



Living Shorelines 101

Paul Lanning, RLA

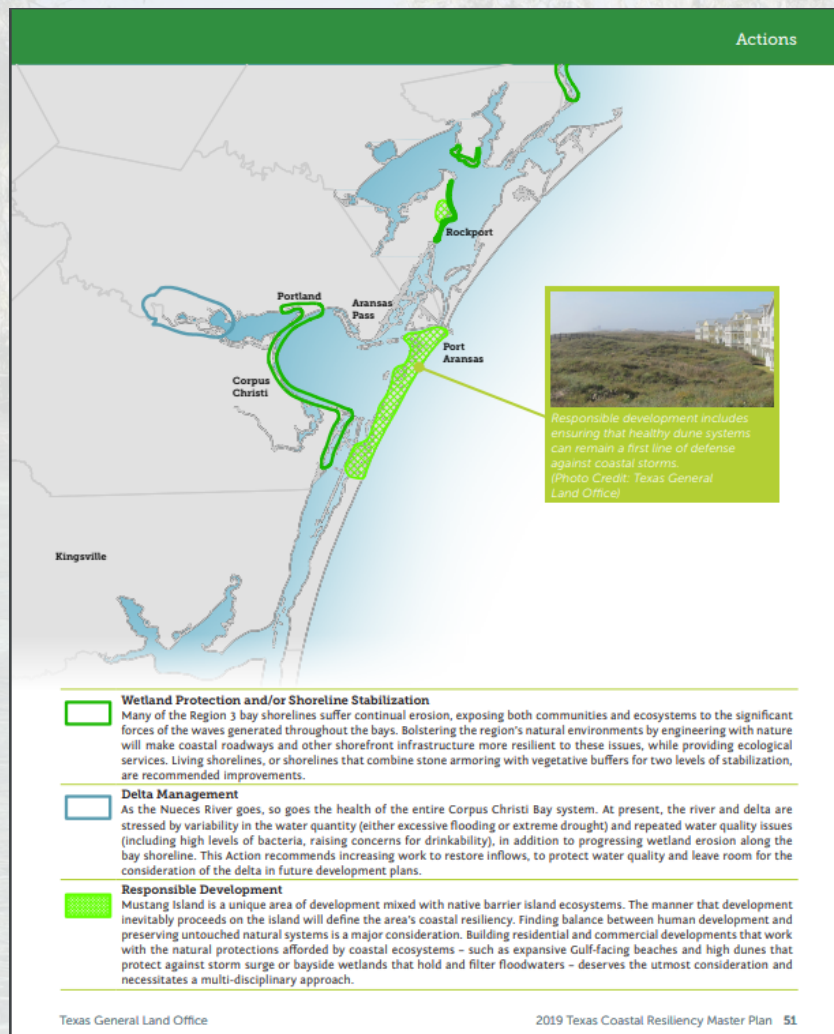
planning@allenes.com

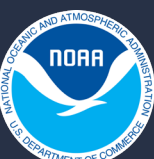
This project is funded, in part, by a Texas Coastal Management Program Grant approved by the Texas Land Commissioner pursuant to National Oceanic and Atmospheric Administration Award No. NA17NOS419139





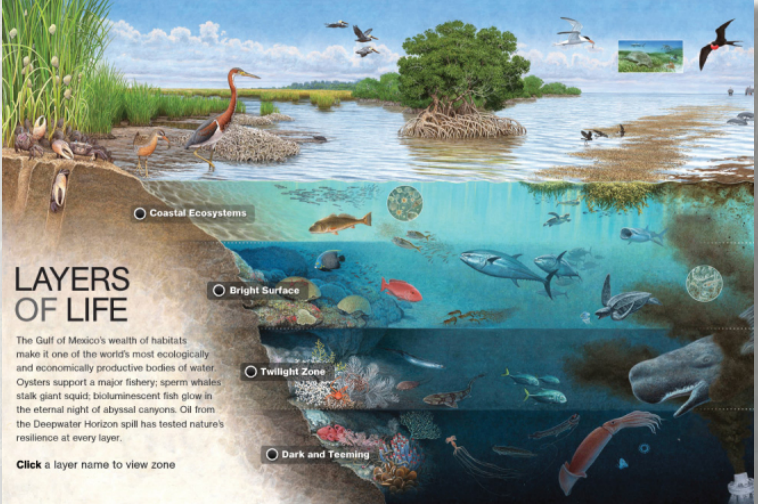
WETLAND PROTECTION AND/OR SHORELINE STABILIZATION





COASTAL ECOSYSTEM BENEFITS

Habitat



Shoreline Stabilization



Tourism, Recreation, Aesthetics

Sediment, Nutrient & Carbon Storage





WE NEED TO WORK TOGETHER TO MAINTAIN A SUSTAINABLE COASTAL ENVIRONMENT DUE TO:

- Increased population growth in coastal regions
- Increased risk of water quality problems
- Loss of beaches
- Loss of marshes/wetlands
- Sea Level Rise
- Subsidence
- Coastal erosion
 - Once beaches and sediment are lost, the cost to rebuild is enormous





COASTAL EROSION



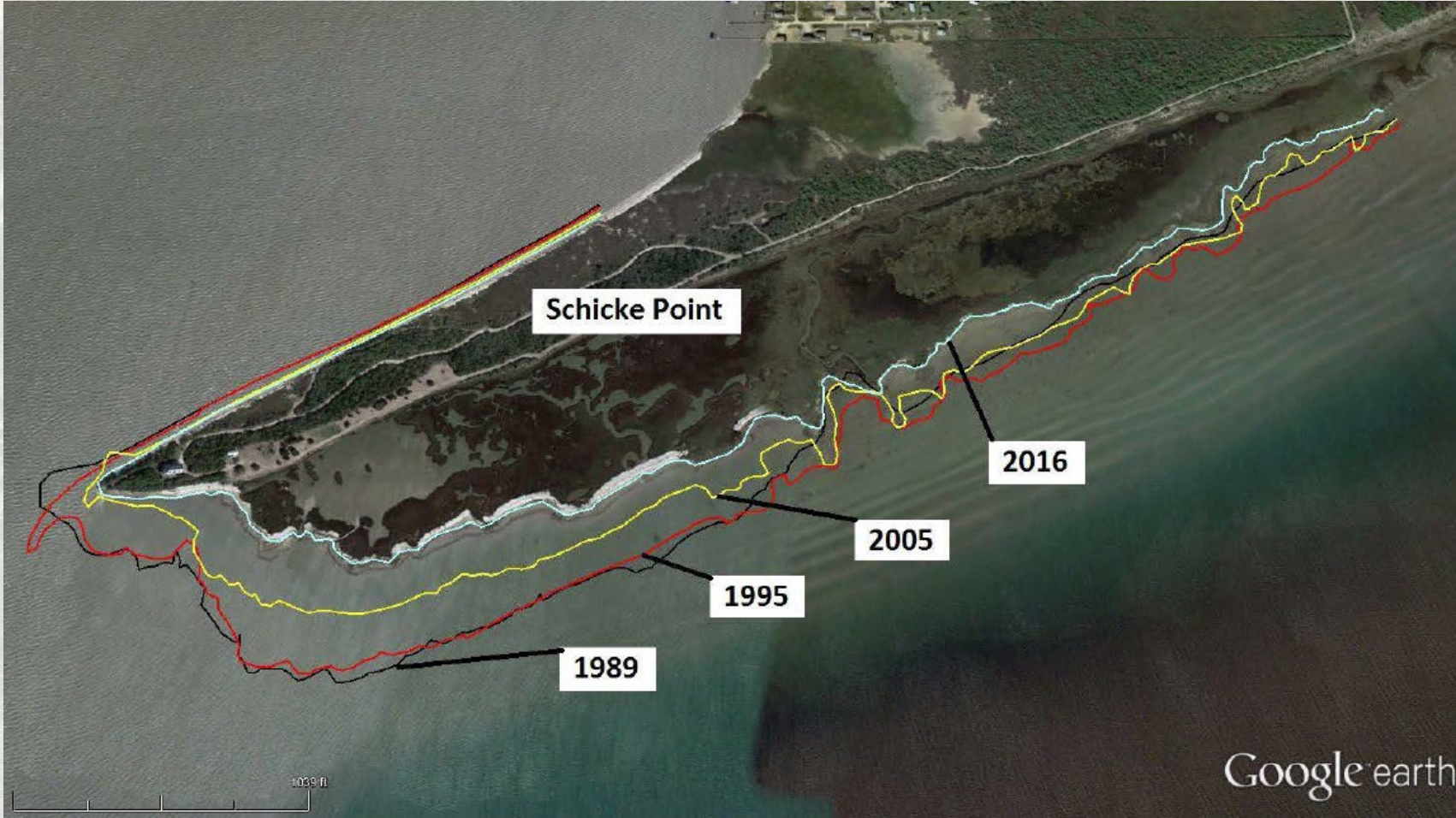
2018

Texas Coastline [Google Earth]





COASTAL EROSION



Schicke Point, Matagorda Bay, Texas [Freese and Nichols]





WHAT FACTORS CREATE EROSION?

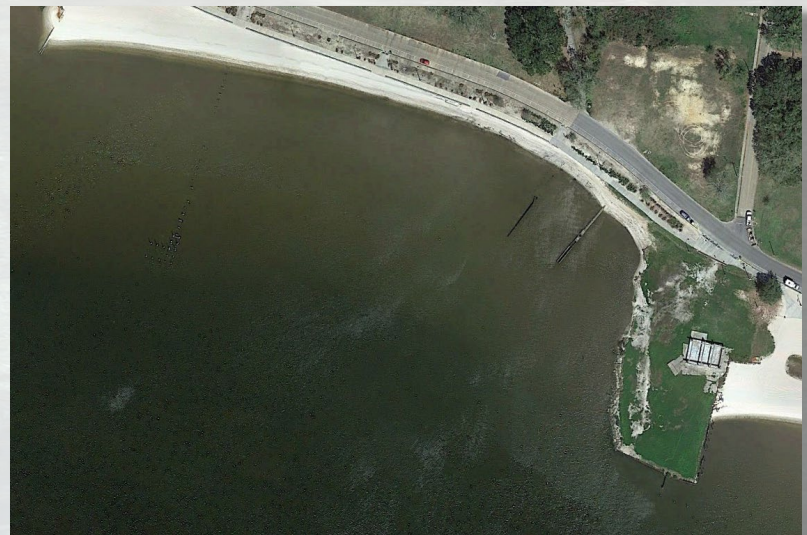
- Wind velocity
- Wave energy and duration
- Fetch (distance that waves can be generated by winds)
- Width and shape of beach/shoreline
- Boat wakes
- Storm water runoff
- Unprotected land on property
- Lack of sediment for longshore transport

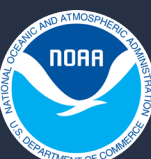




WHAT ARE THE PROBLEMS ASSOCIATED WITH COASTAL EROSION?

- Causes loss of residential and commercial property
- Loss of storm buffering capacity
- Water quality degradation
- Soil loss





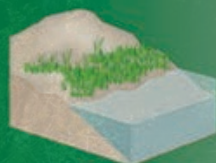
SHORELINE MANAGEMENT

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.



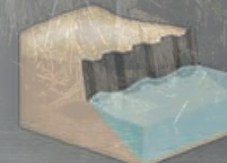
SILLS -
Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.



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.



[Diagram from NOAA Living Shorelines]



DISADVANTAGES OF HARDENED SHORELINES?

- Seawalls can cause erosion to adjacent structures
- Vertical erosion in front of seawall
- Decreased amount of organic matter and biological organisms needed for maintenance of wetlands
- Loss of intertidal habitat (shallow refuge for juvenile fish)
- Need for maintenance after storms
- Loss of beach





WHAT ARE LIVING SHORELINES?

- A “Living Shoreline” is a natural shoreline stabilization approach designed to mimic nature and serve as an alternative to bulkheads, seawalls and other hardened shoreline stabilization methods.
- Living Shorelines utilize natural or recycled materials along with the strategic placement of plants and/or other organic material to reduce erosion and protect property.
- Not a one size fits all solution but a suite of options





BENEFITS OF LIVING SHORELINES

- Reduce wave energy and associated shoreline erosion
- Buffer the effects of storms, especially tropical storms and hurricanes
- Build-up shoreline areas by trapping sediments and stabilizing coastal land.
- Ensure natural sediment movement along shorelines
- Improve water quality in bays and estuaries by filtering pollutants
- Provide for shorelines that are resilient to storms and sea level rise
- Create and connect diverse animal habitats, provide migratory pathways for plants and animals and support valuable fisheries
- Provide recreational opportunities (e.g., fishing and birdwatching)
- Beautify shorelines





LIVING SHORELINES SUPPORT RESILIENT COMMUNITIES

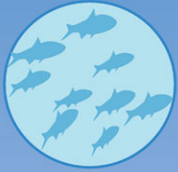
Living shorelines use plants or other natural elements—sometimes in combination with harder shoreline structures—to stabilize estuarine coasts, bays, and tributaries.



One square mile of salt marsh stores the carbon equivalent of **76,000 gal of gas** annually.



Marshes trap sediments from tidal waters, allowing them to **grow in elevation** as sea level rises.



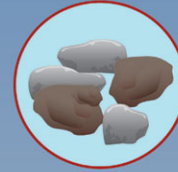
Living shorelines improve **water quality**, provide fisheries **habitat**, increase **biodiversity**, and promote **recreation**.



Marshes and oyster reefs act as natural **barriers** to waves. **15 ft** of marsh can **absorb 50%** of incoming wave energy.



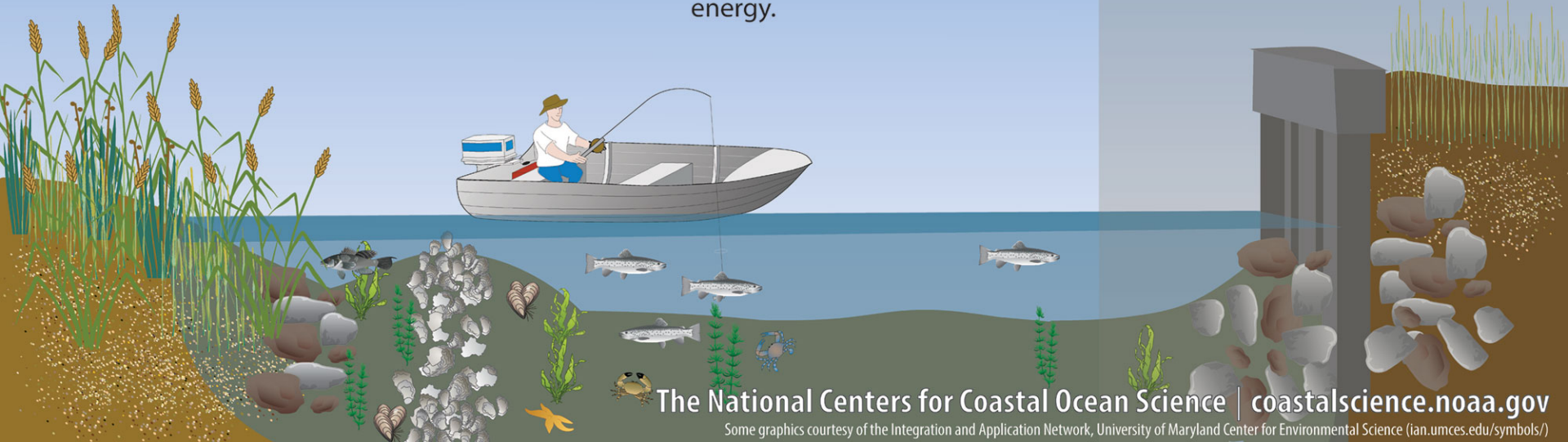
Living shorelines are **more resilient** against storms than bulkheads.



33% of shorelines in the U.S. will be **hardened** by **2100**, decreasing fisheries habitat and biodiversity.

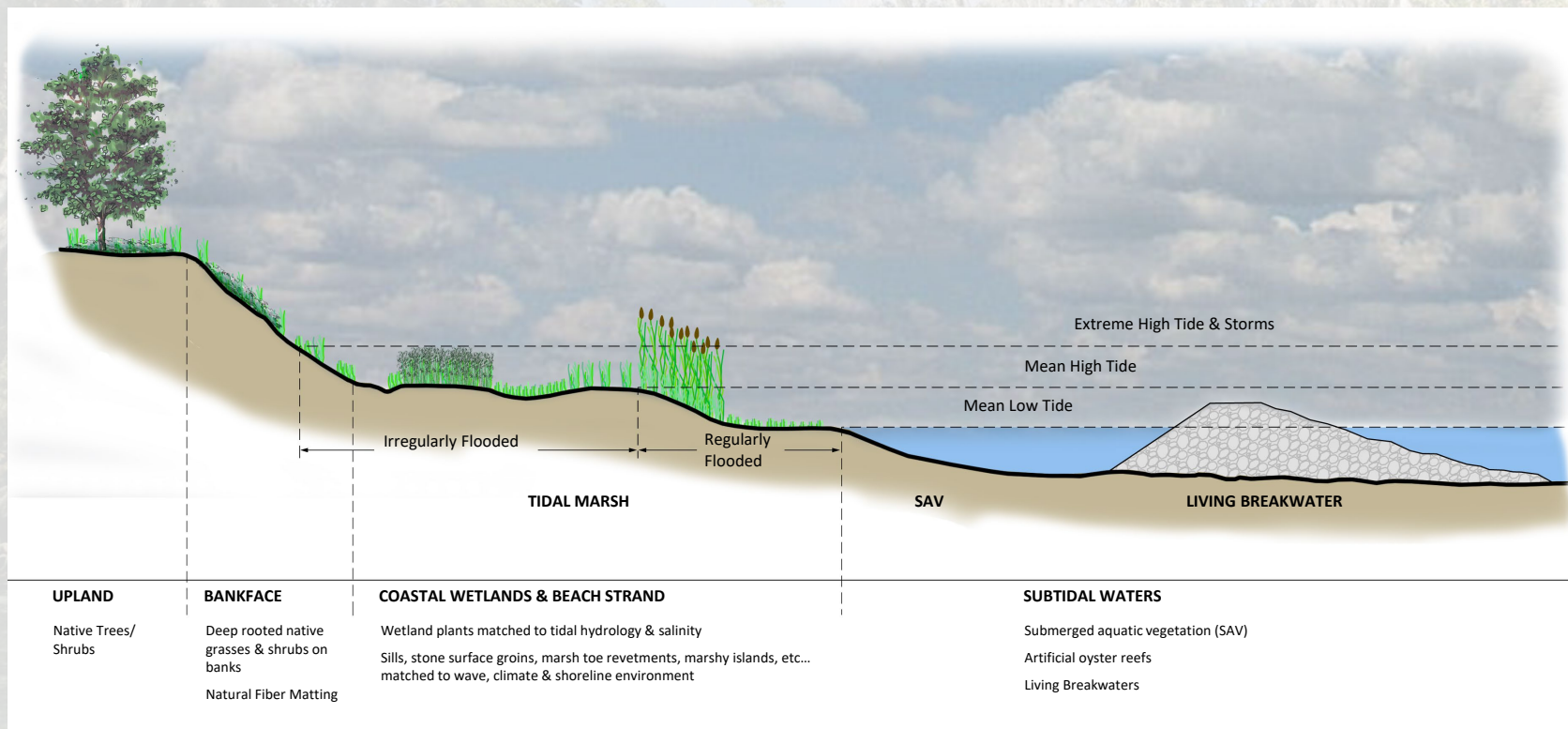


Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create seaward **erosion**.





SHORELINE CROSS-SECTION EXAMPLE



Shoreline Cross-Section [Allen Engineering and Science]





Shoreline Management Options





TYPES OF SHORELINE MANAGEMENT

No Action – Leave shoreline in natural condition; enhance native habitats; reduce risk through land use changes



Texas Coast 2018 [Google Earth]





TYPES OF SHORELINE MANAGEMENT

Vegetative Cover

- Marsh/Wetland Plants
 - Smooth Cordgrass
 - Saltmeadow Cordgrass
 - Black Needlerush
- Dune Plants
 - Sea Oats
 - Coastal Panic Grass

Maintenance: Remove debris, make sure to keep people out of the protected area.



[Florida Living Shorelines]





MARSH/WETLAND PLANT EXAMPLES

- Black Needlerush
(*Juncus roemerianus*)



- Smooth Cordgrass
(*Spartina alterniflora*)





WAVE ATTENUATION BY SMOOTH CORDGRASS (SPARTINA ALTERNIFLORA)

- 50% of wave energy reduced within 5m (16'+/-) of marsh edge; >90% over 20m (65'+/-) of marsh
- Wave energy reduction increases with plant biomass
- Wave energy reduction decreases as inundation depth exceeds canopy height





TYPES OF SHORELINE MANAGEMENT

Marsh Grass Plantings – Native plants introduced at the shoreline to minimize erosion





TYPES OF SHORELINE MANAGEMENT

Dune Restoration



Dune Restoration South Padre Island, Texas [Galveston Bay Foundation]





TYPES OF SHORELINE MANAGEMENT

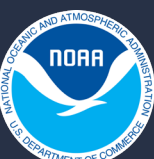
Coir Logs – Anchored natural fiber log with marsh grass planting



*Wrights Landing
St. Johns County, Florida*

Lake Austin, Austin, Texas





TYPES OF SHORELINE MANAGEMENT

Natural Fiber Matting – Stabilize slope and allow for regrowth of vegetation



Delaware Living Shorelines





TYPES OF SHORELINE MANAGEMENT

Oyster balls – Structures designed to create oyster habitat and reduce wave energy



Reef Balls Test Site, Living Shoreline Project, Louisiana [Tetra Tech]

“1 adult oyster can filter up to 50 gallons of water per day”

Indian Riverside Park, Martin County, Florida





TYPES OF SHORELINE MANAGEMENT

Concrete reef balls – Concrete structures used to reduce wave energy and create oyster habitat



Stratford Point, All Habitat Services





TYPES OF SHORELINE MANAGEMENT

Oyster shell/Oyster shell breakwater – Reuse of oyster shells to reduce wave energy



Trinity Center, Pine Knoll Shores, North Carolina Coastal Federation



*Jones Island, North Carolina
Coastal Federation*





TYPES OF SHORELINE MANAGEMENT

Wave Attenuation Devices – Structures used to reduce wave energy and/or build up a beach



Saw Grass Point Marsh

Saw Grass Point Marsh





TYPES OF SHORELINE MANAGEMENT

Wave Attenuation Devices – Structures used to reduce wave energy, build up a beach and/or provide oyster habitat



Oyster Castles
Chincoteague NWR, Virginia





TYPES OF SHORELINE MANAGEMENT



Ecodisk Trays [Reefmaker]



Ecodisk Trays [Reefmaker]





TYPES OF SHORELINE MANAGEMENT



Reef Balls [Reef Ball Foundation, Inc.]



TYPES OF SHORELINE MANAGEMENT



Submerged Oyster Shell Beds, Little Bay, Rockport, Texas [AECOM]





TYPES OF SHORELINE MANAGEMENT

Limestone Breakwater – Structure used to reduce wave energy



Maryland [Kingfisher Environmental Services, Inc.]



Texas General Land Office



Chesapeake Bay Area





LIVING SHORELINE EXAMPLE



Morris Landing, North Carolina





TYPES OF SHORELINE MANAGEMENT

Wooden Sills – Structure used to reduce wave energy



Sheetpile Sill, North Carolina



Dog River Shoreline, Alabama





TYPES OF SHORELINE MANAGEMENT

Sill with Planted Marsh – Low-profile stone structure used to contain sand fill to create a new planted marsh where one does not naturally occur.



VIMS, [K. Duhring]

Allow at least 1-2 weeks of
settlement before planting the
sand fill area

Hybrid Living Shoreline, Delaware





TYPES OF SHORELINE MANAGEMENT

Sill with Planted Marsh - Protect eroding shoreline, restore shoreline wildlife habitat



Hull Springs Farm, Montross, Virginia [Photo: Longwood University]





TYPES OF SHORELINE MANAGEMENT

Marsh Toe Revetment – Freestanding, low-profile structures typically made of stone and placed at the eroding edge of a marsh near the mean low water elevation



Pine Knoll Shores, North Carolina Coastal Federation

Marsh Toe Revetment [Center for Coastal Resources Management]





TYPES OF SHORELINE MANAGEMENT

Breakwater with Transitional Wetland – Similar to Sill, but used in the event of greater water depth, slope of shoreline, higher wave action



North Carolina [North Carolina Coastal Federation]





TYPES OF SHORELINE MANAGEMENT



Great Marsh Island, Jacksonville, Florida [Infrastructure Alternatives, Inc. / Manson Construction Company]





TYPES OF SHORELINE MANAGEMENT



Triton Marine Mattress [JLS Contracting]

2018

Great Marsh Island, Jacksonville, Florida [Google Earth]





TYPES OF SHORELINE MANAGEMENT

Shoreline Revetment – a protective covering on an embankment of earth designed to maintain the slope or to protect it from erosion.



Land and Sea Marine



Land and Sea Marine





TYPES OF SHORELINE MANAGEMENT

Bulkheads

- Vinyl
- Vinyl with toe protection
- Wooden
- Wooden with toe protection

Maintenance: Scour typically occurs, so toe protection might be needed, additional fill and vegetation will need to be installed over time.



L.S.I. Marine Construction





WHICH SHORELINE WOULD YOU WANT?



or





WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

It depends on several factors:

- Landscape setting
- Erosion condition
- Wave climate
- Gradual slope
- Existing erosion buffers
- Willing property owner

Site suitability increases when more than one of these factors is present.

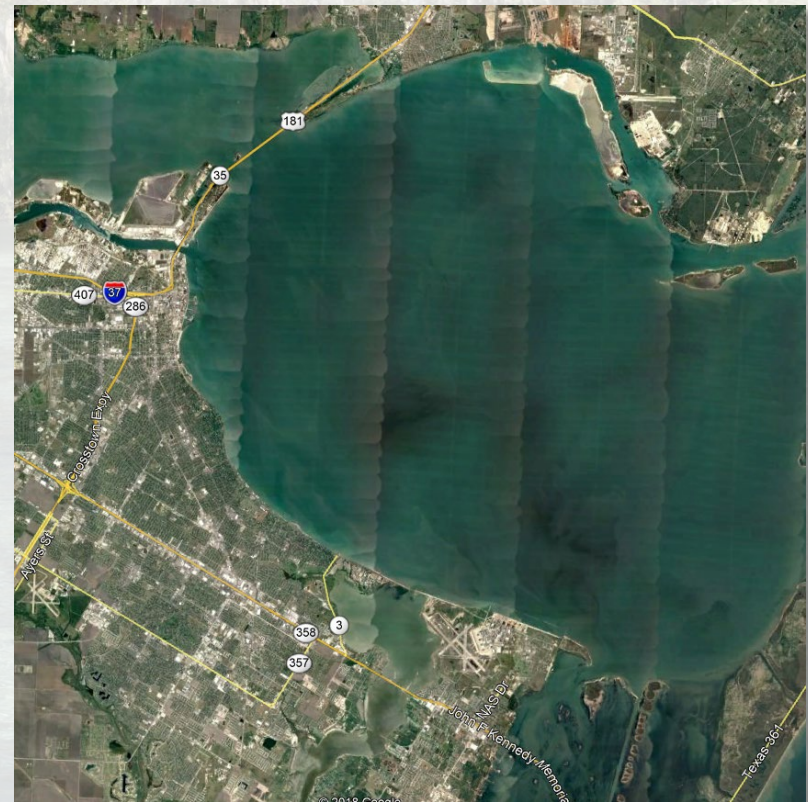




WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Landscape Setting

- Surrounding land and water uses are compatible
 - No upland improvements in close proximity (e.g. road, house, driveway, etc.)
 - No conflicts with navigation interests
- Predictable salinity range & freshwater influence
- Tidal range (small vs. large)
- Shoreline orientation





WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Erosion Condition

- Minor bank erosion and undercutting that needs to be reduced
- Erosion caused by upland runoff, rather than tide and wave action
- Gradual rate of landward retreat
- Minor groundwater flow

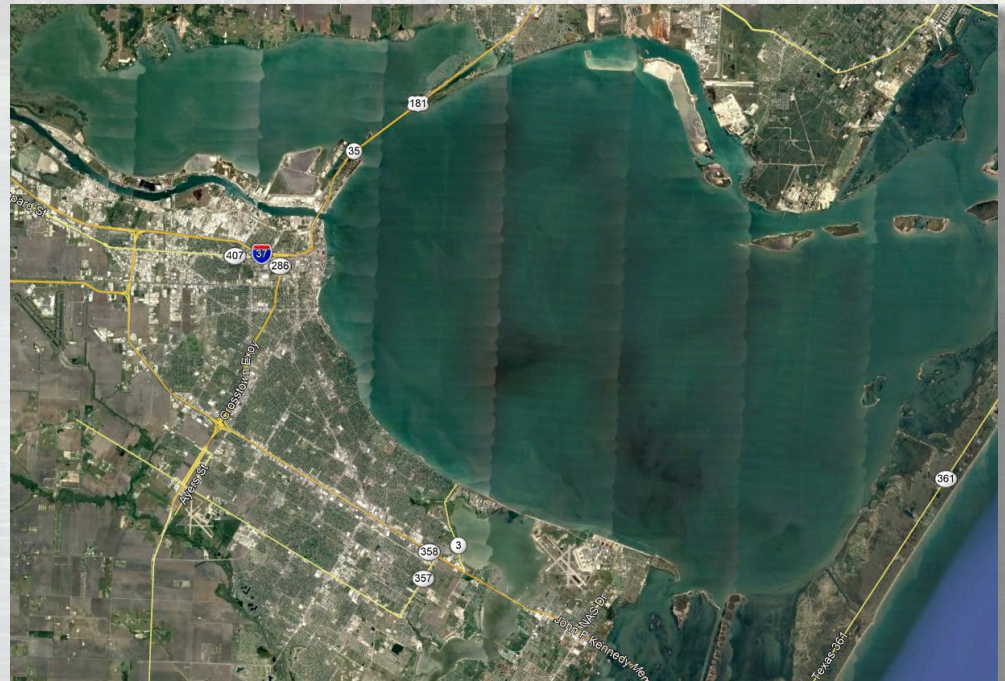




WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Wave Climate

- Low to moderate wave energy
- Regular high tides do not reach the upland bank
- Few boat wakes





WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Gradual Slope

- Bank slopes, not vertical
- Wide and flat intertidal area
- Wide and shallow subaqueous area

A gentle bank slope combined with a wide, flat intertidal area and shallow subaqueous area will dissipate energy and support plant growth.





WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Existing Erosion Buffers

- Riparian Buffer
- Tidal Marsh
- Sand Beach
- Sand Dunes

Existing erosion buffers can be enhanced to increase the level of protection.





WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

Willing Property Owner

- Understands level of protection
- Accepts dynamic shoreline condition
- Tolerates wildlife attracted by habitats
- Willing and able to monitor and maintain





Living Shorelines 101

GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

1. Determine project budget
 - Do you need a phased approach?

Project	Size	Method	Price per Liner foot	Total Price
Clear Lake Forest Park Living Shoreline	750 Linear Feet	Rock Wave break, Newly graded shoreline, wetlands vegetation plantings	\$43.00	\$32,000.00
Shipe Woods Living Shoreline	900 Linear Feet	Rock Breakwater	\$38.00	\$34,000.00
Oyster Lake Living Shoreline	5,200 Linear Feet	Reef Dome Breakwaters	\$33.00	\$170,000.00
East Galveston Bay Living Shoreline – Phase 3	3,000 Linear Feet	Offshore Breakwater	\$31.00	\$91,000.00
East Galveston Bay Living Shoreline – Phase 2	1,900 Linear Feet	Breakwater Fence (removed once vegetation established)	\$6.00	\$11,000.00
East Galveston Bay Living Shoreline	2,000 Linear Feet	Offshore Breakwater	\$20.00	\$39,000.00
Sportsman Road Living Shoreline – Phase 3	1,035 Linear Feet	Reef Ball Breakwater	\$25.00	\$25,000.00
Sweetwater Living Shoreline and Marsh Restoration – Phase 2	500 Linear Feet	Reef Ball Breakwater	\$30.00	\$15,000.00





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

2. Set project goals

- Erosion Prevention
- Water Quality Improvement
- Fish Production
- Habitat Diversity
- Recreational Benefits





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

3. Work/Consult with professionals
 - Coastal Engineers, Landscape Architects, Coastal Biologists, University and Agency Staff, other experts
4. Identify project location and existing shoreline type
 - Natural or Hardened Shoreline
 - Slope
 - Erosion Rates
 - Wave Energy
 - Water Depth
 - Salinity
 - Fetch
 - Longshore Sediment Transport



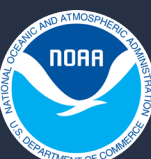


GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

5. Determine which Best Management Practices meets your goals

Practice and Ecosystem Benefits ^{5, 6, 7}					
General Practices	Erosion Prevention	Water Quality Improvement	Fish Production	Habitat Diversity	Recreational Benefits
Marsh Plantings	Reduces wave energy, holds soil and traps sediments in grasses.	Filters runoff, improving quality of water.	Protection and habitat for juvenile fish and feeding areas for adult fish.	Provides food and protection for finfish, shellfish, mammals, and shorebirds.	Not for public use; piers must be elevated.
Coir Logs	Reduces wave energy, holds soil and traps sediments in grasses.			When used in conjunction with marsh grass and other plantings, provides food and protection for finfish, shellfish, mammals, and shorebirds.	Not for public use.
Beach Renourishment	Reduces wave energy, holds soil and traps sediments more effectively than plantings alone.			Reduces habitat diversity by covering existing plants and other organisms with sand. Also increases sediment in breeding grounds which can smother plants and fish eggs.	Provides opportunity for public access to swimmers and boaters.
Oyster Reefs/Balls	Replenishes eroded shorelines and minimizes loss of private property. Reduces wave energy and inland damage from coastal storms.			Provides habitat for shrimp, crabs, clams, snails, worms, and finfish.	In open season, oysters, fish, and crab can be harvested from the reefs located in approved waters. Over-harvesting could eliminate the benefits of this strategy.
Sills with Plantings/Hybrids	Replenishes eroded shorelines and minimizes loss of private property. Reduces wave energy and inland damage from coastal storms.			New marsh may attract a greater diversity of aquatic species, plants and migrant birds. Rocks or recycled material are good habitat for aquatic species, especially oysters. Sill can encourage growth of subaquatic vegetation.	Dry beach habitat is replaced by a marsh sill system. Docks may need to extend longer to reach open water. Recreation marshes attract migrating birds, increasing bird-watching opportunities.
Breakwaters	Spreads out wave energy, but reflects waves that may cause scour or erosion of adjacent shorelines. Also accumulates/blocks sediment that should nourish downstream properties.	No effect.	Barnacles and oysters often settle on breakwaters, providing foraging areas for fish, however the "beach" that is formed from accumulating sediment reduces fish habitat.	Depending on wave energy, can create shellfish and finfish habitat. Can also create conditions for subaquatic vegetation if water depth (amount of light) and sediment content is appropriate. Placement of extra sand on some beaches can impact habitat of protected turtle species.	Construction of breakwater leads to the creation of a new beach, where sediment accumulates.
Bulkhead	Properly built bulkheads provide protection from waves in extreme conditions, but because wave energy is reflected rather than absorbed, reflected waves may cause bottom scour and loss of shoreline vegetation.	If bulkhead base is in the intertidal zone, property owners may plant vegetation to filter and improve water quality, but if vegetation is removed to construct bulkhead on the shoreline, it will lead to a decrease in water quality.	Minimizes or eliminates the marsh/wetlands, reducing habitat and food for fish.	Stops the creation of wetlands. Loss of habitat and connection between terrestrial and aquatic habitats.	Easy access to deeper water.





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

6. Match your Shoreline to Best Management Practice

Shoreline Practices with Pros, Cons and Best Use Areas			
Practice	Pros	Cons	Best Used in Areas with:
Bulkheads	<ul style="list-style-type: none">• Protection from waves in extreme conditions	<ul style="list-style-type: none">• Prone to failure due to upland water pressure and increased erosion on the water side• Loss of filtering ability of vegetation results in decreased water quality• Prevent natural migration of wetlands, shorelines, vegetation• Wave reflection causes increased erosion at base• Eliminates sand transport along the shoreline• Increases erosion of adjacent shorelines• Eliminates aquatic nursery habitat	<ul style="list-style-type: none">• High wave energy• Limited land availability• Narrow canals with steep banks• Structures at risk due to close proximity to shoreline erosion
Revetments	<ul style="list-style-type: none">• Wave reflection less than bulkheads• Low maintenance	<ul style="list-style-type: none">• Installation requires heavy machinery• Expensive	<ul style="list-style-type: none">• High wave energy and no existing marsh
Upland Vegetation - Trees, Shrubs, Grasses and Grass Roots		<ul style="list-style-type: none">• Soil stabilization in upland zone• Stormwater runoff filtration	
Wetland Vegetation - Marsh Grasses		<ul style="list-style-type: none">• Improves finfish and shellfish habitat• Stabilizes soil• Traps sediment• Improves water quality by filtering runoff	
Natural Fiber Logs with Vegetation		<ul style="list-style-type: none">• Low impact• Biodegradable• Traps and retains sediment• Promotes plant growth• Inexpensive and easy to install• Flexible and easy to mold to shape of shoreline	
Natural Fiber Matting with Vegetation		<ul style="list-style-type: none">• Can be used for moderate slopes• Low cost	<ul style="list-style-type: none">• Biodegradable• Traps and retains sediment
Living Breakwaters		<ul style="list-style-type: none">• Wave attenuation• Improved water quality• Increased oyster habitat• Creates a calm area near shoreline that can be planted with vegetation for improved marsh habitat	
Marsh Toe Revetment (Existing Marsh)	<ul style="list-style-type: none">• Maintains land-water interface• Can promote oyster growth• Long lifespan	<ul style="list-style-type: none">• Reduces access to water• Revetment may cover existing habitat	<ul style="list-style-type: none">• Tidal bays
Breakwaters with Transitional Wetlands	<ul style="list-style-type: none">• Stabilization of eroding marsh• Can promote oyster growth• Long lifespan	<ul style="list-style-type: none">• Navigational hazard if not adjacent to shoreline• Expensive	<ul style="list-style-type: none">• Shallow water near marsh edge with firm soil• Low to moderate energy areas where structure is necessary to protect plants• Marsh edge erosion
	<ul style="list-style-type: none">• Absorb waves and create a calm area behind the sill to promote habitat and vegetation growth• Traps sediment, maintains natural shoreline• Maximizes land-water interface• Filters runoff to improve water quality• Provides nursery habitat for juvenile fish		<ul style="list-style-type: none">• Where a structure more substantial than a sill is necessary, due to water depth, underwater slope or high wave action





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

7. Develop timeline
 - Plan for Permitting
 - Plan for Agency/Municipal/USACE Review
 - Plan for Optimal Planting Times
8. Identify project partner(s), (if applicable)
 - Federal
 - State
 - Local
 - Non-Profit Organizations
 - Homeowner's Association
9. Determine permitting requirements
10. Funding for the Project





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

11. Project design and monitoring plan

- Site Inventory and Analysis
 - Focused on coastal erosion factors
- Acquire a survey (if needed)
- Conceptual drawings
- Engineering drawings/cross-sections
- Develop monitoring plan (if needed)

12. Permitting

- Create and submit permit drawings
- Get all approvals/permits

13. Construction





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

14. Post construction monitoring (Not required in most cases)

- Monitoring Methodology
 - What is the success criteria?
- Sampling methods
 - Number, size, location, analytical tools, mapping using GIS
- Monitoring Schedule
 - Growing seasons for vegetation, Tidal or hydrology cycle to assess performance at different times and intervals
- Photos
 - Ground and/or aerial photos taken from the same place (reference)





GENERAL STEPS TO IMPLEMENT A LIVING SHORELINE PROJECT

15. Adaptive management

- Procedures in place to modify the project design in the event the project does not meet the success criteria
- Potential problems include
 - Loss of physical structures from storms
 - Invasive vegetation
 - Hydrological conditions (too wet/too dry)





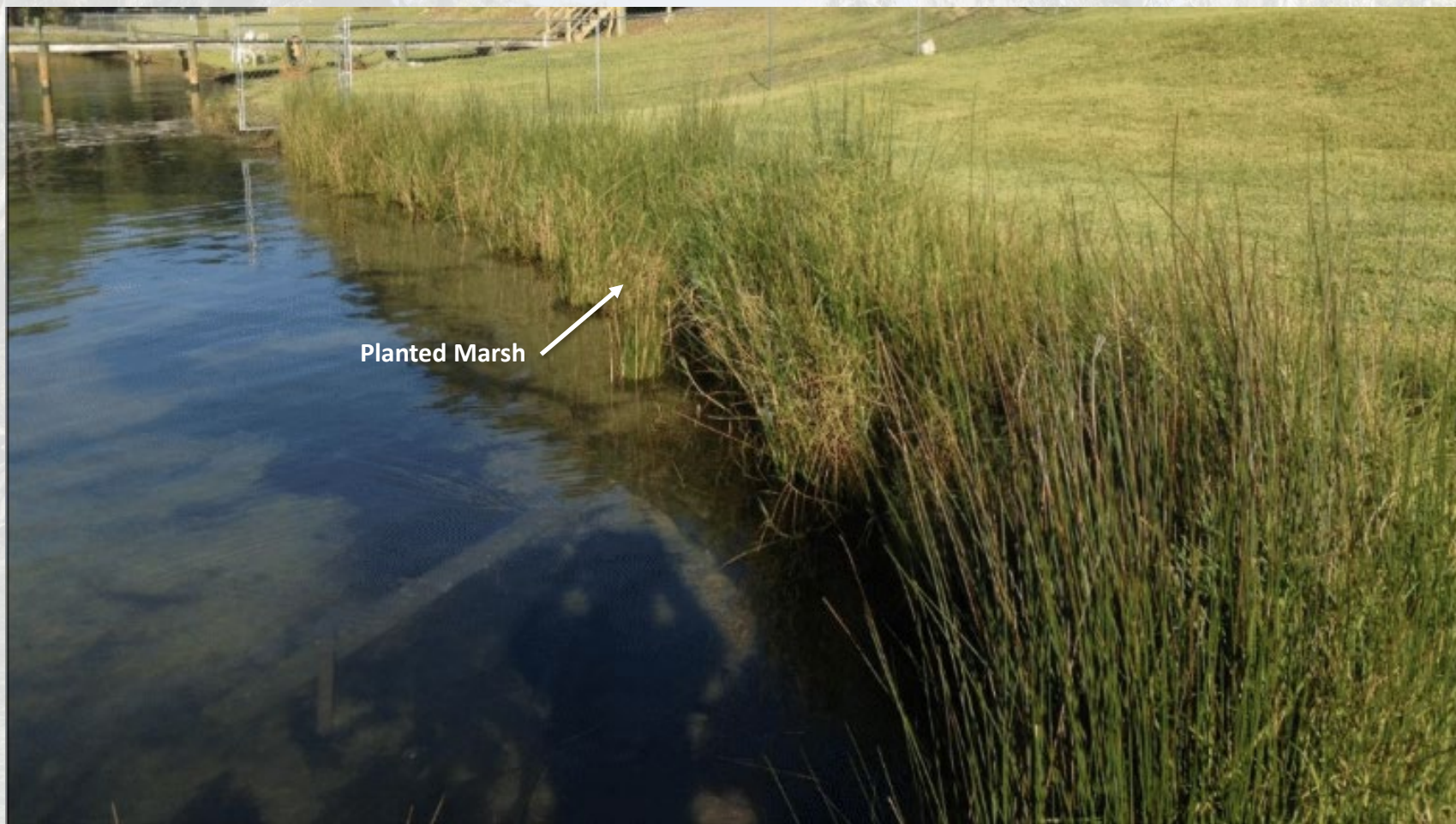
Living Shorelines 101

CASE EXAMPLES





LIVING SHORELINE EXAMPLE





LIVING SHORELINE EXAMPLE



Living Shoreline, Edgewater, Maryland [Arundel Rivers Federation]





LIVING SHORELINE EXAMPLE



Clear Lake Forest Park Living Shoreline, Clear Lake Forest, Texas [Google Earth]





LIVING SHORELINE EXAMPLE



Clear Lake Forest Park Living Shoreline, Clear Lake Forest, Texas [Galveston Bay Foundation]





LIVING SHORELINE EXAMPLE



Clear Lake Forest Park Living Shoreline, Clear Lake Forest, Texas [Galveston Bay Foundation]





LIVING SHORELINE EXAMPLE



Clear Lake Forest Park Living Shoreline, Clear Lake Forest, Texas [Galveston Bay Foundation]





LIVING SHORELINE EXAMPLE



Shipe Woods Living Shoreline, Trinity Bay (East Shore), Texas [Google Earth]





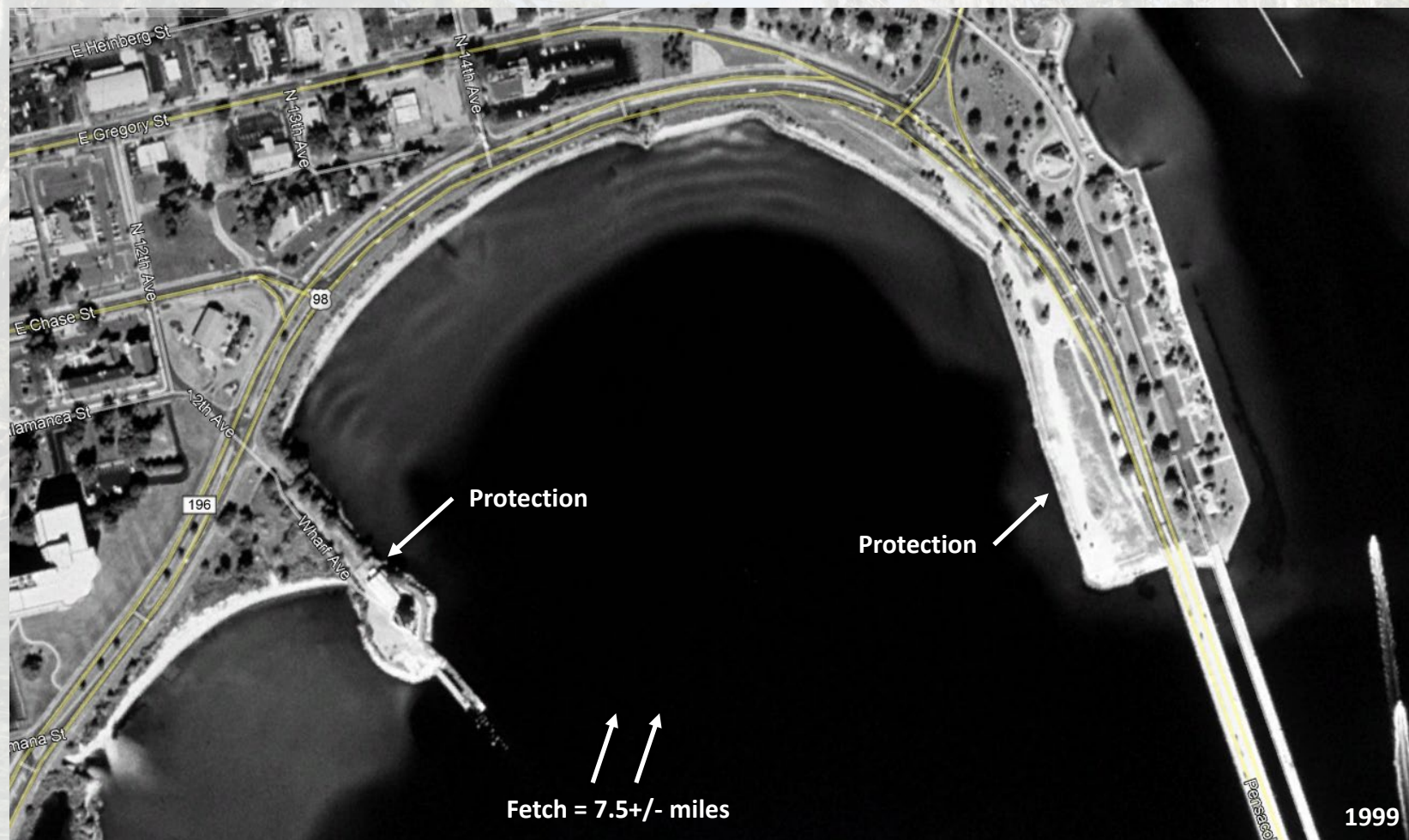
LIVING SHORELINE EXAMPLE— PROJECT GREENSHORES, PENSACOLA, FL

- Multimillion-dollar habitat restoration
- Restored oyster reef, salt marsh and seagrass habitat
- Partners included:
 - Florida's Department of Environmental Protection Northwest Aquatic Preserves, City of Pensacola, Escambia County, Ecosystem Restoration Support Organization, EPA Gulf of Mexico Program, National Fish and Wildlife Service, NOAA, Gulf Power, local agencies, and volunteers (Boy Scout, Cub Scout and Girl Scouts).
- Seven acres of constructed oyster reef
 - 14,000 tons of Kentucky limestone / 6,000 tons of recycled concrete / 40 wave attenuators
- Eight acres of salt marsh
 - 35,000 cubic yards of sand / 40,000 smooth cordgrass plants
- Submerged breakwaters
 - 25,000 cubic yards of recycled concrete





LIVING SHORELINE EXAMPLE LOCATION, LOCATION, LOCATION





LIVING SHORELINE EXAMPLE PHASED APPROACH





LIVING SHORELINE EXAMPLE PHASED APPROACH





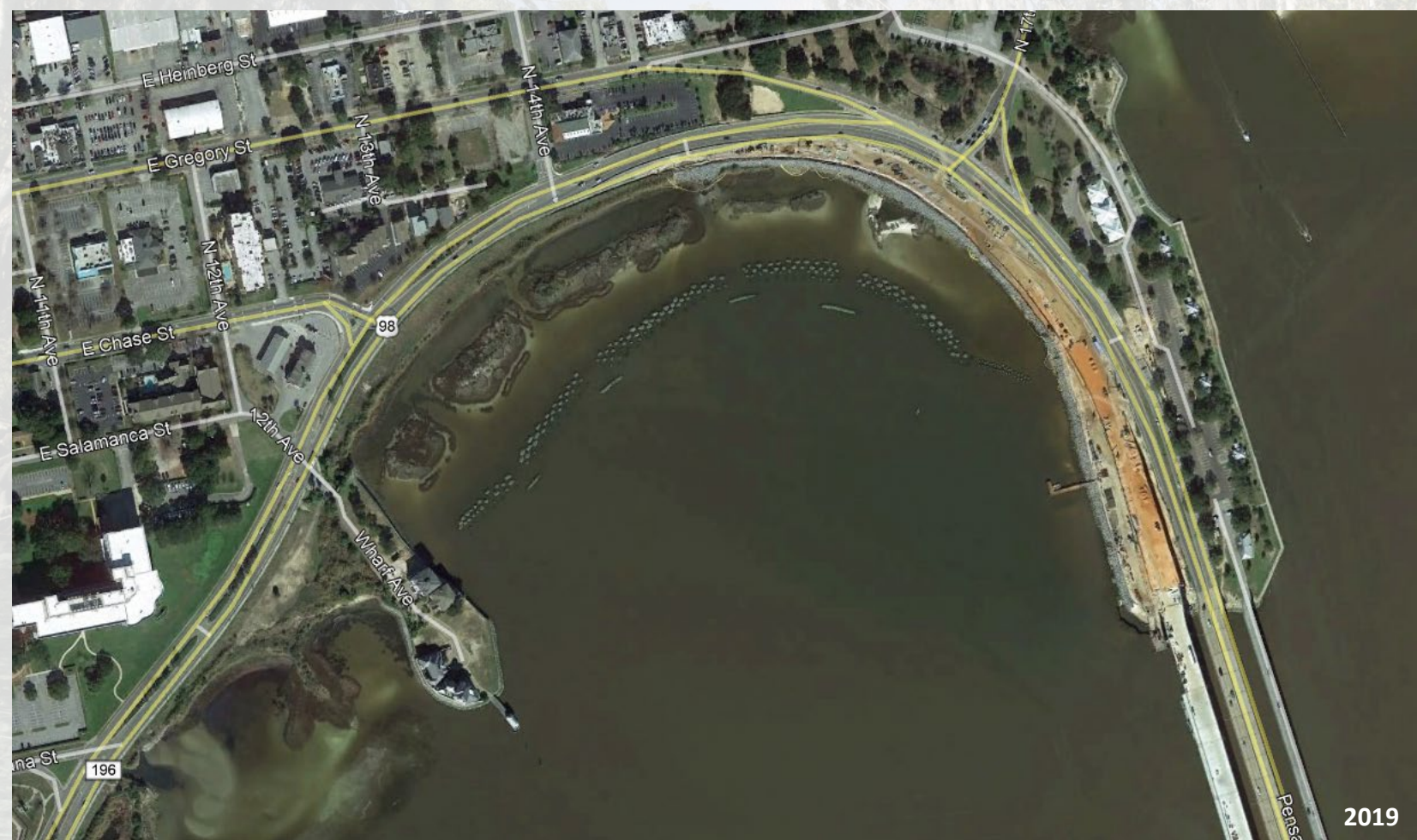
LIVING SHORELINE EXAMPLE



Project GreenShores, Pensacola Bay, Florida [Google Earth]



LIVING SHORELINE EXAMPLE





LIVING SHORELINE EXAMPLE



2019



Project GreenShores, Pensacola Bay, Florida [Google Earth Street View]



LIVING SHORELINE EXAMPLE LOCATION, LOCATION, LOCATION





KEY POINTS

- Living Shorelines are an integral piece of the Texas Coastal Resiliency Plan
- Living Shorelines have many ecosystem service benefits from habitat creation to shoreline protection
- Living Shorelines are better suited for Sea Level Rise
- Living Shorelines can be more cost effective than traditional hardening methods





Thank you for your time! Questions?

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This project is funded, in part, by a Texas Coastal Management Program Grant approved by the Texas Land Commissioner pursuant to National Oceanic and Atmospheric Administration Award No. NA17NOS419139





ADDITIONAL RESOURCES

- Arundel Rivers Federation
 - <http://www.arundelrivers.org/restoration/living-shorelines/>
 - <https://southriverdata.net/>
- Florida Living Shorelines
 - <http://floridalivingshorelines.com/florida-sampler/>
- NOAA
 - <https://www.habitatblueprint.noaa.gov/storymap/ls/>
- Virginia
 - <https://www.arcgis.com/apps/MapJournal/index.html?appid=95bfc110379844d5809bce8d09487538#>

