



# Living Shorelines 101

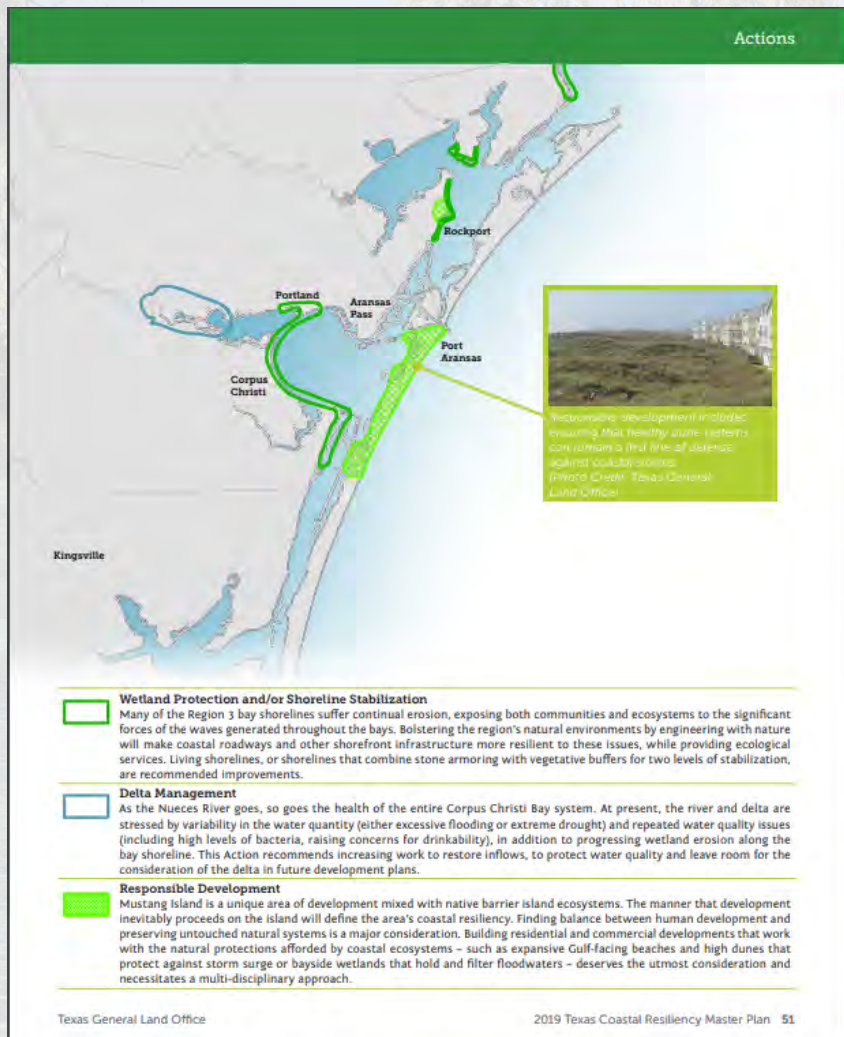
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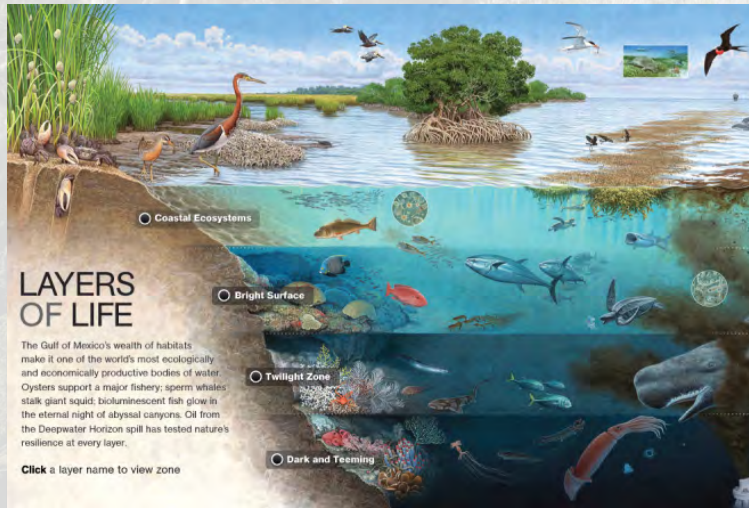
# WETLAND PROTECTION AND/OR SHORELINE STABILIZATION





# 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



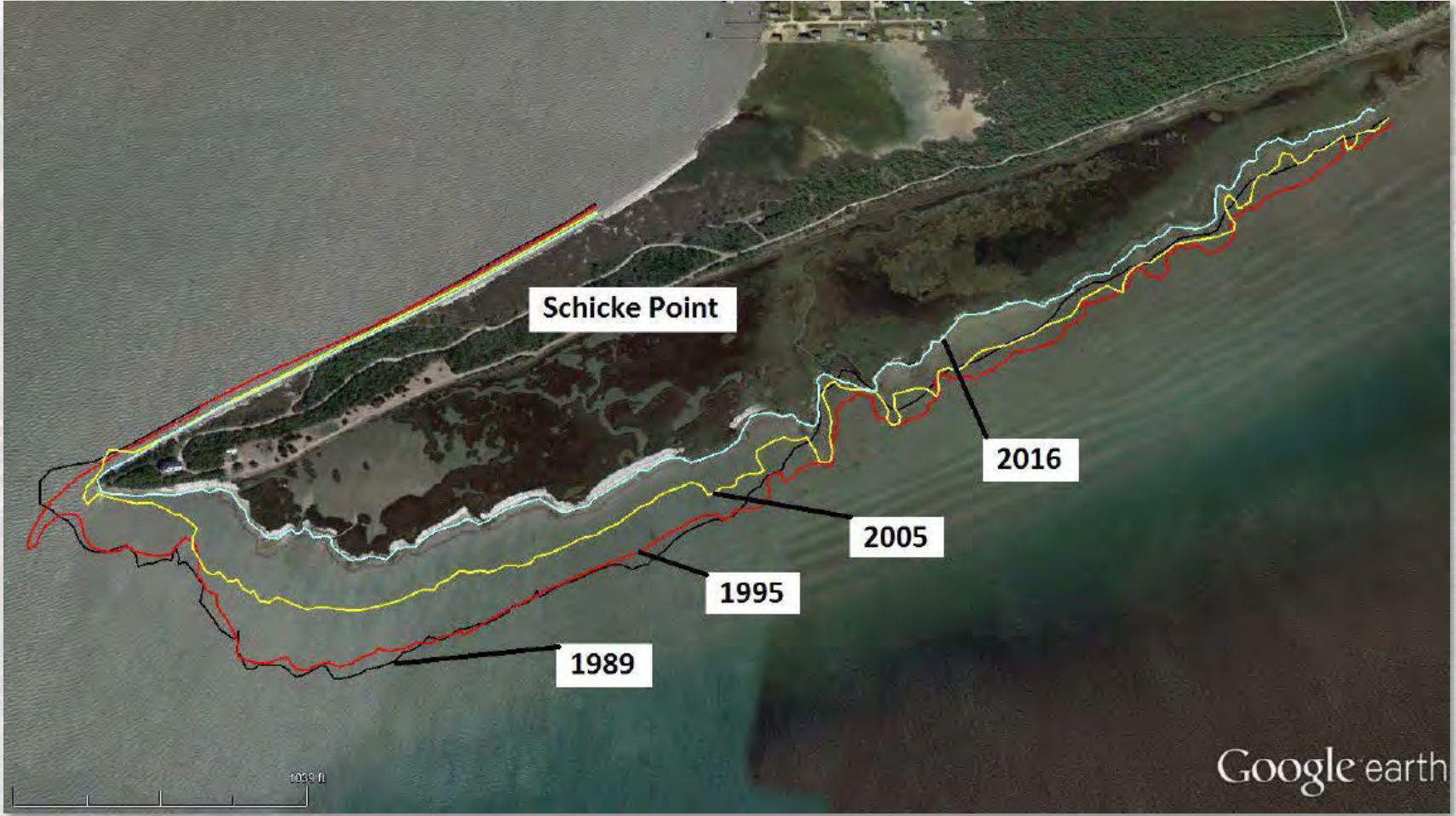
2018

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.

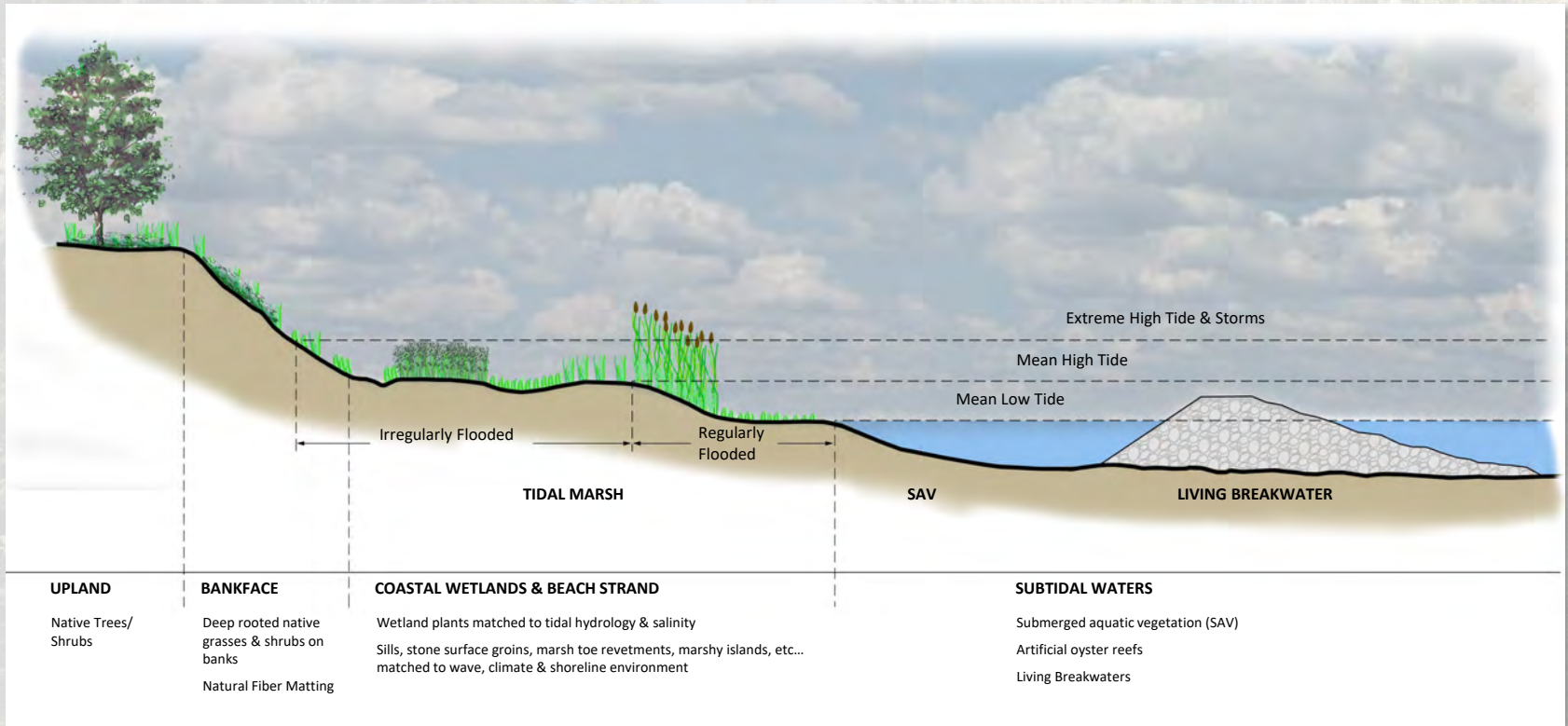


Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create seaward **erosion**.





# 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







# TYPES OF SHORELINE MANAGEMENT

## Vegetative Cover

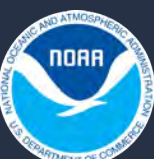
- Marsh/Wetland Plants
  - Smooth Cordgrass
  - Saltmeadow Cordgrass
  - Black Needlerush
- Dune Plants
  - Sea Oats
  - Coastal Panic Grass



*[Florida Living Shorelines]*

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





# 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





# 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



*Jones Island, North Carolina  
Coastal Federation*

*Trinity Center, Pine Knoll Shores, 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*



*Reefmaker*





# 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



Breakwater

Restored Marsh

*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.

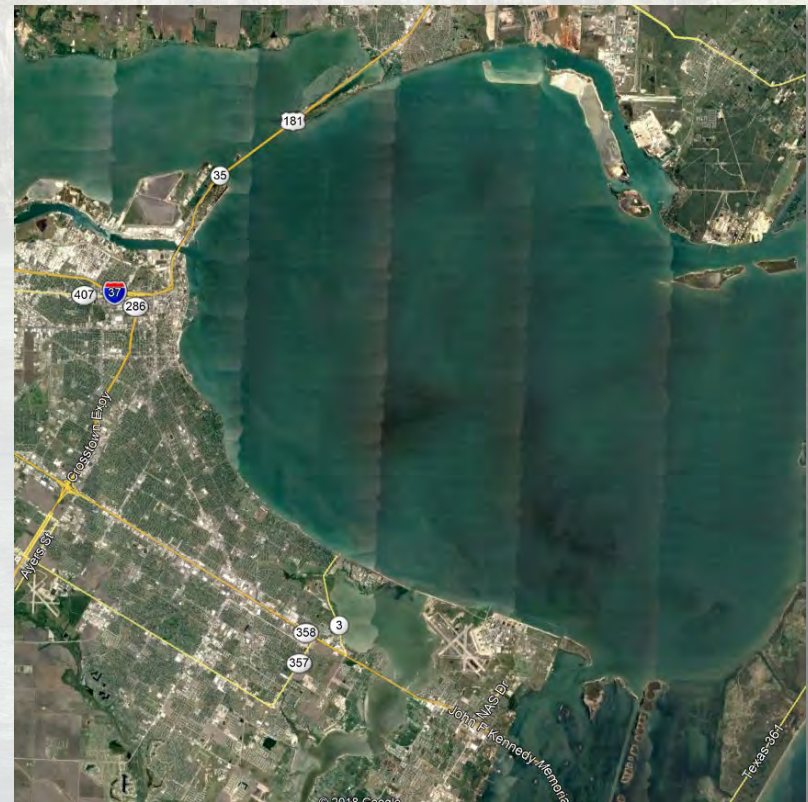




# WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

## 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

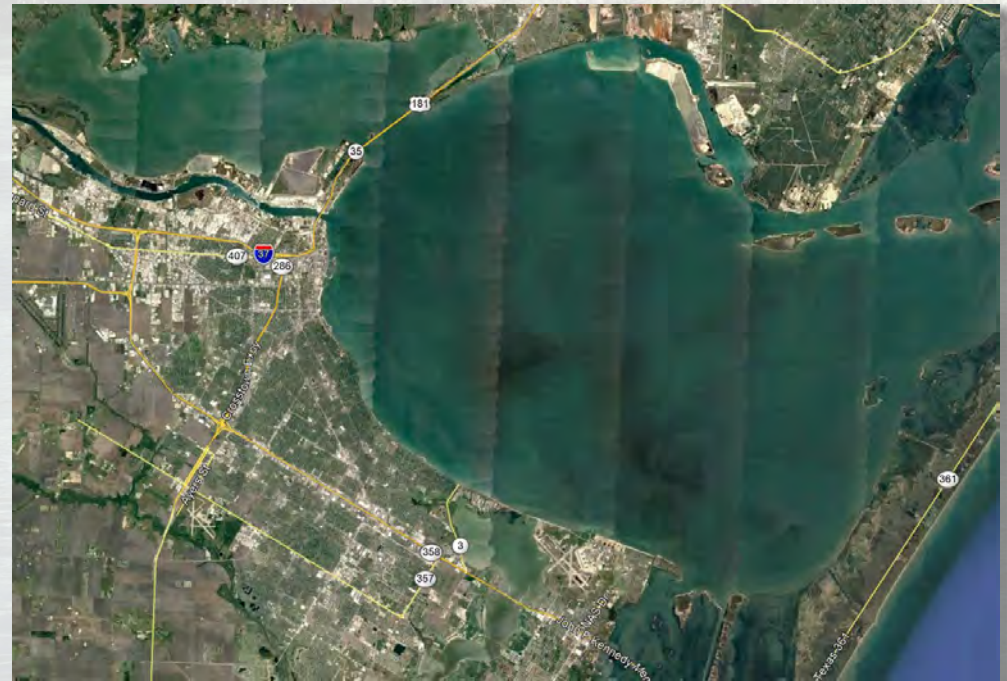




# WHERE ARE LIVING SHORELINE PROJECTS APPROPRIATE?

## 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 <sup>5,6,7</sup>					
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	<b>General Practices</b> <b>Marsh Plantings</b> <b>Coir Logs</b> <b>Beach Renourishment</b>	<b>Erosion Prevention</b> <b>Reduces wave energy, holds soil and traps sediments in grasses.</b> <b>Reduces wave energy, holds soil and traps sediments more effectively than plantings alone.</b> <b>Replenishes eroded shorelines and minimizes loss of private property. Reduces wave energy and inland damage from coastal storms.</b>	When used in conjunction with marsh grass and other plantings, provides food and protection for finfish, shellfish, mammals, and shorebirds.  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 habitat for shrimp, crabs, clams, snails, worms, and finfish.  New marsh will 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.	Not for public use.  Provides opportunity for public access to swimmers and boaters.  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.  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.	
Beach Renourishment					
Oyster Reefs/Balls					
Sills with Plantings/Hybrids					
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.
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"> <li>Prevents loss of water on adjacent coastline</li> </ul>	<ul style="list-style-type: none"> <li>Tends to failure due to upland water pressure and increased erosion on the seaward</li> <li>Loss of filtering ability of vegetation results in decreased water quality</li> <li>Prevent natural migration of wetlands, shorelines, vegetation</li> <li>Wave reflection causes increased erosion at base</li> <li>Channelized transport along the shoreline</li> <li>Increases erosion of adjacent shorelines</li> <li>Eliminates aquatic nursery habitat</li> </ul>	<ul style="list-style-type: none"> <li>High wave energy</li> <li>Localized instability</li> <li>Shoreline eroding with steep banks</li> <li>Structure at risk due to close proximity to shoreline erosion</li> </ul>
Revetments	<ul style="list-style-type: none"> <li>More reflective than bulkheads</li> <li>Low maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Installation requires heavy machinery</li> <li>Expensive</li> </ul>	<ul style="list-style-type: none"> <li>High wave energy and/or eroding beach</li> </ul>
<b>Upland Vegetation - Trees, Shrubs, Grasses and Grass Roots</b>		<ul style="list-style-type: none"> <li>Soil stabilization in upland zone</li> <li>Stormwater runoff filtration</li> </ul>	
<b>Wetland Vegetation - Marsh Grasses</b>		<ul style="list-style-type: none"> <li>Improves finfish and shellfish habitat</li> <li>Stabilizes soil</li> <li>Traps sediment</li> <li>Improves water quality by filtering runoff</li> </ul>	
<b>Natural Fiber Logs with Vegetation</b>		<ul style="list-style-type: none"> <li>Low impact</li> <li>Biodegradable</li> <li>Traps and retains sediment</li> <li>Promotes plant growth</li> <li>Inexpensive and easy to install</li> <li>Flexible and easy to mold to shape of shoreline</li> </ul>	
<b>Natural Fiber Matting with Vegetation</b>		<ul style="list-style-type: none"> <li>Can be used for moderate slopes</li> <li>Low cost</li> </ul>	<ul style="list-style-type: none"> <li>Biodegradable</li> <li>Traps and retains sediment</li> </ul>
<b>Living Breakwaters</b>		<ul style="list-style-type: none"> <li>Wave attenuation</li> <li>Improved water quality</li> <li>Increased oyster habitat</li> <li>Creates a calm area near shoreline that can be planted with vegetation for improved marsh habitat</li> </ul>	
Marsh Toe Revetment (Existing Marsh)	<ul style="list-style-type: none"> <li>Maintain bank/soil stability</li> <li>Can promote oyster growth</li> <li>Long lifespan</li> <li>Facilitation of oyster growth</li> <li>Can promote oyster growth</li> <li>Long lifespan</li> </ul>	<ul style="list-style-type: none"> <li>Reduces erosion to marsh</li> <li>Environmentally sensitive location</li> </ul>	<ul style="list-style-type: none"> <li>Shallow marsh near marsh edge with firm soil</li> <li>Low to moderate energy wave where structure is necessary to protect plants</li> <li>Marsh edge erosion</li> </ul>
Breakwaters with Transitional Wetlands	<ul style="list-style-type: none"> <li>Absorbs waves and creates a calm area behind the wall to promote oyster and vegetation growth</li> <li>Traps sediment, maintains natural shoreline</li> <li>Maintains land-water interface</li> <li>Allows runoff to improve water quality</li> <li>Provides nursery habitat for juvenile fish</li> </ul>	<ul style="list-style-type: none"> <li>Not required if not adjacent to shoreline</li> <li>Expensive</li> </ul>	<ul style="list-style-type: none"> <li>Marshes or oyster reefs preferred than wall if necessary, due to wave depth, moderate slope or high wave action</li> </ul>







# 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



Planted Marsh





# 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



Breakwater

Restored Marsh

Galveston  
**BAY**  
Restoration Site

*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





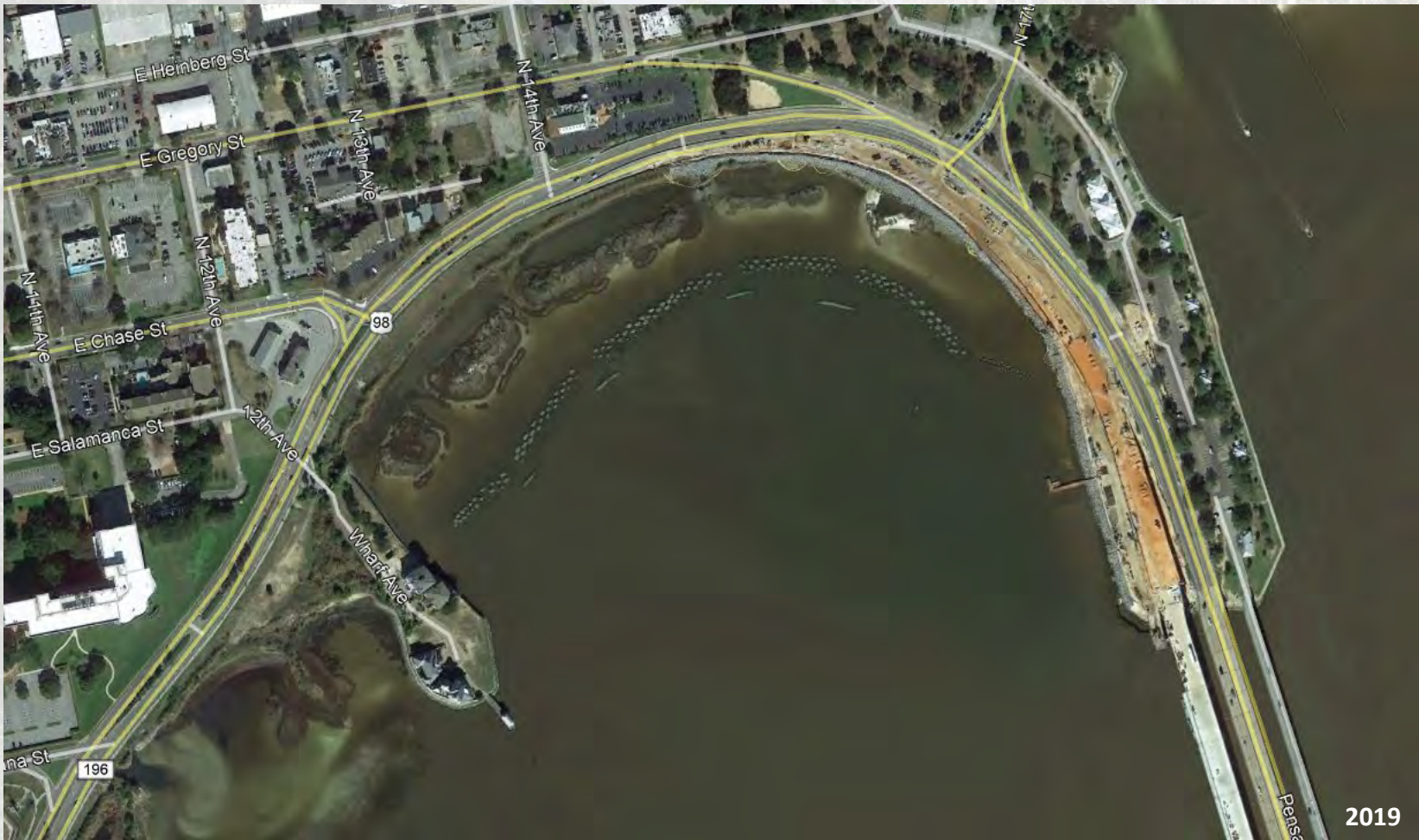


# LIVING SHORELINE EXAMPLE





# LIVING SHORELINE EXAMPLE





# LIVING SHORELINE EXAMPLE



2019

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





# LIVING SHORELINE EXAMPLE LOCATION, LOCATION, LOCATION



2013





# 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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# 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#>

