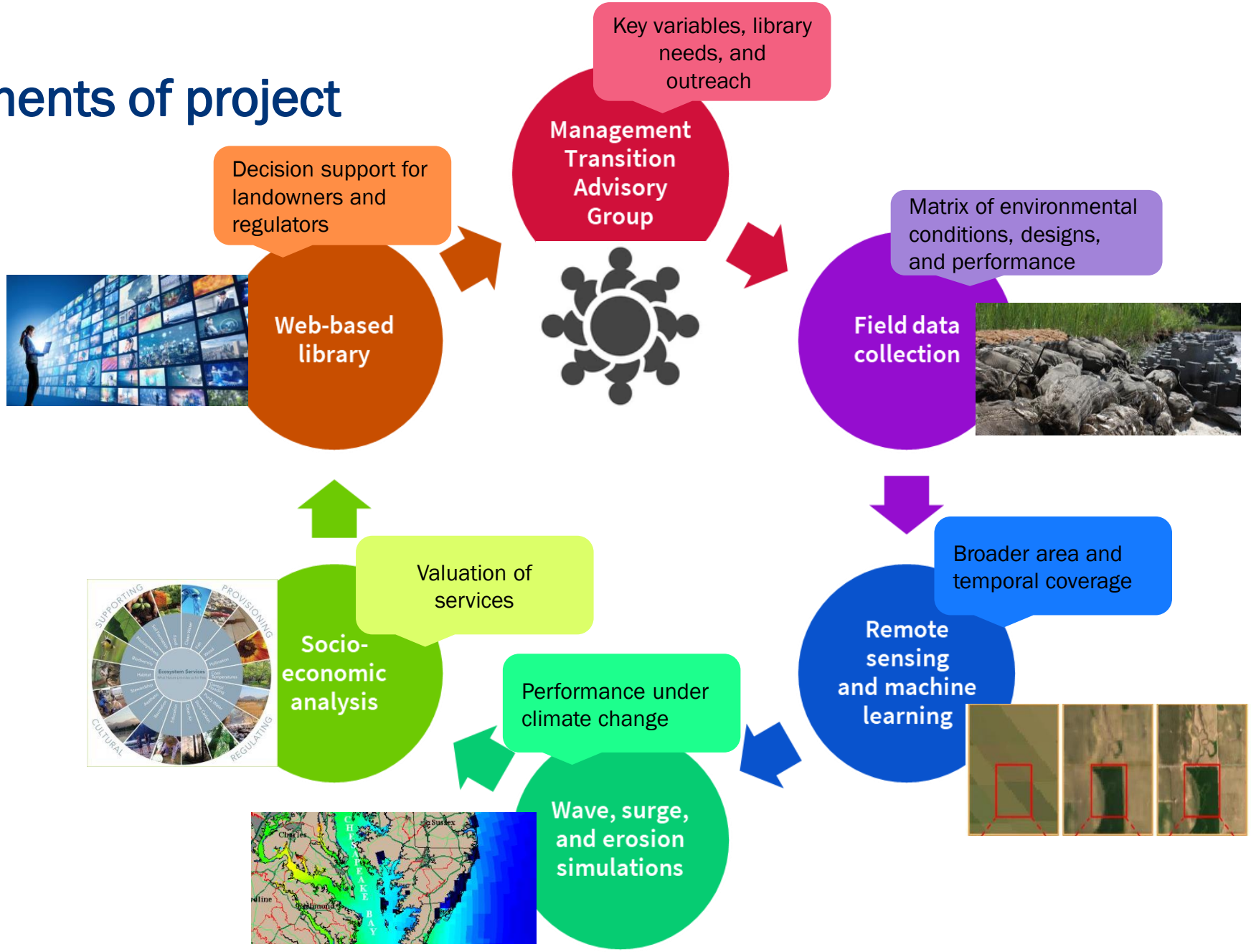
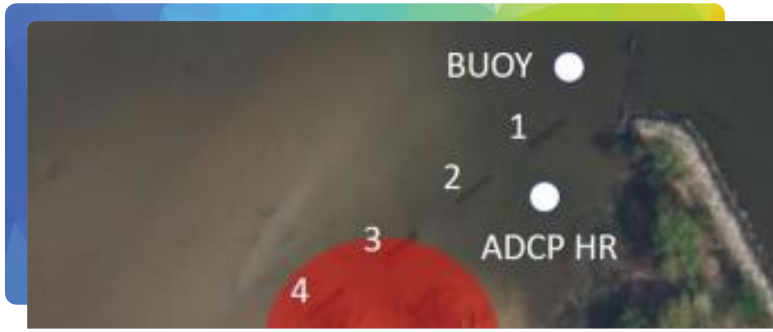


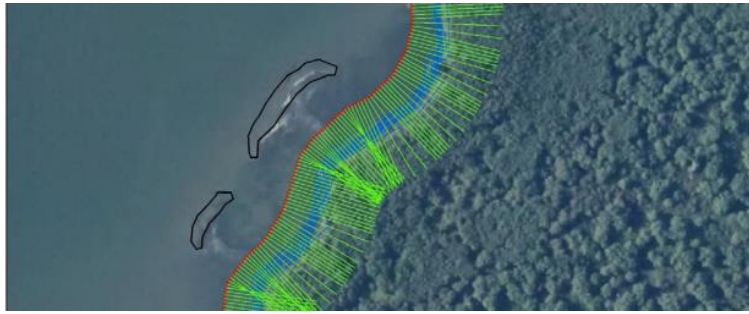
Management Transition Advisory Group

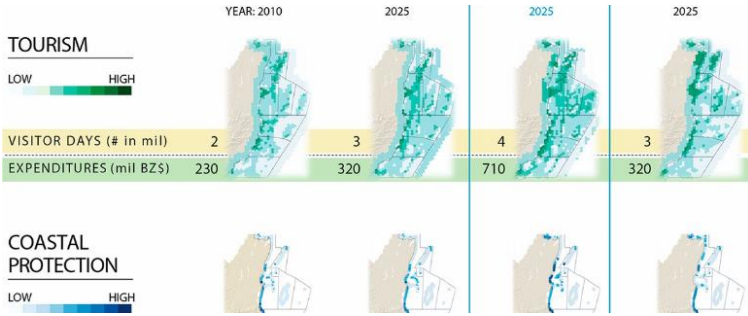
- MTAG
  - Site selection
  - Performance metrics
  - Scenarios and data needs
  - Online library format
  - Outreach and science communication
- Adaptive in nature
  - Meet at least twice a year
  - Sub-groups meet on a more regular basis
  - Scientific and technical outreach
  - Local community buy-in

Post-implementation monitoring to establish ground-truth points and monitoring metrics

- Sites being monitored
  - Six sites in Maryland
  - Many sites in Virginia (~20)
  - Two ESLR sites
- Factors monitored
  - Medium- and high- wave energy climates
  - Wave transmissivity
  - Coastal erosion and progradation
  - Marsh recruitment and migration
- Socio-economic benefits
  - Primary data elicitation
  - Benefit-relevant indicators and composite indices
  - Benefit transfer

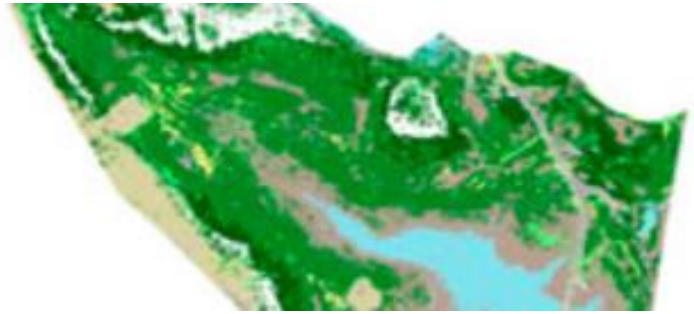


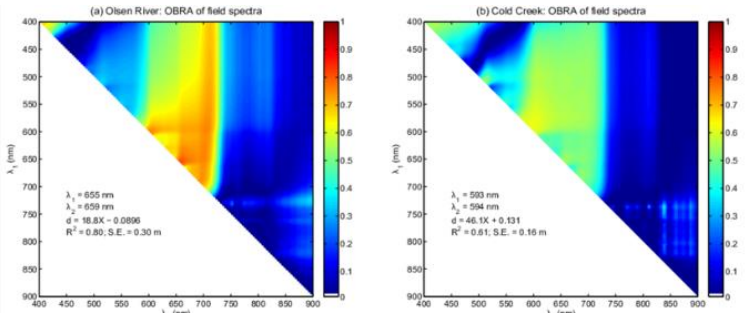




Remote sensing for wider areal and longer temporal coverage

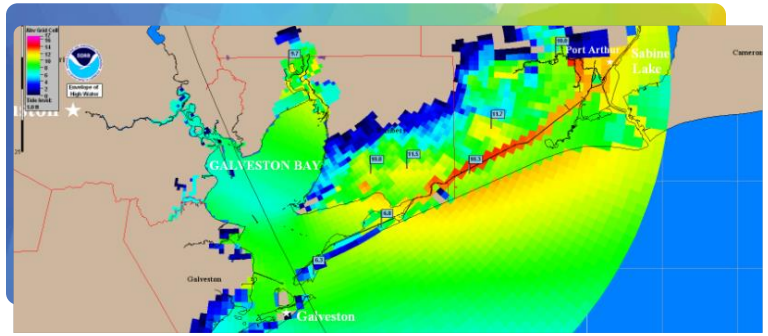
- Multiple sources for spatial, temporal, and spectral coverage
  - MODIS (500m, hyperspectral, daily)
  - SWAT (100m, multispectral, 3-5 days)
  - LANDSAT (30m, multispectral, 14 days)
  - Sentinel I and II (10m, InSAR, multispectral, 3-5 days)
  - WorldView and Planet (<1m, RGB, on-demand)
- Machine learning model applied to other sites
  - Data fusion from multiple sources
  - Environment and approach type classification
  - Band ratio-based regression to get performance

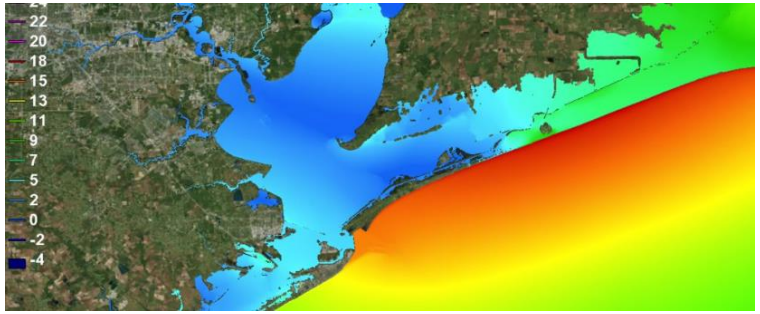


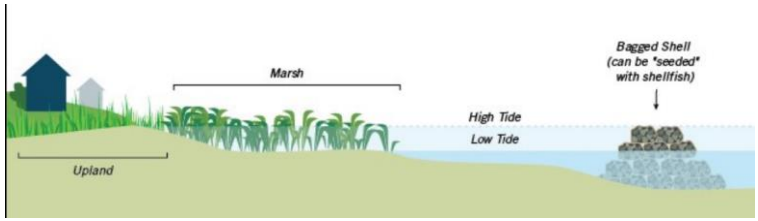


Numerical modeling to incorporate sea level rise and future storms

- SLOSH/simplified modeling for area-wide analysis of
  - Sea level rise
  - Design storms
  - Selecting living shoreline approach types
- ADCIRC + SWAN modeling to include
  - Sea level rise
  - Design storms
  - Specific solution performance
- SLAMM and InVEST modeling to include sea level rise and surge effects
  - Marsh migration trajectory
  - Land use land cover change
  - Other ecosystem benefits

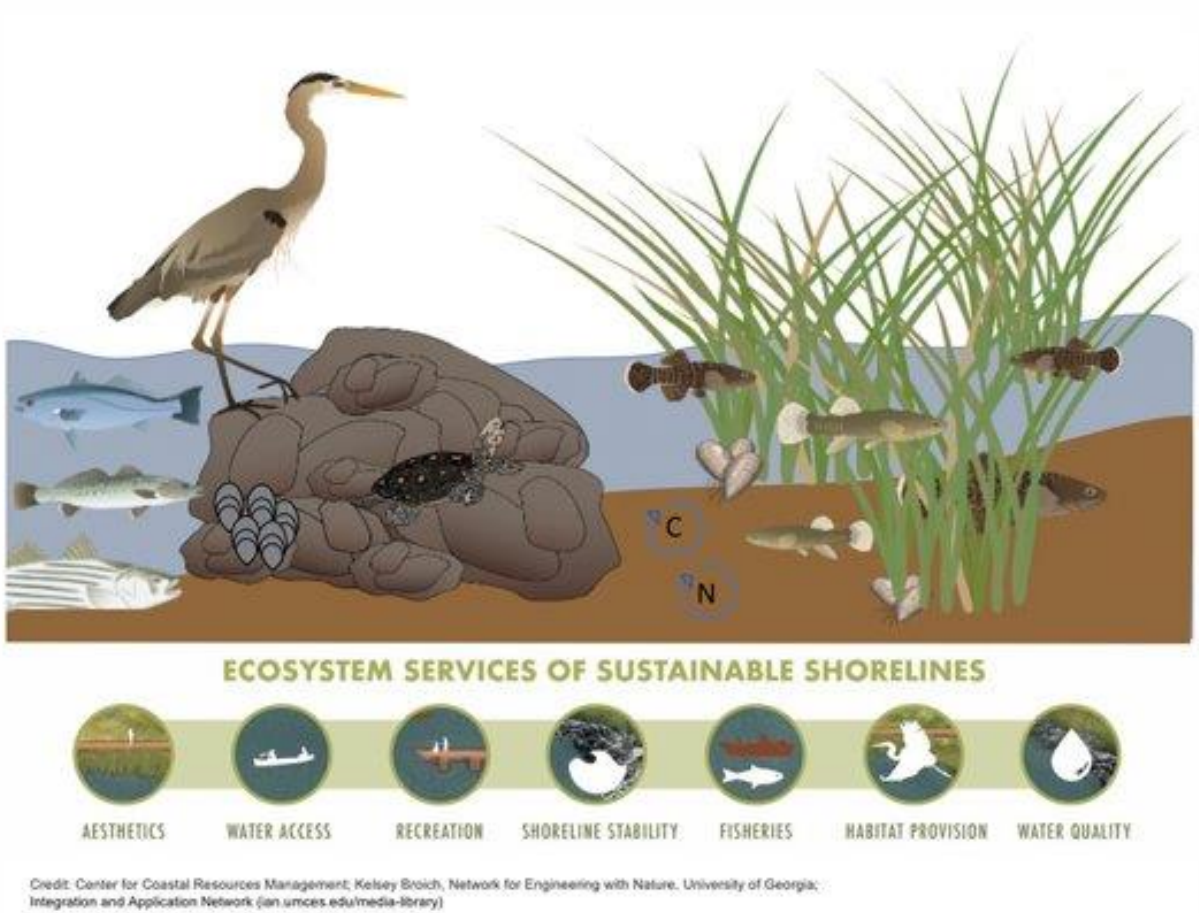






Socioeconomic analyses – valuing ecosystem services related tc climate resilience, people, and habitat

- Revenue and livelihoods – quantifying aquaculture and blue economy benefits
- Recreation – fishing, birding, paddling, tourism
- Carbon storage
- Water quality improvement
- Fish and crustacean habitat creation and preservation
- Marsh migration and restoration, and habitat reconnection



Credit: Center for Coastal Resources Management; Kelsey Broich, Network for Engineering with Nature, University of Georgia; Integration and Application Network (ian.umces.edu/media-library)

Web-based library for decision-making

- Stakeholder-driven library of performance metrics
  - Search and display interface
  - Spatially explicit
  - What are the environmental and climate resilience variables of concern?
  - What are the desired climate resilience objectives?
  - What are the general design elements?
  - What is the performance envelope?


I WANT TO
BELIEVE

Okay...
but how?

Questions?

Vamsi Krishna Sridharan, Ph.D., M.ASCE
Water Resources Innovation Manager
Tetra Tech
vamsi.sridharan@tetratech.com
(650) 862-2658

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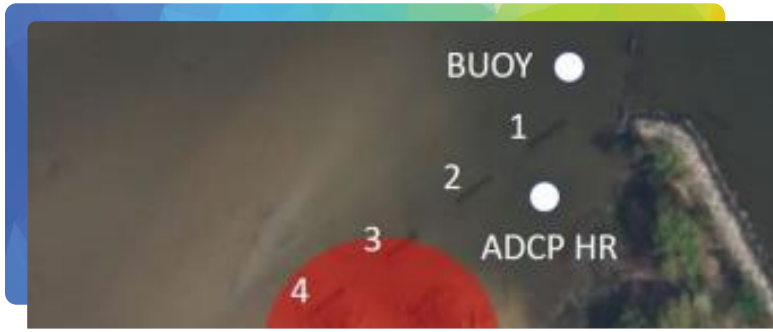

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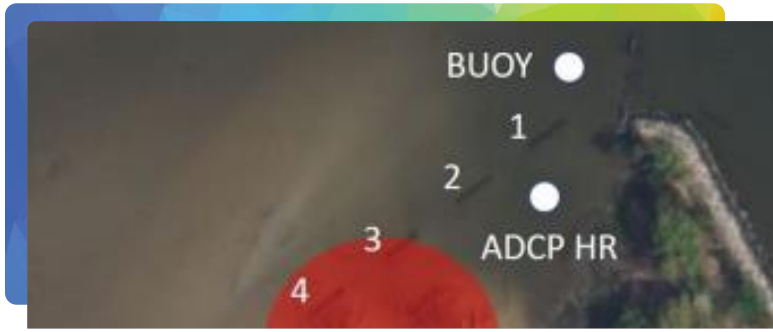

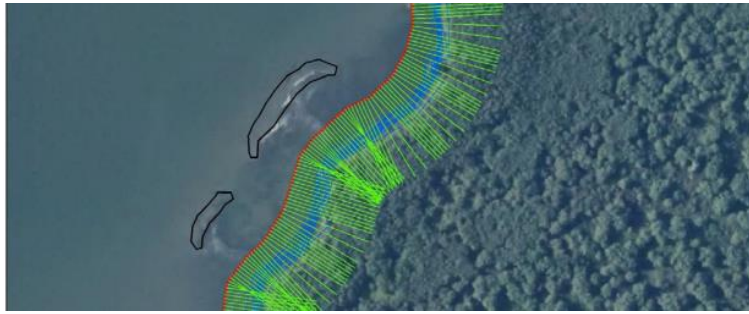

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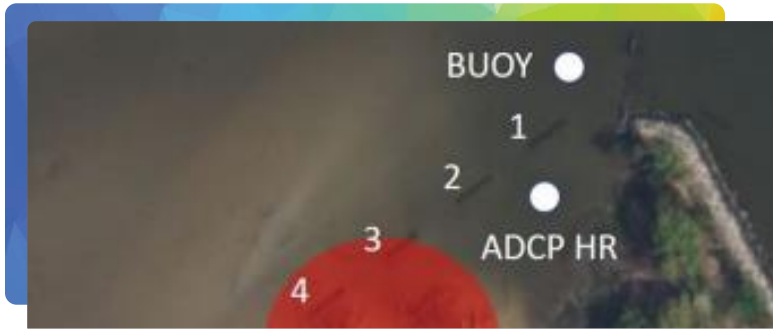

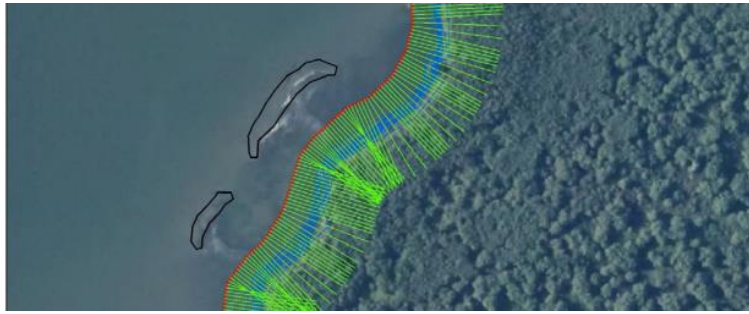

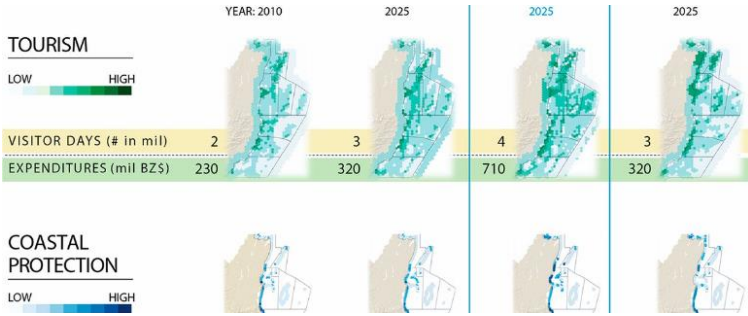

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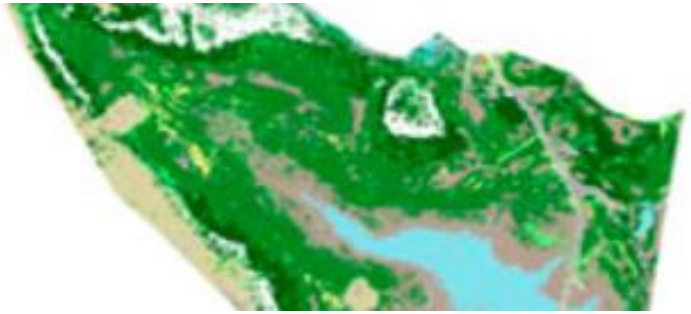

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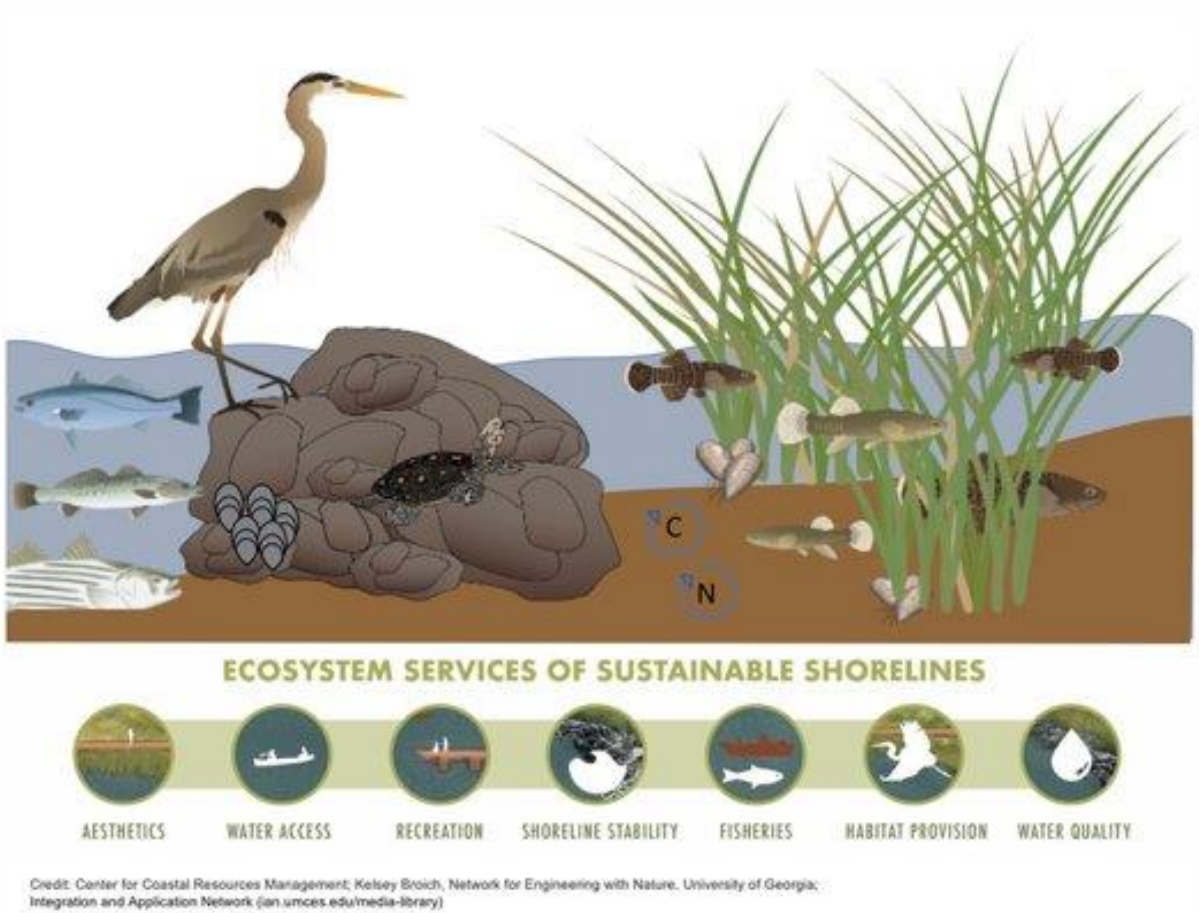

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