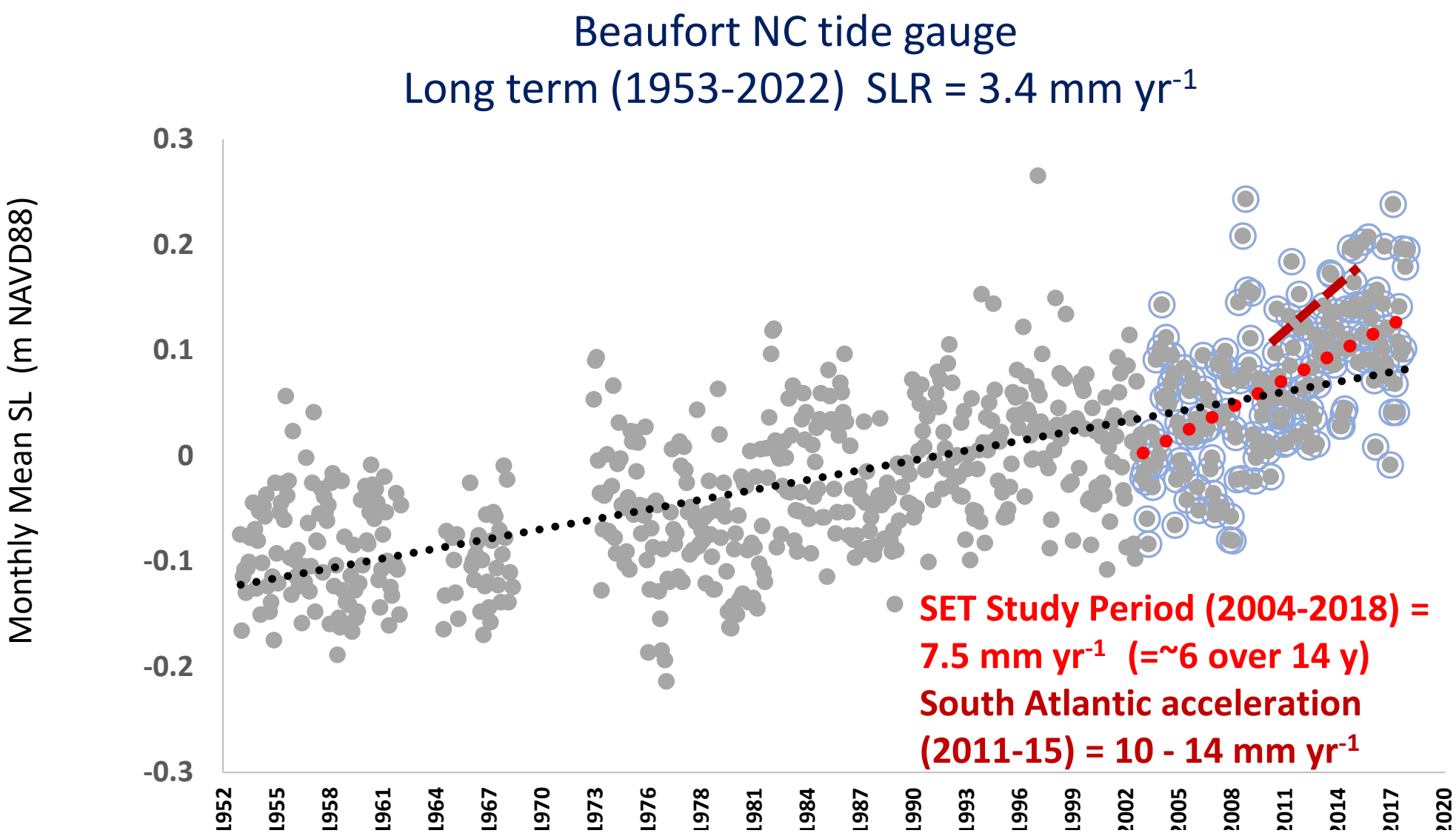
Climate Change Implications for Living Shoreline Design and Permitting

- Observed climate change (SLR) impacts on Natural and LS marshes in NC (2004-2020)
- Future SLR and modeled marsh response (2020-2050)
- Ecosystem services (habitat, nutrient uptake and WQ, carbon storage)
- Coastal squeeze and habitat trade-offs

Application of dredged sediment to fragmented saltmarsh
Camp Lejeune, NC 2018

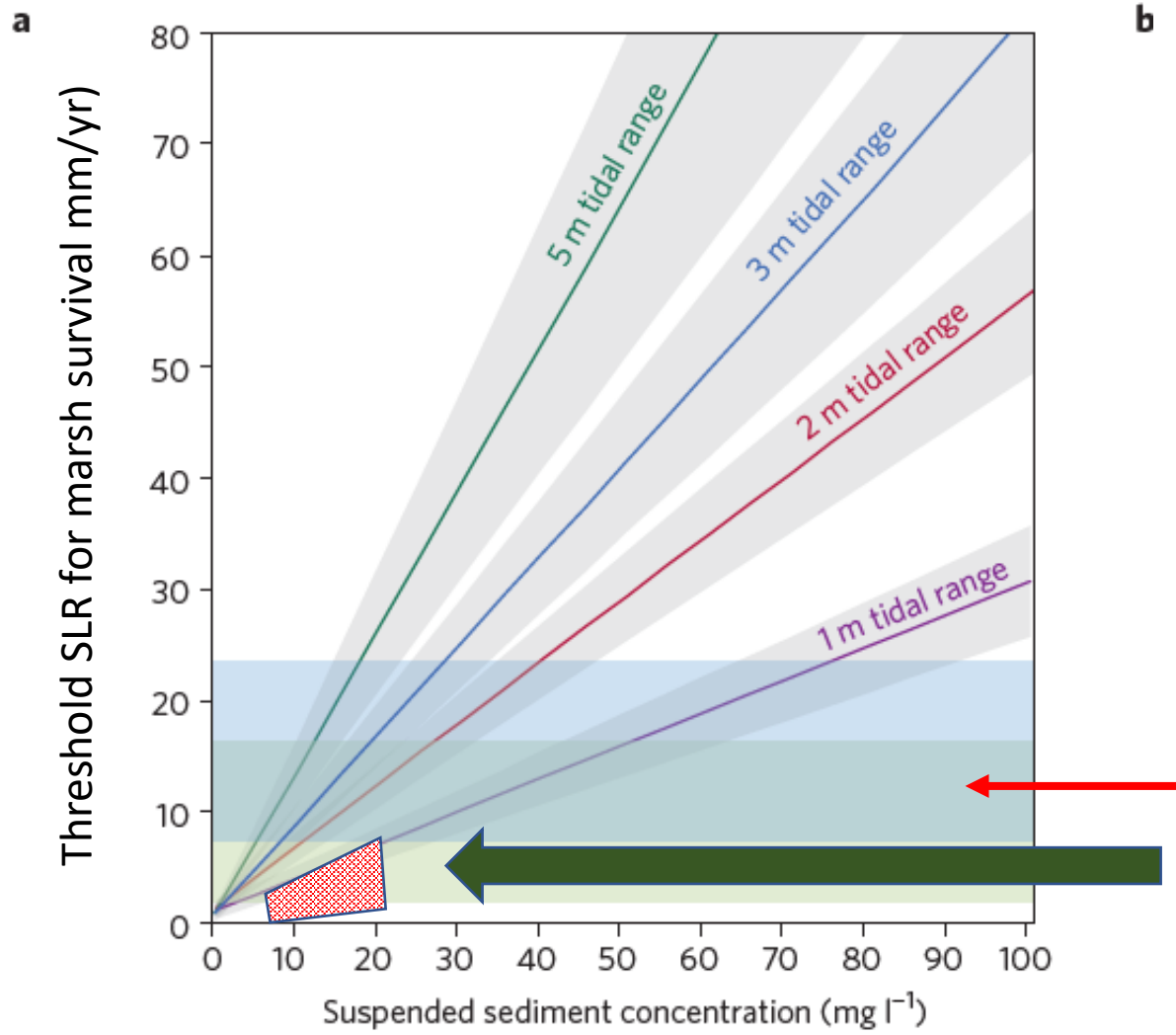
Relative Sea Level Rise



Sea level along the U.S. coastline is projected to rise, on average, 10 - 12 inches (0.25 - 0.30 meters) in the next 30 years (2020 - 2050)

North Carolina marshes are especially vulnerable to SLR

Tide Range and Suspended Sediment Concentration are Drivers of Marsh Survival



NC SLR

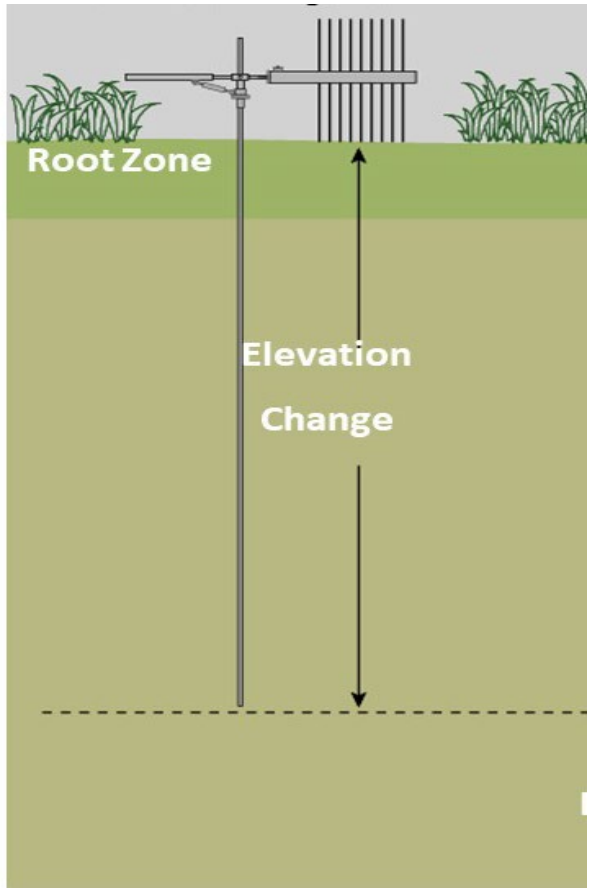
NC Salt marsh sed supply and tidal range

From Kirwan et al. 2016 Nature Climate Change

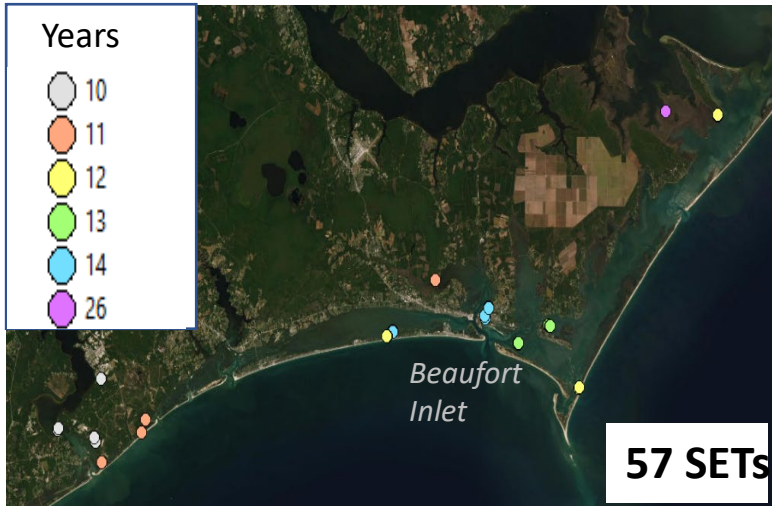
NC Salt Marsh Elevation Change

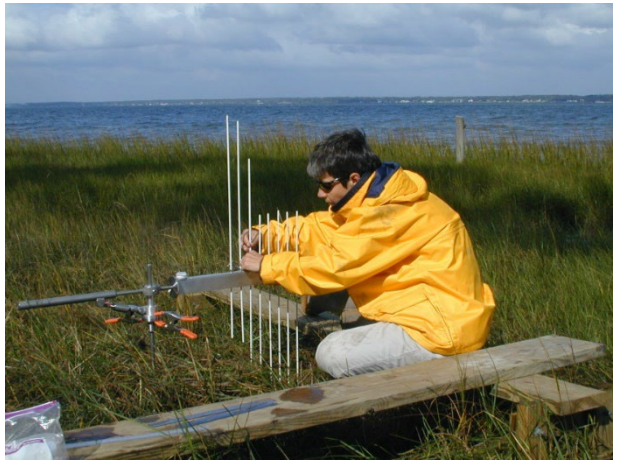
Keeping up?

Surface Elevation Table



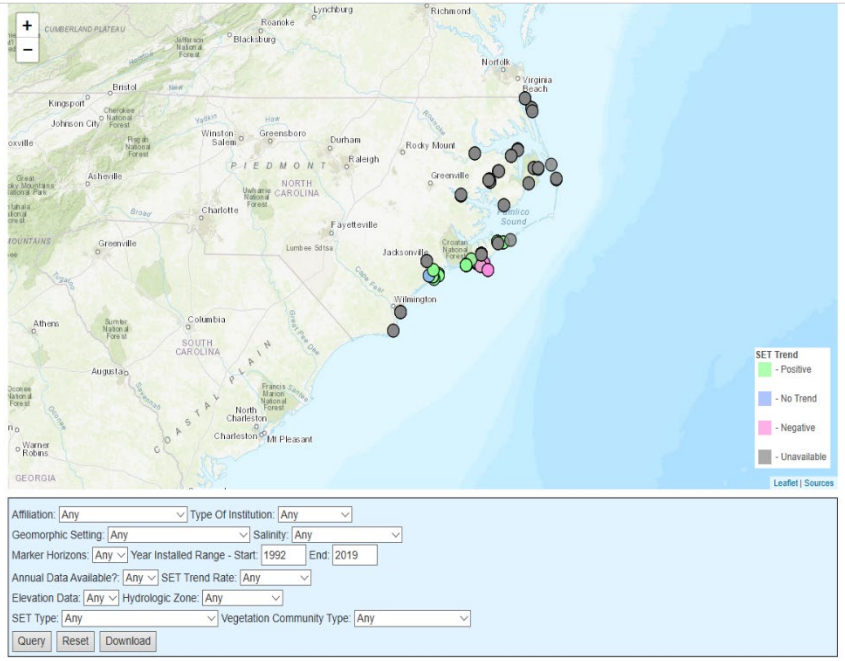
Location of study SETs



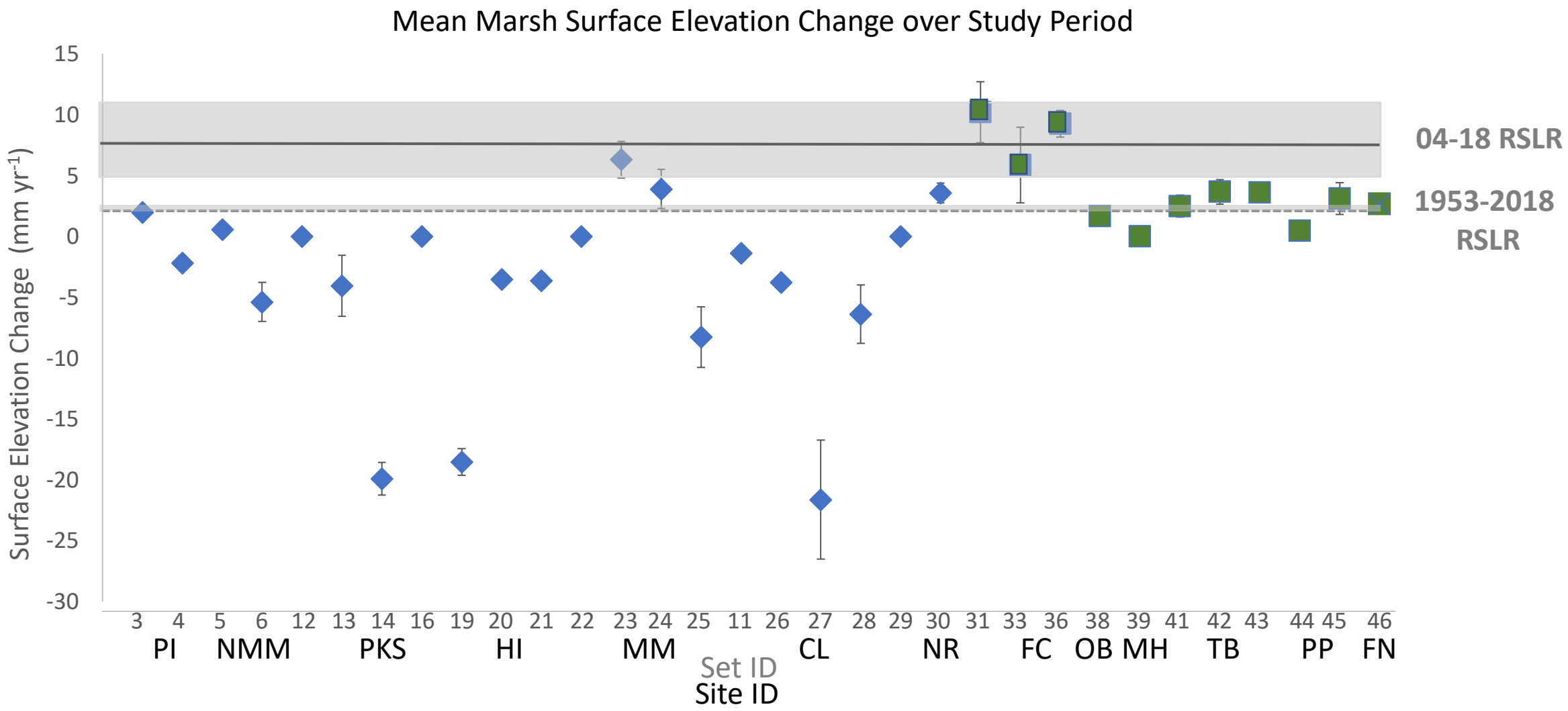


Reading SET at Pine Knoll Shores

SET distribution in NC



https://ncseagrant.ncsu.edu/program-areas/sustainable-communities/north-carolina-sentinel-site-cooperative/nc-set-community-of-practice/



20 SETS failed to keep up with long-term RSLR of 3.1 mm/yr

Only 4 SETs kept up with Study Period RSLR of 7.5 mm/yr

1-2 yr post-installation

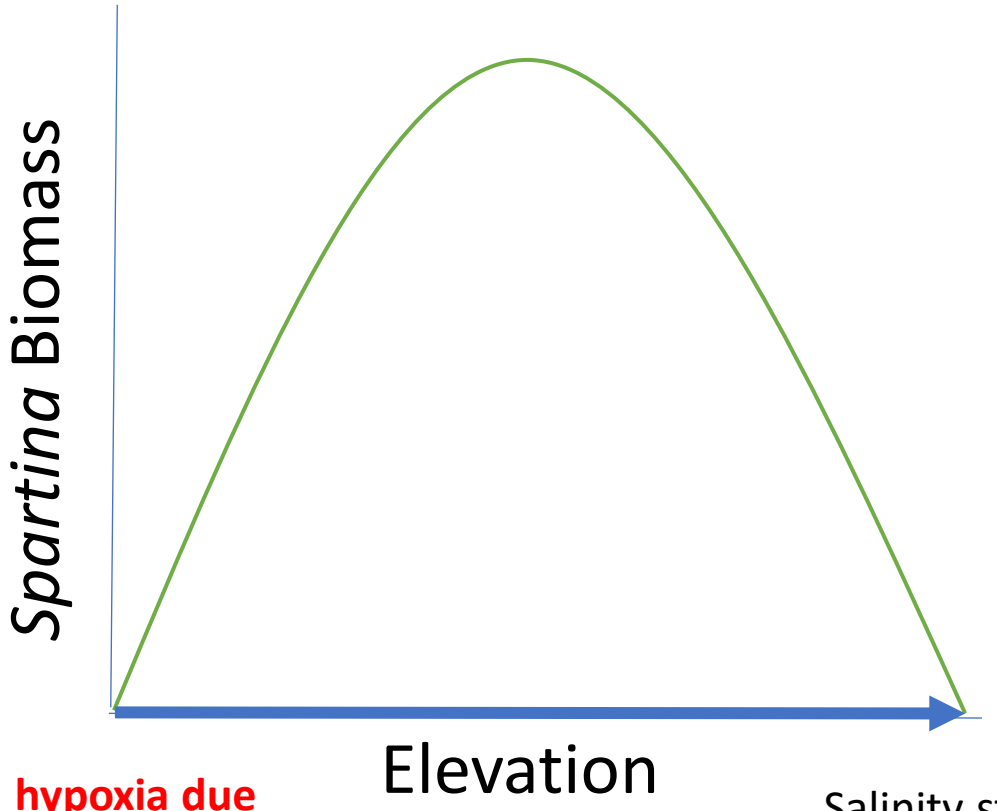
12-14 yr post-installation

Dramatic elevation changes in shoreline marshes, especially at sites with high wave energy

Currin et al 2017

Coastal marsh responses to sea level rise

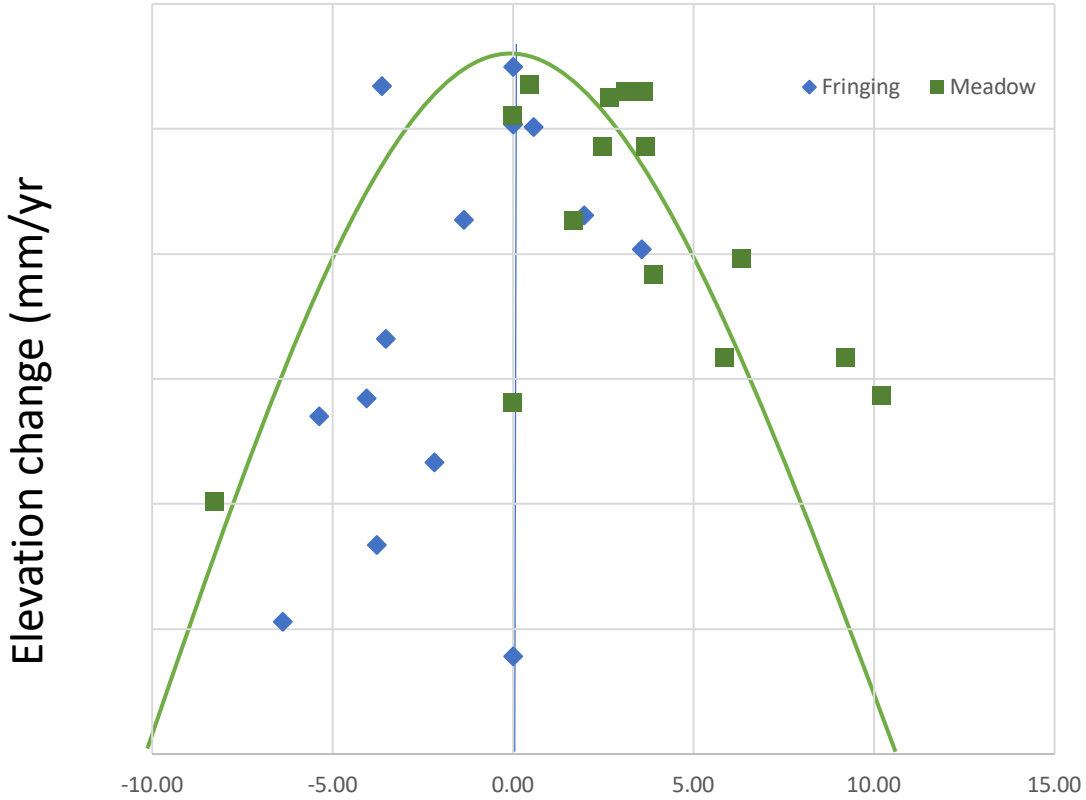
Optimal conditions for plant growth occur near MSL



hypoxia due to long flooding durations

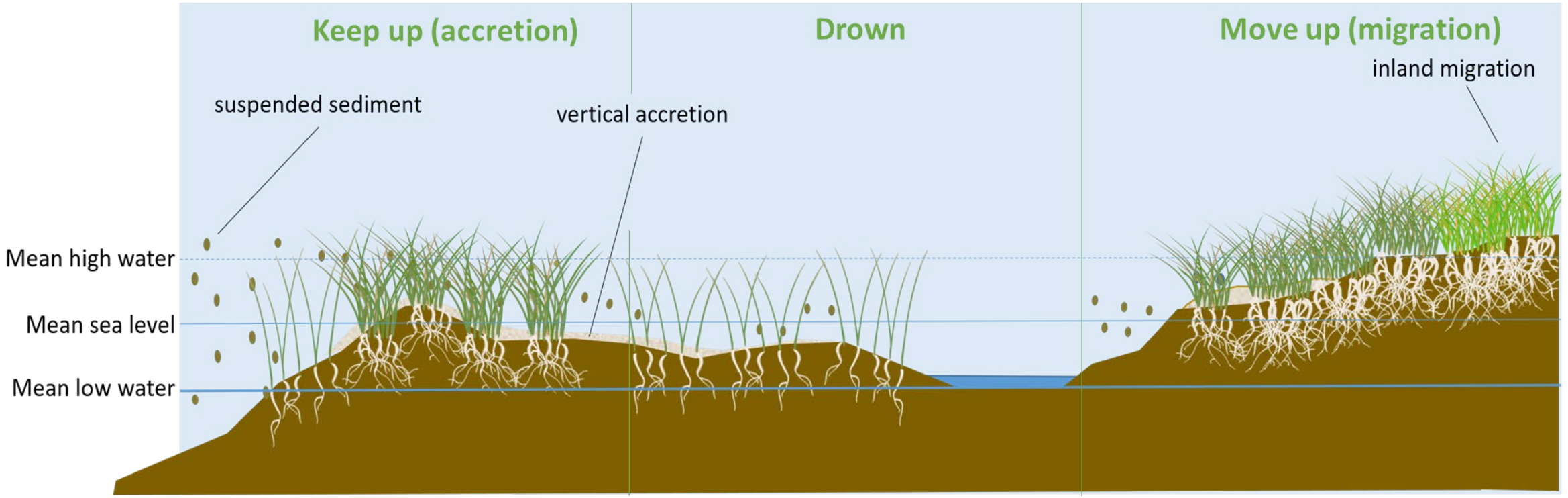
Salinity stress, competition

Greatest sediment accretion increase near MSL

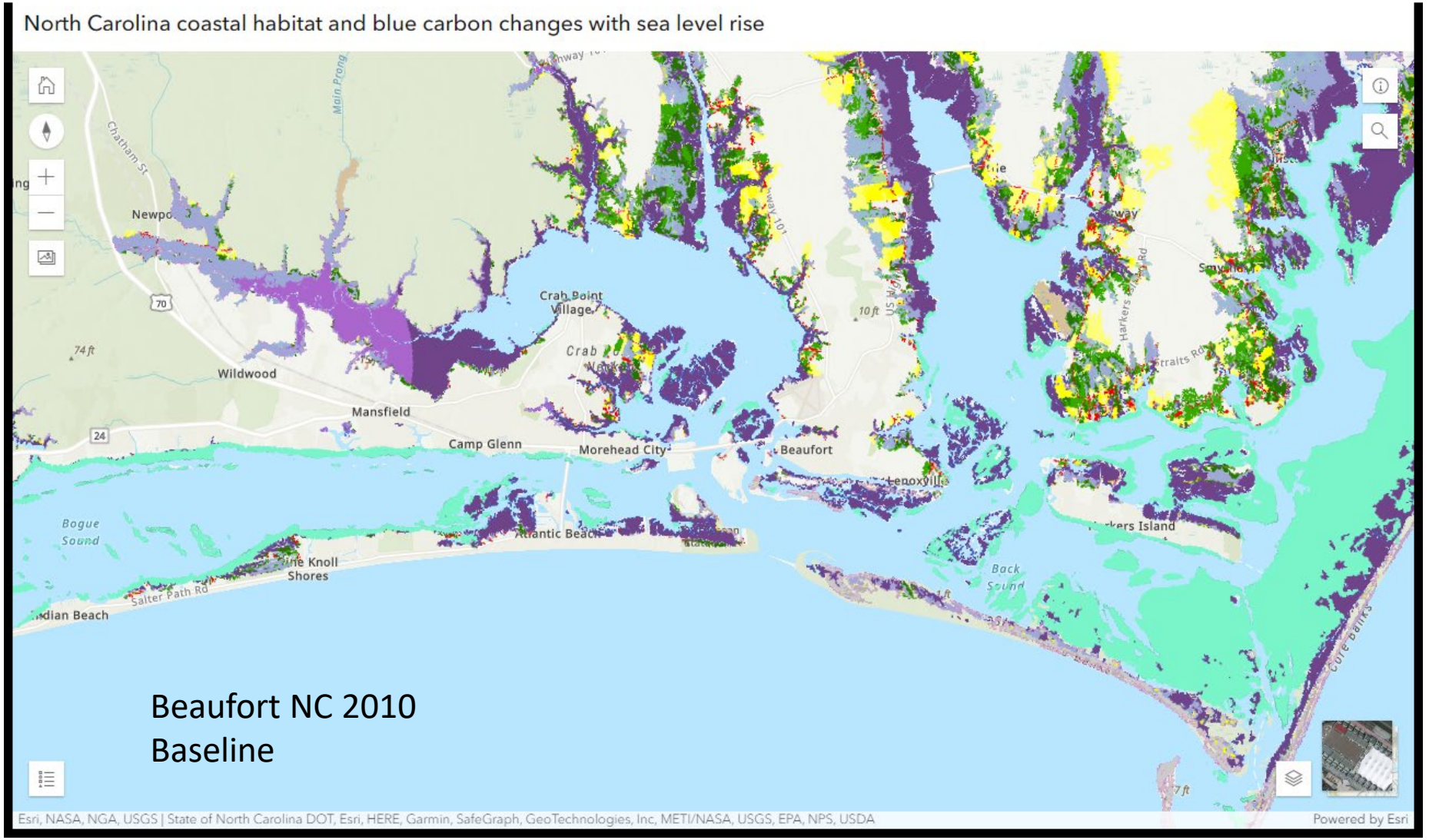


Elevation Relative to MHW

Salt marsh response to future SLR



Warnell, Olander & Currin 2022. Sea level rise drives carbon and habitat loss PLOS Climate doi.org/10.1371/journal.plcm.0000044



Hi-lo salinity marsh

Drowned saltmarsh

Migrated saltmarsh

Accreting saltmarsh

Eroded saltmarsh

Seagrass

Lost Seagrass

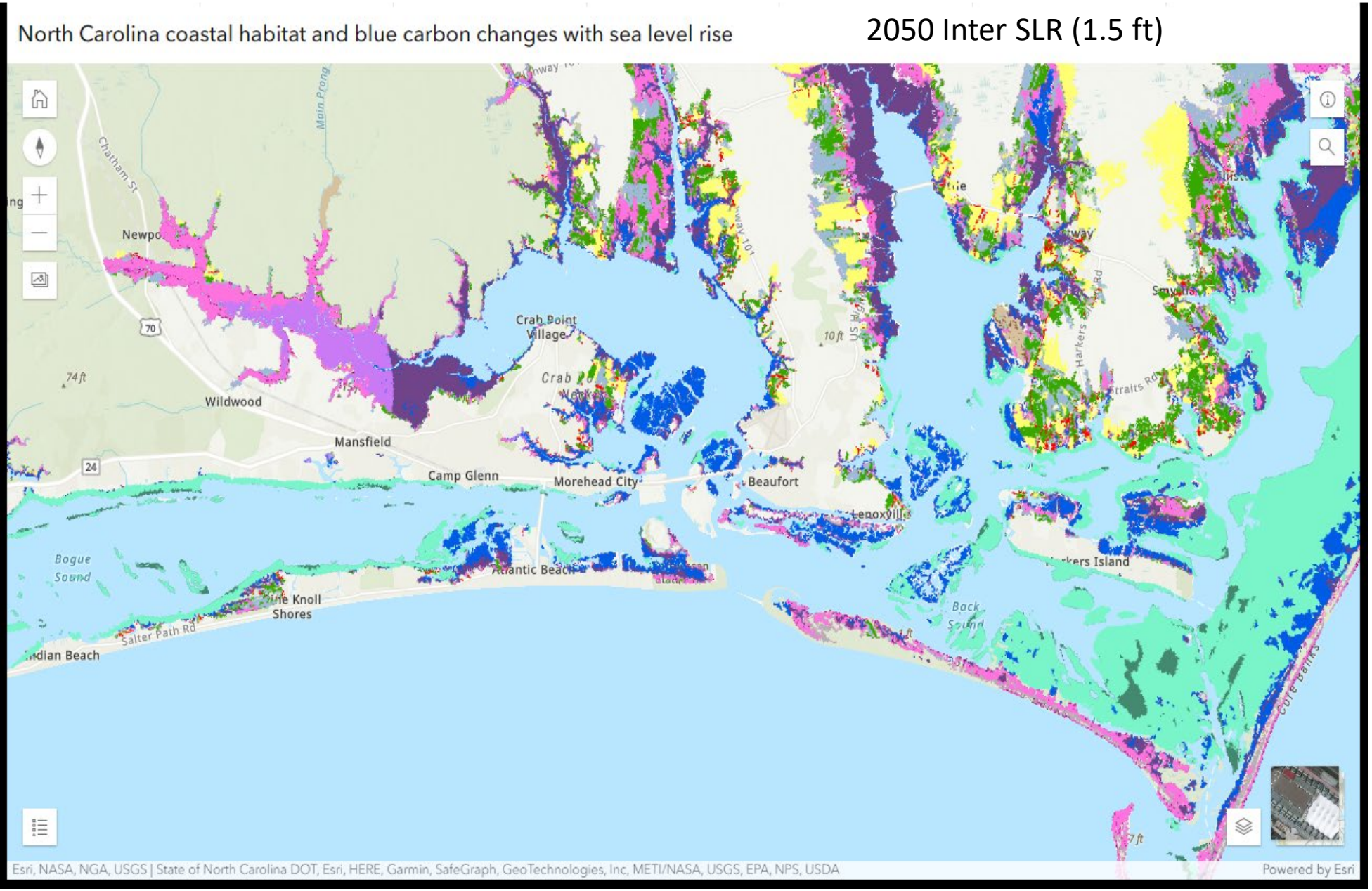
Agriculture

Warnell, Olander & Currin 2022. Sea level rise drives carbon and habitat loss PLOS Climate doi.org/10.1371/journal.plcm.0000044

https://dukeuniv.maps.arcgis.com/apps/instant/portfolio/index.html?appid=416a01c29cfd4a77af998d225478ba63

North Carolina coastal habitat and blue carbon changes with sea level rise

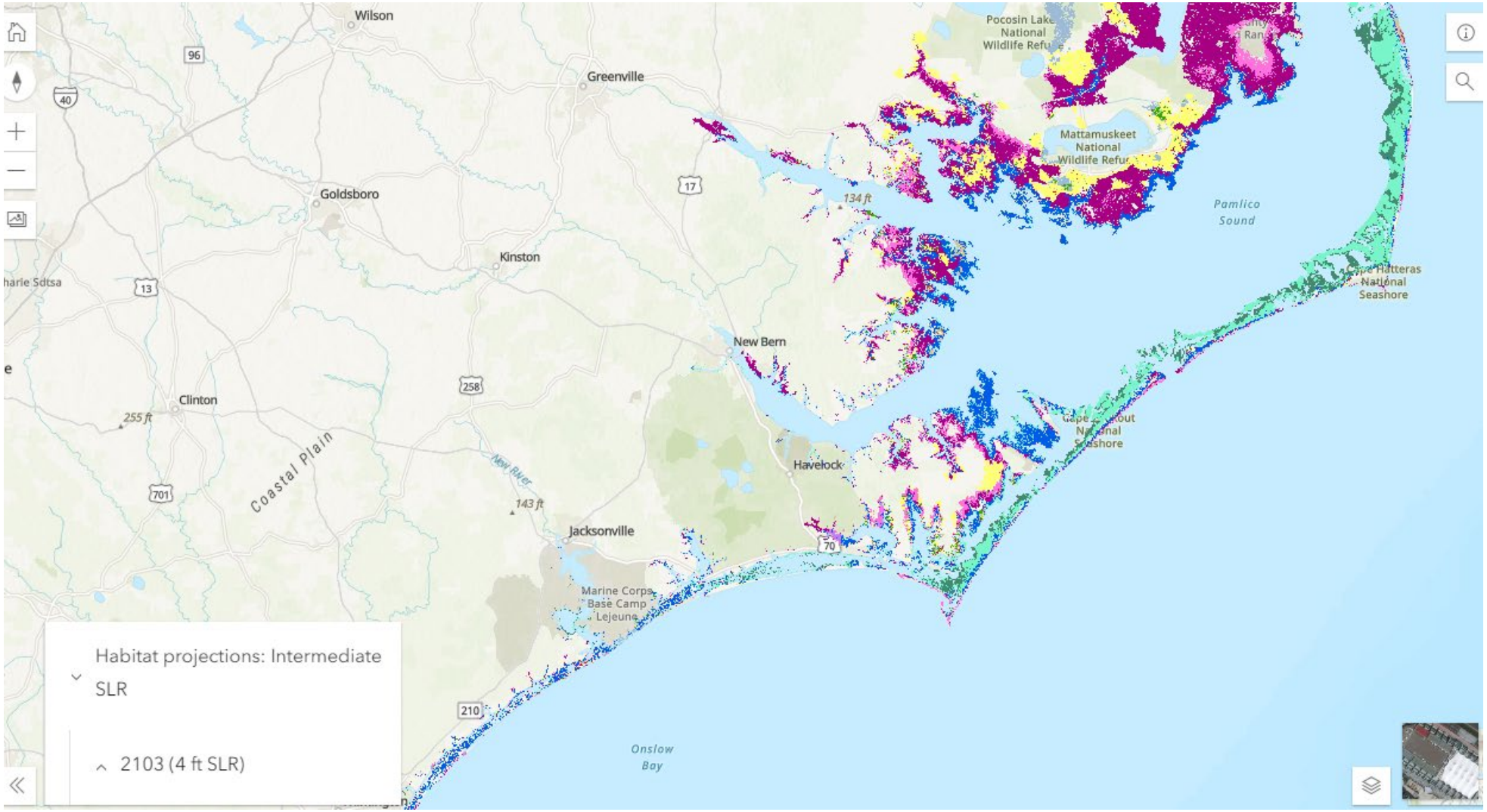
2050 Inter SLR (1.5 ft)



- Hi-lo salinity marsh
- Drowned saltmarsh
- Migrated saltmarsh
- Accreting saltmarsh
- Eroded saltmarsh
- Seagrass
- Lost Seagrass
- Agriculture
- Forest

North Carolina coastal habitat changes with sea level rise

2104 Intermediate SLR



Drowned saltmarsh

Migrated saltmarsh

Accreting saltmarsh

Eroded saltmarsh

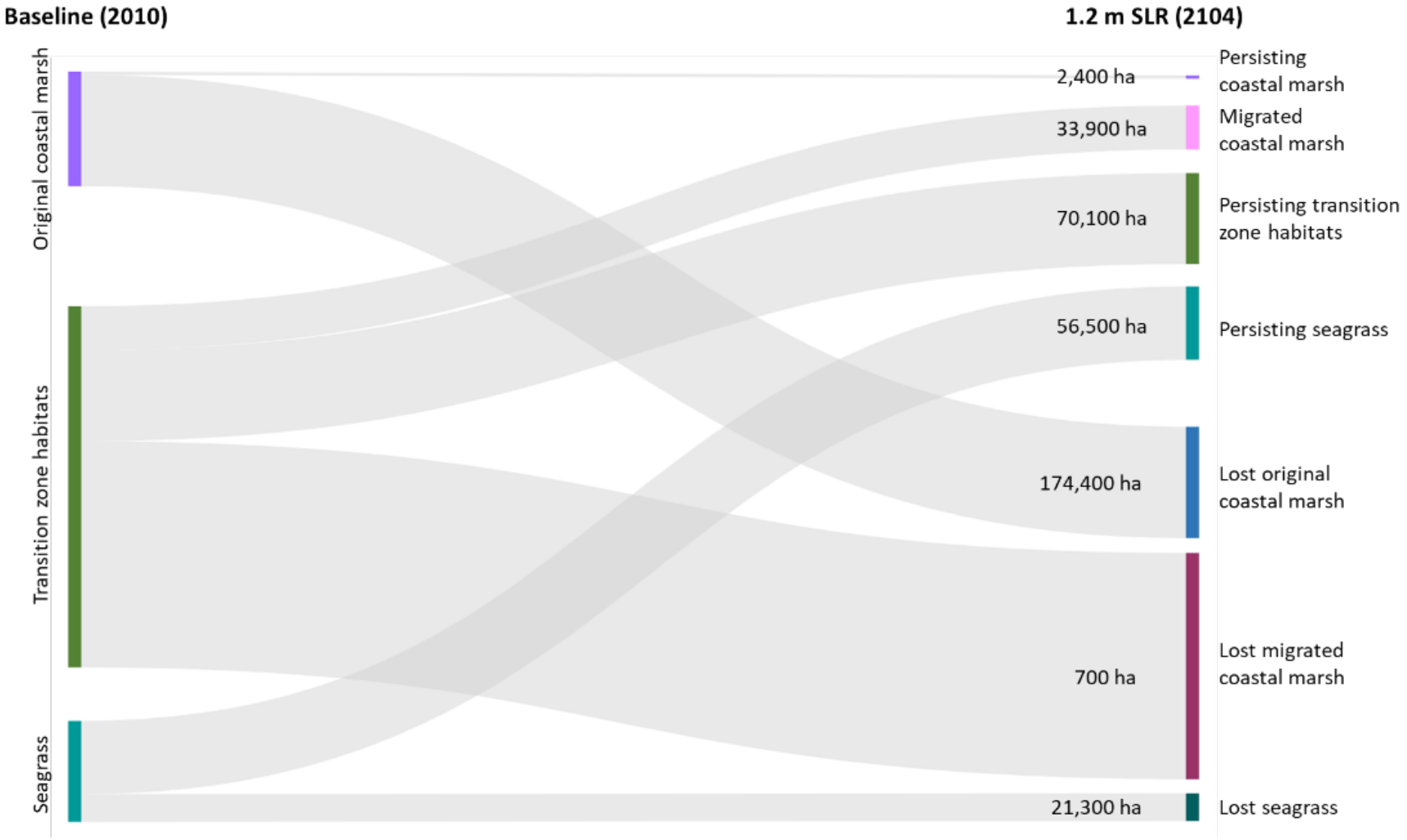
Seagrass

Lost Seagrass

Agriculture

https://dukeuniv.maps.arcgis.com/apps/instant/portfolio/index.html?appid=416a01c29cfd4a77af998d225478ba63

2010 – 2104 NC Coastal Habitat Change Intermediate SLR

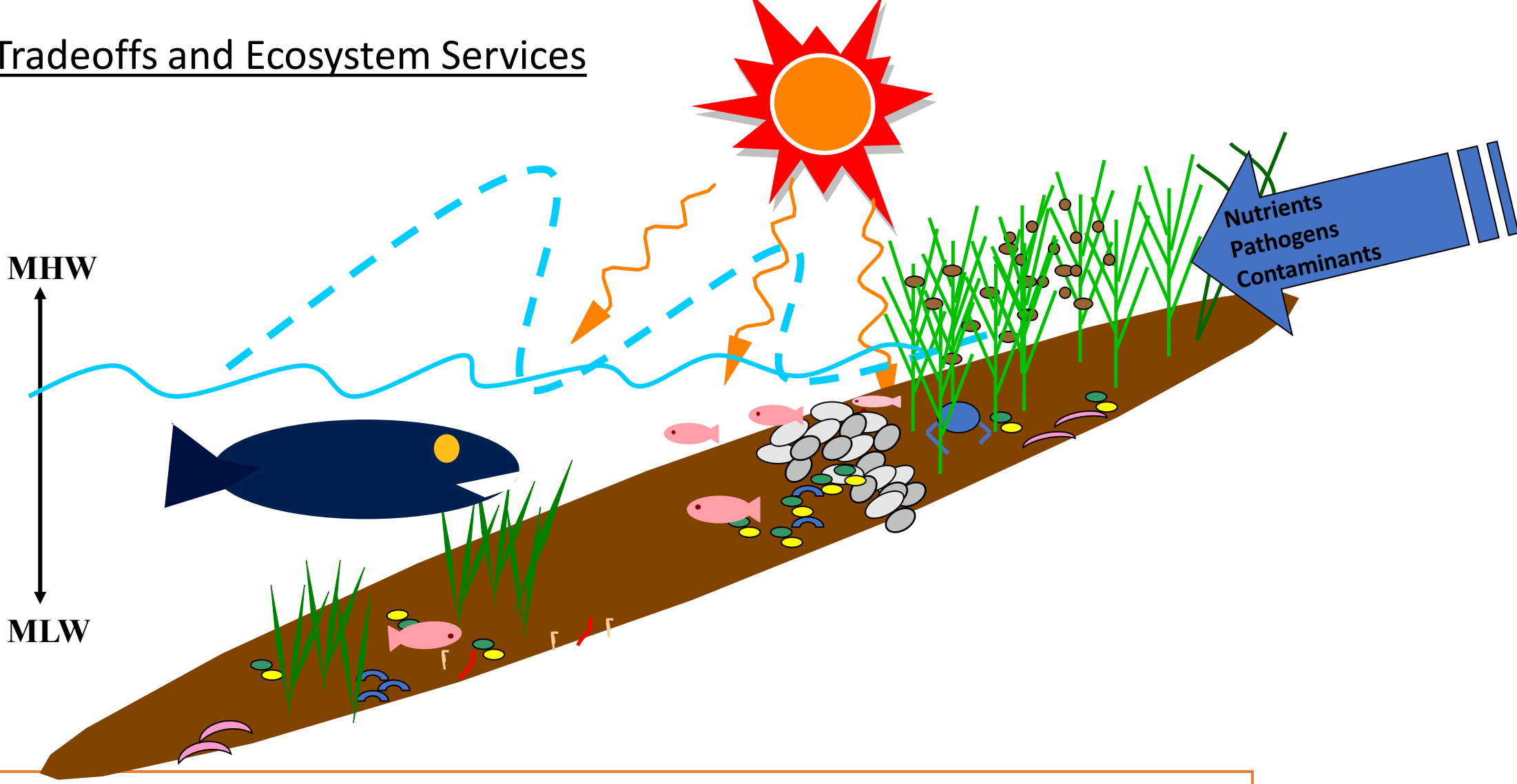


More than 50% loss of salt marsh habitat

Estimated 25% seagrass loss ???

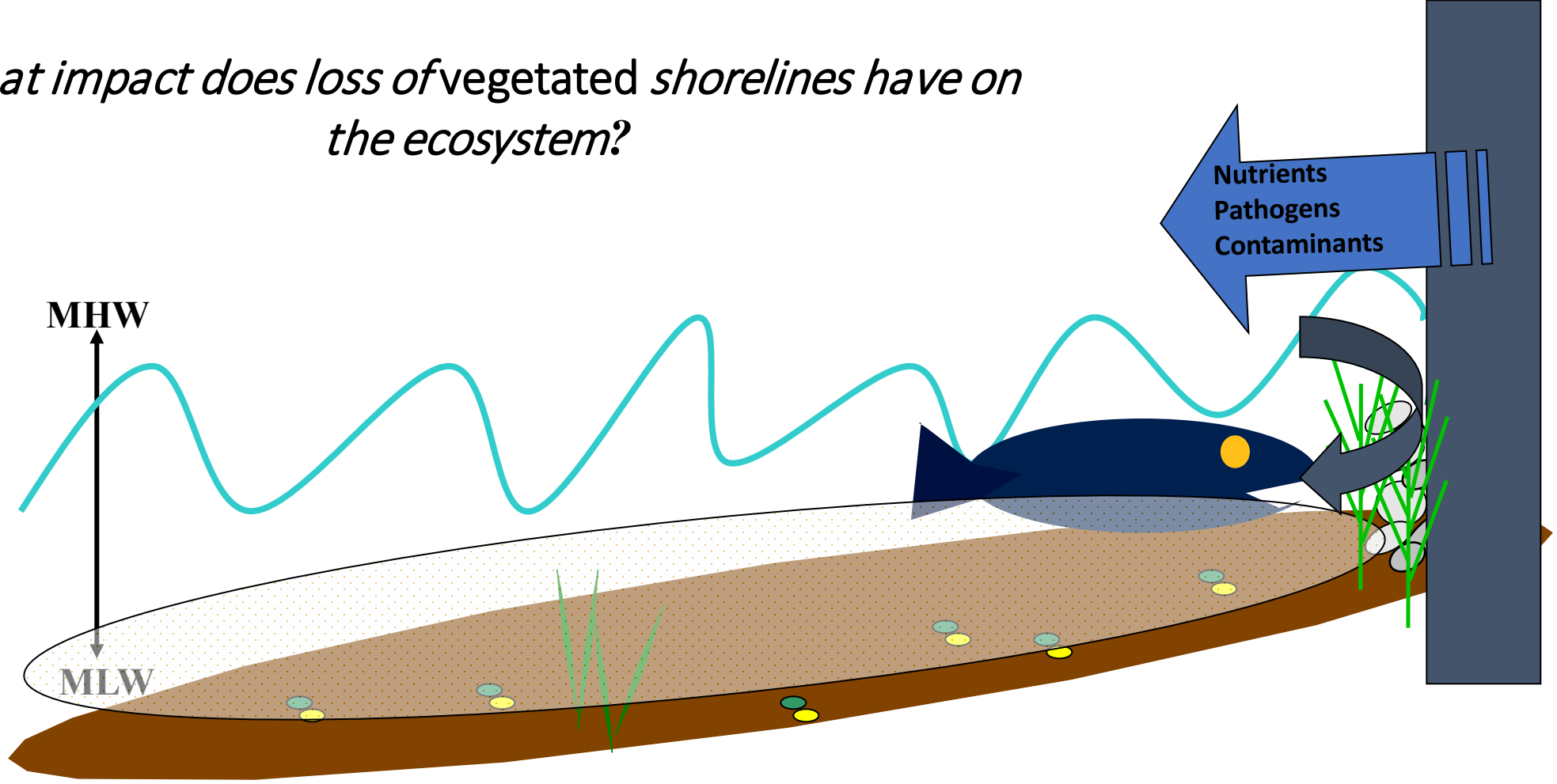
Warnell et al. 2022

Habitat Tradeoffs and Ecosystem Services



Nutrient inputs are reduced by plant uptake and microbial activity (denitrification)
Pathogens immobilized or broken down by sun while in shallow-water
Reduction of wave energy by plants and oyster reefs
Sediment erosion and resuspension reduced by marsh plants, algal mats
Vital nursery habitat for fish, shellfish

What impact does loss of vegetated *shorelines have on the ecosystem?*



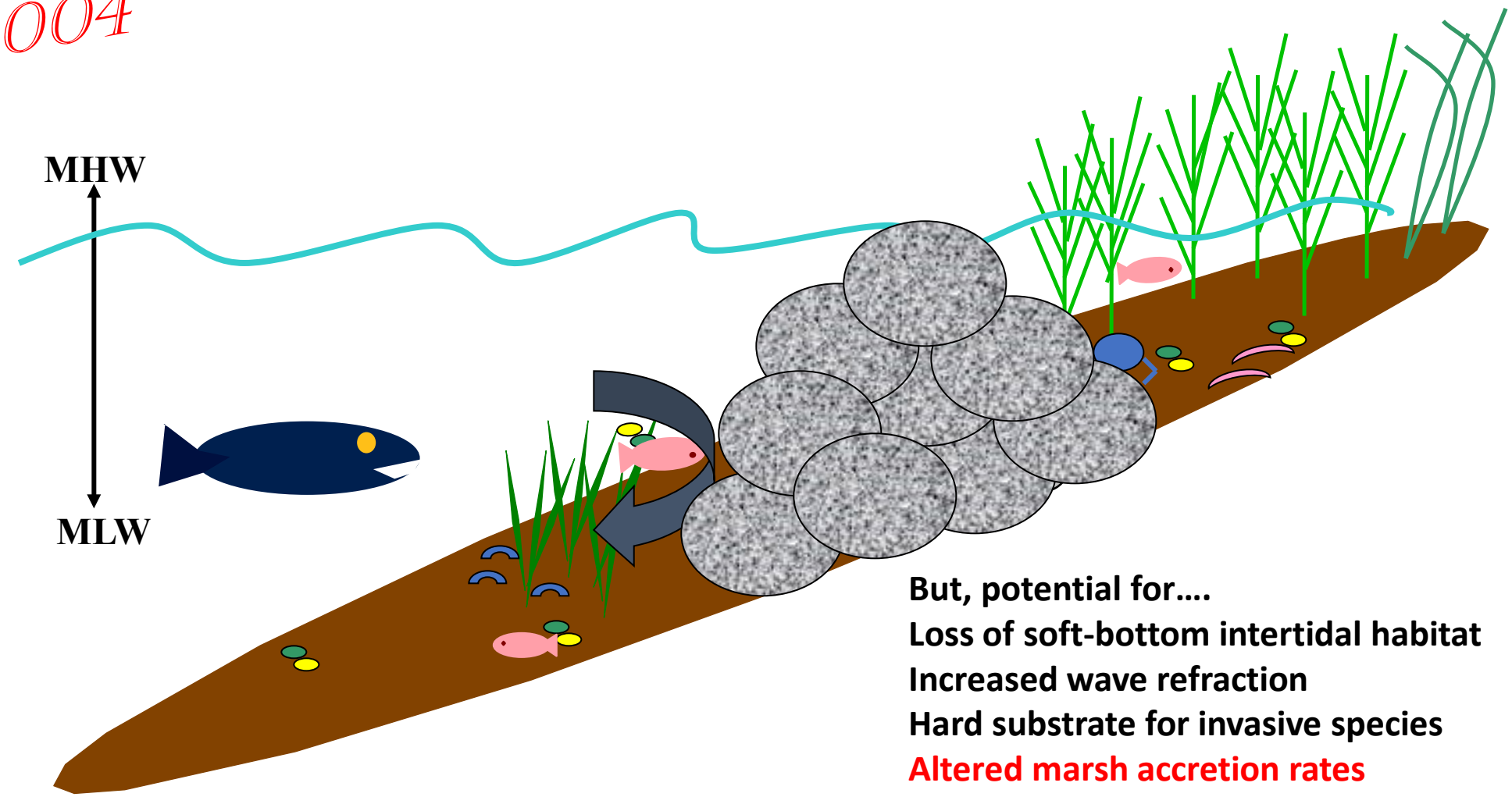
Loss of intertidal vegetated habitats results in loss of ecosystem services

- **Scour deepens bottom**
- **Results in loss of plant communities and shallow-water refuge**
- **Increased wave energy increases sediment resuspension, which decreases light reaching bottom, reducing seagrass and phytoplankton productivity**

CIRCA 2004

Offshore Sills or breakwaters- a better solution?

Preserves marsh habitat along shoreline

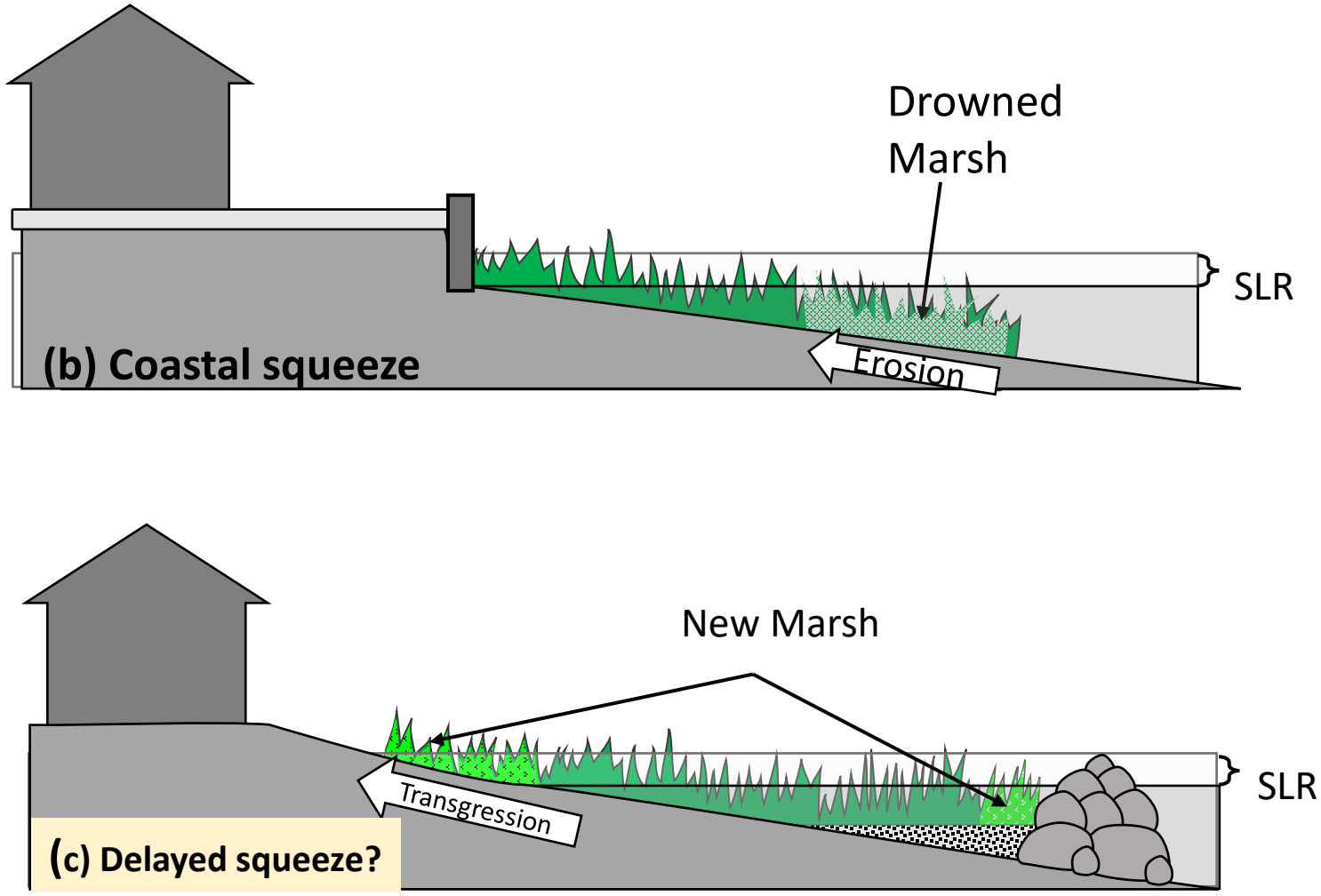


But, potential for….
Loss of soft-bottom intertidal habitat
Increased wave refraction
Hard substrate for invasive species
Altered marsh accretion rates

Design carefully and avoid overbuilding

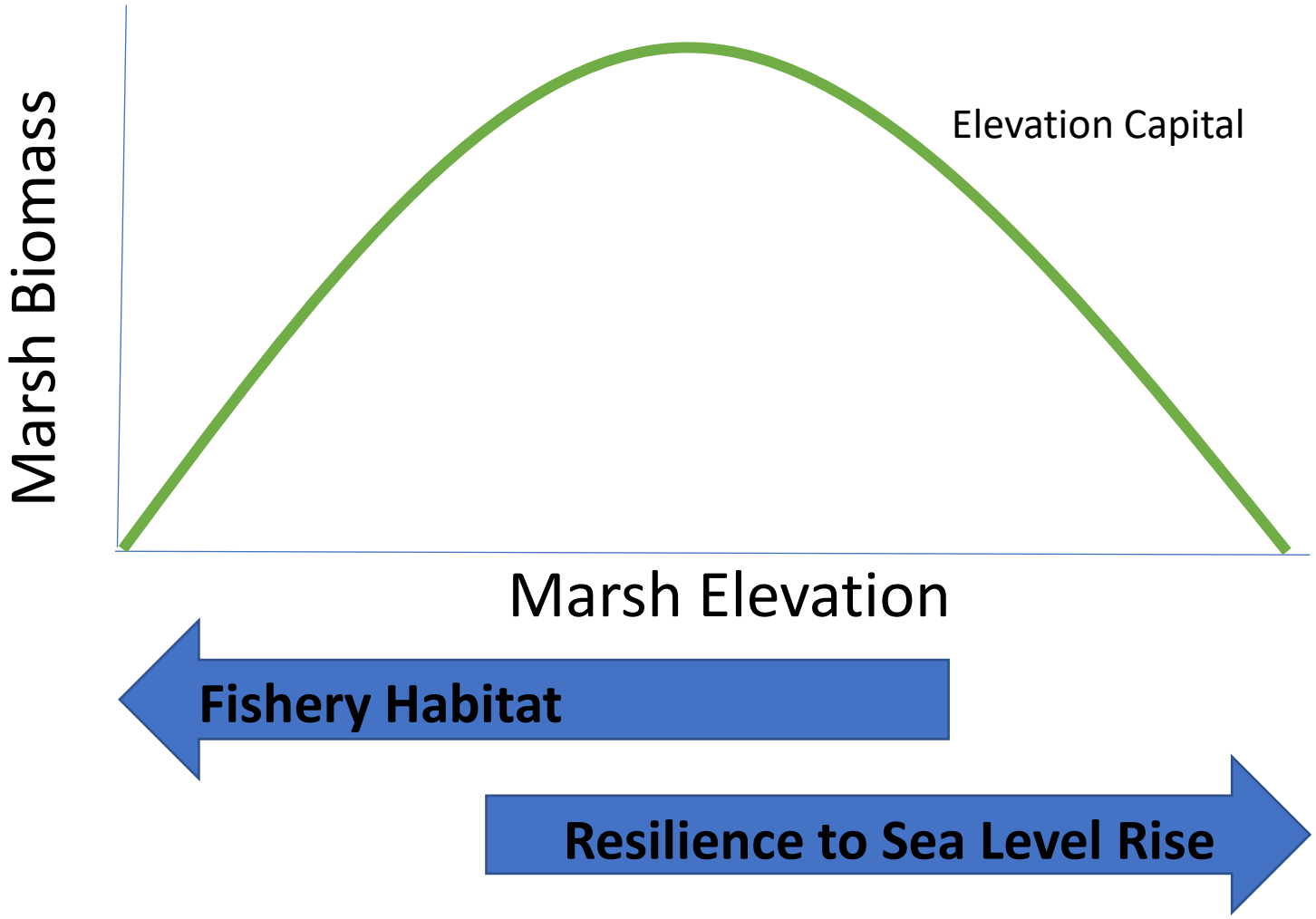
Habitat Tradeoffs and Ecosystem Services

Using Living Shorelines to protect property and Infrastructure



Currin 2019. Living Shorelines for Coastal Resiliency in *Coastal Wetlands: An Integrated Assessment.* Elsevier

How to balance Resiliency and Ecosystem Services?



-SLR, wave energy, erosion, droughts, storms and built infrastructure will increase

-Conservation and restoration will need to plan for FUTURE conditions