November 2013

ALTERNATIVE SHORELINE MANAGEMENT GUIDEBOOK

MDMR

MISSISSIPPI DEPARTMENT OF MARINE RESOURCES

Contents

ABOVE
Keegan Inlet East Bank.
Image: Allen Engineering and Science

FRONT & BACK COVER
Ocean Springs Shoreline.
Image: Allen Engineering and Science

Document developed by Allen Engineering and Science for the Mississippi Department of Marine Resources

1.0
INTRODUCTION

ABOVE LEFT
Bayou/Marsh.
Image: Allen Engineering and Science

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ABOVE RIGHT
Bayou/Marsh.
Image: Allen Engineering and Science

1.1 Background

Mississippi's shorelines are instrumental to the ecological and economic health of the coast. The intertidal zone where water meets the land is a diverse and productive ecosystem, which provides foraging, breeding, and sheltering opportunities to many coastal species. These coastal species provide the residents of the Mississippi Gulf Coast with recreational and commercial fishing opportunities.

Mississippi is home to 370 miles of coastline including beaches, bayous, rivers, and islands as well as 436,000 acres of estuarine wetlands comprised of 65,453 acres of tidal wetlands and 370,547 acres of non-tidal wetlands.[1]

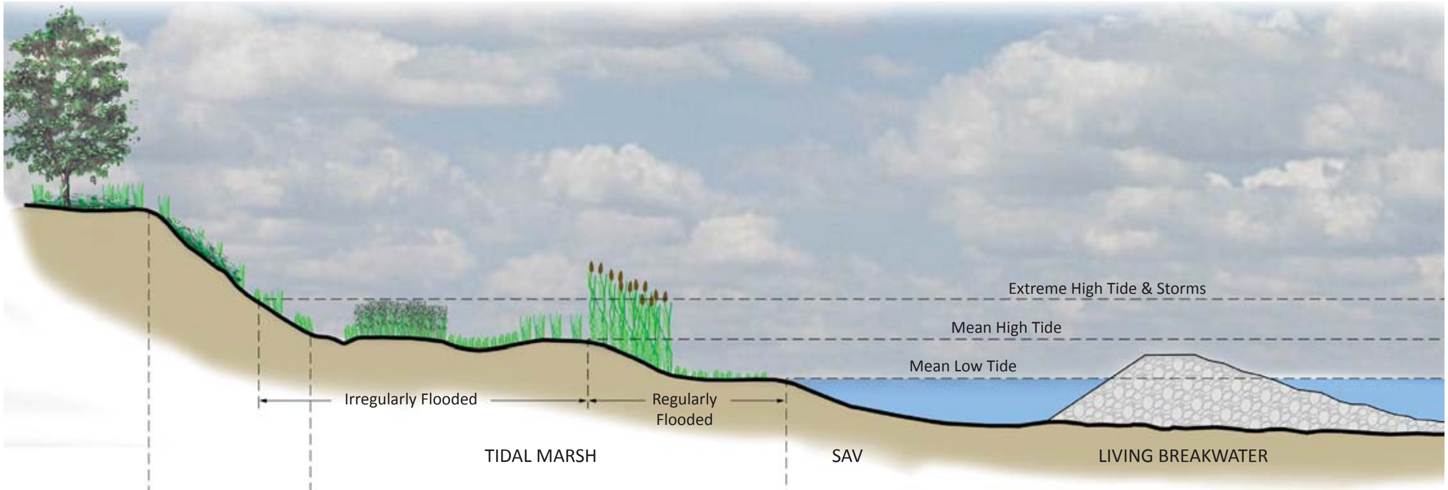
Mississippi relies on its healthy and productive fish and shellfish populations, including:

- Shrimp, Eastern Oysters, and Blue Crab (Food and Commercial fishing)
- Atlantic Croaker, Spot, and Sand Seatrout (bottomfish)
- Gulf Menhaden (fishmeal and oil)
- Striped Mullet, Spotted Seatrout, Red Drum, Southern King Fish, Sheepshead, Black Drum, and Southern Flounder (food and recreational fishing)

The Mississippi commercial seafood industry accounted for more than $231 million in sales in 2011. Recreational fishing provided nearly $146 million in sales in 2011.[2]

1.2 Shoreline Management

Coastal shorelines have changed and eroded as a result of natural processes governed by climate, geology, ocean currents, waterbody depths, and wind.[3] In addition to natural factors contributing to erosion and shoreline change, coastal development and human activities have exacerbated these changes. Efforts to prevent or control erosion must be balanced with ecological impacts and costs. The overwhelming response to shoreline erosion in Mississippi has been to protect the shorelines through bulkheads or other hardening strategies. These hard structures reduce habitat by separating land



from water interfaces. They also reflect waves off the shoreline to unprotected areas, causing erosion of the land below the bulkhead and increased water depth at the shore.[3]

Nearly all Gulf seafood species rely on the local marshes for nursery habitat and food.

To balance shoreline protection and ecological preservation, property owners and government agencies should consider new shoreline management practices. Hardened shorelines may be necessary in areas with high wave action, high erosion rates and steep slopes. In other areas, alternative strategies, including living shorelines and hybrid stabilization projects, may be the most cost-effective, attractive and ecologically sensitive.

1.3 What is a Living Shoreline?

A "living shoreline" describes a natural approach to shoreline stabilization that reduces erosion while restoring, preserving or creating valuable habitat along the shore. These strategies include the use of vegetative plantings (upland and marsh), oyster shell structures, earthen materials, natural fiber products, or a combination of structures and vegetation to stabilize the shoreline. Instead of drowning the shoreline habitats and changing shoreline landscapes, living shorelines encourage the preservation and growth of shoreline habitats and improved water quality. Living shorelines are not flood prevention measures, but rather, erosion prevention measures. By installing living shorelines where appropriate, property owners can make a significant cumulative impact on the restoration and preservation of Mississippi shorelines and habitat.

Benefits of Living Shorelines

- *Increased fish/wildlife habitat*
- *Increased property value*
- *Erosion reduction*
- *Pollution reduction through natural buffers/filters*
- *Create sense of place*
- *Improved water quality*
- *Cost-saving*

Types of Living Shorelines & Hybrids

- *Vegetation - Marsh Grass, Upland Trees/Shrubs*
- *Natural Fiber Logs or Matting with Vegetation*
- *Sediment-Filled Geotextile Tubes*
- *Sills with Vegetation*
- *Marsh Toe Revetment*
- *Oyster Balls/Oyster Reefs*
- *Clean Fill/Dredge Material with Vegetation*
- *Living Breakwaters*

1.4 Factors to Consider when Selecting Shoreline Management Practices

Selecting the most appropriate type of management practice depends upon the type of shoreline and other site conditions such as wave energy, water depth and slope. The figure above depicts the primary zones for coastal habitats as subtidal waters; coastal wetlands and beach strand; bankface; and upland buffer zone. The typical "living shoreline" treatments are depicted for each zone.

Factors to Consider when Selecting Shoreline Practices

- *Type of Shoreline*
- *Rate of Erosion*
- *Slope*
- *Erosional Forces*
- *Wave Energy*
- *Water Depth*
- *Offshore Ground Surface*
- *Salinity*
- *Fetch*
- *Longshore Sediment Transport*

TOP
Coastal Shoreline Continuum & Typical "Living Shorelines" Treatments.[4]
Image: Allen Engineering and Science Adapted from NOAA Habitat Conservation

Considerations for property owners when starting a shoreline management project:

Shoreline Type - Is the shoreline a marsh, beach, cove or hardened shoreline?

Slope - What is the slope of the bank leading to the water? Is it gradual or steep? The rate of erosion combined with the type of shoreline will help select the most appropriate stabilization strategy.

Rate of Erosion - Has the erosion been occurring gradually over time, or is it a rapid erosion measureable in inches or feet per year? Rapid erosion may indicate the need for a hard or hybrid solution, involving stone or concrete.

Erosional Forces - Is the erosion due to high wave action, passing boats, high winds, or simply the water-land interface? This information will help determine whether the proposed shoreline strategy will include a structure to decrease the wave force.

Wave Energy - Some shoreline management approaches are more adaptable to high energy wave action. Other approaches such as vegetation without structures, are more appropriate in areas with low wave energy.

Water Depth - How deep is the water immediately offshore? This will help determine which plants will be appropriate and whether fill/rock needs to be placed to promote an environment beneficial to the plantings.

Offshore Ground Surface - Is the offshore surface sand, silt, clay, gravel, or shell? This will affect the types of materials placed, based on anticipated settling.

Salinity - Is the waterbody salt water, brackish or fresh water? The salinity level will determine what plants are appropriate for the location.

Fetch - How far is it to the nearest opposite shore? A long fetch is more likely to result in high wind and wave energy.

Longshore Sediment Transport - Consider existing transport of sediment along the shoreline. Do adjacent properties rely on existing sediment transport for beach or marsh nourishment?

ABOVE
Timber Bulkhead, Gulf Hills, MS.
Image: Allen Engineering and Science

General Practices	Erosion Prevention
Marsh Plantings	Reduces wave energy, holds soil and traps sediments in grasses.
Coir Logs	Reduces wave energy, holds soil and traps sediments more effectively than plantings alone.
Beach Renourishment	Replenishes eroded shorelines and minimizes loss of private property. Reduces wave energy and inland damage from coastal storms.
Oyster Reefs/Balls	Reduces wave energy, traps sediment and adds shell material to living reef.
Sills with Plantings/ Hybrids	Absorbs and spreads out wave energy; traps sediments to counter changing sea levels. May reflect wave energy; however, leading to erosion in adjacent areas.
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.

General Practices	Shoreline Type			
	Marsh	Cove	Beach	Hardened
Marsh Plantings				
Coir Logs				
Beach Nourishment				
Oyster Reefs/Balls				
Sills with Plantings/ Hybrids				
Breakwaters				
Bulkhead				

Practice and Ecosystem Benefits [5, 6, 7]

Water Quality Improvement	Fish Production	Habitat Diversity	Recreational Benefits
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.
When used in conjunction with marsh grass and other plantings, coir logs filter runoff, improving quality of water.	Allows marsh to establish in higher erosion areas, creating protection and habitat for fish.	When used in conjunction with marsh grass and other plantings, provides food and protection for finfish, shellfish, mammals, and shorebirds.	Not for public use.
Beaches provide minimal filtration and are often the site of high bacteria concentrations from stormwater system discharge. Sand filters to the existing stormwater outfalls have been used in other areas, and could improve beach water quality.	Fish eggs and microorganisms are often smothered by highly turbid water in beach environments.	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.
Filters runoff and surrounding water, improving quality of water.	Fosters development of oysters, thus creating feeding areas, habitat for fish, and crab.	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.
Filters runoff, improving quality of water.	Nursery and habitat for fish.	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.
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.
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.

Practice and Site Conditions

	Slope			Rate of Erosion			Wave Energy			Water Depth			Fetch		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Shallow	Moderate	Deep	Short	Medium	Long

Legend:	
	Best management strategy
	Good management strategy
	Least effective management strategy

2.0

HARD SHORELINE MANAGEMENT PRACTICES

TOP
Steel Bulkhead, Biloxi, MS.
Image: Allen Engineering and Science

MIDDLE
Rock Revetment.
Image: NCCOS

BOTTOM
Groins
Image: North Carolina Department of Environmental and Natural Resources

"Hard" structures are practices that armor the shoreline including bulkheads, seawalls, rip-rap, jetties, groins, and breakwaters. These hard practices are used in high-energy areas and are designed to slow erosion rates landward of the structure. Unfortunately, erosion is often worsened seaward of the hard structure. Hard structures can lead to loss of beach and habitat, as well as altered shoreline and water dynamics.

Mississippi marshes are disappearing at approximately 200 acres per year.[8]

2.1 Traditional Hardening Practices

2.1.1 Bulkheads

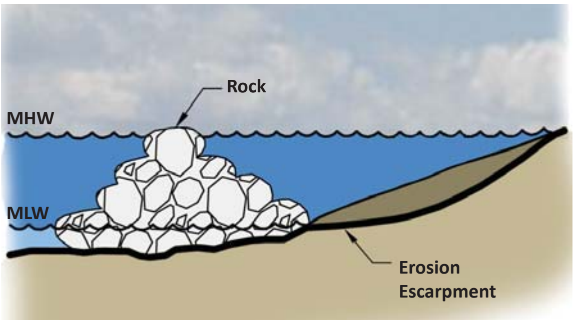
Bulkheads are vertical structures constructed of timber, steel, vinyl, rock, or concrete. They are placed parallel to the eroding shoreline on the water-side. Bulkheads are used to hold back the land and can withstand moderate to high wave energy. There are many situations where bulkheads are not appropriate, and in fact, damaging. Except for certain scenarios, other methods of shoreline management are preferred over bulkheads.

2.1.2 Revetment

Revetment is a sloped seawall built of concrete or rip-rap rock. These structures are sloped against a bank and placed parallel to the shoreline. Revetments are used to protect land from erosion and absorb wave energy.[9]

2.1.3 Groins

Constructed of timber, rock, concrete, or vinyl, groins are constructed perpendicular to the shore. Groins are typically built on straight stretches of beach in a series of parallel structures. The placement perpendicular to the shore allows groins to trap sand from longshore transport (movement of sand along the shoreline), which then builds out the upland on the updrift side.[10]

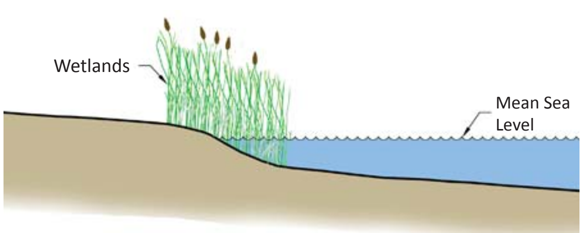


2.1.4 Rock Sills

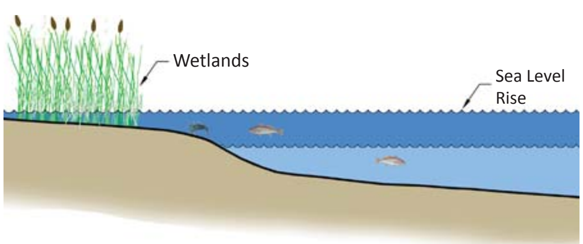
Rock sills are structures placed in the water parallel to shore made of rip-rap. The sills dissipate wave energy, protect eroding areas, and provide habitat for aquatic organisms. These sills are segmented and constructed 6 to 12 inches above mean high water, allowing waves and wildlife to pass over and between, providing a connection between the water and land. The sill may provide habitat for aquatic organisms like algae, shellfish, crustaceans and fish.

2.1.5 Breakwaters

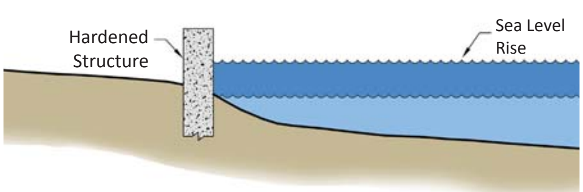
Breakwaters are wave attenuators typically built with timber, rock or concrete. They are placed parallel to the shore and are larger and further offshore than sills. Breakwaters are used to reduce wave energy on the shoreline and trap sand between the shore and the structure. This trapped sand can increase the beach in the area of the breakwaters, but is considered "stolen sand" somewhere downdrift, which accelerates the downdrift erosion.[11]



Current Conditions



Wetlands Migrate Inland with Rise of Water



Wetlands Drown due to Hardened Structure

WHEN ARE HARDENING STRUCTURES APPROPRIATE AND WHEN ARE THEY NOT DESIRABLE?

Hard structures can protect properties, roadways and buildings from heavy erosion and high wave action. Specific conditions can warrant a hardened shoreline, such as an area with steep slopes and high wave action, where no alternative other than armoring can be accommodated.

However, hardening techniques can be costly and typically cause increased erosion along adjacent shorelines, due to their interruption of natural shoreline processes and sand movement. Additionally, hardened shorelines can result in loss of habitat, including wetlands and intertidal areas.

Groins and jetties create blockages for longshore sand transport, "robbing" downdrift areas of needed sediment necessary for nourishing coastal beaches, wetlands and marshes.[11] Without the natural renourishment from sediment transport along the shoreline, these downdrift areas experience increased erosion, loss of beach, and loss of habitat. Bulkheads prevent natural migration of wetlands and sediment, resulting in the drowning of vegetation and valuable fish/shellfish habitat.

Hardened shorelines may be necessary in areas with high wave action and high erosion rates, near critical structures or infrastructure. However, in other areas, alternative strategies may be the most cost-effective, aesthetic and ecologically sensitive.

TOP LEFT
Sill section view.
Image: Allen Engineering and Science Adapted from North Carolina Department of Environmental and Natural Resources: Division of Coastal Management

MIDDLE LEFT
Breakwaters, Presque Isle, PA.
Image: U.S. Army Corps of Engineers

BOTTOM LEFT
Figure demonstrating bulkhead drowning wetlands.
Image: Allen Engineering and Science Adapted from VIMS

ABOVE
Old Fort Bayou
Image: Allen Engineering and Science

3.0

SOFT OR LIVING SHORELINE PRACTICES AND HYBRIDS

Wetland vegetation removes pollutants from stormwater runoff and reduces erosion by stabilizing the soil.

ABOVE LEFT
Keegan's Inlet, Biloxi, MS, east bank, 2007.
Image: BMI Environmental, Inc. / Harrison County

ABOVE RIGHT
Keegan's Inlet, Biloxi, MS, east bank, 2013. Clean fill, regraded and planted with marsh vegetation.
Image: Allen Engineering and Science

"Soft" or "living" shoreline practices are designed to control erosion by preserving natural coastal processes and encouraging habitat restoration through nourishment of coastal wetlands, marshes and beaches. These practices include strategic placement of plants, stone, sand fill, and other organic structural materials (oyster shells, coir logs, etc.).

3.1 Living Shoreline Practices

3.1.1 Clean Fill/Dredge Material, Re-grade, & Re-vegetate

Clean fill (dredge material or other sand) can dissipate wave energy and provide surface to plant vegetation in the upland buffer and bankface zones. Usually graded as a gentle bank slope with vegetation planted after the fill material is placed.

3.1.2 Upland Vegetation: Trees, Shrubs, and Grass Roots

Trees, shrubs and grass roots stabilize riparian zone (upland buffer) above high tide, stabilize soil, filter runoff, and provide habitat. Planted vegetation should be native species that can withstand periodic saltwater inundation.

3.1.3 Wetland Vegetation: Marsh Grasses

Marsh grasses and other vegetation dissipate wave energy, filter upland runoff and improve habitat for fish and wildlife. Marsh grass can be planted by itself in low wave energy locations, but for other scenarios, should be combined with other strategies.

3.1.4 Natural Fiber Logs with Vegetation

Natural fiber logs, also called coir logs, are coconut fibers bound together with biodegradable netting and are used to stabilize the toe of a slope and minimize bank erosion. These bio-logs are placed at the base of bank slopes or in the water and can trap and retain sediment, retain moisture for plant growth, and provide bank stability for vegetation. Coir logs are inexpensive and can be placed by a property owner or small group. Small rocks, called rock footers, and stakes are used to anchor the natural fiber logs along the shoreline.

3.1.5 Natural Fiber Matting with Vegetation

Natural fiber matting is made of biodegradable organic materials, including coconut fiber, wood, straw, or jute. The mat is used in over eroding coastal areas or on entire slopes to trap sediment and encourage growth of vegetation. The matting should be planted with vegetation to enhance shoreline stabilization. The matting can be used in combination with natural fiber logs for increased stabilization.

3.1.6 Sediment-Filled Geotextile Tubes

These tubes, typically 8 -12 feet in diameter, are a beneficial use of dredged material. Sediment-filled geotextile tubes can be placed under water to stabilize the shoreline or along a beach, to stabilize the upland area behind the beach. When utilized on the beach, they can be placed in a trench along the inland side of the beach, parallel to the shoreline. The tube is then covered with sand and planted with vegetation, creating a dune-effect and protecting infrastructure inland of the tube.

Submerged sediment-filled geotextile tubes are placed offshore underwater and stabilize the shoreline by minimizing wave energy and trapping sediment landward of the structure. The tubes can also create a hard surface for oyster reefs to establish.

TOP
Marsh Grasses.
Image: Allen Engineering and Science

BOTTOM LEFT
Natural fiber log, shortly after installation and planting. Gulf Hills, MS.
Image: MSDMR

BOTTOM MIDDLE
Natural fiber matting installed with natural fiber logs.
Image: D2 Land and Water Resource

BOTTOM RIGHT
Geotextile tube inducing wave breaking for wave attenuation.
Image: Axis Ingenieria

3.1.7 Living Breakwaters

Living breakwaters are constructed of rock, oyster shell, recycled concrete, or timber fencing and placed parallel to the shore in medium- to high-energy open-water environments. The living breakwaters dissipate wave energy and trap sediment. To create a "living" breakwater, these materials are seeded with oyster spat and planted with vegetation. The oysters and vegetation strengthen the breakwater, as well as improve water quality.

3.1.8 Native Oyster Reefs

Oyster reefs can be enhanced or created at living shoreline sites to serve as natural shoreline protective structures. The reefs can dissipate wave energy, decrease coastal erosion, increase habitat for fish species, improve water quality, and provide protection for vegetation.

3.1.9 Small Concrete Oyster Balls

Oyster balls are hollow concrete structures strategically placed to dissipate wave energy and provide habitat by creating a hard surface for oysters to construct an oyster reef. These structures also decrease coastal erosion and provide shelter for vegetation.

One oyster can filter as much as 20-40 gallons of water per day![12]

ABOVE TOP
Timber wave breakwater fence with marsh vegetation. Dog River, Alabama.
Image: NOAA/ South Coast Engineers

ABOVE MIDDLE
Concrete Oyster Ball.
Image: Allied Concrete Company

BOTTOM RIGHT
Oyster reef.
Image: Jonathan Wilker/ Purdue University

3.2 Hybrid Practices

Hybrid practices combine structures and vegetative approaches when the wave energy conditions require structural protection. These practices are designed to preserve, protect and create habitat while minimizing shoreline erosion.

3.2.1 Sill with Planted Marsh

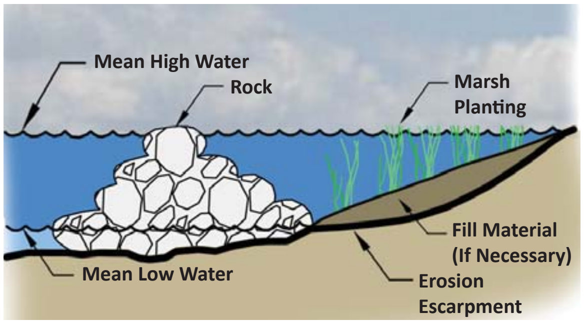
Low elevation stone structure used to trap sediment to promote marsh growth and habitat development behind the structure. They are typically placed with only 6 inches above the water at high tide, parallel and close to the shore.[13] Sand fill is placed behind the structure to create conditions to plant marsh plugs where a marsh does not naturally exist. Vegetation appropriate for the site conditions is planted in the fill behind the protective sill. Filter fabric is a porous layer placed beneath the sill to prevent the sand fill from moving through the rip-rap. Sills can protect shoreline plants by breaking the wave energy and trapping sediment landward. The low profile design allows water to pass over and through it, bringing necessary sediment to the marsh. Appropriate for tidal bayous, shorelines with failed bulkheads/revetments and lawns, adjacent to graded banks, and in shallow water with a hard sand bottom.

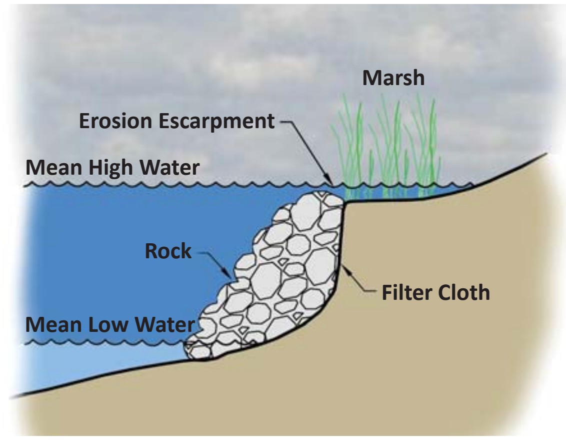
3.2.2 Marsh Toe Revetment (Existing Vegetation)

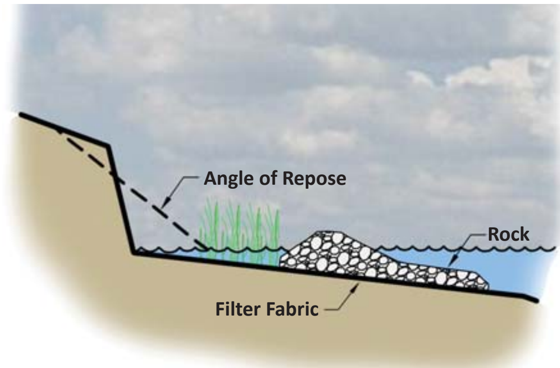
Revetments are composed of rip-rap installed parallel to the shoreline along an existing marsh. Filter fabric is placed beneath the rip-rap to prevent sand movement through the stabilization structure, to minimize the erosion. Implement when an existing marsh is experiencing erosion or where an upland bank is eroding despite having marsh vegetation. By dissipating wave energy, the marsh toe revetment can provide protection to existing vegetation, as well as improved erosion control for the marsh and bank.

3.2.3 Breakwater with Transitional Wetland

Similar to sills with planted marshes, breakwaters calm wave energy, creating a protective area for wetland habitat development and growth. Waves that overtop the breakwater can then be dissipated by the wetland plants. Breakwaters would be appropriate to use instead of sills when a more substantial structure is necessary, either due to water depth, slope under the water, or higher wave action.







Note: Overtopping Wave Energy Dissipated by Native Plants

TOP
Sill with planted marsh section view.
Image: Allen Engineering and Science adapted from North Carolina Department of Environmental and Natural Resources: Division of Coastal Management

MIDDLE TOP
Marsh Toe Revetment.
Image: Allen Engineering and Science Adapted from North Carolina Department of Environmental and Natural Resources

MIDDLE BOTTOM
Breakwater with Transitional Wetland.
Image: Allen Engineering and Science Adapted from Shoreline Specialists

BOTTOM
Sill with a planted marsh.
Image: K. Duhring

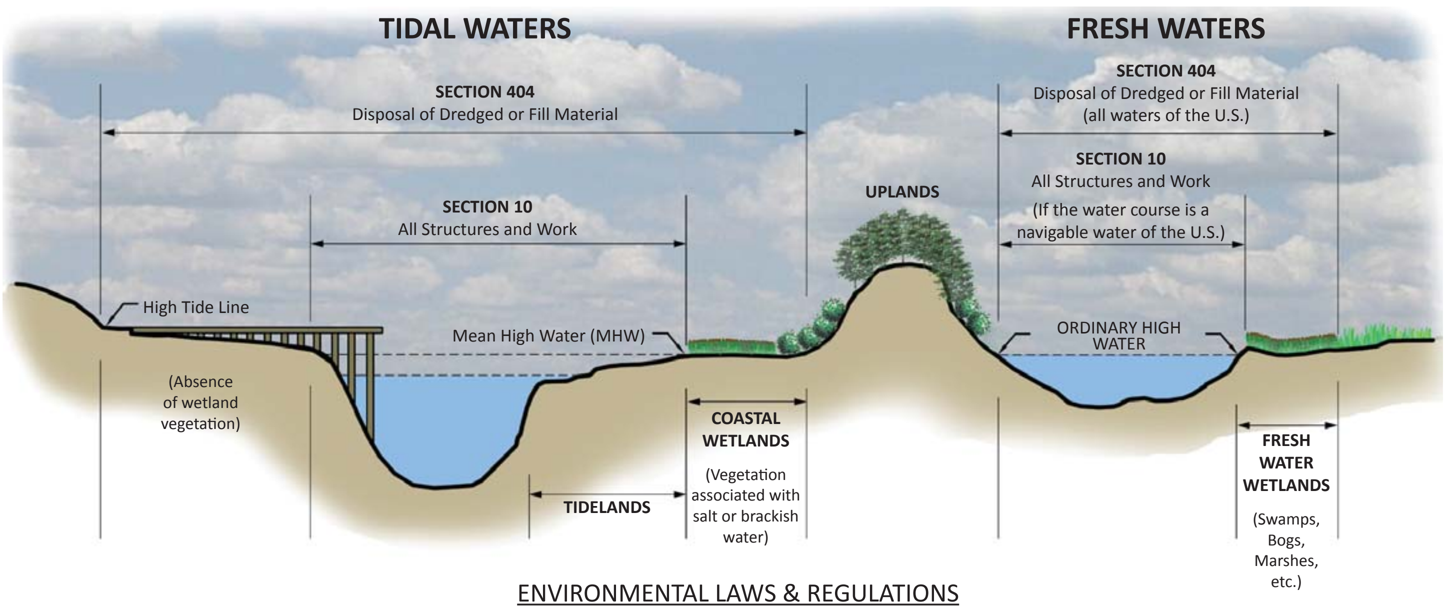
Shoreline Practices with Pros, Cons and Best Use Areas		
Practice	**Pros**	
Bulkheads	• Protection from waves in extreme conditions	
Revetments	• Wave reflection less than bulkheads • Low maintenance	
Groins/Jetties	• Increased sand on updrift side maintains beach	
Sills	• Wave attenuation • Habitat Creation • Fishing Destination	
Breakwaters	• Can withstand high wave activity • Can remain effective with minor damage • Does not interrupt natural shoreline • Low maintenance • Create habitat between breakwater and shoreline	
Clean Fill/ Dredge Material	• Encourages vegetation	
Upland Vegetation - Trees, Shrubs, Grasses and Grass Roots	• Soil stabilization in upland zone • Stormwater runoff filtration	
Wetland Vegetation - Marsh Grasses	• Improves finfish and shellfish habitat • Stabilizes soil • Traps sediment • Improves water quality by filtering runoff	
Natural Fiber Logs with Vegetation	• 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	• Can be used for moderate slopes • Low cost • Biodegradable • Traps and retains sediment	
Living Breakwaters	• Wave attenuation • Improved water quality • Increased oyster habitat • Creates a calm area near shoreline that can be planted with vegetation for improved marsh habitat	
Sediment-Filled Geotextile Tubes	• Effective erosion control • Beneficial use of dredged material	
Native Oyster Reefs	• Wave attenuation • Traps sediment • Improves water quality • Habitat development	
Small Concrete Oyster Balls	• Wave attenuation • Shelter for vegetation • Improves water quality • Habitat development	
Sill with Planted Marsh	• Absorbs waves and creates a calm area behind the sill to promote habitat and vegetation growth • Traps sediment; maintains natural shoreline • Filters runoff to improve water quality • Provides nursery habitat for juvenile fish • Maintains land-water interface • Can promote oyster growth • Long lifespan	
Marsh Toe Revetment (Existing Marsh)	• Stabilization of eroding marsh • Can promote oyster growth • Long lifespan	
Breakwaters with Transitional Wetlands	• Absorbs waves and creates a calm area behind the sill to promote habitat and vegetation growth • Traps sediment; maintains natural shoreline • Maintains land-water interface • Filters runoff to improve water quality • Provides nursery habitat for juvenile fish	

	Cons	Best Used in Areas with:
	• Prone to failure due to upland water pressure and increased erosion on the waterside • 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 • Loss of intertidal zone • Eliminates aquatic nursery habitat • Expensive to Repair	• High wave energy • Limited land availability • Narrow canals with steep banks • Structures at risk due to close proximity to shoreline erosion
	• Installation requires heavy machinery • Expensive	• High wave energy and no existing marsh
	• Erosion on downdrift side • Unnatural beach shape • Disrupts natural longshore sediment transport	• Where beach development necessary and downdrift beach not neccessary
	• Navigation hazard if not adjacent to shoreline • May cover existing habitat	• Moderate wave energy without conditions for vegetation
	• Expensive • Reduces habitat through beach formation • Navigational hazard • Trapped sand "stolen" from other areas • Subject to settling and erosion	• Moderate to high wave energy • Areas where boat wake activity and/or sand movement along the shore exists • Desire for enhanced sand beach, not marsh
	• Not effective alone in high wave energy areas	• Low wave energy • Vegetation
	• Does not improve stabilization in wetland or subtidal zones	• Appropriate soil type for native species
	• May not be able to withstand high wave action or high winds without protection • Growth may be seasonal	• Low energy shorelines with minimal boat wake action
	• Not for use in high wave energy areas or steep slopes • Can shift if not staked properly	• Low energy, as they are intended to biodegrade over time once vegetation is established.
	• Not for use in high wave energy areas	• Moderate slopes
	• Navigation hazard • Expensive • Trapped sand "stolen" from other areas	• Moderate to high wave energy, where sills not substantial enough • Absence of submerged aquatic vegetation[14] • Firm soil
	• Large-scale construction • Generally a multi-owner project	• Conditions requiring submerged structure
	• Navigation hazard	• Low energy with only minor erosion • Signs of conditions conducive for oyster growth
	• Can settle if soil too soft	• Firm sand bottom to minimize settlement • Low energy with only minor erosion
	• Navigational hazard if not adjacent to shoreline • Sill may cover existing habitat	• Signs of conditions conducive to marsh growth • Shorelines with sunlight • Shorelines with failed bulkheads • Shallow water with hard sand bottom • Tidal bayous
	• Reduces access to water • Revetment may cover existing habitat	• Shallow water near marsh edge with firm soil • Low to moderate energy areas where structure is necessary to protect plants • Marsh edge erosion
	• Navigational hazard if not adjacent to shoreline • Expensive	• Where a structure more substantial than a sill is necessary, due to water depth, underwater slope or high wave action

Living Shoreline Practice Design Considerations	
Soft/Hybrid Practices	**Design Considerations**
Clean Fill/ Dredge Material	• Use with vegetative plantings or a containment structure such as coir logs or sills, depending on location.
Upland Vegetation	• Select native vegetation based on soil and wind conditions at the site. • Select vegetation that can withstand periodic inundation by saltwater.
Wetland Vegetation	• Increase rate of success by planting native marsh grasses in the spring and in areas of existing marsh with less than 3 miles of open water.[4] Select native plant species based on appropriate turbidity and salinity levels.
Natural Fiber Logs	• Coir logs need to be secured in place, typically with stakes, parallel to the shoreline, so they are not shifted or dislodged by the moving water. These stakes can be placed through the log or tightly adjacent to the log.
Natural Fiber Matting	• Remove stones and debris from slope before placing matting. Matting is typically in rolls; place by rolling down the slope and overlap each roll. Matting will need to be stapled or staked in place. Seeding can occur before or after placing matting.
Living Breakwaters	• Complete survey for submerged aquatic vegetation before starting project.[14]
Sediment-Filled Geotextile Tubes	• Tubes and placement must be designed to smoothly dissipate energy, not too high and not too low.[14]
Oyster Reefs	• Place below mean low tide or an intertidal area.
Small Concrete Oyster Balls	• Use marine friendly concrete (pH similar to saltwater).
Sill with Planted Marsh	• Place near mean low water line.[13] • Allow a few weeks for sand fill to settle before planting. • Consider tide variation levels within planting area when designing slope of sill. • Filter fabric is placed under rock. • Place near mean low water line. • Height near mean high water in low energy settings and raised 1-2 feet above mean high water in moderate energy settings.[13] • Place gaps at natural channels or at least every 100 feet.[14] • Be cautious during construction to not damage existing marsh by access routes or material storage. • Sill should be open ended to allow water flow, should not tie into bank.
Marsh Toe Revetment (Existing Marsh)	• Place near mean low water line. • Height near mean high water in low energy settings and raised 1-2 feet above mean high water in moderate energy settings.[13] • Place gaps at natural channels or at least every 100 feet.[14] • Be cautious during construction to not damage existing marsh by access routes or material storage.
Breakwaters with Transitional Wetlands	• Height should be near mean high water in low energy settings to allow water flow. • Height can be 1-2 feet above mean high water in moderate energy settings. • If total length is greater than 100 feet, provide periodic gaps. • Wait 1-2 weeks after breakwater installation before planting the fill area, to allow for settlement. • Place tidal gaps at natural marsh channels. • Height should be near mean high water in low energy locations. Height can be raised 1-2 feet above mean high water in moderate energy locations.

4.0

PERMITTING RESOURCES



ENVIRONMENTAL LAWS & REGULATIONS

ABOVE
Environmental Laws & Regulations.
Image: Allen Engineering and Science Adapted from NOAA

4.1 Steps to Successful Shoreline Management

Engaging the Mississippi Department of Marine Resources (MDMR) early in the process is key to the success of a shoreline management project. The Mississippi Department of Marine Resources' Office of Coastal Zone Management issues permits jointly with the United States Army Corps of Engineers, Mobile District for projects constructed within the coastal zone, involving impacts to the waters of the United States, including wetlands.

The following steps are recommended:

- Understand your neighbors shoreline plans.
- Request pre-application meeting with MDMR.
- Conduct a site assessment to determine the amount of shoreline to be protected, feasibility of the project, and type of structure that can be installed.
- Hire contractor/consultant to consult on project.
- Obtain a project design and cost estimate.
- Apply for and receive permit(s) if necessary.

Your shoreline design should consider your neighbors' shoreline plans, as most shoreline approaches will be more effective when multiple properties can work together to implement similar approaches. Additionally, some shoreline treatments can have negative impacts updrift or downdrift. Considering your neighbors' plans will help minimize these conflicts. Before constructing a shoreline stabilization project, property owners should contact the state regulatory agency to apply for a construction permit. Ask for an application and information regarding the permitting process. Property owners will likely need to contact an engineer to perform a survey of their property to determine the type of structure that will be most suitable for erosion control. In addition, schedule a pre-application meeting with the regulatory agencies to ensure that your project can be approved and to expedite the application process.

The next step is completing a joint application with MDMR/USACE. Property owners file the application with MDMR, which then coordinates with other applicable agencies. During this process, the following should be included:

- Completed application form
- A narrative project description,
- A vicinity map,
- An agent authorization (if desired), and
- An environmental assessment.

Upon completing this process, if it is determined that a living shoreline project is the preferred stabilization technique, a Mississippi General Permit may be available.

For more details on the permitting process see: http://www.dmr.ms.gov/index.php/coastal-resources-management/wetland-permitting

4.2 Who to Contact

Bureau of Wetland Permitting
Mississippi Department of Marine Resources
1141 Bayview Avenue
Biloxi, MS 39530
Phone: (228) 523-4144
DMR Switchboard: (228) 374-5000
Website: http://www.dmr.ms.gov

U.S. Army Corps of Engineers, Mobile District Regulatory Division
Mobile, AL 36602
Phone: (251) 690-2658
Website: http://www.sam.usace.army.mil/
Biloxi Field Office
Phone: (228) 523-4116

5.0

MISSISSIPPI GULF COAST LIVING SHORELINE PROJECT EXAMPLES

TOP
Site of Gulf Hill Coir Log project at low tide, September 17, 2013. Coir log has degraded as designed and juncus roe has become well-established.
Image: Allen Engineering and Science

MIDDLE
Rip-rap has slowed the culvert discharge flow and stabilized the shoreline.
Image: Allen Engineering and Science

BOTTOM
Coir logs with juncus roe plugs placed along bank. September 2009
Image: MDMR

5.1 Gulf Hills Coir Log[15]

Where: Gulf Hills, Old Fort Bayou, MS
Shoreline Type: Bayou Cove
Who: Gulf Hills Garden Club
Boat Wake Exposure: Low
When: September 2009
Project Length: 200 feet

Why: Extreme bank erosion was occurring due to high velocity flow through a road culvert into the cove. Roads, yards and houses are in close proximity to the bayou in this neighborhood and bulkheads are prevalent.[15]

What: Rip-rap was installed adjacent to the culvert to minimize the speed of the culvert discharge. Twenty coir logs were placed along the remainder of the shoreline, staked and planted with 500 juncus roe plugs.[15]

Results: The total cost of the project was $6,102 ($30.5 per foot). Sediment was trapped behind the coir logs as planned. Coir logs remained in place long enough to promote vegetation growth to stabilize the bank. No damage occurred from Tropical Storm Ida (tides 4-5 feet above normal, winds 50 mph). No additional erosion has been observed since the vegetation was established and the coir log has degraded as designed.[15]

5.2 Keegan Inlet[16]

Where: Keegan Bayou, Biloxi, MS
Shoreline Type: Mouth of Bayou
Who: City of Biloxi
Boat Wake Exposure: Moderate
When: Completed December 2007
Project Length: West Shoreline length - 50 linear feet (approx. 200 square feet of fringe marsh)
East Shoreline Length - 75 linear feet (approx. 3,750 square feet of fringe marsh)

Why: Habitat restoration, erosion control and aesthetics; the old bridge abutment was an eyesore and a restriction to tidal flow and habitat growth.[16]

What: The old bridge abutment and fill was removed, new fill material was placed and graded, and fringe marsh was restored. In addition to improving habitat and aesthetics, the new marsh reduces the restrictions of the tidal flow at the mouth of Keegan Bayou.[16]

Results: Fringe marsh establishment was successful with the substrate graded to the appropriate elevation, based on the adjacent marsh. The Spartina alterniflora has thrived in this location and appears to be hardy, growing well in the wide range of temperatures and salinities. Erosion protection (silt fence or shell/small rip-rap mixed substrate) was important during construction to maintain the new fill and bare soil while planting.[16]

TOP LEFT
East bank of Keegan Inlet, Biloxi, September 2013, 5 years after living shoreline construction. Marsh vegetation healthy and well-established
Image: Allen Engineering and Science

TOP RIGHT
Keegan Inlet east bank, before project.
Image: BMI Environmental Services/ Harrison County

MIDDLE RIGHT
Keegan Inlet west bank, during construction.
Image: BMI Environmental Services/ Harrison County

BOTTOM RIGHT
Keegan Inlet east bank, after marsh plug plantings.
Image: BMI Environmental Services/ Harrison County

ABOVE
Gulf National Seashore
Image: Eco-Systems

6.0

PLANT LIST

Potential Plant list for Living Shoreline Vegetative Restoration Acitivities in Coastal Mississippi [17,18,19]		
Grasses, Sedges, and Rushes		
Common Name	**Scientific Name**	**Location**
Seashore saltgrass	*Distichlis spicata*	Saltwater, Brackish, and Tidal Freshwater Marshes
Sawgrass	*Cladium jamaicense*	Brackish and Tidal Freshwater Marshes
Gulf coast spikerush	*Eleocharis cellulosa*	Brackish and Tidal Freshwater Marshes
Soft rush, Common rush	*Juncus effusus*	Tidal Freshwater Marsh
Black needlerush	*Juncus roemerianus*	Saltwater and Brackish Marshes
Hairawn muhly	*Muhlenbergia capillaris*	Dune
Gulfhairawn muhly	*Muhlenbergia filipes*	Brackish and Tidal Freshwater Marshes
Bitter panicum, Bitter panicgrass	*Panicum amarum*	Dune
Maidencane	*Panicum hemitomon*	Tidal Freshwater Marsh
Seashore paspalum	*Paspalum vaginatum*	Brackish and Tidal Freshwater Marshes
Gulf bluestem	*Schizachyrium maritimum*	Dune
Coastal bluestem, Shore little blue stem, Seacoast little bluestem	*Schizachyrium littorale*	Dune
California bulrush	*Schoenoplectus californicus*	Tidal Freshwater Marsh
Saltmarsh bulrush	*Schoenoplectus robustus*	Saltwater and Brackish Marshes
Smooth cordgrass	*Spartina alterniflora*	Saltwater and Brackish Marshes
Marshhay cordgrass, Saltmeadow cordgrass	*Spartina patens*	Saltwater and Brackish Marshes
Gulf cordgrass	*Spartina spartinae*	Brackish and Tidal Freshwater Marshes
Seashore dropseed	*Sporobolus virginicus*	Saltwater Marsh
Seaoats	*Uniola paniculata*	Dune
Forbs and Wildflowers		
Sea oxeye daisy	*Borrichia frutescens*	Saltwater and Brackish Marsh
American searocket	*Cakile edentula*	Upland Buffer
Beach bean	*Canavalia rosea*	Dune
Partridge pea	*Chamaecrista fasciculata*	Dune
Blanket flower	*Gaillardia pulchella*	Upland Buffer
Beach sunflower	*Helianthus debilis*	Dune
Camphorweed	*Heterotheca subaxillaris*	Upland Buffer
Beach morningglory	*Ipomoea imperati*	Dune
Railroad vine, Bayhops	*Ipomoea pes-caprae*	Dune
Narrowleaf evening primrose	*Oenothera fruticosa*	Upland Buffer
Sea purslane	*Sesuvium portulacastrum*	Saltwater Marsh and Dune
Seaside goldenrod	*Solidago sempervirens*	Saltwater, Brackish, and Saltwater Marshes and Dune
Trailing wildbean	*Strophostyles helvola*	Upland Buffer

Trees and Shrubs

Common Name	Scientific Name	Location
Eastern baccharis	*Baccharis halimifolia*	Saltwater and Brackish Marsh, and Tidal Freshwater Marshes
Sea oxeye daisy	*Borrichia frutescens*	Brackish Marsh, Mangrove Swamp, Dune
Sugarberry, Texas sugarberry, Hackberry	*Celtis laevigata*	Saltwater Marsh, Dune
Salt heliotrope	*Heliotropium curassavicum*	Dune
Dahoon holly	*Ilex cassine*	Dune
Yaupon holly	*Ilex vomitoria*	Brackish Marsh, Dune
Marsh elder, Jesuit's bark	*Iva frutescens*	Saltwater and Brackish
Seashore elder	*Iva imbricata*	Dune
Salt matrimony vine, Carolina wolf berry, Christmas berry, and Carolina desert	*Lycium carolinianum*	Saltwater Marsh, Dune
Southern magnolia	*Magnolia grandiflora*	Tidal Swamp
Sweetbay magnolia	*Magnolia virginiana*	Tidal Swamp
Wax myrtle	*Morella cerifera*	Tidal Freshwater Marsh, Tidal Swamps, and Dunes
Red mulberry	*Morus rubra*	Saltwater Marsh, Dune
Blackgum, Swamp tupelo	*Nyssa biflora*	Tidal Freshwater Marsh, Tidal Swamps, and Dunes
Swamp bay	*Persea palustris*	Tidal Swamp
Slash pine	*Pinus elliottii*	Tidal Swamp
Sand live oak	*Quercus geminata*	Dunes
Cabbage palm	*Sabal palmetto*	Brackish Marsh, Mangrove Swamp, Tidal Swamp, and Dune
Saw palmetto	*Serenoa repens*	Dune
Bald cypress	*Taxodium distichum*	Tidal Swamp

* The above plant list is meant only as a guide. Please consult your local nursery to determine appropriate plant material for your specific project.

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ABOVE
Marsh Plantings at
Front Beach.
Ocean Springs, MS
Image: Allen Engineering and Science

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