Are we designing functional and resilient coasts?

The socio-ecological consequences of shoreline hardening

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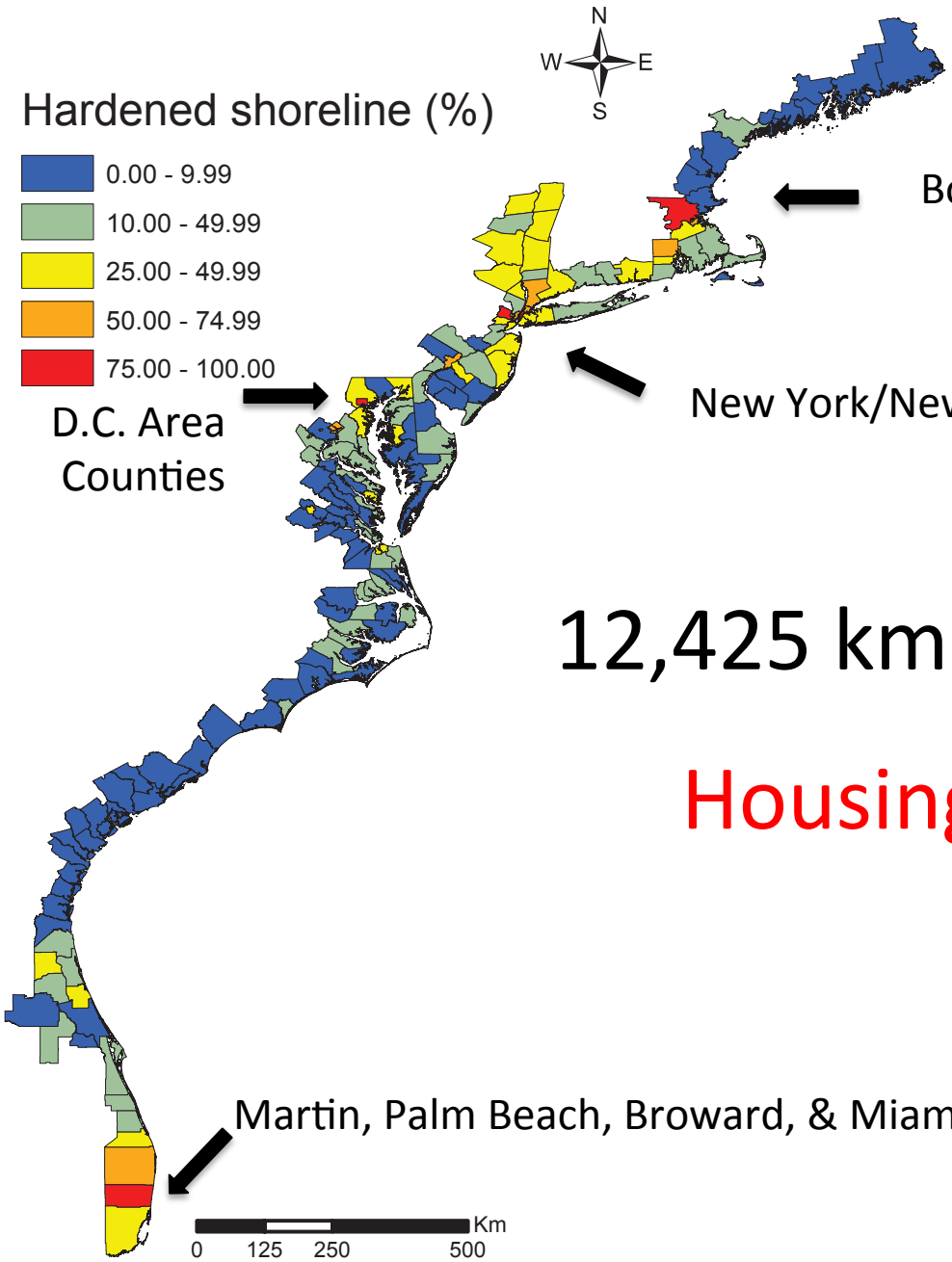
December 7, 2016

Shoreline Hardening

How much of the US coastline is hardened?

Atlantic Sheltered Coast



Boston Area Counties

New York/New Jersey Counties

D.C. Area Counties

Martin, Palm Beach, Broward, & Miami-Dade Counties, FL

12,425 km (13%) hardened

Housing density

Gittman et al. 2015. *Frontiers in Ecology and the Environment*

14% (22,000 km) hardened

Do hardened shorelines provide functional habitat?

Seawalls/Bulkheads Riprap revetments Breakwaters

Meta-analysis methods

Metric	Structure Type	No. Studies	No. Responses
Biodiversity	Seawall	11	20
	Riprap	8	14
	Breakwater	5	11
Abundance	Seawall	22	67
	Riprap	7	22
	Breakwater	8	36

Nekton

Flora

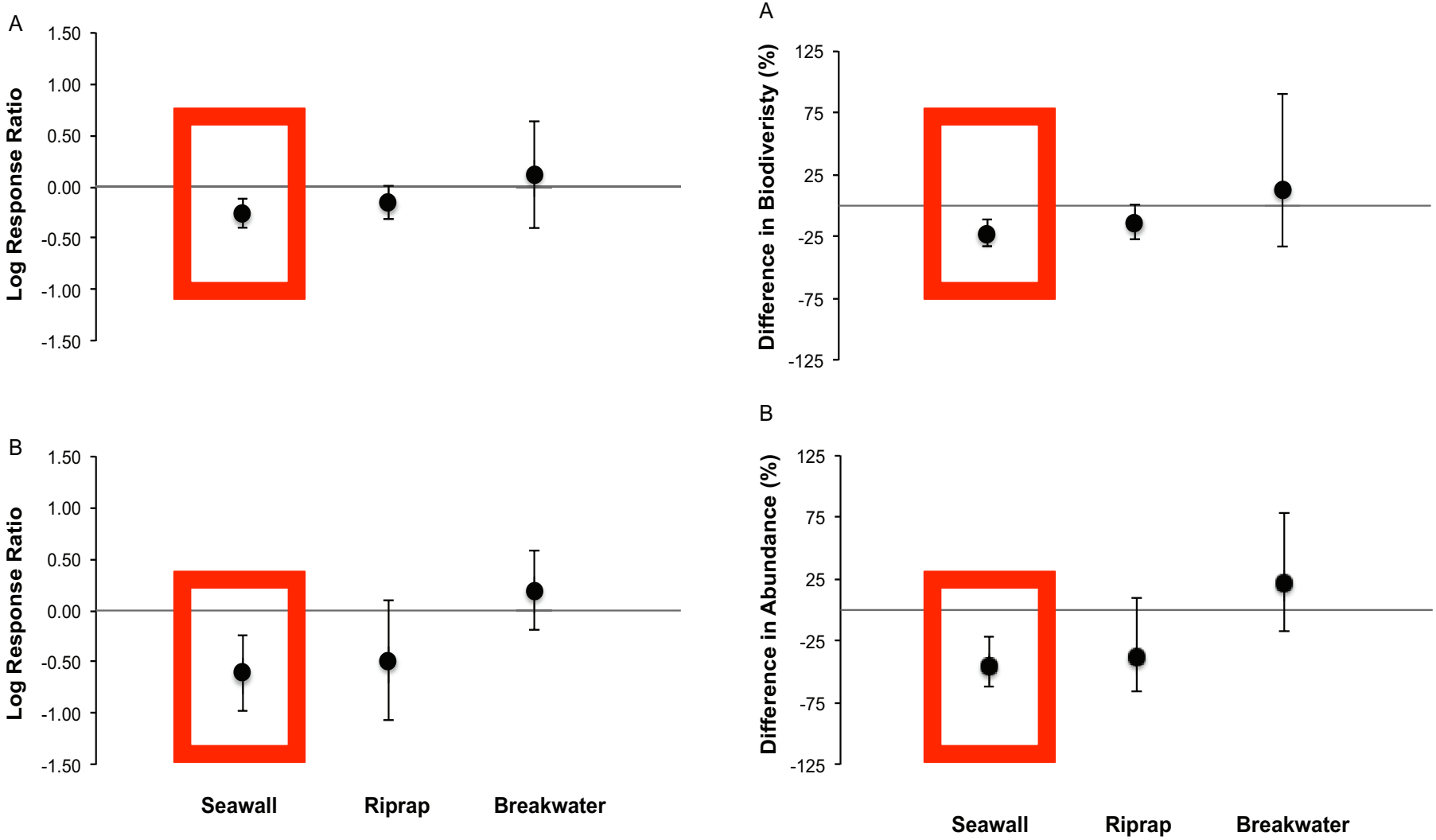
Epibiota

Birds

Benthic infauna

Gittman et al. 2016 *BioScience*

Shoreline hardening effects



Gittman et al. 2016 *BioScience*

Affected flora and fauna

- Benthic infauna (e.g., Seitz et al. 2006):
  - Polychaetes, amphipods
  - Clam (*Macoma balthica*)

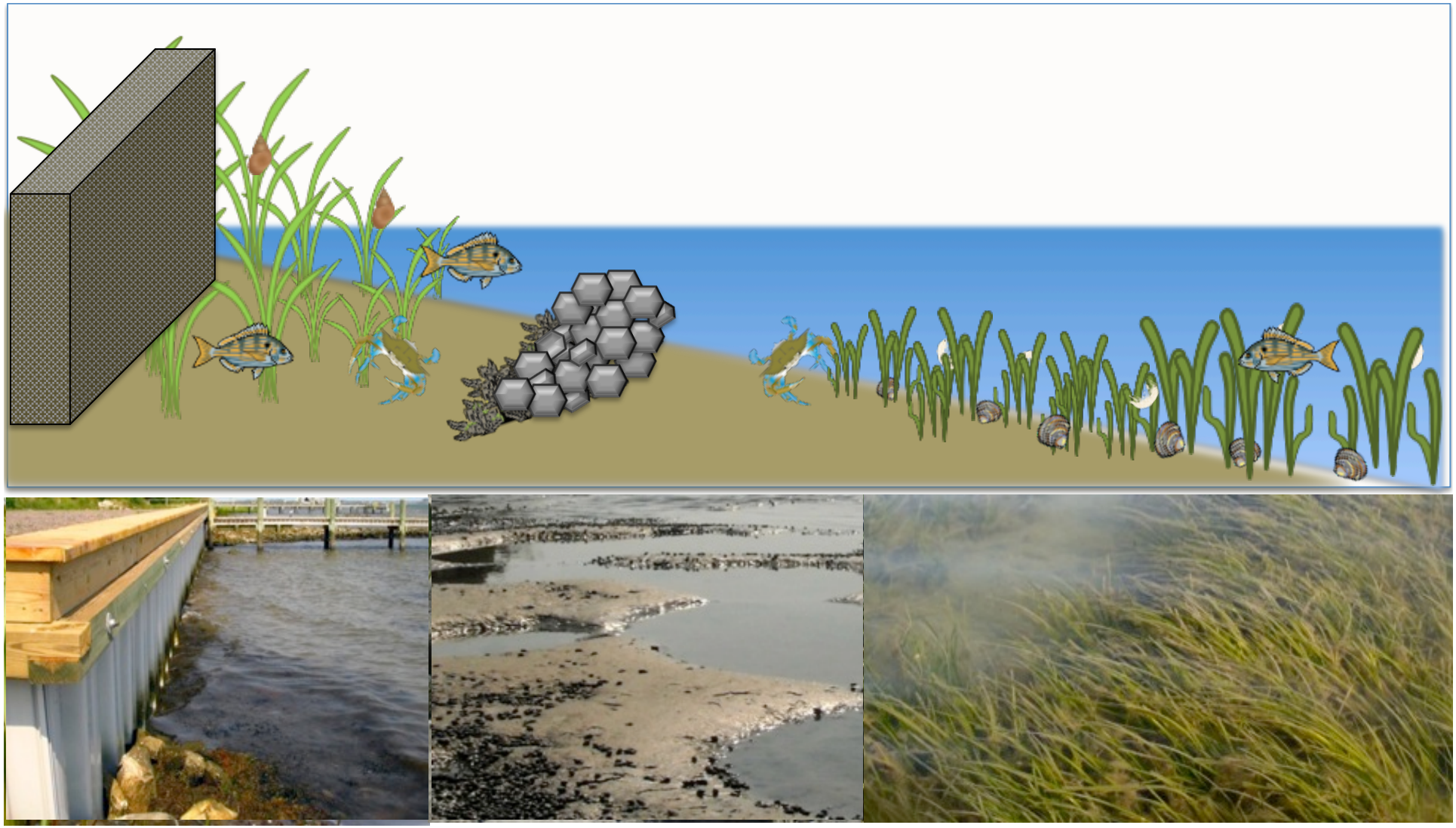
- Shore birds (e.g., Dugan et al. 2006, 2008):
  - Spotted sandpiper (*Actitis macularius*)
  - Sanderling (*Calidris alba*)
  - Willet (*Tringa semipalmata*)
  - Killdeer (*Charadrius vociferus*)

- Nekton (Peterson et al. 2000, Gittman et al. 2016, Seitz et al. 2006)
  - Blue crabs (*Callinectes sapidus*)
  - Mummichogs (*Fundulus heteroclitus*)
  - Penaeid shrimp
  - Spot (*Leiostomus xanthurus*)

How do we integrate ecology and engineering?

Living shorelines

"A living shoreline incorporates vegetation or other 'soft' elements alone or in combination with some type of harder shoreline structure (e.g. oyster reefs or rock sills) for added stability. Living shorelines maintain continuity of the natural land - water continuum and reduce erosion while providing habitat value and enhancing coastal resiliency. (NOAA 2015).



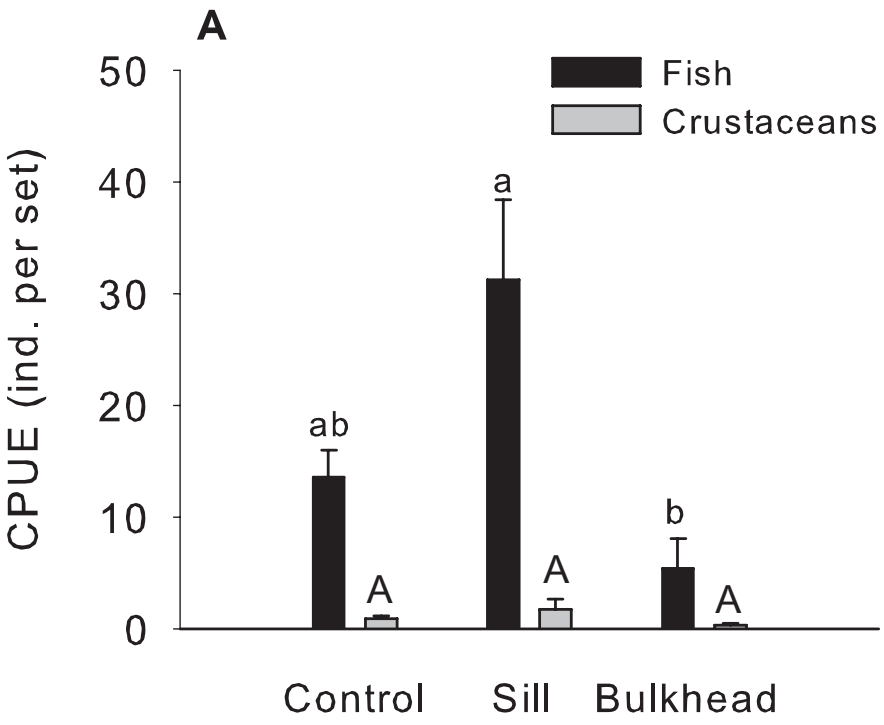
How does the habitat provided by living shorelines compare to the habitat provided by natural shorelines or seawall/bulkhead shorelines?

Living Shoreline Habitat Function

Gittman et al. 2016 *Ecological Applications*

Bulkheads vs. Living Shorelines

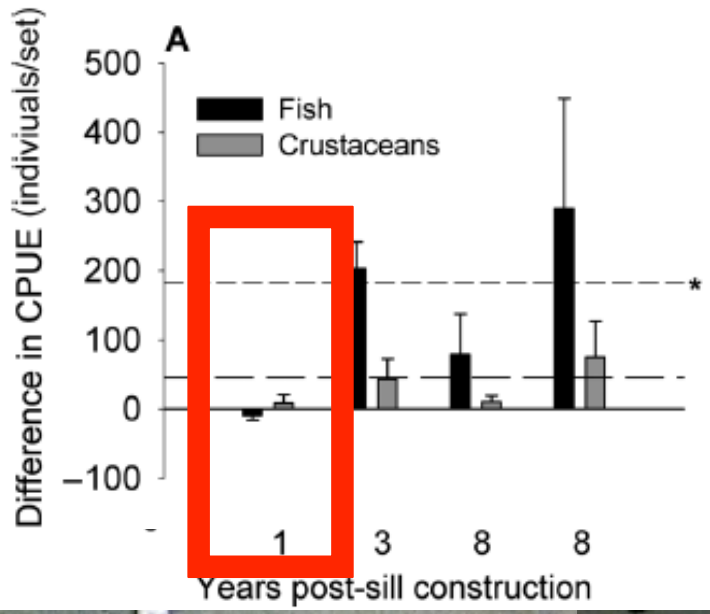
Unvegetated edge

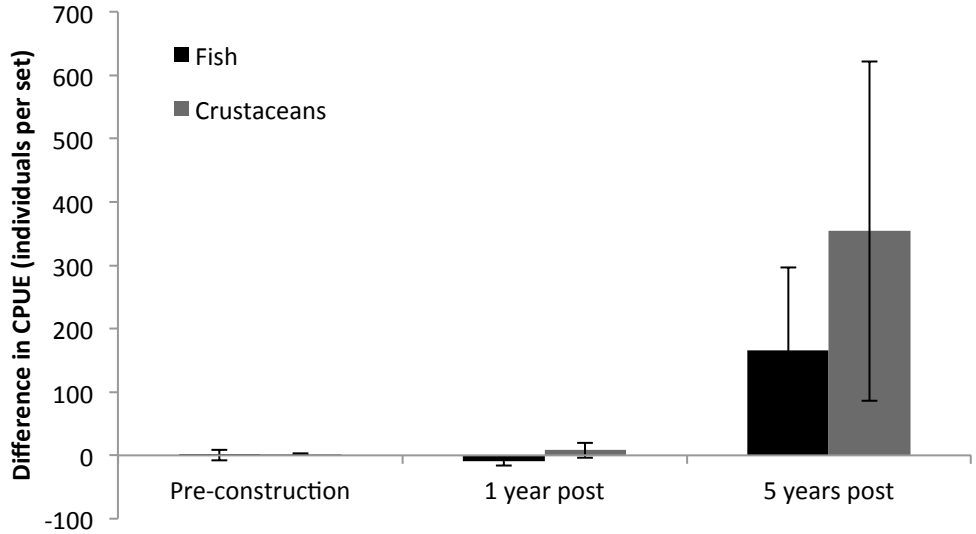


Control Sill Bulkhead

Gittman et al. 2016 *Ecological Applications*

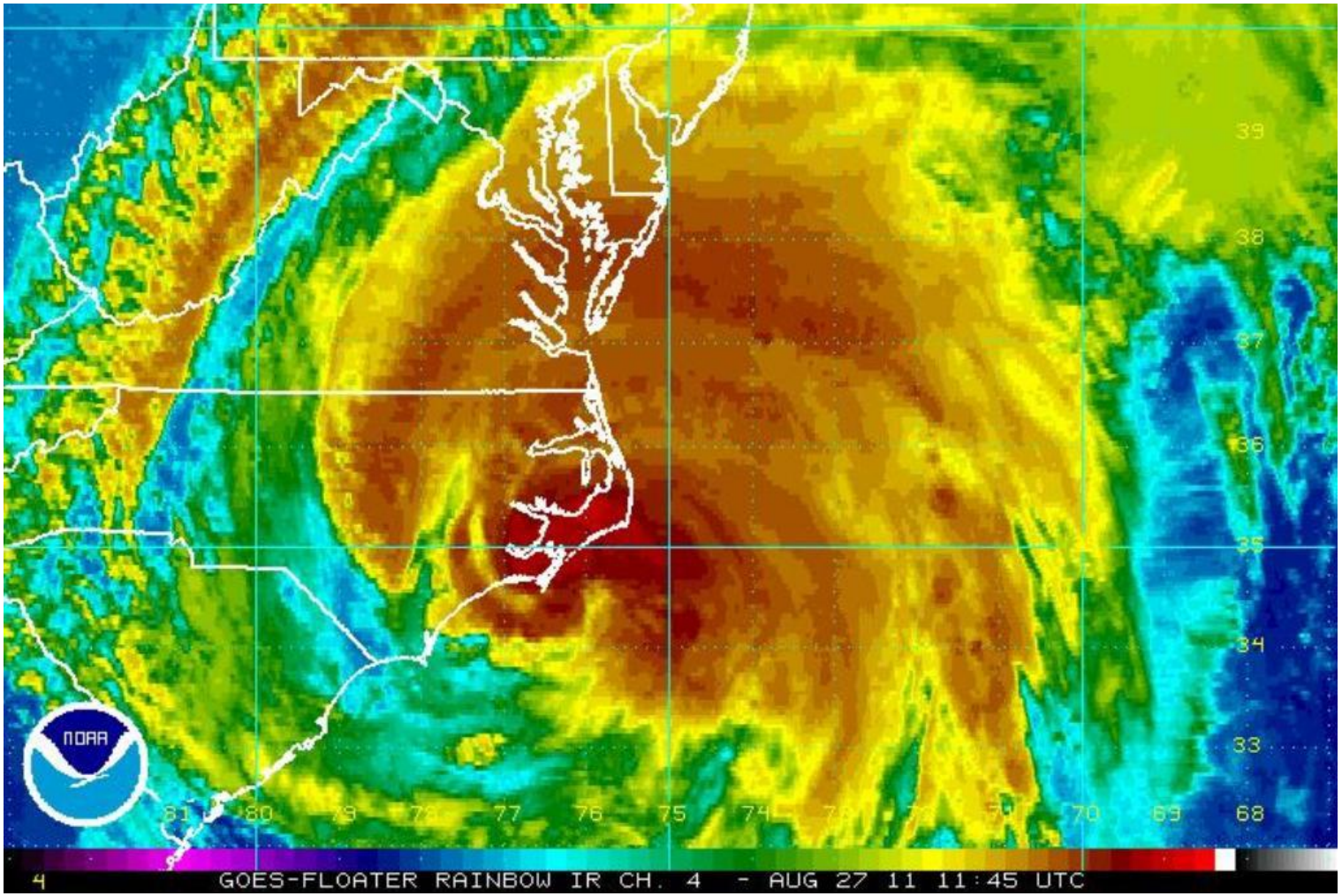
Living shoreline habitat development





Smith, Gittman et al. *In prep*

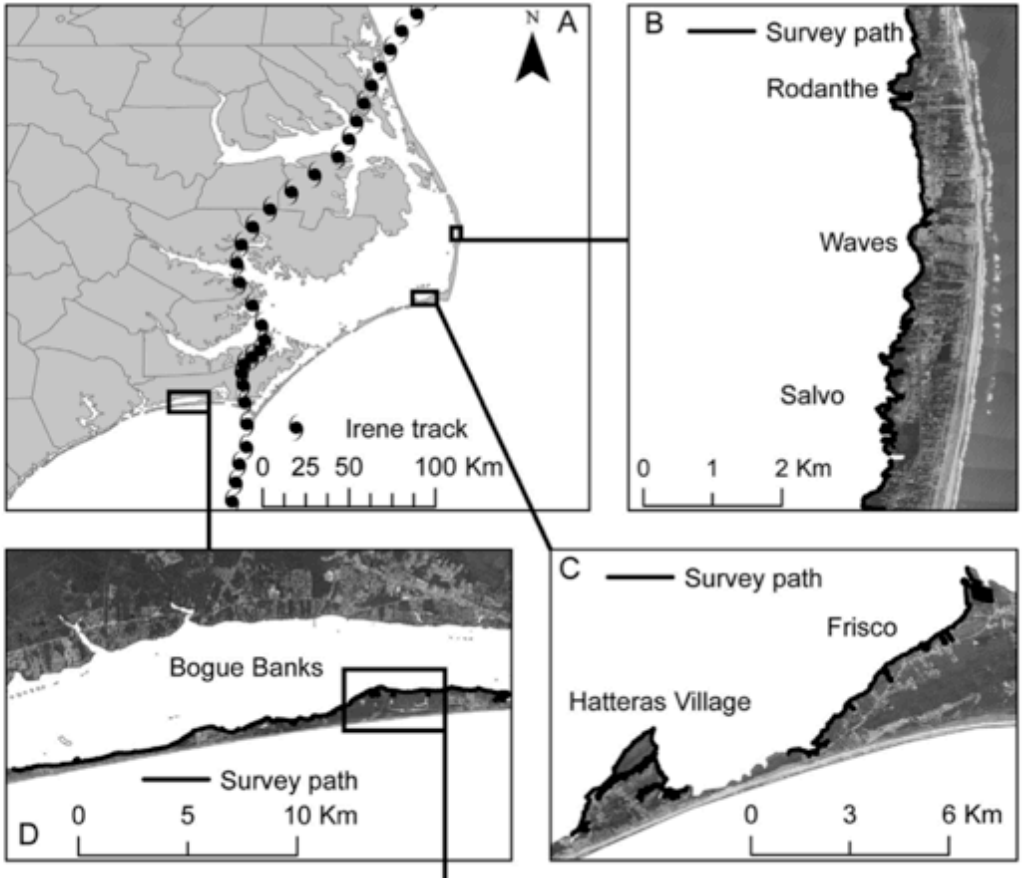
Ecosystem Engineering & Coastal Resilience

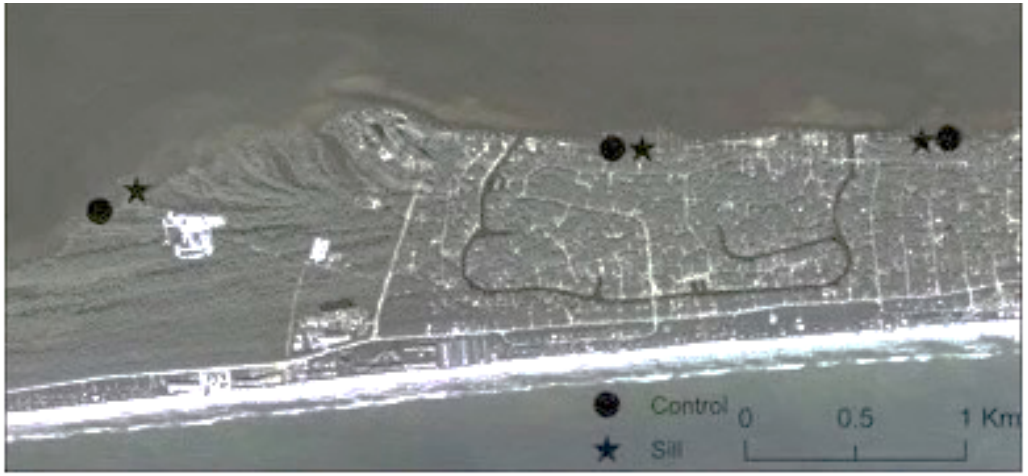


Hurricane Irene
August 2011

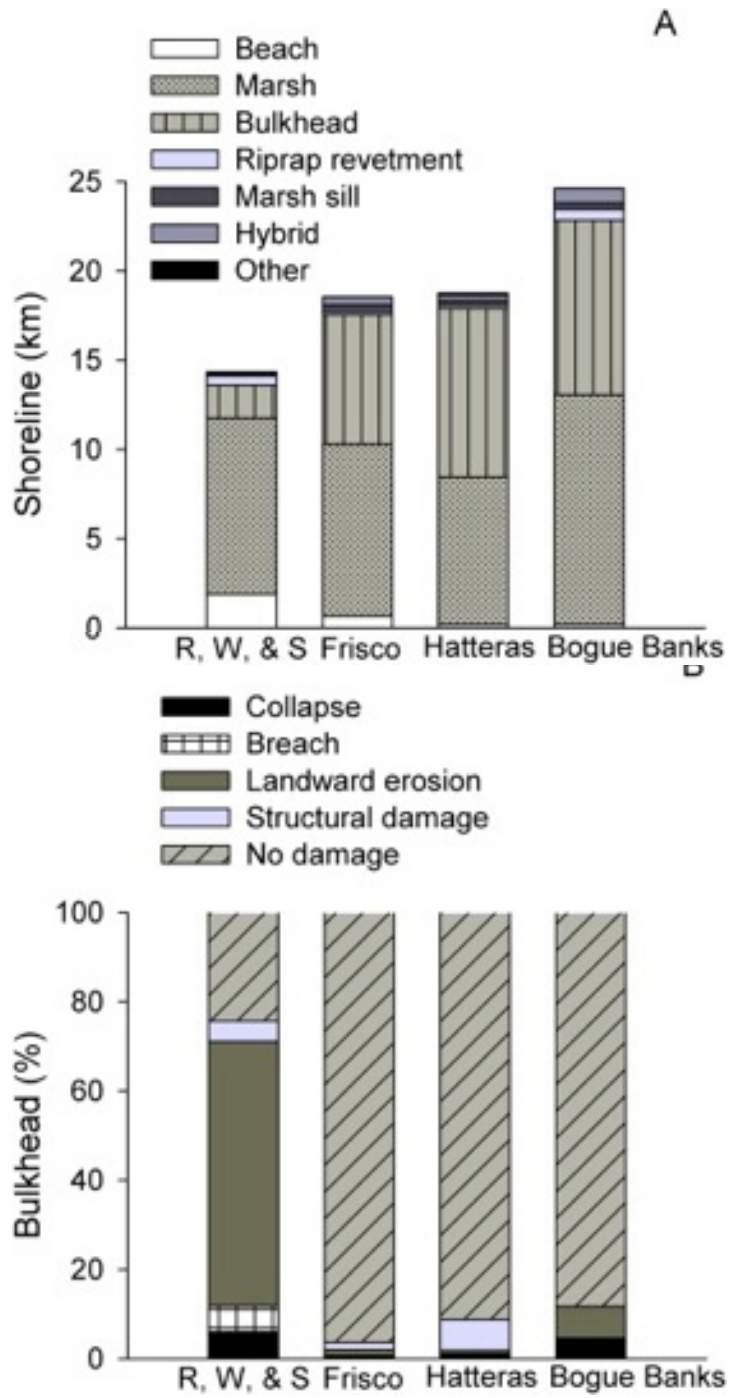
NOAA 2011

Survey methods



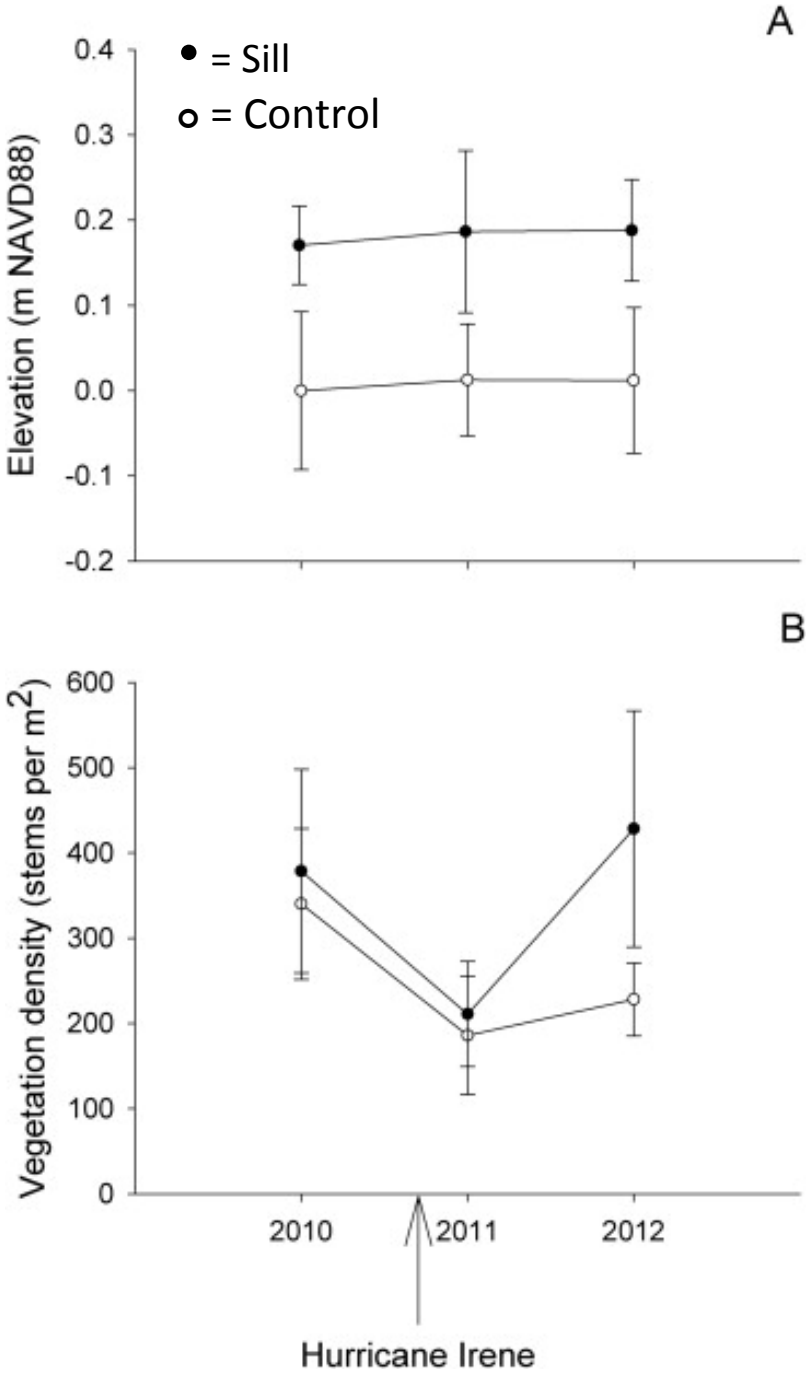


Post-hurricane survey results



Gittman et al. 2014. *Ocean & Coastal Management*

Living shoreline resilience



Gittman et al. 2014 *Ocean & Coastal Management*

Before

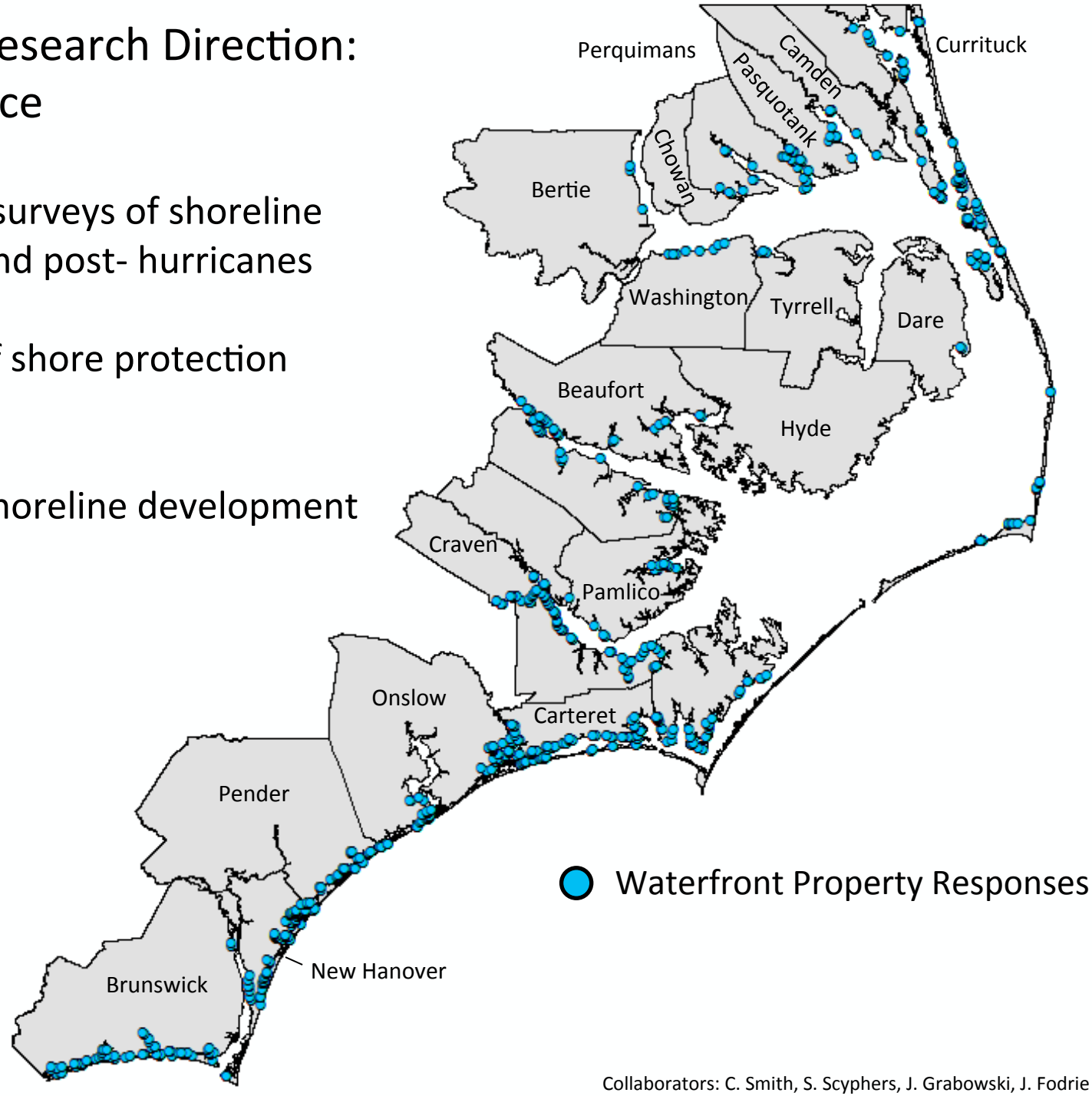
Hurricane Irene (2011)

Before

Hurricane Matthew (2016)

Current/Future Research Direction: Shoreline resilience

- Field and social surveys of shoreline condition pre- and post- hurricanes
- Social surveys of shore protection decisions
- Tracking living shoreline development through time



Collaborators: C. Smith, S. Scyphers, J. Grabowski, J. Fodrie

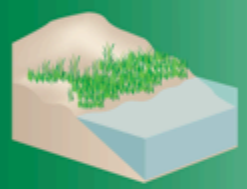
Policy & Management Implications

US Army Corps of Engineers®

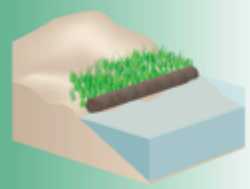
HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GREEN - SOFTER TECHNIQUES → **GRAY - HARDER TECHNIQUES**

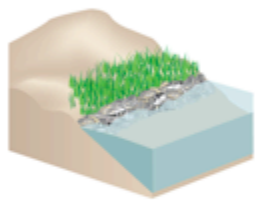
Living Shorelines



VEGETATION ONLY - Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.

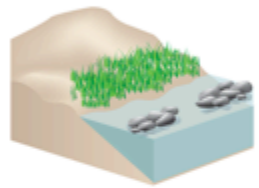


EDGING - Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.

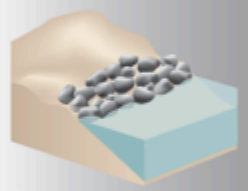


SILLS - Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.

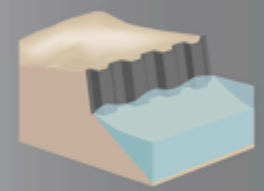
Coastal Structures



BREAKWATER - (vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.



REVETMENT - Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



BULKHEAD - Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

Acknowledgements

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